2004-04-23 FONSI
EAST O'AHU TRANSMISSION PROJECT, 46KV PHASED PROJECT VOL 2 OF 2
APPENDICES

APR 2 3 2005

Hawaiian Electric Company, Inc.

East O'ahu Transmission Project
46kV Phased Project

FINAL ENVIRONMENTAL ASSESSMENT

Volume 2 of 2
APPENDICES

January 2005

FILED
2005 JAN -7 P 3:15
PUBLIC UTILITIES COMMISSION

RECEIVED
'05 APR -8 P12:14
DEPT. OF ENVIRONMENTAL QUALITY CONTROL

Hawaiian Electric Company, Inc.

East O'ahu Transmission Project
46kV Phased Project

FINAL ENVIRONMENTAL ASSESSMENT

Volume 2 of 2
APPENDICES

Prepared by Belt Collins Hawaii Ltd.

January 2005

Table of Contents

Table of Contents

Volume 1: Report

EXECUTIVE SUMMARY ES-1

TABLE OF CONTENTS i

ACRONYMS AND ABBREVIATIONS vii

CHAPTER 1
INTRODUCTION

1.1 Proposed Action 1-1
1.2 Background 1-2
1.2.1 Kamoku–Pūkele 138kV Transmission Line (via Wa'ahila Ridge) 1-5
1.2.2 46kV Phased Project 1-5
1.3 Purpose of This Document 1-6

CHAPTER 2
PURPOSE AND NEED

2.1 Pūkele Substation Reliability Concern 2-5
2.2 Ko'olau/Pūkele Overload Situation 2-8
2.3 Downtown Substation Reliability Concern 2-11
2.4 Downtown Overload Situation 2-13
2.5 East O'ahu Service Area Loads 2-15

CHAPTER 3
PROPOSED ACTION AND ALTERNATIVES

3.1 Description of Proposed Action 3-1
3.1.1 Phase 1 Construction Activities 3-3
3.1.2 Phase 2 Construction Activities 3-21
3.1.3 Operational Activities 3-35
3.2 Description of Alternatives 3-44
3.2.1 Background 3-44
3.2.2 Alternatives Evaluated In This EA 3-45
3.2.3 Alternatives Considered and Eliminated from Further Analysis 3-47

CHAPTER 4
AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES

4.1 Introduction 4-1
4.2 Land Use 4-1
4.2.1 Existing Conditions 4-1
4.2.2 Potential Impacts and Actions to Minimize Impacts 4-2
4.3 Infrastructure 4-8
4.3.1 Electrical 4-8
4.3.2 Potable Water 4-11
4.3.3 Wastewater 4-13
4.3.4 Drainage 4-14
4.3.5 Communications 4-16
4.3.6 Solid Waste 4-18
4.4 Roads and Traffic 4-20
4.4.1 Existing Conditions 4-20
4.4.2 Potential Impacts and Actions to Minimize Impacts 4-29
4.5 Public Health and Safety 4-42
4.5.1 Noise Environment 4-42
4.5.2 Emergency Response 4-48
4.5.3 Schools 4-50
4.6 Soils and Topography 4-52
4.6.1 Existing Conditions 4-52
4.6.2 Potential Impacts and Actions to Minimize Impacts 4-55
4.7 Water Resources 4-56
4.7.1 Existing Conditions 4-56
4.7.2 Potential Impacts and Actions to Minimize Impacts 4-58
4.8 Air Quality 4-60
4.8.1 Existing Conditions 4-60
4.8.2 Potential Impacts and Actions to Minimize Impacts 4-61
4.9 Cultural Resources 4-61
4.9.1 Archaeological Resources 4-61
4.9.2 Traditional Cultural Practices 4-63
4.9.3 Historic Resources 4-65
4.10 Visual and Aesthetic Resources 4-66
4.10.1 Existing Conditions 4-66
4.10.2 Potential Impacts and Actions to Minimize Impacts 4-67

4.11 Biological Resources 4-68
4.11.1 Existing Conditions 4-68
4.11.2 Potential Impacts and Actions to Minimize Impacts 4-69
4.12 Socioeconomic Environment 4-69
4.12.1 Existing Conditions 4-70
4.12.2 Potential Impacts and Actions to Minimize Impacts 4-73
4.13 Electric and Magnetic Fields (EMF) 4-78
4.13.1 Introduction 4-78
4.13.2 EMF Overview 4-79
4.13.3 Magnetic Field Evaluation for the Proposed Action 4-94
4.13.4 Prudent Avoidance 4-97

CHAPTER 5
OTHER CONSIDERATIONS

5.1 Secondary and Cumulative Impacts 5-1
5.1.1 Secondary Impacts 5-1
5.1.2 Cumulative Impacts 5-1
5.2 Irretrievable and Irreversible Commitment of Resources 5-12
5.3 Summary of Permits and Approvals 5-12
5.4 Summary of Potential Impacts and Management and Design Constraints 5-14
5.5 Finding Of No Significant Impact Determination 5-27
5.5.1 Applicant 5-27
5.5.2 Approving Agency 5-27
5.5.3 Brief Description of the Proposed Action 5-27
5.5.4 Determination and Reasons Supporting Determination 5-27
5.5.5 Name, Address, and Phone Number of Contact Person for Further Information 5-31

CHAPTER 6
PUBLIC PARTICIPATION

6.1 Pre-Assessment Consultation 6-1
6.2 Draft EA Comments and Responses 6-3
6.2.1 Comments Received Within the 30-day Comment Period 6-7
6.2.2 Comments Received After Close of 30-day Comment Period 6-215

CHAPTER 7
REFERENCES 7-1

List of Figures

Figure 1-1 Proposed Action–46kV Ductlines and Affected Substations 1-3
Figure 2-1 138kV Transmission Line System and Power Plants 2-2
Figure 2-2 Proposed 46kV Subtransmission Connections 2-3
Figure 2-3 East O'ahu Service Area 2-4
Figure 2-4 Pūkele Substation Reliability Concern 2-7
Figure 2-5 Ko'olau/Pūkele Overload Situation 2-9
Figure 2-6 Downtown Substation Reliability Concern 2-12
Figure 2-7 Downtown Overload Situation 2-14
Figure 3-1 Project Area and Neighborhoods 3-2
Figure 3-2 Proposed Construction Activities–Phase 1 3-5
Figure 3-3 Typical Ductline with Circuits and Typical Manhole 3-12
Figure 3-4 Phase 1 Construction Schedule 3-22
Figure 3-5 Proposed Construction Activities–Phase 2 3-23
Figure 3-6 Typical Ductline and Circuits for Directional Drilling Option 3-32
Figure 3-7 Phase 2 Construction Schedule 3-36
Figure 3-8 Diagram of Operational Capability–Phase 1 3-41
Figure 3-9 Diagram of Operational Capability–Phase 2 3-42
Figure 3-10 Alternative Alignments 3-46
Figure 4-1 Special Districts 4-3
Figure 4-2 Land Uses in Kaka'ako Community Development District 4-4
Figure 4-3 City and County Zoning Map 4-5
Figure 4-4 Makaloa Corridor 4-21
Figure 4-5 Vehicular Volumes by Time of Day–Phase 1 4-23
Figure 4-6 King Street Corridor 4-26
Figure 4-7 Vehicular Volumes by Time of Day–Phase 2 4-27
Figure 4-8 Census Tracts 4-71
Figure 4-9 Electromagnetic Spectrum 4-81
Figure 4-10 Diagram of Cable and Current Configurations For Magnetic Field Cancellation 4-99

List of Tables

Table 3-1 Phase 1 Construction Activities 3-7
Table 3-2 Typical Equipment for Phase 1 Construction Activities 3-16
Table 3-3 Phase 2 Construction Activities 3-25
Table 3-4 Typical Equipment for Phase 2 Construction Activities 3-29
Table 3-5 Summary of Operational Activities 3-38
Table 3-6 Operational Impacts Under Pūkele Substation Reliability Concern 3-39
Table 4-1 Summary of Special Districts and Associated Zoning 4-2
Table 4-2 Major Drainage Features 4-15
Table 4-3. 2004 Traffic Conditions Makaloa Street–Kapi'olani Boulevard Area 4-24
Table 4-4 2004 Traffic Conditions King Street Corridor 4-28
Table 4-5 Potential Traffic Impacts and Actions to Minimize Impacts Makaloa Corridor 4-30
Table 4-6 Potential Traffic Impacts and Actions to Minimize Impacts Pumehana Street Area 4-32
Table 4-7 Potential Traffic Impacts and Actions to Minimize Impacts Date Street Area 4-33
Table 4-8 Potential Traffic Impacts and Actions to Minimize Impacts Winam Avenue Area 4-35
Table 4-9 Potential Traffic Impacts and Actions to Minimize Impacts King Street Corridor (Open Trenching Option) 4-36
Table 4-10 Potential Traffic Impacts and Actions to Minimize Impacts King Street Corridor (Partial Directional Drilling Option) 4-37
Table 4-11 Comparison of Alternatives Based on Number of Days/Nights Traffic Impacted 4-39
Table 4-12 Potential Traffic Impacts and Actions to Minimize Impacts Alternative Alignment 1 (Kāheka–Kapi'olani) 4-40
Table 4-13 Potential Impacts and Actions to Minimize Impacts Alternative Alignment 2 (Kalauokalani–Kapi'olani) 4-41
Table 4-14 Maximum Permissible Sound Levels in dBA 4-43
Table 4-15 Construction Noise Sources and Actions to Minimize Impacts 4-45
Table 4-16 Soil Types 4-53
Table 4-17 Business Inventory 4-72
Table 4-18 Construction-related Employment and Incomes 4-74
Table 4-19 State Revenues Associated With Construction (Millions of 2004 Dollars) 4-76
Table 4-20 Typical Magnetic Field Values for Household Appliances 4-83

Table 4-21 Guidelines on Limits of Exposure to 50/60-Hz Electric and Magnetic Fields 4-86
Table 4-22 State Regulations that Limit Field Strengths on Transmission Line Rights-of-Way (ROW) 4-87
Table 5-1 Additional Traffic Impacts and Actions to Minimize Impacts with BRT 5-8
Table 5-2 Summary of Government Permits and Approvals 5-13
Table 5-3 Summary of Potential Impacts and Management and Design Constraints 5-14
Table 6-1 Pre-Assessment Consultations 6-1
Table 6-2 Distribution List 6-3

Volume 2: Appendices

Appendix A Horizontal Directional Drilling Feasibility Study
Appendix B Traffic Impact Study Final
Appendix C Cultural Resource Studies
C1 Archaeological Assessment
C2 Cultural Impact Assessment
Appendix D Magnetic Field Evaluation
D1 Magnetic Field Evaluation
D2 Addendum Magnetic Field Evaluation

Acronyms and Abbreviations

AAQS	Ambient Air Quality Standards
ADPV	average delay per vehicle
bgs	below ground surface
BLNR	Board of Land and Natural Resources
BMP	best management practices
BOE	Board of Education
BRT	Bus Rapid Transit
BWS	Board of Water Supply
CDP	Census Defined Place
CDUP	Conservation District Use Permit
CEIP	Campbell Estate Industrial Park
CFR	Code of Federal Regulations
CHP	combined heat and power
CIA	Cultural Impact Assessment
CIP	Campbell Industrial Park
circuits	underground subtransmission lines
CMU	concrete masonry units
dB	decibel
dBA	A-weighted sound level in decibels
DG	distributed generation
DOE	Department of Education
DOH	Department of Health
DOT	Department of Transportation
DP	City and County of Honolulu's Development Plan
DPP	Department of Planning and Permitting
DPR	Department of Parks and Recreation
DSM	demand side management
DTS	Department of Transportation Services
EA	Environmental Assessment
EIS	environmental impact statement
ELF	extremely low frequency
EMF	Electric and Magnetic Fields
EMS	Energy Management System
EOTP	East O'ahu Transmission Project
EPA	United States Environmental Protection Agency
F	Fahrenheit

FHWA	Federal Highway Administration
FONSI	Finding of No Significant Impact
GIS	gas insulated switchgear
HAR	Hawai'i Administrative Rules
HCDA	Hawai'i Community Development Authority
HDD	horizontal directional drilling
HECO	Hawaiian Electric Company, Inc.
HFD	Honolulu Fire Department
HIOSH	Hawai'i Occupational Safety & Health Administration
hp	horsepower
HPD	Honolulu Police Department
HPFF	high pressure fluid filled
HPP	Honolulu Power Plant
HRS	Hawai'i Revised Statutes
Hz	Hertz
IARC	International Agency for Research on Cancer
kcmil	A unit of measure where one kcmil is equal to 1,000 circular mils. A circular mil is the area of a circle with a diameter of one thousandth (0.001) of an inch.
kV	kilovolt
LM	load management
LOS	levels of service
LUO	Land Use Ordinance
LW	live working
mg	milligram
mG	milligauss
MS4	municipal separate storm sewer system
msl	mean sea level
MSW	municipal solid waste
MTBE	methyl tertiary butyl ether
MUZ-c	mixed-use zone commercial emphasis
MVA	megavolt ampere
MW	megawatts
NA	not available
NAAQS	National Ambient Air Quality Standards
NERC	North American Electric Reliability Council
NIEHS	National Institute of Environmental Health Sciences
NIH	National Institutes of Health

NPDES	National Pollutant Discharge Elimination System
NRC	National Academy of Sciences National Research Center
NTP	National Toxicology Program
OEQC	Office of Environmental Quality Control
OSHA	Occupational Safety and Health Administration
PCBs	polychlorinated biphenyls
Proposed Action	46kV Phased Project
PUC	Public Utilities Commission
RAPID	Research and Public Information Dissemination
RCP	reinforced concrete pipe
RCRA	Resource Conservation and Recovery Act
ROH	Revised Ordinances of Honolulu
ROW	right-of-way
SOP	standard operating procedure
TCLP	Toxicity Characteristic Leaching Procedure
TCP	Traditional Cultural Practices
TPC	transmission planning criteria
TPH	total petroleum hydrocarbons
UIC	underground injection control
USC	United States Code
USDA	United States Department of Agriculture
USGS	United States Geological Survey
V/C	volume-to-capacity
VPD	vehicles per day
WWTP	wastewater treatment plant
XLPE	cross-linked polyethylene

Appendix A

Horizontal Directional Drilling Feasibility Study

Hawaiian Electric Company, Inc.

East Oahu Transmission Project
Phase 2 – 46 kV Lines

Horizontal Drilling Feasibility Study

Prepared for
Hawaiian Electric Company
Honolulu, Hawaii 96840

August 4, 2004

PROJECT NUMBER:
105240

PROJECT CONTACT:
Jack Hand (POWER)

EMAIL: jhand@powereng.com
PHONE: 208-788-3456
FAX: 208-788-2082

PROJECT CONTACT:
Bill Riall (POWER)

EMAIL: briall@powereng.com
PHONE: 208-788-0313
FAX: 208-788-0525

POWER ENGINEERS

Table of Contents

Executive Summary ..... *v*

1 Project Description *1*

2 General Overview of Horizontal Directional Drilling *3*

2.1 Machines 3
2.1.1 Small to Medium Rigs 3
2.1.2 Large Rigs 3

2.2 Technique 3
2.2.1 Drill Profile Design Parameters 3
2.2.2 Pilot Hole 4
2.2.3 Monitoring the Drill Path 4
2.2.4 Enlarging the Pilot Hole 4
2.2.5 Product Pipeline Pullback 5

3 General HDD Issues to Consider *6*

3.1 Geotechnical Information 6

3.2 Geotechnical Information Available for the Partial HDD Project Route 6

3.3 Casing Materials 7

3.4 Casing Selection for the Partial HDD Project Route 8
3.4.1 Single Three-Circuit Casing with Long Bores 8
3.4.2 Three Bundled Casings with Long Bores 8
3.4.3 Three Individual Casings with Multiple Short Bores 8

3.5 Cable Ampacity 8
3.5.1 Steady State Ampacity Analysis 9
3.5.2 Transient Ampacity Analysis 9
3.5.3 Ampacity Required for the Partial HDD Project Route 9

3.6 Installation Configurations 10
3.6.1 Standard Duct Bank 10
3.6.2 Deep Steel Casing 10
3.6.3 Shallow Multiple Steel Casings 10
3.6.4 Shallow Multiple HDPE Casings 11

3.7 Conductor Types 11
3.7.1 Aluminum Conductor 11
3.7.2 Copper Conductor 12

3.8 Workspace at the Drill Entry Area 12
3.8.1 Large HDD Rig 12
3.8.2 Small HDD Rig 12

3.9 Lay Down Area 12

3.10 Traffic 13
3.10.1 Emergency Vehicle Routes 13
3.10.2 Bus Rapid Transit (BRT) 14
3.11 Noise 14
3.11.1 Sound Emission Abatement 14
3.12 Permitting 15
3.13 Requirements of Other Agencies 15
3.13.1 Department of Public Works 15
3.13.2 Board of Water Supply 15
3.14 Water Requirements 15
3.15 Bentonite Based Slurry 15
3.16 Cutting And Slurry Disposal 16
3.17 Inadvertent Returns 16
3.18 Risks 16
3.18.1 Geotechnical Risks 17
3.18.2 Undocumented Obstacles and Crossings 17
3.18.3 Drill Profile Accuracy 17
3.18.4 Non-continuous Pullback 17
3.18.5 Inadvertent Returns 17
4 Large HDD Machine with Single 36-inch Steel Casing 18
4.1 Geotechnical Information 18
4.2 Casing Materials 18
4.2.1 Steel Pipe 18
4.2.2 HDPE 18
4.3 Cable Ampacity 18
4.4 Conductor Types 19
4.5 Workspace at the Drill Entry Area 19
4.5.1 Drill Location 1 – Ewa Drill (2,450 feet) 19
4.5.2 Drill Location 1 – Diamond Head Drill (1,950 feet) 20
4.5.2 Drill Location 2 – Ewa Drill (1,950 feet) 20
4.6 Lay Down Area 20
4.6.1 Pullback from Manhole 1 to Manhole 2 20
4.6.2 Pullback from Manhole 3 to Manhole 2 21
4.6.3 Pullback from Manhole 3 to Manhole 4 21
4.7 Traffic 21
4.8 Noise 21
4.9 Permitting 21

4.10 Water Requirements 22
4.11 Cutting and Slurry Disposal 22
4.12 Risks 22
4.13 Cost 23
4.14 Setup Drawing 23
4.15 Schedule 23
5 Large HDD Machine with Three 10-inch HDPE or Three 8-inch Steel Casings 27
5.1 Geotechnical Information 27
5.2 Casing Materials 27
5.2.1 HDPE 27
5.2.2 Steel Pipe 27
5.3 Cable Ampacity 27
5.3.1 HPDE 28
5.3.2 Steel 28
5.4 Conductor Types 28
5.5 Workspace at the Drill Entry Area 28
5.6 Lay Down Area 28
5.6.1 Pullback from Manhole 1 to Manhole 2 29
5.6.2 Pullback from Manhole 3 to Manhole 2 29
5.6.3 Pullback from Manhole 3 to Manhole 4 29
5.7 Traffic 29
5.8 Noise 29
5.9 Permitting 29
5.10 Water Requirements 29
5.11 Cutting and Slurry Disposal 30
5.12 Risks 30
5.13 Cost 31
5.14 Setup Drawing 31
5.15 Schedule 31
6 Small to Medium HDD Machine with Three 10-inch HDPE Casings 35
6.1 Geotechnical Information 35
6.2 Casing Materials 35
6.3 Cable Ampacity 35
6.4 Conductor Types 36

6.5 Workspace at the Drill Entry Area 36
6.6 Lay Down Area 36
6.7 Traffic 37
6.8 Noise 37
6.9 Permitting 37
6.10 Water Requirements 37
6.11 Cutting and Slurry Disposal 37
6.12 Risks 38
6.13 Cost 38
6.14 Setup Drawing 38
6.15 Schedule 38
7 Summary Table 42
8 Conclusion and Recommendations 43

Appendices

A Cable Pulling Tensions
B Route Information
C Casing Material and Selection
D Cable Ampacity
E Cost Estimates
F Reference List

Executive Summary

HECO retained POWER Engineers, Inc. (POWER) to provide a feasibility study for installing three 46kV circuits in King Street from Cooke Street to McCully Street utilizing horizontal directional drilling technology.

The study reviewed the following:

- Equipment requirements
- Workspace requirements
- Cable ampacity
- Casing material alternatives
- Noise and traffic impacts from construction activity
- Costs

During the initial investigation, POWER has determined that the areas from Archer Substation to an area near the intersection of Cooke Street and King Street, and the area Diamond Head of Washington Middle School should be conventionally trenched. In the Archer Substation/Cooke Street area, numerous bends are required to route the cables from the substation located within HECO's Ward Avenue facility, onto Cooke Street and then around the corner onto King Street. HDD techniques require nearly straight sections. In the area Diamond Head of Washington Middle School to McCully Street, there are insufficient workspace and lay down areas to consider HDD. Additionally, due to the present electrical configuration, there is no common termination point for all three circuits; rather, each circuit is to be terminated in a different location. With no common terminus, a single borehole will not allow access to each circuit. Therefore, this study examines the use of HDD techniques on King Street from Cooke Street to Washington Middle School, a length of approximately 6,350 feet. For the purposes of this study, the area of King Street from Cooke Street to Washington Middle School will be referred to as the "partial HDD project route."

For the partial HDD project route, POWER identified four possible horizontal directional drill installation methodologies and reviewed the advantages and disadvantages of each method. HDD is not infeasible for King Street between Cooke Street and Washington Middle School; however there are several challenges that must be resolved before HDD can be considered a practical alternate to conventional trenching. These points of concern are discussed below.

Ampacity
In terms of ampacity, regardless of the HDD installation methodology, neither aluminum nor copper conductor met the design criteria of 678 amps. If HECO were willing to accept that these cables could be loaded for only up to six hours, then 1500 kcmil aluminum conductor would meet this limited criterion. Otherwise, conventional trenching must be utilized.

Traffic
Traffic lanes on King Street are 10 feet wide and therefore two lanes will have to be blocked at the drill rig site for 27 to 152 days, depending on the installation methodology

selected. Equipment required for HDD cannot be removed from the roads during peak traffic hours on a daily basis. Therefore, exceptions to the requirements of the City and County of Honolulu Street Usage Permits will be necessary for HDD to be feasible.

To avoid blocking cross traffic on major cross streets, such as Keeaumoku Street and Kalakaua Avenue, it would be necessary to install the product pipeline in a shallow trench that is plated so cross traffic is not impacted. For the scenario utilizing the small to medium drill rig and short bores, nearly every cross street along King Street could be blocked at some time during pullback. The need to trench major roadway intersections, with the related traffic disruptions, would negate some of the hoped-for benefits leading to the consideration of the use of HDD technology.

Noise

Installation of an HDPE casing with a large HDD machine would generate multiple sound sources. At the drill rig, a maximum of 108 dBA can be expected. The sound from other sources, such as the mud pump, can be expected to be on the same order of magnitude. Incorporating sound barriers in close proximity to the machine may reduce noise levels to 70 dBA. Smaller drill rigs have lower power and water requirements and therefore, when properly equipped with high noise reduction mufflers, are quieter. Regardless, a special noise permit will be required for either size drill rig.

If these problems can be overcome, HDD may be feasible. However, logistics for the drilling and pullback operations along King Street between Cooke Street and McCully Street will be challenging due to the urban setting. HECO will need cooperation from the City and property owners in the area to proceed.

1 *Project Description*

Hawaiian Electric Company (HECO) is proposing to construct new electric power facilities in the East Oahu area to improve the reliability of electric service to customers. Most power on Oahu is produced in the Ewa area and flows to east Oahu through two corridors of 138 kV lines (the Northern Corridor and the Southern Corridor). Presently, these two corridors are not connected at the eastern end, so there is no way to move electric power between these corridors in East Oahu. This project, named the "East Oahu Transmission Project", is designed to connect these two electrical corridors to improve reliability and flexibility in delivering power to customers in the eastern Oahu area (downtown to Hawaii Kai and Kahuku to Makapuu).

The Proposed Action would reconfigure and connect existing 46 kV circuits from Pukele Substation at the end of the Northern Transmission Corridor with existing and new 46 kV circuits from the Southern Transmission Corridor. This action is planned in two independent phases. The first phase, Phase 1, is designed to address the electrical concerns expected to need earliest attention. It would address the potential overload of the transmission lines providing power to the Koolau Substation, which in turn affects Pukele Substation, and would partially address reliability concerns associated with Pukele and Archer Substations. Phase 2 activities would address remaining areas still vulnerable to the Pukele Substation reliability concern.

Phase 1 involves the installation of 0.5 miles of underground ductline[1] for 46kV subtransmission lines, and related work at eight substations, in order to interconnect three 46kV circuits out of the Pukele Substation, at the end of HECO's Northern 138kV transmission corridor, to four 46kV lines connected to HECO's Southern 138kV transmission corridor. Phase 1 activities would occur in the Ala Moana, Waikiki, McCully, Moiliili, and Kapahulu areas.

Phase 2 involves the installation of 1.9 miles of underground ductline for 46kV subtransmission lines, and related work at one substation, in order to interconnect four out of the five remaining 46kV circuits out of the Pukele Substation to three other 46kV lines connected to HECO's Southern 138kV transmission corridor. Phase 2 would occur in the Kakaako, Ala Moana, and McCully areas, predominantly on King Street.

In March, 2004, the City Department of Facilities Maintenance requested that HECO consider the use of Horizontal Directional Drilling (HDD) along King Street in the Phase 2 portion of the proposed 46kV Phased Project. This request was made to HECO by the City agency during the course of a consultation meeting for the environmental assessment being prepared for the project.

HECO retained POWER Engineers, Inc. (POWER) to provide a feasibility study for installing three 46kV circuits in King Street from Cooke Street to McCully Street utilizing horizontal directional drilling technology.

---

1 The term "ductline" is used to describe the underground corridor that houses multiple ducts or pipes encased in concrete. One duct could be used to contain one cable or multiple cables, depending on the size of the ducts and cables. Three cables make up one 46 kV "circuit."

The study will review the following:

- Equipment requirements
- Workspace requirements
- Cable ampacity
- Casing material alternatives
- Noise and traffic impacts from construction activity
- Costs

POWER has determined that the areas from Archer Substation to an area near the intersection of Cooke Street and King Street, and the area Diamond Head of Washington Middle School should be conventionally trenched. A more complete discussion of this follows later in the report. Therefore, this study examines the use of HDD techniques on King Street from Cooke Street to Washington Middle School, a length of approximately 6,350 feet. For the purposes of this study, this will be referred to as the "partial HDD project route".

2 General Overview of Horizontal Directional Drilling

Originally used in the 1970s, directional crossings are a marriage of conventional road boring and directional drilling of oil wells. Pipelines have been installed for carrying oil, natural gas, petrochemicals, water, sewerage and other products. Ducts have been installed to carry electric and fiber optic cables. Besides crossing under rivers and waterways, installations have been made crossing under highways, railroads, airport runways, shore approaches, islands, areas congested with buildings, pipeline corridors, future water channels and urban development.

The longest installation, since the inception of horizontal directional drilling, has been approximately 7,000 feet with pipe diameters up to 60 inches. Although directional drilling was originally used primarily on the U.S. Gulf Coast through alluvial soils, more and more crossings are being undertaken through gravel, cobble, glacial till and hard rock. Adequate space must be available to allow rigs to setup permanently for the duration of the installation.

2.1 Machines

There are numerous types of machines available for HDD. They are primarily categorized by thrust and pullback force capabilities.

2.1.1 Small to Medium Rigs

Small to medium sized rigs have thrust and pullback forces of less than 50,000 pounds. Typically these rigs have ranges limited to 2 to 1,500 feet and can install 2 to 20 inch product casings depending on length and specific forces.

2.1.2 Large Rigs

Large sized rigs have thrust and pullback forces greater than 50,000 up to 1,000,000 pounds. Bore ranges can exceed 5,000 feet and typically can be used to install 6 to 60 inch product casings.

For this analysis, we will refer to the small to medium rigs as small rigs.

2.2 Technique

2.2.1 Drill Profile Design Parameters

The drill profile is designed after the geotechnical investigation is complete, and the location of existing obstacles and crossings, such as other utilities, are determined. The drill profile is designed to allow a minimum depth of cover below surface grade and all obstacles. The recommended minimum depth of cover below surface grade is 10 feet to prevent loss of drilling fluids.

The entry angle can be between 8° and 20° for most installations. It is preferable that straight tangent sections are drilled before the introduction of a long radius curve. The radius of the curve is constrained by the bending characteristic of the product pipeline. A general "rule-of-thumb" for steel pipe is that the radius of curvature is approximately 100 feet for each one-inch of pipe diameter.

The drill profile follows a downward sloping curve to the design elevation. Long horizontal bores can be made at this elevation before curving up towards the exit point. The exit angle should be kept between 5° and 12° to facilitate handling of the product pipeline during pullback and to facilitate handling of the casing when connecting to the extension of the existing duct line or manholes.

2.2.2 Pilot Hole

A pilot hole is drilled beginning at a prescribed angle from horizontal and continues under and across obstacles along the design profile made up of straight tangents and long radius arcs. Concurrent to drilling the pilot hole, the contractor may elect to run a larger diameter "wash pipe" that will encase the pilot drill string. The wash pipe acts as a conductor casing, providing rigidity to the smaller diameter pilot drill string and also holding the drilled hole open if it becomes necessary to retract the pilot string for bit changes.

Directional control is brought about by a small bend in the drill string just behind the cutting head. The pilot drill string is not rotated except to orient the bend. If the bend is oriented to the right, the drill path then proceeds in a smooth radius bend to the right.

2.2.3 Monitoring the Drill Path

The drill path is monitored by an electronic package housed in the pilot drill string near the cutting head. The electronic package detects the relation of the drill string to the earth's magnetic field and gravitational fields and the drill string's inclination. This data is transmitted back to the surface where calculations are made as to the location of the cutting head.

Most downhole survey tools are electronic devices that provide a magnetic azimuth, for right and left control, and inclination, for up and down control. Surface locators can also be used in conjunction with the downhole electronic package. Other methods of tracking the progress of the bore can be used if site access conditions permit, such as radio transmitters. Alternate methods such as gyroscoping, ground penetrating radar or "intelligent pigs"[2] may also be used to determine the as-built position.

The accuracy of the drill profile is largely dependent on variations in the earth's magnetic field. Large steel structures such as bridges, pilings, other pipelines and transmission lines affect magnetic field readings. However, a reasonable drill target at the pilot hole exit location is 10 feet left or right, and –10 feet to +30 feet in length. In large, open areas, this level of accuracy is usually acceptable. However, in an urban environment with numerous utilities in the roadway, such as this, as the drill rig approaches the surface, care must be taken to accurately track the progress of the bore by installing a radio transmitter in the drill string and carefully monitoring the drill path.

2.2.4 Enlarging the Pilot Hole

Once the pilot hole is complete, it must be enlarged for the product pipeline. For example, if a 36-inch diameter pipeline is to be installed, the hole may be

[2] Intelligent pigs are devices that are inserted into and travel throughout the length of a pipeline to provide information on the condition of the pipe or the contents.

enlarged to 48 to 54 inches in diameter or sometimes even larger. This is accomplished by "pre-reaming" the hole to successively larger diameters. The reamer is attached to the drill string on the end opposite the drilling rig and pulled back into the pilot hole. Joints of drill stem are removed as the reamer makes its way back to the entry pit. Large quantities of slurry are pumped into the hole to maintain the integrity of the bore and to flush out cuttings. Back reaming removes the soils that will be replaced by the casing.

2.2.5 Product Pipeline Pullback

When the drilled hole is large enough, the product pipeline is pulled through it. The pipeline is fabricated at the exit end of the bore. A reamer is attached to the drill string and then connected to the pipeline pull head via a swivel. The swivel prevents any translation of the reamer's rotation into the pipeline string. The drilling rig then begins the pullback operation by rotating and pulling on the drill string. High volumes of drilling slurry are circulated to lubricate the pipeline allowing for a smooth pullback into the drilled hole. The pullback continues until the reamer and pipeline break ground at the drilling rig.

3 General HDD Issues to Consider

In order to make a determination that a project can be directionally drilled, numerous factors must be taken into consideration. An evaluation of these factors will determine if HDD is the appropriate technique to be used. A discussion of the factors that should be evaluated follows.

POWER has determined that the areas from Archer Substation to an area near the intersection of Cooke Street and King Street, and the area Diamond Head of Washington Middle School should be conventionally trenched. In the Archer Substation/Cooke Street area, numerous bends are required to route the cables from the substation located within HECO's Ward Avenue facility, onto Cooke Street and then around the corner onto King Street. HDD techniques require nearly straight sections. In the area Diamond Head of Washington Middle School to McCully Street, there are insufficient workspace and lay down areas to consider HDD. Additionally, due to the present electrical configuration, there is no common termination point for all three circuits; rather, each circuit is to be terminated in a different location. With no common terminus, a single borehole will not allow access to each circuit. Therefore, this study examines the use of HDD techniques on King Street from Cooke Street to Washington Middle School, a length of approximately 6,350 feet. For the purposes of this study, the area of King Street from Cooke Street to Washington Middle School will be referred to as the "partial HDD project route."

3.1 Geotechnical Information

Geotechnical information is required to confirm the type of soils that will be encountered during the bore. This information is used to:

- Determine the downhole equipment required
- Determine penetration rates
- Ensure that the driller will have the proper bits and tooling
- Determine the thermal resistivity of the soil for cable ampacity calculations

When conducting a geothermal investigation for an HDD project, the number of exploration holes is a function of the proposed installation length and the complexity of the strata. If the report indicates anomalies, discontinuity in the strata, the presence of rock or large concentrations of gravel, it is advisable to take additional boring samples to better define the strata.

3.2 Geotechnical Information Available for the Partial HDD Project Route

Five boreholes drilled at various locations along the partial HDD project route identified sands and clay silts with some weathered coral interspersed. POWER's review of the bore logs indicate that in regard to the geotechnical conditions, HDD techniques are not infeasible for the majority of the partial HDD project route.

While enough geotechnical data was provided to determine that HDD is not infeasible, if HECO decides to pursue HDD, it is POWER's recommendation that additional test borings be taken to verify the soil strata types. The new borings should be strategically located to supplement the available geotechnical data. Additional test

samples will also supply the information needed to optimize cable pulling, locate manholes and ensure an efficient and cost effective drilling operation.

3.3 Casing Materials

Many different types of casing and conduit materials are available for use with HDD installations. Materials used for electric utility installations include steel and polyvinyl chloride (PVC) conduit, while materials used in other piped utilities include large diameter steel pipes with inner ducts spaced by bore spacers and high-density polyethylene (HDPE). Steel pipe has been used for pipe type cable installations with HDD techniques to cross under obstacles such as highways, waterways and airport runways. Many installations of steel pipe in such crossings have been made using various coatings to protect the pipes. More recently, fusion bonded epoxy coatings protected by other coatings such as epoxy based concrete have been used. These newer coatings are more abrasion resistant when being pulled through the bores.

The following table provides generalized recommendations for the selection of steel pipe wall thickness relative to pipe diameter. These recommendations are meant to be used only as a starting point in the design process. It is recommended that in the final design, specific stresses be calculated and compared with allowable limits.

Diameter (D)	Steel Pipe Wall Thickness (t)
6 in. and smaller	0.250 in.
6 to 12 in.	0.375 in.
12 to 30 in	0.500 in.
For 30 in. and larger	OD/t= DR= 50

High Density Polyethylene (HDPE) conduits are available in many sizes and wall thickness. For HDPE pipe, a standard dimension ratio (outside diameter divided by wall thickness) of 11 or less is recommended. In addition, the pipe manufacturer should be consulted to confirm availability of a specific size and grade of HDPE.

Common to all sizes of HDPE pipe is the method of joining the duct lengths by fusion butt-welding. This is accomplished by placing the ends of the pipe to be joined in a bonding machine where they are aligned and milled. The pipe is heated and forced together under pressure while molten to produce a weld. Properly made joints are stronger than the pipe itself. This differs from steel pipe welds, which are time consuming and for which x-rays must be taken to ensure the integrity of the weld.

A weld bead is formed both inside and outside of the joint. If necessary, the inner weld bead can be removed, either by machine or hand depending on the pipe inside diameter, to produce an absolutely smooth interior. One disadvantage of HDPE is that it has a relatively high thermal resistivity on the order of 400 °C-cm/W. The walls of the pipes being proposed in this study are thicker than the normally used PVC materials in HDD installations. This application will have higher pullback tensions, requiring the installed casing and ducts to have higher tensile strengths enough to withstand the rigors of installation.

During the design, the stresses imposed during construction and when in-service must be calculated and checked to be within allowable limits for the grade of material

selected. The stresses at each state must be considered individually and in combination. These are the stresses that result from spanning between rollers prior to pullback, hydrostatic testing pressures, pulling forces during installation, the radius of curvature as the pipe enters the ground, the drilling profile curvature, external pressures in the drilled hole and the working pressure.

Additional information about casing and conduit selection is included as Appendix D.

3.4 Casing Selection for the Partial HDD Project Route

Based on identified potential workspace locations, the longest conceivable bore for the partial HDD project route is approximately 2,450 feet. This would be the segment from Cooke Street to McKinley High School. Two possible scenarios were evaluated -- a single large casing with inner ducts, or multiple smaller casings. Steel and HPDE casings were evaluated. Initial calculations eliminated the use of HDPE casing with a 30-inch or greater outer diameter, because the commercially available casing sizes would not have sufficient tensile strength required for the pullback operation.

3.4.1 Single Three-Circuit Casing with Long Bores

If a single casing is used, a 36-inch outer diameter casing will be required to provide space inside for inner ducts to install nine cables suitably spaced for ease of future maintenance and to better dissipate heat. HDPE casings of this large size are not commercially available and would need to have such thick walls to attain sufficient tensile strength for pullback that there would be inadequate space for the cables and heat dissipation. For these reasons, the use of HDPE as the outer casing was eliminated and only steel considered.

HDPE inner ducts provide adequate tensile strength for the installation of the duct bundle within the casing because they do not have to withstand the rigors of the pullback operation by the HDD machine. Due to the large diameter of the casing, and its accompanying 3,600-foot bending radius, it is estimated the minimum installation depth would be 50 feet.

3.4.2 Three Bundled Casings with Long Bores

If three bundled casings are used, three bundled 10-inch HDPE pipes or three bundled 8-inch steel pipes could be used as the casing material for a single longest bore of up to 2,450 feet. The bending radius for this smaller diameter pipe is substantially less than that for a 36-inch casing, resulting in a minimum bore depth of 13.9 feet.

3.4.3 Three Individual Casings with Multiple Short Bores

If three individual casings are used, three 10-inch HPDE pipes would be installed, one at a time, over distances of approximately 500 feet. As mentioned above, the bending radius for this smaller diameter pipe is substantially less than that for a 36-inch casing, resulting in a minimum bore depth of 13.9 feet

3.5 Cable Ampacity

When current flows on an electrical cable, heat is generated. Ampacity is dependent on the ability of the heat produced to dissipate into the surrounding earth. In general, the deeper a conductor is located below surface grade, the more difficult it is for that heat to dissipate. The soil surrounding the cables acts as an insulating material,

trapping heat from escaping. Since HDD installations are typically much deeper below surface grade than conventional trenching, the thermal resistivity characteristics of the soil become more important. However, if the conduits are located below the water table, good thermal energy transfer between the electrical cables and the surrounding earth is expected and the depth becomes less important.

Based on the geotechnical report, borehole #5 located near Washington Middle School identified soil with high thermal resistivity. As a result, the last 25 to 30 feet from the ends of the bores to the manhole locations, where the drills near the surface, should be trenched and the native soil replaced with fluidized thermal backfill.[3]

When current flows on an electrical conductor, it takes a finite amount of time for the cables to heat up. For this reason, cables are rated for steady-state operation to ensure conductor temperatures do not exceed levels that would damage the cable. In addition, cables can be operated at a higher current level, for a much shorter period of time, before causing permanent damage to the cable. For this reason, steady state and transient ampacity analyses are conducted.

Unique to steel pipes is the ampacity loss due to eddy and circulating currents that would be induced in the steel casing. It is estimated that ampacity of the cable would suffer a 10% loss due to these currents, thereby derating the cables (See Ampacity Table in Appendix E).

3.5.1 Steady State Ampacity Analysis

The term "steady state" means a continuous current for the cables just sufficient to produce asymptotically the maximum conductor temperature with the surrounding ambient conditions assumed constant.

3.5.2 Transient Ampacity Analysis

Transient thermal analysis is performed to assess the maximum permissible currents that a cable can sustain over a specific period of time without violating cable material thermal specifications. These violations could either lead to imminent cable failure or substantially shorten the cable's life expectancy by causing premature damage to the cable.

For the transient analysis, the following assumptions were made:

- One amp as normal load on each circuit
- Ultimate short circuit is 5,000 amps for a duration of 30 cycles
- Open sheath splices and single point grounded cable sections
- Load factor of 0.7[4]

3.5.3 Ampacity Required for the Partial HDD Project Route

Regardless of the construction method, HECO requires three circuits installed at 46kV. These circuits will be used when the Pukele Substation is out of service.

---

[3] Fluidized thermal backfill is a concrete mixture with low thermal resistivity properties. It is used in lieu of native soil to backfill a trench because its heat dissipation properties allow the cables to operate at lower temperatures than native soil. Lower temperatures increase the current carrying capacity of the cables and reduce risk of overheating and damage.

[4] Load factor is defined as the load current over a given time period (typically 24-hours) divided by the peak current.

Therefore the normal loading on these circuits is zero. The following Pukele Outage ampacity requirements were supplied by HECO:

Pukele Outage Ampacity Requirements

Circuit	Amps	Year
Archer 45	280A 362A	2009 2029
Archer 47	326A 421A	2009 2029
Archer 48	649A ** 678A	2009 2029

** This forecasted ampacity requirement in 2029 for the Archer 48 circuit is 838 amps. However, 838 amps will be difficult to achieve even using conventional open trench construction. Therefore, HECO requires that for the partial HDD project, the minimum allowable ampacity is 678 amps, as this is the ampacity that would be achievable if conventional trenching were utilized. Regardless of the method of construction, as future loads occur, HECO plans to evaluate and redistribute loads in the Archer Substation service area to balance the loads between the eight 46 kV circuits fed from Archer Substation and prevent load on the Archer 48 circuit from increasing to 838 amps.

Detailed ampacity calculations are included in Appendix E.

3.6 Installation Configurations

Several different installation configurations were considered.

3.6.1 Standard Duct Bank

The duct bank consists of nine 5-inch PVC ducts arranged in a 3-row by 3-column array. The dimensions of the concrete envelope of the duct bank are 32-inches high by 31-inches wide. The top of the duct bank is at a depth of 44-inches below surface grade. Ambient soil temperature of 25°C was assumed, as well as a rho[5] of 60°C-cm/W for concrete and 110°C-cm/W for the native soil. Ambient air temperature of 40°C was also assumed.

3.6.2 Deep Steel Casing

The 36-inch steel casing consists of nine 5-inch HDPE ducts arranged in a 3-row by 3-column array by using bore spacers. For this analysis it was assumed that the casing is buried at a depth of 50 feet below surface grade. Ambient soil temperature of 25°C was assumed, as well as a rho of 60°C-cm/W for casing grout and 110°C-cm/W for the native soil. Ambient air temperature of 40°C was also assumed.

3.6.3 Shallow Multiple Steel Casings

Installation of the cables in shallow multiple steel casings would utilize a cradled configuration, one circuit in each of the three casings as shown below. The installation depth was modeled at 20 feet below surface grade. During

[5] Rho is the unit of measure of thermal resistivity. Thermal resistivity is an indication of how strongly a material opposes a change in temperature. A material with a low thermal resistivity transfers heat easily.

installation of the ducts, considerable over reaming of the borehole will occur and the annulus of the bore between its wall and the casings would be filled with drilling fluids and cuttings. Since this material will have a rho most likely larger than the native soils, a space around the pipes was modeled with a rho of 120 °C-cm/W. Other assumptions are air temperature of 40 °C, soil temperature of 25°C and rho of the native soil of 110°C-cm/W.

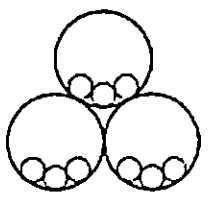


Figure 3-1: Cables in Cradled Configuration

3.6.4 Shallow Multiple HDPE Casings

Installation of the cables in shallow multiple HDPE casings would utilize a cradled configuration, one circuit in each of the three casings. The installation depth was modeled at 20 feet below surface grade. During installation of the ducts, considerable over reaming of the borehole will occur and the annulus of the bore between its wall and the casings would be filled with drilling fluids and cuttings. Since this material will have a rho most likely larger than the native soils, a space around the pipes was modeled with a rho of 120 °C-cm/W. Other conditions are air temperature 40 °C, soil temperature 25°C, rho of native soil is 110°C-cm/W.

3.7 Conductor Types

HECO typically installs 46 kV, 1500 kcmil aluminum cross-linked polyethylene cable.[6] HECO desires to use this same cable for the EOTP to minimize cable accessories and tools that must be kept in stock. Although aluminum conductor is desired, aluminum and copper conductors were considered in this analysis.

3.7.1 Aluminum Conductor

Aluminum conductors are typically used by HECO. The typical specification for the conductor is ASTM B3 in ¾ hardness (1350-H16). Aluminum conductors have a lower ampacity than copper conductors of the same size, in the same operating conditions. In addition, aluminum conductors have a tensile strength of 6,000 psi, which results in lower allowable pulling tensions. The advantage of aluminum conductor is that it is lower in weight and typically less costly than copper conductor.

[6] Kcmil is a unit of measure where one kcmil is equal to 1000 circular mils. A circular mil is the area of a circle with a diameter of one thousandth (0.001) of an inch.

3.7.2 Copper Conductor

Copper conductors are generally used in electrical installations where larger current carrying capabilities are needed. The typical specification for the conductor is ASTM B8 annealed after stranding. Copper conductors have a tensile strength of 8,000 to 10,000 psi, which results in higher allowable pulling tensions. Although HECO prefers to use aluminum conductor, copper conductor was evaluated because of its superior current carrying capabilities and tensile strength for longer pulls.

3.8 Workspace at the Drill Entry Area

A key consideration of HDD projects is that the drilling equipment must remain in position for the duration of the installation.

Heavy equipment is required at the entry and exit points of the bore. Different workspace requirements are necessary for the different size rigs. Once equipment has been set in place, this equipment cannot be moved until the segment is completed.

3.8.1 Large HDD Rig

The large rig requires a minimum 100-foot wide by 150-foot long area, extending from the entry point away from the installation. The entry point should be at least 10 feet inside the prescribed area. Since many components of the rig spread have no predetermined position, the rig site can be made up of smaller irregular areas. Operations are facilitated if the area is level, hard and clear of overhead obstructions.

3.8.2 Small HDD Rig

The small rig requires a minimum 12-foot wide by 100-foot long area, extending from the entry point away from the installation. The installation point's leading edge can be very close to the installation boundary, since the rig is smaller and the entry pit does not have to be as large as for the larger machine. Many of the features of the larger machines, such as the mud pump, are incorporated on the chassis of the smaller machine, making these machines more "self-contained." Additional space is necessary for a mud mixing truck and some method of cleaning mud returns, such as a truck with a vacuum pump and tank to suck up the returned mud. Much of the heavier mud recycling equipment and tanks is purely optional with the smaller rigs, since with the smaller rigs, large volumes of cuttings and slurry are not generated.

3.9 Lay Down Area

In the pipeline lay down area, sufficient length of workspace is necessary to fabricate the product pipeline into one continuous string. For example, if manholes are located 2,450 feet apart, then a length of 2,450 feet should be available beyond the exit pit for product pipe lay down prior to pullback into the drilled hole.

The width can be as little one traffic lane for product casing assembly and pullback, but a second lane will be intermittently blocked to unload pipe as needed. Tie-ins of successive strings during the pullback operation increase the risk of the pre-reamed hole collapsing. In addition, the risk of the casing sticking during pullback increases

considerably because the pullback operation will have to start and stop for the addition of each successive string. This increases the risk of not completing an installation successfully. For the case at hand, if the large casing option is to be considered, the risk of collapse and sticking will increase.

Logistics for the drilling and pullback operations along King Street between Cooke Street and McCully Street will be difficult due to the urban setting. HECO will need cooperation from the City and property owners in the area to make HDD feasible.

3.10 Traffic

HDD techniques can minimize traffic disruption when boring underneath and perpendicular to a roadway. However, due to the need for drill entry areas and lay down areas, HDD can sometimes cause, rather than minimize, additional traffic disruption. Regardless of the casing size or drill lengths, advanced traffic planning would minimize traffic disruption. In addition, an intensive information campaign will be necessary to notify the public of the construction locations.

City and County of Honolulu Street Usage Permits generally allow the following:

- Only one lane of traffic can be closed during work
- Normal work hour closures are from 8:30 AM to 3:00 PM
- Equipment must be removed from roads during peak traffic hours
- Special permits will be required to work outside normal hours, for example at night

Exceptions to the requirements of the City and County of Honolulu Street Usage Permits will be necessary for HDD to be feasible. For example, equipment required for HDD cannot be removed from the roads during peak traffic hours on a daily basis.

To avoid completely blocking the heavily traveled streets crossing King Street, a shallow trench would have to be dug across those intersections that could be blocked by the HDD pipe assembly and pulling operation. The pipe could then be laid out, assembled and placed within the trench and the trench could be covered with steel plates to allow vehicular travel. After the drilling operations are complete, the temporary trench would be backfilled and the roadway surface restored. However, the need to trench major roadway intersections, with the related traffic disruptions, would negate some of the hoped-for benefits leading to consideration of the use of HDD technology.

3.10.1 Emergency Vehicle Routes

During product casing pullback operations, hospital emergency entrances and other emergency routes cannot be blocked. Details will have to be developed with all emergency services during detailed design.

3.10.2 Bus Rapid Transit (BRT)

The City of Honolulu has plans to develop BRT, an electric bus system, in the makai curb lane of a portion of the King Street route. The timing and location of this project must be considered during detailed design.

HDD requires a continuous time period to complete pullback operations. The necessity for continuous disruption during pullback operations must be weighed against the traffic impacts of conventional trenching.

3.11 Noise

Directional drilling equipment produces noise. The State of Hawaii Department of Health Office of Radiation and Noise Control monitors compliance with noise level rules.

In general, allowable noise levels at the property line in a business district are as follows:

60 dBA from 7:00 a.m. to 10:00 p.m.
50 dBA from 10:00 p.m. to 7:00 a.m.

A special permit is required for noise levels in a business district at the property line for the following:

≤ 95 dBA from 5:30 p.m. to 9:00 a.m.
> 95 dBA from 9:00 a.m. to 5:30 p.m. (except holidays and Sundays)

The noise level produced by HDD is greater than the regulatory limits, especially if the large HDD rigs are used. Small rigs will also exceed the requirements of the rules unless they are equipped with special mufflers and sound deadening devices.

Special sound barriers to redirect and absorb sound can be erected to mitigate anticipated noise levels. Contractors have utilized sound barrier walls to reflect noise and absorb a percentage of the sound waves. If even then the anticipated noise level still exceeds allowable noise limits, HECO would need to acquire a special permit. A special permit will likely take 3 to 4 months to obtain and may require a public notice and hearing.

3.11.1 Sound Emission Abatement

Sound emission abatement at a directional drilling site can be accomplished utilizing one of several methods depending on the desired outcome. Various types of materials and equipment can be utilized for the absorption, re-direction or dissipation of both long and short sound waves.

When determining a noise mitigation program for a given site and surrounding environment, the various considerations include:

- Assessment of the area for identification of land uses that may be affected by the proposed construction noise
- Evaluation of noise levels from equipment during peak operation

- Determination of existing noise levels in the vicinity of the proposed construction sites
- Examination and evaluation of noise abatement measures

3.12 Permitting

No special permits are required for directional drilling beyond those that would be required for conventional trenching.

3.13 Requirements of Other Agencies

Other City and County agencies were consulted to determine the additional requirements for HDD.

3.13.1 Department of Public Works

In general, crossings by all other utilities shall be greater than 24-inches from existing waster water lines without encasement of these lines. In addition, the Department requires approval of HECO's design drawings. The City & County of Honolulu Department of Public Works Waste Water Management has no known proposed projects that would conflict with the proposed project.

3.13.2 Board of Water Supply

The Board of Water Supply can provide a set of water distribution maps for the area and a list of standard notes to be included on HECO design drawings. In general, all water lines are buried with 3 feet of minimum cover. The Board is unaware of any new projects in the area of proposed work.

3.14 Water Requirements

Horizontal directional drilling machines require a city water hookup for machines greater then 50,000 lbs. The small machines will utilize a water truck, which will require refilling at the drill location daily.

3.15 Bentonite Based Slurry

The directional crossing process requires the use of large volumes of slurry that functions:

- Provide hydraulic cutting
- Provide energy to the drill motor
- Lubricate the cutting head
- Transport drill cuttings to the surface
- Stabilize the hole against collapse
- Guard against loss of slurry into surrounding formations.[7]

The slurries most commonly used are bentonite based. Bentonite is a naturally occurring Wyoming clay known for its hydrophilic characteristics. Often polymer extenders are added to enhance certain characteristics such as to prevent clays gumming the cutting heads. Polymer based muds have been used where intrusion of salt water into the bore has caused "clumping" of the bentonite.

7 The bentonite builds a cake inside the hole left by the pilot bore and back reamer. As water migrates into the soil surrounding the hole, the bentonite and other additives form a cake that holds the soil back helping to keep the hole open

The slurry is pumped downhole and circulates back to the surface where it is collected in "return pits." These pits typically have a volume of at least 500 cubic feet. Depending on the nature of the project, the slurry is pumped from the return pits to a "settling and containment pit." These pits vary in size depending on pumping rates and contain the slurry for recycling or disposal.

Slurry that has been circulated downhole and collected in the containment pit is then passed through machinery that separates the cuttings from the slurry. This process involves a series of shaking sieves and various size hydroclones. Wet cuttings are removed for disposal and the remaining drilling slurry is recycled into the drill rig.

3.16 Cutting And Slurry Disposal

Large amounts of slurry will be disposed during and/or at the end of a project. Cuttings from the reamed hole plus at least a volume of mud equal to the volume of the casing must be removed from site. If the large HDD machine is used, the volume of cutting and slurry to be removed for this project will require transportation to an intermediate site for drying and mixing of dried materials with the wet spoils. The materials would be dried until they pass the "paint filter" test meaning there is no free water present. The dried materials would then be properly disposed.

If working in an area of existing soil contamination, the slurry would be tested and disposed in compliance with government requirements. If the slurry does not contain any subsurface contaminants, once dried, the material can either be disposed of at an approved landfill or taken by a local contractor for use as fill or topping at another construction site on Oahu.

3.17 Inadvertent Returns

Inadvertent returns, called frac-outs, can occur when drilling fluids, injected under high pressure and flow rates during the drilling operation, find an unanticipated path to an area remote of the intended location. Unanticipated fissures in the soil layers that allow the drilling fluids to rise to the earth's surface or enter an unintended estuary or storm drain cause frac-outs.

If flow rates are low and caught early enough, frac-outs can be minimized with fluid additives composed of a material that plugs off small fissures in the soils surrounding the bore.

Proper planning, including adequate geotechnical borings, will minimize the risk of frac-out. Recordation of readings of mudflow rates and pressures facilitates early detection of frac-out.

Since frac-outs are not uncommon and difficult to predict, the issue should be included in presentations to permitting bodies prior to construction.

3.18 Risks

The risks associated with HDD are different than those encountered during traditional open trench construction.

3.18.1 Geotechnical Risks

There is always the risk that unknown soil conditions exist between geotechnical bore locations. For example, if unanticipated hard rock is encountered, drilling through this rock may take substantially longer than estimated.

With the known geotechnical data in the King Street area, the subsurface conditions are suitable for large HDD machines because the soils are of the same geologic type and are firm enough to reasonably ensure directional control of the bore. Additionally, no tooling changes would have to be made during any one bore to accommodate outcroppings of rock, and no soft areas would be encountered that might jeopardize steering control.

3.18.2 Undocumented Obstacles and Crossings

Directional drills are designed to avoid existing obstacles and crossings, such as other utilities. Accurate drawing records are not always available meaning there is always the risk that undocumented obstacles will be encountered.

3.18.3 Drill Profile Accuracy

As discussed earlier, a reasonable drill target at the pilot hole exit location is 10 feet left or right, and –10 feet to +30 feet in length. For the partial HDD project route, this level of inaccuracy is not acceptable.

3.18.4 Non-continuous Pullback

If the product pipeline cannot be fabricated into one continuous string, the risk of not completing an installation increases. Tie-ins of successive strings during the pullback operation increase the risk of the pre-reamed hole collapsing and the risk of the casing sticking during pullback increases considerably because the pullback operation will have to start and stop for the addition of each successive string.

3.18.5 Inadvertent Returns

Even with proper planning and adequate geotechnical borings there is the risk of frac-outs. In addition to work stoppage and immediate cleanup, there is the risk that the borehole will need to be abandoned and another path followed.

4 *Large HDD Machine with Single 36-inch Steel Casing*

For this scenario, two drill locations and four manholes are required. Drill location #1 is located at McKinley High School and drill location #2 is at Washington Middle School. At drill location #1, bores will be drilled in the Ewa direction (2,450 feet) and then the Diamond Head direction (1,950 feet). At drill location #2, one bore will be drilled in the Ewa direction (1,950 feet). Manholes will be located near Cooke Street (MH1), at drill location #1 (MH2), between Cedar and Sheridan Streets (MH3) and at drill location #2 (MH4). Figure 4-1 shows the overall layout for this scenario.

4.1 Geotechnical Information

As discussed in section 3.5, based on the geotechnical report, the soil in the area near Washington Middle School has a high thermal resistivity. As a result, the last 25 to 30 feet from the ends of the bores to the manhole location, where the drills near the surface, should be trenched and the native soil replaced with fluidized thermal backfill. For the remainder of the route, the majority of the casing will be below the water table and therefore good thermal energy transfer between the electrical cables and the surrounding earth is expected.

4.2 Casing Materials

4.2.1 Steel Pipe

In this scenario the installation would use of a 36-inch steel casing with 0.750-inch thickness. The minimum-bending radius of the casing would be 3,600 feet resulting in an installation depth of 50 feet below grade.

4.2.2 HDPE

HDPE cannot be used as an external casing due to lack of tensile strength at the larger sizes that would be necessary for longer distances. For long steel casings, inner ducts are normally used to facilitate installation of the power cables within the casings. Due to the long length of this bore, estimated to be 2,450 feet, one option for these inner ducts would be HDPE. HDPE inner ducts would be non-metallic ducts that could withstand the stresses of being pulled this length within the steel casing.

Typically when inner ducts are installed in a large steel casing, the ducts are installed using spacers to separate the ducts to allow for grouting. When installing inner ducts, torsion induced during pullback can cause the ducts to "corkscrew" into the casing. This is a concern when trying to maintain circuit position through the length of the casing. On short "jack and bore" installations, a metal angle iron track is installed in the bottom of the casing to prevent "corkscrewing" of the inner ducts. This may not be appropriate in a long length casing such as proposed here and therefore it may not be possible to maintain the orientation of the ducts for the length of the bore. Each duct would then need to be proofed and labeled at each end to ensure proper phasing.

4.3 Cable Ampacity

Enhanced thermal performance can be achieved by filling the space between the individual conduits and the casing with a flowable grout that is injected into the voids

between the inner ducts and outer casing under pressure. The grout material is typically a Portland cement and sand with low thermal resistivity properties. This weak concrete mixture is not intended to have any structural properties and does not harden. In the case of a long bore, grouting becomes a challenge due to the crushing pressures of the grout on the inner ducts. Pressure on the steel casing will be introduced when pumping the grout. This can be managed by filling the inner ducts with water prior to grouting.

Grouting on long bores is normally done by using a sacrificial pipe installed approximately 1/3 the length of the bore from each end. Grout is pumped from both ends towards the center prior to grouting the ends. Due to the bore's length, it is uncertain if this method will ensure complete fill. It may be necessary to flood the normally grouted space with water and accept less than optimal thermal performance since the thermal resistivity of water is greater than that of grout. In addition, sacrificial pipes also reduce available duct space within the inner diameter of the casings.

For the ampacity studies in this evaluation, POWERs modeled the casing filled with grout. Further investigation will be necessary if this scenario is selected. The ampacities calculated using the CymeCap computer program were reduced by 10% to account for eddy and circulating current losses in the steel casing. The ampacities that can be expected include:

For steady state condition
1500 kcmil aluminum conductor: 514 amps
1500 kcmil copper conductor: 636 amps

For the six hour transient loading condition
1500 kcmil aluminum conductor: 1207 amps

4.4 Conductor Types

Neither aluminum nor copper conductor met the design criteria of 678 amps. If HECO were willing to accept that these cables could be loaded for only up to six hours, then 1500 kcmil aluminum conductor would meet this limited criterion.

4.5 Workspace at the Drill Entry Area

The project will require three separate drills from two drill locations. A steel casing with an outer diameter of 36-inches is required to accommodate nine 5-inch ducts.

There are two sites that are technically feasible for setting up large drill rigs on King Street. They are in lanes 2 and 3 in front of McKinley High School, drill location 1, and lanes 2 and 3 in front of Washington Middle School, drill location 2.

4.5.1 Drill Location 1 – Ewa Drill (2,450 feet)

A large HDD rig will be setup in lanes 2 and 3 in front of McKinley High School. Ancillary equipment associated with the drilling will be setup in McKinley High School near the Piikoi street end of the campus. This setup is shown in Figure 4-2. A pilot hole would be drilled toward Ewa along King Street approximately 2,450 feet to a point near Cooke Street, manhole 1.

The drill path would reach a depth of 50 feet below grade with an entry angle of 10 degrees. The hole would then be back reamed to between 54 and 60 inches to permit adequate space to pull in the inner ducts. The reaming would most likely have to be a multi pass operation with each pass enlarging the hole. Adequate mud flow rates will be used to ensure the large volumes of cuttings can remain suspended in the drilling fluid and be transported back to the drill rig for separation and removal as the drilling fluid is re-circulated through the system.

When back reaming is completed, the casing will be pulled from near Cooke Street to McKinley High School where manhole 2 will be located.

4.5.2 Drill Location 1 – Diamond Head Drill (1,950 feet)

The drill rig would then be turned around and would bore in the Diamond Head direction along King Street, a distance of 1,950 feet, to an exit point on King Street between Cedar and Sheridan Streets. The hole would then be back reamed and the casing pulled from the location between Cedar and Sheridan Streets to McKinley High School. This exit point would ultimately become manhole 3.

4.5.2 Drill Location 2 – Ewa Drill (1,950 feet)

The drill rig would then be relocated to the Washington Middle School and a pilot hole drilled in the Ewa direction a distance of 1,950 feet to intersect the other bore on King Street between Cedar and Sheridan Street. The hole would then be back reamed and the casing pulled from the location between Cedar and Sheridan Streets to Washington Middle School where manhole 4 will be located.

4.6 Lay Down Area

Once the borehole is opened to its final diameter, the casing will be pulled back into the reamed hole. One challenge to installing a steel casing of these lengths will be finding sufficient space to layout continuous pullback lengths. Prior to pullback, the contractor would close the appropriate traffic lane, move the casing in line with the drill rig and begin pullback. The pullback would continue until completion with breaks when additional sections of casing are joined to the casing string.

It is possible to finish pullback by the Monday morning rush hour if work commences on Saturday and no unforeseen problems are encountered. Unforeseen problems such as equipment failure or underground anomalies increase the possibility that pullback will still be taking place on Monday morning.

4.6.1 Pullback from Manhole 1 to Manhole 2

The product casing would be assembled along King Street from manhole #1 located near Cooke Street toward Alapai Street in sections as long as allowable. If unable to layout beyond Alapai Street and the King/Kapiolani fork, manhole #1 may need to be relocated. The lay down area for assembling the casing material would be approximately 600 feet long and would extend along King Street in the Ewa direction from the intersection of Cooke and King Streets. Based on this, it is estimated that a minimum of four sections of pullback would be required. This will increase the pullback time and risk due to casing assembly time. There is a risk of hole collapse and the risk of overcoming static surface friction when re-starting the pullback operation. Although this risk exists, it is a not uncommon in urban areas to pullback in multiple sections. Pullback for a 2,450-foot bore will

take 30 to 40 hours for the 36-inch casing and an additional 3 to 4 hours for each joint made during pullback.

Once the casing is pulled to McKinley High School from manhole #1 near Cooke Street, both product ends would be capped and buried at design grade.

4.6.2 Pullback from Manhole 3 to Manhole 2

From manhole 3 near Sheridan Street, the casing assembly area will be along King Street towards Punahou Street. During this pullback operation, Keeaumoku Street and Kalakaua Avenue need to be closed to traffic for the duration of the pullback period. This 1,950 foot drill would take 25 to 35 hours to complete, with an additional 3 to 4 hours required for each joint made during pullback.

4.6.3 Pullback from Manhole 3 to Manhole 4

Likewise for the section from Washington Middle School, manhole 4, towards manhole 3 near Sheridan Street, the casing assembly area will be along King Street from manhole 3 near Sheridan Street towards McKinley High School. During this pullback operation, Pensacola and Piikoi streets will need to be closed to traffic for the duration of the pullback period. Similarly, this 1,950 foot drill would take 25 to 35 hours to complete, with an additional 3 to 4 hours required for each joint made during pullback.

4.7 Traffic

As discussed in section 3.10, detailed advanced traffic planning is required. This scenario would require lane closure of two lanes of King Street for 35 days.

Due to the size of the casing, it may not feasible to construct a shallow trench to avoid blocking major intersections during pullback. The following intersections could be blocked as follows:

Intersection	Days Blocked
Alapai Street and King/Kapiolani Fork	3 days
Keeaumoku Street & Kalakaua Avenue	3 days
Pensacola & Piikoi Streets	3 days

4.8 Noise

Installation of a single 36-inch steel casing with a large HDD machine would generate multiple sound sources. At the drill rig, a maximum of 108 dBA can be expected. The sound from other sources, such as the mud pump, can be expected to be on the same order of magnitude, i.e. between 100 to 110 dBA, without sound barriers. Incorporating sound barriers in close proximity to the machine may reduce noise levels to 70 dBA. It is expected that a combination of noise reducing techniques and noise barriers will be utilized.

4.9 Permitting

A City and County of Honolulu Street Usage Permit and a Special Noise Permit would be required.

4.10 Water Requirements

The large HDD machine requires a city water hook-up.

4.11 Cutting and Slurry Disposal

Drilling fluid equal in volume to that of the casing will be displaced from the hole. This fluid will have to be either saved for future use in the next bore or disposed of by drying or adding other dry material to it so that it can be sent to a landfill or used as fill or topping at another construction site on Oahu.

Assuming minimal loss of fluid, a relatively simple calculation of volumes of material to be disposed of can be performed.

The volume of soils to be removed is calculated as follows:

Outer Diameter of Reamed Hole: 60 inches
Length of Largest Bore: 2,450 feet

Volume of Soil: $\pi \times \left(\frac{30}{12}\right)^2 x 2{,}450\ ft.$

= 48,105.6 cubic feet = 1781.7 cubic yards

Volume of Drilling Fluid: $\left[\pi\left(\frac{30}{12}\right)^2 - \pi\left(\frac{18}{12}\right)^2\right] x 2{,}450\ ft.$

Total Volume: 1781.7 + 1140.3 = 2922 cubic yards

Assuming the wet cuttings and mud would be mixed with a dry material of equal volume, the total volume of excess material for disposal or recycling would be 5,844 cubic yards. This material would weigh approximately 100 pounds per cubic foot or 2,700 pounds per cubic yard. Using a cost of $10 per cubic yard for hauling and $75 per ton for tipping, the disposal charge would be:

Volume = 5,844 cubic yards
Weight = 2,700 pounds per cubic yard
Cost to Haul = $10 per cubic yard
Cost of Tipping = $75 per ton X (2,700 pounds per cubic yard/2,000 pounds per ton)
= $101.25 per cubic yard or $265.36 per foot for a 60-inch diameter bore

Total Cost = (5,844 X 10) + (5,844 X 2,700 X 75) = $650,145 for a 2,450 foot bore

For a bore length of 6,350 feet, the total cost of spoils disposal is $1,685,036. This does not include the cost for dry material to mix with the wet cuttings.

4.12 Risks

There is always the risk that unknown soil conditions exist between geotechnical bore locations. For example, if unanticipated hard rock is encountered, drilling through this rock may take substantially longer than estimated.

With the known geotechnical data in the King Street area, the subsurface conditions are suitable for large HDD machines because the soils are of the same geologic type and are firm enough to reasonably ensure directional control of the bore. Additionally, no tooling changes would have to be made during any one bore to accommodate outcroppings of rock, and no soft areas would be encountered that might jeopardize steering control.

In addition, associated with pullback in sections, there is the risk of hole collapse and the risk of overcoming static surface friction when re-starting the pullback operation.

4.13 Cost

Cost estimates for HDD are shown in Appendix F. Note however that this cost is for directional drilling only. The initial installation cost of Phase 2, of which the cost for HDD is a part, is $17 to $19 million, as estimated by HECO in the memo attached in Appendix F. Note that this cost includes the section from Washington Middle School to McCully Street that must be conventionally trenched.

4.14 Setup Drawing

Figure 4-2 shows the setup required for this scenario.

4.15 Schedule

Day 1:	**Mobilize at McKinley High School** ▪ HDD rig trailers ▪ Drill ▪ Control cabinet ▪ Mud cleaner and mixer ▪ Auxiliary equipment
Day 2:	▪ Connect equipment except for drill
Day 3:	▪ Close lanes one and two to excavate needed trench ▪ Plate lane one ▪ Close lanes two and three to excavate entry pit ▪ Install hydraulic, mud circulation, electric lines and drill rig
Day 4:	▪ Drill pilot hole 2,450 feet to manhole 1 near Cooke Street
Day 5:	▪ Continue drilling pilot hole to manhole 1
Day 5:	▪ Complete drilling pilot hole to manhole 1
Day 7:	▪ Commence back reaming from manhole 1 to McKinley High School
Day 8:	▪ Continue back reaming from manhole 1 to McKinley High School
Day 9:	▪ Finish back reaming hole from manhole 1 to McKinley High School
Day 10:	**24-hour operation commences** ▪ Casing transported in 40 foot sections to King Street lane 2 Ewa of manhole 1 for assembly in closed traffic lane ▪ Begin assembly of casing and pullback in approximately 600-foot sections. **Alapai Street and King/Kapiolani fork could be closed**
Day 11:	▪ Continue casing assembly and pullback **Alapai Street and King/Kapiolani fork could be closed**
Day 12:	▪ Complete casing assembly and pullback **Alapai Street and King/Kapiolani fork could be closed** **24-hour operation ends**
Day 13:	▪ Turn drill rig around ▪ Dig entry pit towards Sheridan Street
Day 14:	▪ Drill pilot hole 1,950 feet to manhole 3

Day 15:	▪ Continue drilling pilot hole to manhole 3
Day 16:	▪ Continue drilling pilot hole to manhole 3
Day 17:	▪ Complete pilot hole to manhole 3 ▪ Commence back reaming from manhole 3 to McKinley High School
Day 18:	▪ Continue back reaming from manhole 3 to McKinley High School
Day 19:	▪ Complete back reaming from manhole 3 to McKinley High School
Day 21:	**24-hour operation commences** ▪ Casing transported in 40 foot sections to King Street lane 2 Diamond Head of manhole 3 for assembly in closed traffic lane ▪ Begin assembly of casing and pullback in approximately 600-foot sections **Keeaumoku Street and Kalakaua Avenue could be closed**
Day 22:	▪ Continue casing assembly and pullback **Keeaumoku Street and Kalakaua Avenue could be closed**
Day 23:	▪ Complete casing assembly and pullback **Keeaumoku Street and Kalakaua Avenue could be closed** **24-hour operation ends**
Day 24-26:	▪ De-mobilize drill rig and repair street at McKinley High School
Day 27:	▪ Perform maintenance to drill rig
Day 28:	**Mobilize at Washington Middle School** ▪ HDD rig trailers ▪ Drill ▪ Control cabinet ▪ Mud cleaner and mixer ▪ Auxiliary equipment
Day 29	▪ Close lanes one and two to excavate needed trench ▪ Plate lane one ▪ Close lanes two and three to excavate entry pit ▪ Install hydraulic, mud circulation, electric lines and drill rig
Day 30:	▪ Drill pilot hole 1,950 feet to manhole 3
Day 31:	▪ Continue drilling pilot hole to manhole 3
Day 32:	▪ Complete pilot hole to manhole 3 ▪ Commence back reaming from manhole 3 to Washington Middle School
Day 33	▪ Continue back reaming from manhole 3 to Washington Middle School
Day 34:	▪ Complete back reaming from manhole 3 to Washington Middle School
Day 35:	**24-hour operation commences** ▪ Casing transported in 40 foot sections to King Street lane 2 Ewa of manhole 3 for assembly in closed traffic lane ▪ Begin assembly of casing and pullback in approximately 600-foot sections **Pensacola and Piikoi Streets could be closed**
Day 36:	▪ Continue casing assembly and pullback **Pensacola and Piikoi Streets could be closed**
Day 37:	▪ Complete casing assembly and pullback **Pensacola and Piikoi Streets could be closed** **24-hour operation ends**
Day 38:	▪ Remove drill rig from King Street and repair street at Washington Middle School
Day 39:	▪ De-mobilize drill rig from Washington Middle School

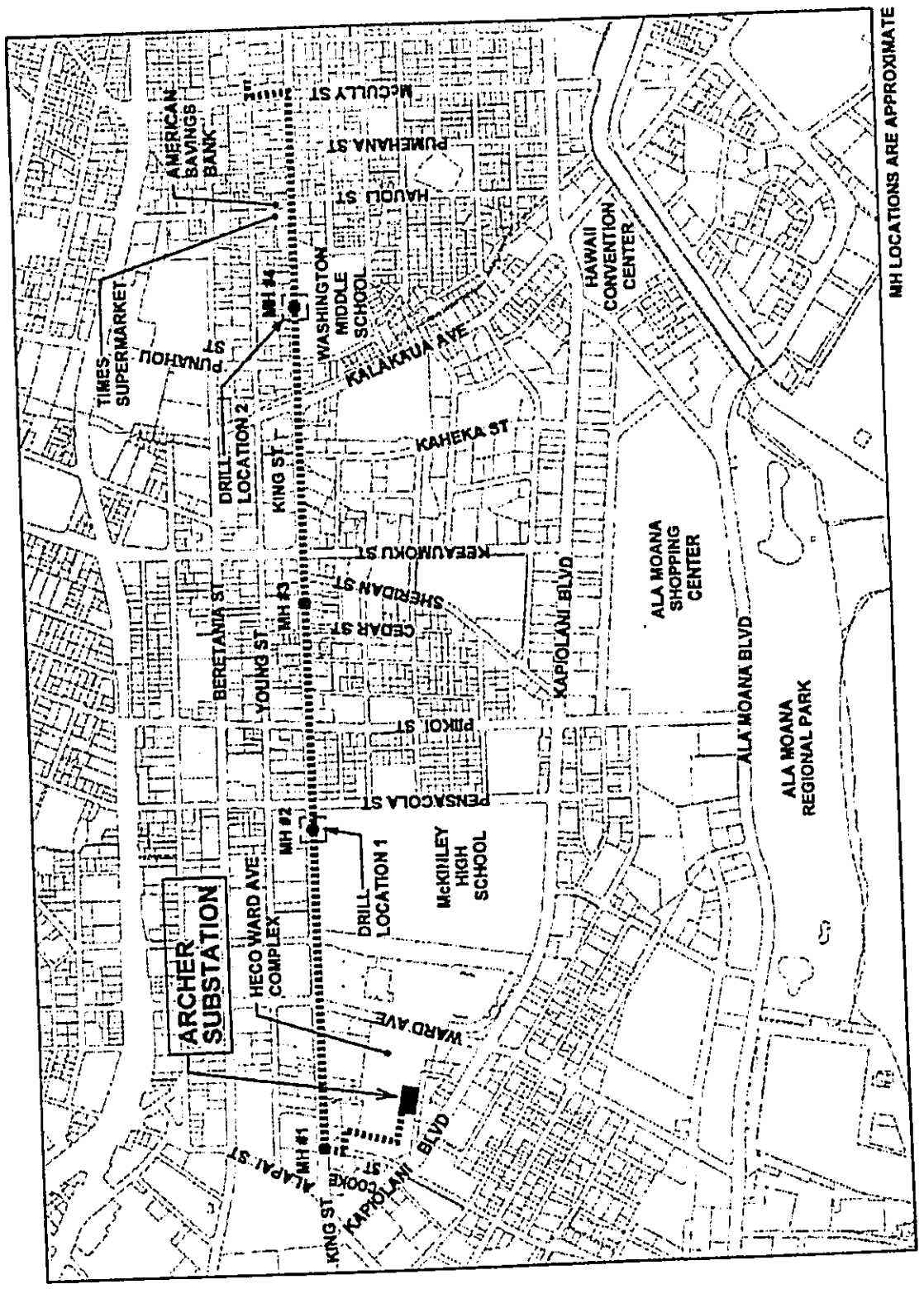

MH LOCATIONS ARE APPROXIMATE
TIMES SUPERMARKET
AMERICAN SAVINGS BANK
PUNAHOU ST
DRILL LOCATION 2
MH #4
KING ST
WASHINGTON MIDDLE SCHOOL
McCULLY ST
PUMEHANA ST
HAUOLI ST
KALAKAUA AVE
KAHEKA ST
HAWAII CONVENTION CENTER
KEEAUMOKU ST
SHERIDAN ST
CEDAR ST
BERETANIA ST
YOUNG ST
MH #3
KAPIOLANI BLVD
ALA MOANA SHOPPING CENTER
ALA MOANA BLVD
ALA MOANA REGIONAL PARK
PIIKOI ST
PENSACOLA ST
MH #2
DRILL LOCATION 1
McKINLEY HIGH SCHOOL
ARCHER SUBSTATION
HECO WARD AVE COMPLEX
WARD AVE
MH #1
ALAPAI ST
KING ST
COOKE ST
KAPIOLANI BLVD

Figure 4-1

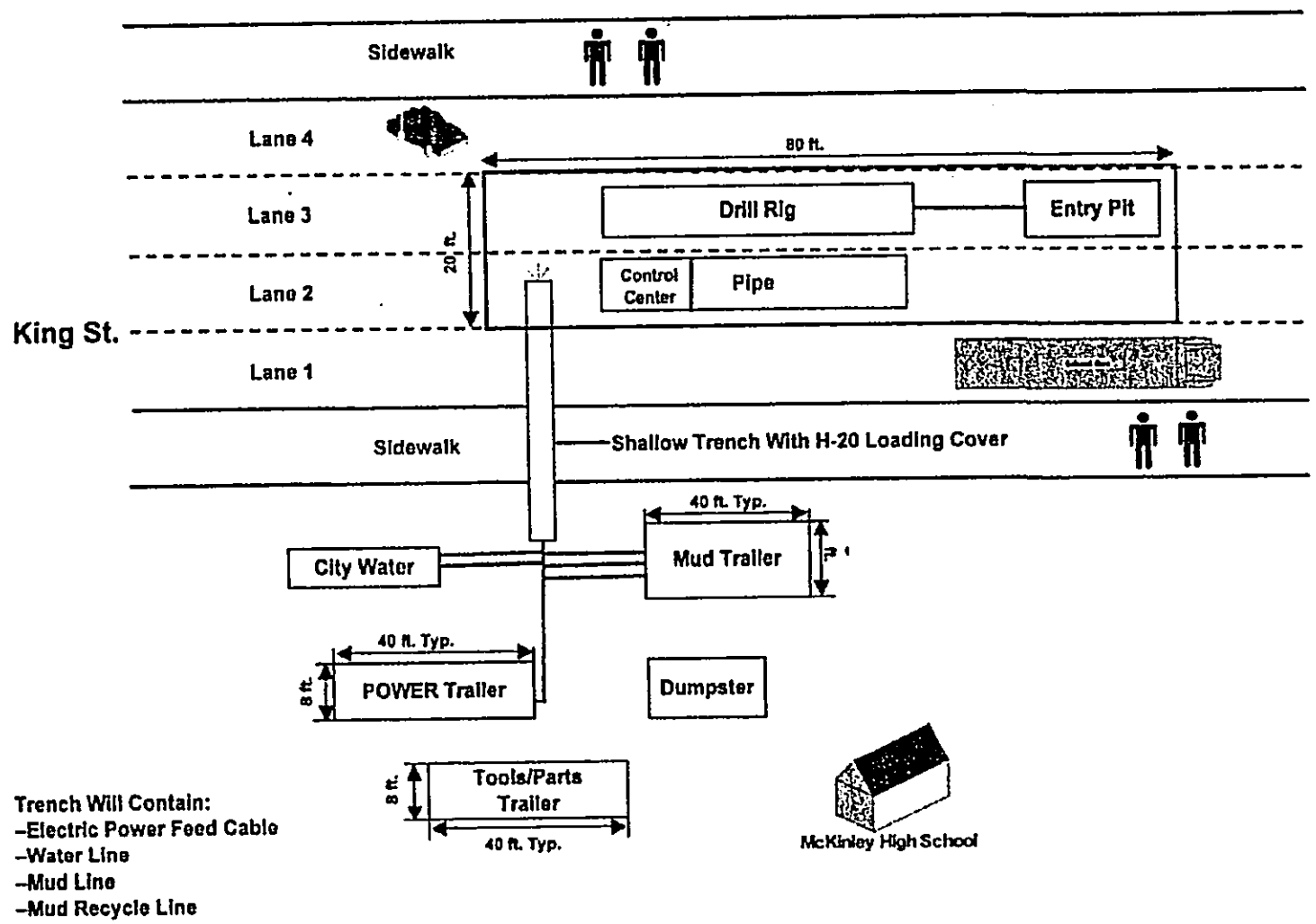

Large HDD Setup at McKinley High School
Sidewalk
Lane 4
80 ft.
Lane 3
Drill Rig
Entry Pit
20 ft.
Lane 2
Control Center
Pipe
King St.
Lane 1
Sidewalk
Shallow Trench With H-20 Loading Cover
40 ft. Typ.
City Water
Mud Trailer
40 ft. Typ.
8 ft.
POWER Trailer
Dumpster
8 ft.
Tools/Parts Trailer
40 ft. Typ.
McKinley High School
Trench Will Contain:
-Electric Power Feed Cable
-Water Line
-Mud Line
-Mud Recycle Line

Figure 4-2

5 *Large HDD Machine with Three 10-inch HDPE or Three 8-inch Steel Casings*

In terms of layout, this scenario is identical to the previous. Two drill locations and four manholes are required. Drill location #1 is located at McKinley High School and drill location #2 is at Washington Middle School. At drill location #1, bores will be drilled in the Ewa direction (2,450 feet) and then the Diamond Head direction (1,950 feet). At drill location #2, one bore will be drilled in the Ewa direction (1,950 feet). Manholes will be located near Cooke Street (MH1), at drill location #1 (MH2), between Cedar and Sheridan Streets (MH3) and at drill location #2 (MH4). Figure 5-1 shows the overall layout for this scenario. The difference with this scenario is that it involves the installation of three bundled ducts, HDPE or steel. One bore would be made to accommodate the non-spaced bundle of three ducts.

5.1 Geotechnical Information

See section 4.1.

5.2 Casing Materials

5.2.1 HDPE

This scenario involves the installation of three 10-inch High Density Polyethylene Ducts (HDPE). It was assumed that a minimum-bending radius for the bundle of 3 ducts would be 800 feet. With this bending radius, the minimum depth that one could install the bundle, based on HDD limitations and consideration of expected obstacles such as box culvert storm drains, is an installation depth of 20 feet. This would be advantageous in that greater ampacity for a given cable size would result.

HDD contractors consider HDPE a more desirable duct type because it is easier to assemble when compared to steel and is more flexible, thereby allowing tighter bending radii for a given size casing. From an ampacity standpoint, HDPE also eliminates losses due to eddy and circulating currents that occur in steel casings.

A diameter ratio (DR) 11 pipe was selected and modeled. This pipe has an outer diameter of 10.75 inches and an inner diameter of 7.62 inches. However, due to the length of the bore, estimated to be 2,450 feet for the longest bore, a DR 9 pipe may be required. This pipe has an outer diameter of 10.75 inches and an inner diameter of 8.2 inches. This pipe will provide more tensile strength for the pullback in the longer bore and more inner diameter to install the cable.

5.2.2 Steel Pipe

A sub-alternate to this would be to install 3-8-inch steel casings using the same technique. A steel casing was modeled using a 10% de-rating factor for the steel.

5.3 Cable Ampacity

The ampacities expected for these scenarios depend on the casing material used.

5.3.1 HPDE

The following ampacity can be expected for three 10-inch HDPE:

For steady state condition
1500 kcmil aluminum conductor: 493 amps
1500 kcmil copper conductor: 600 amps

For the six hour transient loading condition
1500 kcmil aluminum conductor: 1226 amps

5.3.2 Steel

The following ampacity can be expected for three 8-inch steel casings assuming a 10% derating:

For steady state condition
1500 kcmil aluminum conductor: 515 amps
1500 kcmil copper conductor: 627 amps

For the six hour transient loading condition
1500 kcmil aluminum conductor: 1052 amps

5.4 Conductor Types

Neither aluminum nor copper conductor met the design criteria of 678 amps. If HECO were willing to accept that these cables could be loaded for only up to six hours, then 1500 kcmil aluminum conductor would meet this limited criterion.

5.5 Workspace at the Drill Entry Area

For a bundle of three 10-inch outer diameter HDPE or three 8-inch steel casings installed in a single bore. The installation techniques are similar to those in the single steel casing system discussed above except that the minimum bending radius for the casings would be substantially less then the 3,600 feet required for the 36-inch outer diameter steel casing. It is estimated that the minimum-bending radius could be reduced to 800 feet, which would result in a minimum bore depth of 13.9 feet. with a 10° entry angle. However, based on prior knowledge of the depths associated with box culvert storm drains and other below ground utility installations, POWER recommends an installation depth of 20 feet. This would allow a 1,200-foot bending radius using a 10° entry angle.

The drilling activities would proceed as described in section 4.5.

5.6 Lay Down Area

Once the borehole is opened to its final diameter, all three product casings will be laid out in the second traffic lane prior to pullback. An estimated 1,200-foot space would be available to lay out casings. As a result, the pullback operation will need to be accomplished in stages. As mentioned previously, there is additional risk associated with starting and stopping the pullback operation.

To avoid completely blocking the heavily traveled streets crossing King Street, a shallow trench could be dug across those intersections that would be blocked by the HDD pipe assembly and pulling operation. The pipe could then be laid out, assembled

and placed within the trench and the trench could be covered with steel plates to allow vehicular travel. After the drilling operations are complete, the temporary trench would be backfilled and the roadway surface restored. During detailed design, HECO may be able to optimize manhole locations to lessen traffic impacts on some cross streets. However, the need to trench major roadway intersections, with the related traffic disruptions, would negate some of the hoped-for benefits leading to consideration of the use of HDD technology.

5.6.1 Pullback from Manhole 1 to Manhole 2

The product casing would be assembled along King Street from manhole #1 located near Cooke Street toward Alapai Street in sections. To avoid blocking Alapai Street and the King/Kapiolani Fork, it may be necessary to install the product pipeline in a shallow trench that is plated so cross traffic is not impacted.

5.6.2 Pullback from Manhole 3 to Manhole 2

From manhole 3 near Sheridan Street, the casing assembly area will be along King Street towards Punahou Street. To avoid blocking Keeaumoku Street and Kalakaua Avenue, it may be necessary to install the product pipeline in a shallow trench that is plated so cross traffic is not impacted.

5.6.3 Pullback from Manhole 3 to Manhole 4

Likewise for the section from Washington Middle School, manhole 4, towards manhole 3 near Sheridan Street, the casing assembly area will be along King Street from manhole 3 near Sheridan Street towards McKinley High School. Similarly, to avoid blocking Pensacola and Piikoi Streets, it may be necessary to install the product pipeline in a shallow trench that is plated so cross traffic is not impacted.

5.7 Traffic

As discussed in section 3.10, detailed advanced traffic planning is required. This scenario would require lane closure of two lanes of King Street for 27 days.

5.8 Noise

Installation of a HDPE casing with a large HDD machine would generate multiple sound sources. At the drill rig, a maximum of 108 dBA can be expected. The sound from other sources, such as the mud pump, can be expected to be on the same order of magnitude, i.e. between 100 to 110 dBA, without sound barriers. Incorporating sound barriers in close proximity to the machine may reduce noise levels to 70 dBA. It is expected that a combination of noise reducing techniques and noise barriers will be utilized.

5.9 Permitting

A City and County of Honolulu Street Usage Permit and a Special Noise Permit would be required.

5.10 Water Requirements

The large HDD machine requires a city water hook-up.

5.11 Cutting and Slurry Disposal

A circle whose diameter is 23 inches can circumscribe three 10-inch casings. A bore must be opened to a 30-inch outer diameter to accommodate the 3-10 inch HDPE or 3-8 inch steel pipes. The volume of slurry and cuttings that must be disposed of is as follows:

Outer Diameter of Reamed Hole: 30 inches
Length of Largest Bore: 2,450 feet

$$V = \pi\left[\left(\frac{15}{12}\right)^2 - \left(\frac{3X8.625}{12.2}\right)^2\right] x\,2{,}450 =$$

$$V = \pi\left[\left(\frac{15}{12}\right)^2 - \left(\frac{8.625}{8}\right)^2\right] x\,2{,}450 =$$

$$= \pi[1.563\ 1.162]x\,2{,}450$$

= 3086.5 feet3 = 114.3 cubic yards

Total volume of wet materials = 445.4 + 114.3 = 559.7 cubic yards

Assuming the wet cuttings and mud would be mixed with a dry material of equal volume then the total volume to be land filled would be 1,119.4 cubic yards. The material would weigh approximately 100 pounds per cubic foot or 2,200 pounds per cubic yard. Using a cost of $10 per cubic yard for hauling and $75 per ton for tipping fee, the disposal charge would be:

Volume = 1,119.4 cubic yards
Weight/yd^3 = 2,700 pounds
Cost to haul = $10 per cubic yard
Cost of Tipping = $75 per ton X (2,700 pounds per cubic yard/2,000 pounds per ton)
= $101.25 per cubic yard

Total Cost = 1,119.4 x $101.25 + $10 x 1,119.4 = $124,533.25 for 2,450 feet or $50.83/foot

For a bore length of 6,350 feet, the total cost of spoils disposal would be:

Total Cost = 6,350 x $50.83 = $322,800

For a bore length of 6,350 feet, the total cost of spoils disposal is $322,880. This does not include the cost for dry material to mix with the wet cuttings.

5.12 Risks

There is always the risk that unknown soil conditions exist between geotechnical bore locations. For example, if unanticipated hard rock is encountered, drilling through this rock may take substantially longer than estimated.

With the known geotechnical data in the King Street area, the subsurface conditions are suitable for large HDD machines because the soils are of the same geologic type and are firm enough to reasonably ensure directional control of the bore. Additionally, no tooling changes would have to be made during any one bore to accommodate outcroppings of rock, and no soft areas would be encountered that might jeopardize steering control.

In addition, associated with pullback in sections, there is the risk of hole collapse and the risk of overcoming static surface friction when re-starting the pullback operation.

5.13 Cost

Cost estimates for HDD using three 10-inch HDPE casings is shown in Appendix F. Note however that this cost is for directional drilling only.

Due to electrical losses from eddy and circulating currents, material and labor costs associated with welding and handling the 8-inch steel casings will not be evaluated in detail. The 10-inch HDPE casing is the better choice.

Utilizing a large machine to install a "bundle" of 3-10 inch HDPE ducts between four manholes located along King Street provides the lowest estimated HDD cost for the scenarios evaluated. Overriding space and traffic restriction difficulties make this a less desirable alternative.

5.14 Setup Drawing

Figure 5-2 shows the setup required for this scenario.

5.15 Schedule

Day 1:	**Mobilize at McKinley High School** ▪ HDD rig trailers ▪ Drill ▪ Control cabinet ▪ Mud cleaner and mixer ▪ Auxiliary equipment
Day 2:	▪ Connect equipment except for drill
Day 3:	▪ Close lanes one and two to excavate needed trench ▪ Plate lane one ▪ Close lanes two and three to excavate entry pit ▪ Install hydraulic, mud circulation, electric lines and drill rig
Day 4:	▪ Drill pilot hole 2,450 feet to manhole 1 near Cooke Street
Day 5:	▪ Continue drilling pilot hole to manhole 1
Day 5:	▪ Complete drilling pilot hole to manhole 1
Day 7:	▪ Commence back reaming from manhole 1 to McKinley High School
Day 8:	▪ Finish back reaming hole from manhole 1 to McKinley High School
Day 9:	**24-hour operation commences** ▪ Casing transported in 40 foot sections to King Street lane 2 Ewa of manhole 1 for assembly in closed traffic lane ▪ Begin assembly of casing and pullback at 500 feet per 8-hour shift ▪ HECO yard used as lay down area to speed casing assembly
Day 10:	▪ Complete casing assembly and pullback **24-hour operation ends**

Day 11:	▪ Turn drill rig around ▪ Dig entry pit towards Sheridan Street
Day 12:	▪ Complete casing assembly and pullback **24-hour operation ends**
Day 13:	▪ Drill pilot hole 1,950 feet to manhole 3
Day 14:	▪ Continue drilling pilot hole to manhole 3
Day 15:	▪ Commence back reaming from manhole 3 to McKinley High School
Day 16:	▪ Complete back reaming from manhole 3 to McKinley High School
Day 17:	**24-hour operation commences** ▪ Casing transported in 40 foot sections to King Street lane 2 Diamond Head of manhole 3 ▪ Begin assembly of casing and pullback at 500 feet per 8-hour shift
Day 18:	▪ Complete casing assembly and pullback **24-hour operation ends**
Day 19-20:	▪ De-mobilize drill rig and repair street at McKinley High School
Day 21:	▪ Perform maintenance to drill rig
Day 22:	**Mobilize at Washington Middle School** ▪ HDD rig trailers ▪ Drill ▪ Control cabinet ▪ Mud cleaner and mixer ▪ Auxiliary equipment
Day 23	▪ Close lanes one and two to excavate needed trench ▪ Plate lane one ▪ Close lanes two and three to excavate entry pit ▪ Install hydraulic, mud circulation, electric lines and drill rig
Day 24:	▪ Drill pilot hole 1,950 feet to manhole 3
Day 25:	▪ Complete pilot hole to manhole 3 ▪ Commence back reaming from manhole 3 to Washington Middle School
Day 26:	▪ Continue back reaming from manhole 3 to Washington Middle School
Day 27:	▪ Complete back reaming from manhole 3 to Washington Middle School ▪ Prepare casings for pullback
Day 28:	**24-hour operation commences** ▪ Casing transported in 40 foot sections to King Street lane 2 Ewa of manhole 3 for assembly in closed traffic lane ▪ Begin assembly of casing and pullback in approximately 500-foot sections
Day 29:	▪ Complete casing assembly and pullback **24-hour operation ends**
Day 30:	▪ Remove drill rig from King Street and repair street at Washington Middle School
Day 31:	▪ De-mobilize drill rig from Washington Middle School

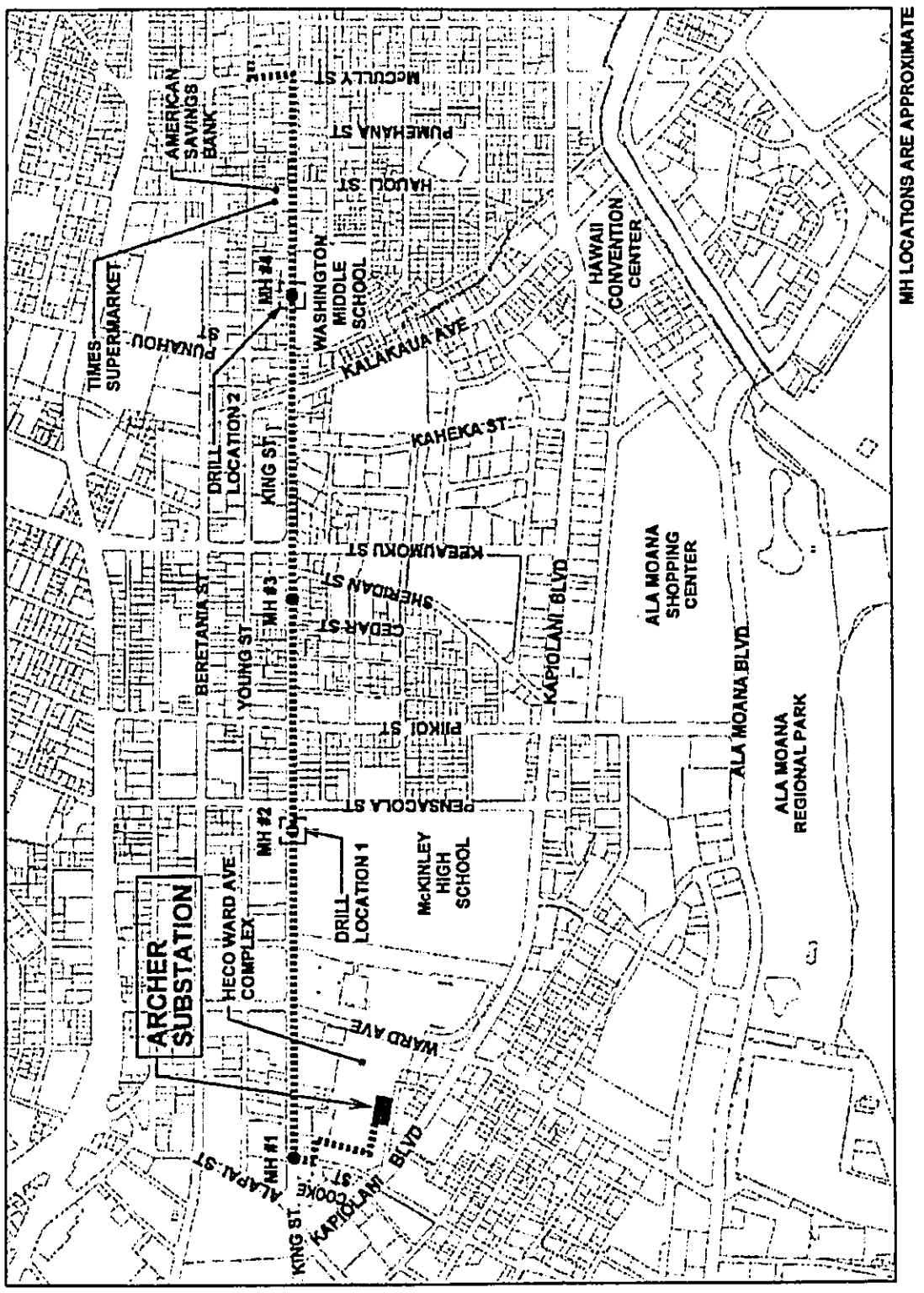

MH LOCATIONS ARE APPROXIMATE
ARCHER SUBSTATION
HECO WARD AVE COMPLEX
BERETANIA ST
YOUNG ST
KING ST
DRILL LOCATION 2
TIMES SUPERMARKET
AMERICAN SAVINGS BANK
MH #1
MH #2
MH #3
MH #4
ALAPAI ST
COOKE ST
KING ST
KAPIOLANI BLVD
WARD AVE
DRILL LOCATION 1
McKINLEY HIGH SCHOOL
PENSACOLA ST
PIIKOI ST
CEDAR ST
SHERIDAN ST
KEEAUMOKU ST
KAHEKA ST
KALAKAUA AVE
WASHINGTON MIDDLE SCHOOL
HAUOLI ST
PUMEHANA ST
McCULLY ST
PUNAHOU ST
KAPIOLANI BLVD
ALA MOANA SHOPPING CENTER
HAWAII CONVENTION CENTER
ALA MOANA BLVD
ALA MOANA REGIONAL PARK

Figure 5-1

Large HDD Setup at McKinley High School

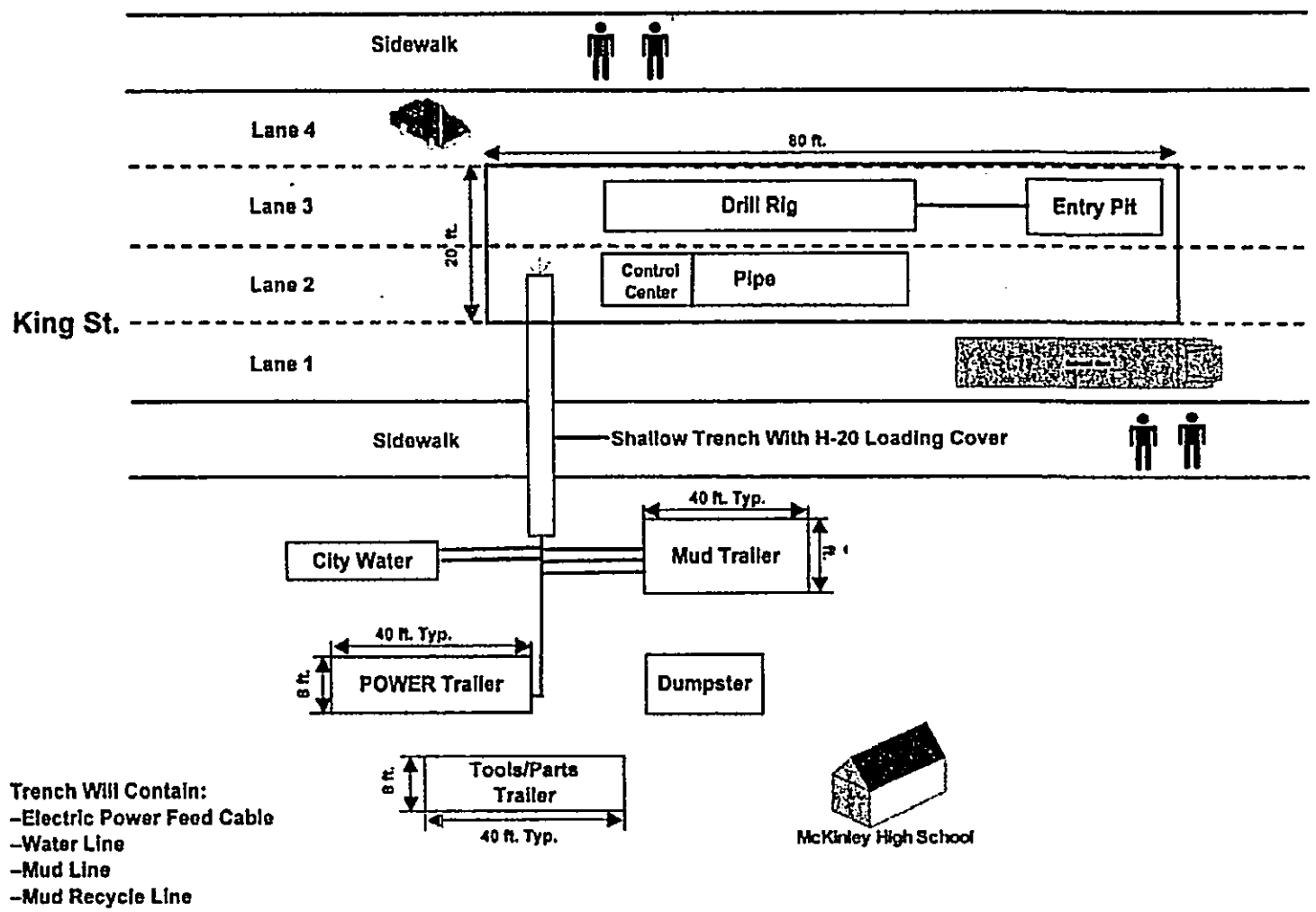


Figure 5-2

6 *Small to Medium HDD Machine with Three 10-inch HDPE Casings*

For this scenario it is estimated that a total of 14 manholes will be required. Three individual 10-inch HPDE casings would be installed, one at a time, over distances of approximately 500 feet. Therefore, six drills, three in each direction are required from every other manhole. Figure 6-1 shows a general layout of this scenario.

6.1 Geotechnical Information

See section 4.1.

6.2 Casing Materials

The small HDD machine is capable of single duct installations in shorter runs of less than 600 feet. For these shorter bores, 8-5/8-inch outer diameter, 6.9-inch inner diameter, DR 11, size pipe. The biggest concern with this type of installation would be any duct ovality induced by the pullback operation. A circle circumscribing the three electrical cables that will be used in this installation is 6.43 inches, allowing only 0.47 inches of clearance. A 10-inch outer diameter, DR 9 or 11 duct is recommended.

6.3 Cable Ampacity

In this type of installation the cables would be installed in trefoil configuration, one circuit in each of the ducts. As stated above, the installation depth was modeled at 20 feet. During installation of the ducts, considerable over reaming of the borehole will occur and the annulus of the bore between its wall and the casings would be filled with drilling fluids and cuttings.

The following ampacity can be expected for three 10-inch HDPE:

<u>For steady state condition</u>
1500 kcmil aluminum conductor: 493 amps
1500 kcmil copper conductor: 600 Amps

<u>For the six hour transient loading condition</u>
1500 kcmil aluminum conductor: 1226 amps

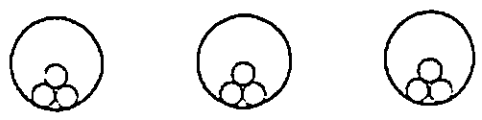


Figure 6-2: Cables in Trefoil Configuration

6.4 Conductor Types

Neither aluminum nor copper conductor met the design criteria of 678 amps. If HECO were willing to accept that these cables could be loaded for only up to six hours, then 1500 kcmil aluminum conductor would meet this limited criterion.

6.5 Workspace at the Drill Entry Area

The smaller directional drilling rigs have the advantage of taking up much less space and could be setup within two lanes of traffic to drill between manholes. The rig could be set up at every other manhole. The contractor would drill in one direction, and then the drill rig will be turned around to bore in the opposite direction. Estimated production rates indicate that it would take approximately three weeks to accomplish six bores. Bores would be located approximately five feet apart. Below is a table of approximate manhole locations along King Street indicating locations where the drill rig would be setup:

Manhole Number	Approximate Manhole Location	HDD Machine Location
1	Intersection of Cooke and King Street.	Yes, one direction only
2	Intersection of Archer Lane and King Street.	No
3	West of intersection of Ward Avenue and King Street.	Yes
4	400 feet east of Ward Avenue and King Street.	No
5	890 feet east of Ward Avenue between Blaisdell Center and McKinley High School.	Yes
6	200 feet west of Pensacola and King Street intersection.	No
7	Midway between Pensacola and Piikoi Street.	Yes
8	200 feet east of Piikoi and King Street intersection.	No
9	Midway between Birch and Cedar Streets.	Yes
10	West of Sheridan and King Street intersection.	No
11	200 feet east of intersection of Keeaumoku and King Streets	Yes
12	West of Kaheka and King Street intersection.	No
13	West of Kalakaua Avenue and King Street intersection	Yes
14	130 feet east of Punahou and King Street intersection near Washington Middle School	No

A specific intersection can be avoided by drilling in only one direction. Additionally, other adjustments to manhole locations or drilling directions can be made if necessary.

The drilling rig must remain in position long enough to complete the bore and pullback of any one casing.

6.6 Lay Down Area

Staging areas for the installation would have to be found for casing and equipment storage. On the Diamond Head end of the project, Washington Middle School could be used as a staging area for manholes 9 to 14. Similarly, manholes 8 to 4 could be marshaled from McKinley High School and manholes 1 to 3 from HECO's Ward Avenue facility.

A typical installation can be discussed using manholes 12, 13 and 14. The drill rig would be setup just west of the intersection of Kalakaua Avenue and King Street, manhole 13. A pilot hole would be drilled in the Diamond Head direction to the

location of manhole 14. The hole would be back reamed until it is enlarged to a 12-inch to 16-inch diameter. Casing would be assembled in lane two requiring a lane closure of 10 to 12 hours for assembly and an additional 10 hours for pulling the casing back into the reamed bore. Two additional bores would be extended in the same direction with pipe assembly and pullback operations accomplished as described above. Once the three Diamond Head bores are completed, the rig would be turned around and the same operation would take place between manholes 12 and 13.

To avoid completely blocking the heavily traveled streets crossing King Street, a shallow trench would have to be dug across those intersections that would be blocked by the HDD pipe assembly and pulling operation. The pipe could then be laid out, assembled and placed within the trench and the trench could be covered with steel plates to allow vehicular travel. After the drilling operations are complete, the temporary trench would be backfilled and the roadway surface restored. During detailed design, HECO may be able to optimize manhole locations to lessen traffic impacts on some cross streets. However, the need to trench major roadway intersections, with the related traffic disruptions, would negate some of the hoped-for benefits leading to consideration of the use of HDD technology.

6.7 Traffic

Traffic lanes on King Street are 10 feet wide and therefore two lanes will have to be blocked at the drill rig site. As discussed previously, detailed advanced planning is required. This scenario would require lane closure of two lanes of King Street for 152 days and nearly every cross street along King Street could be blocked at some time during pullback.

If necessary, the small rig can be broken down and moved after each individual bore is completed in a minimal amount of time (estimated at 2 hours). Therefore, at each drill location, the small rig could be setup and broken down six times. However, the overall length of the construction would be extended due to the inefficiencies associated with mobilizing and demobilizing.

6.8 Noise

Smaller drill rigs generally have lower power and water requirements and therefore, when properly equipped with high noise reduction mufflers, are quieter. In addition it is easier to add special sound deadening housing to this type of machine making these rigs more feasible in a congested area.

6.9 Permitting

A City and County of Honolulu Street Usage Permit and a Special Noise Permit would be required.

6.10 Water Requirements

Smaller drill rigs require less water and can be supplied by a water truck rather than a hook-up to a supply city water supply.

6.11 Cutting and Slurry Disposal

Small drill rigs will not generate large volumes of material for disposal. The mud from the small rigs is generally not recycled because the volume is low, although it is

possible to do so. The vacuum extractor is used to suck up excess mud and would be emptied into a dump truck or container as needed. A pump and truck with a tank will typically be able to handle the cutting and slurry disposal efficiently.

6.12 Risks

See section 4.12.

6.13 Cost

This scenario requires the addition of an estimated 11 extra manholes and associated splices. Each casing would have to be installed in a separate bore. Cost estimates for HDD are shown in Appendix F. Note however that this cost is for directional drilling only. The total initial installation cost for Phase 2, of which the cost for HDD is a part, is $13 to $15 million, as estimated by HECO in the memo attached in Appendix F.

6.14 Setup Drawing

Figure 6-3 shows the setup required for this scenario.

6.15 Schedule

Day 1:	• Dig entry pit • Set up drill rig in lanes 2 and 3 at manhole 1 • Begin drilling pilot hole 1
Day 2:	• Complete pilot hole 1 • Begin back reaming hole from manhole 2 to manhole 1 • Drill toward manhole 2 • Casing 1 being assembled on sidewalk • Assembly complete at end of shift
Day 3:	• Close lane 1 for 1 hour to move assembled casing into lanes 2 and 3 • Pullback casing to manhole 1
Day 4:	• Drill pilot hole 2 • Casing 2 being assembled on sidewalk
Day 5:	• Begin back reaming hole from manhole 2 to manhole 1
Day 6:	• Close lane 1 for 1 hour to move assembled casing into lanes 2 and 3 • Pullback casing to manhole 1
Day 7:	• Drill pilot hole 3 • Casing 3 being assembled on sidewalk
Day 8:	• Begin back reaming hole from manhole 2 to manhole 3
Day 9:	• Close lane 1 for 1 hour to move assembled casing into lanes 2 and 3 • Pullback casing to manhole 3
Day 10:	• Demobilize drill rig • Move to next manhole 3 • Install manhole 1
Day 11:	• Complete duct to manhole connections
Day 12:	• Pull cable manhole 2 to manhole 1
Day 13	• Contingency day
Day 14:	• Dig entry pit • Set up drill rig in lanes 2 and 3 at manhole 3 • Begin drilling pilot hole 1
Day 15:	• Complete pilot hole 1 • Begin back reaming hole from manhole 2 to manhole 3 • Drill toward manhole 2

	• Casing 1 being assembled on sidewalk • Assembly complete at end of shift
Day 16:	• Close lane 1 for 1 hour to move assembled casing into lanes 2 and 3 • Pullback casing to manhole 3
Day 17:	• Drill pilot hole 2 • Casing 2 being assembled on sidewalk
Day 18:	• Begin back reaming hole from manhole 2 to manhole 3
Day 19:	• Close lane 1 for 1 hour to move assembled casing into lanes 2 and 3 • Pullback casing to manhole 3
Day 20:	• Drill pilot hole 3 • Casing 3 being assembled on sidewalk.
Day 21:	• Begin back reaming hole from manhole 2 to manhole 3
Day 22:	• Close lane 1 for 1 hour to move assembled casing into lanes 2 and 3 • Pullback casing to manhole 3
Day 23:	• Turn rig around • Drill pilot hole 1 • Casing 1 being assembled on sidewalk
Day 24:	• Begin back reaming hole from manhole 4 to manhole 3
Day 25:	• Close lane 1 for 1 hour to move assembled casing into lanes 2 and 3 • Pullback casing to manhole 3
Day 26:	• Drill pilot hole 2 • Casing 2 being assembled on sidewalk
Day 27:	• Begin back reaming hole from manhole 4 to manhole 3
Day 28:	• Close lane 1 for 1 hour to move assembled casing into lanes 2 and 3 • Pullback casing to manhole 3
Day 29:	• Drill pilot hole 3 • Casing 3 being assembled on sidewalk.
Day 30:	• Begin back reaming hole from manhole 4 to manhole 3
Day 31:	• Close lane 1 for 1 hour to move assembled casing into lanes 2 and 3 • Pullback casing to manhole 3
Day 32:	• Demobilize drill rig • Move to next manhole 5 • Install manhole 2
Day 33:	• Install manhole 3 • Complete duct to manhole connections
Day 34:	• Pull Cable manhole 3 to manhole 4
Day 35	• Contingency day
Day 36 to 58	• Repeat at manhole 5
Day 59 to 81	• Repeat at manhole 7
Day 82 to 104	• Repeat at manhole 9
Day 105 to 127	• Repeat at manhole 11
Day 128 to 150	• Repeat at manhole 13
Day 151	• Break down
Day 152	• Contingency day

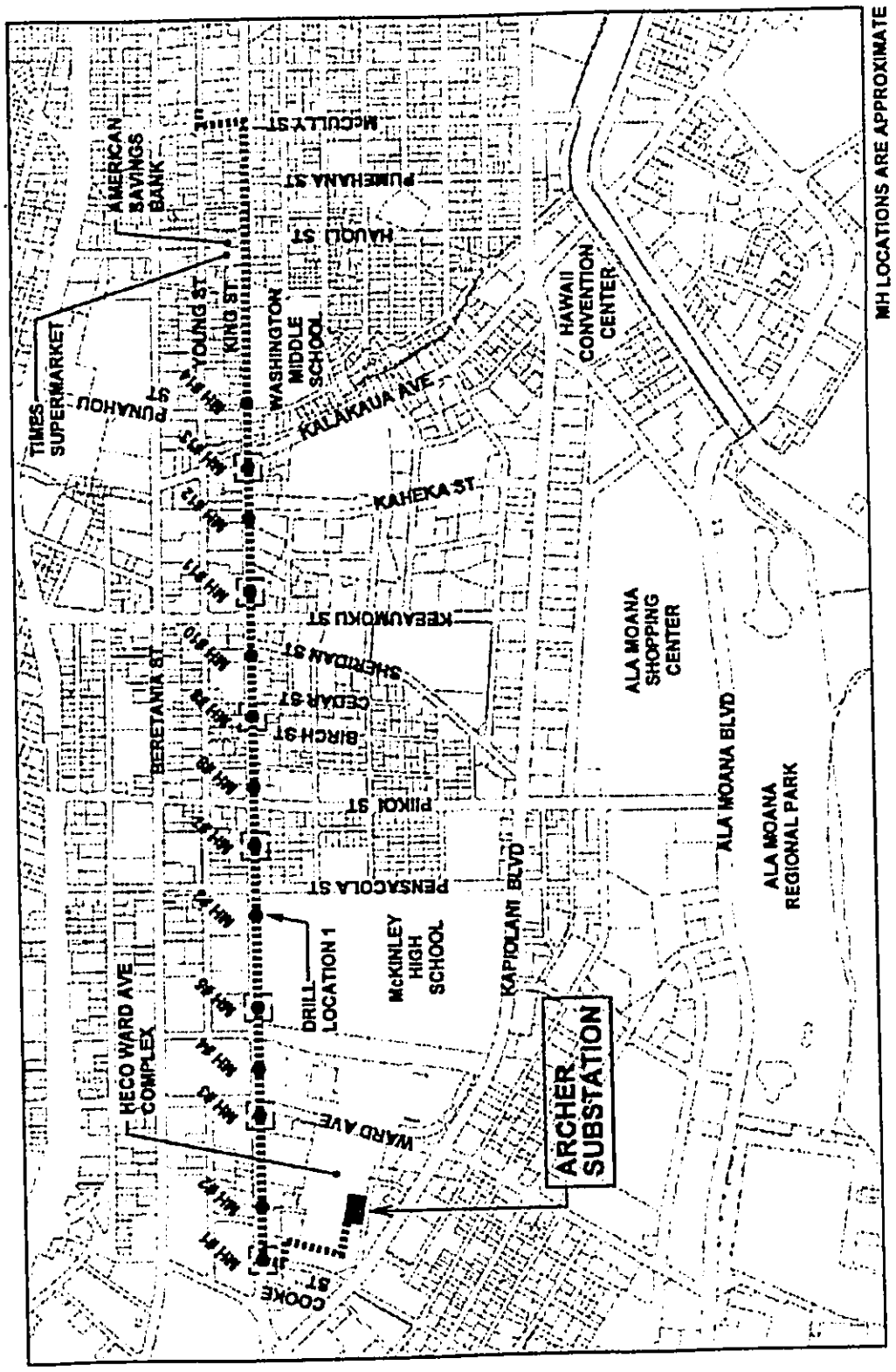

TIMES SUPERMARKET
AMERICAN SAVINGS BANK
PUNAHOU ST
YOUNG ST
KING ST
WASHINGTON MIDDLE SCHOOL
McCULLY ST
PUNCHBOWL ST
HAUOLI ST
KALAKAUA AVE
KAHEKA ST
HAWAII CONVENTION CENTER
ALA MOANA SHOPPING CENTER
ALA MOANA BLVD
ALA MOANA REGIONAL PARK
KEEAUMOKU ST
SHERIDAN ST
CEDAR ST
BIRCH ST
PIIKOI ST
BERETANIA ST
PENSACOLA ST
DRILL LOCATION 1
McKINLEY HIGH SCHOOL
KAPIOLANI BLVD
ARCHER SUBSTATION
HECO WARD AVE COMPLEX
WARD AVE
COOKE ST
MH LOCATIONS ARE APPROXIMATE

Figure 6-2

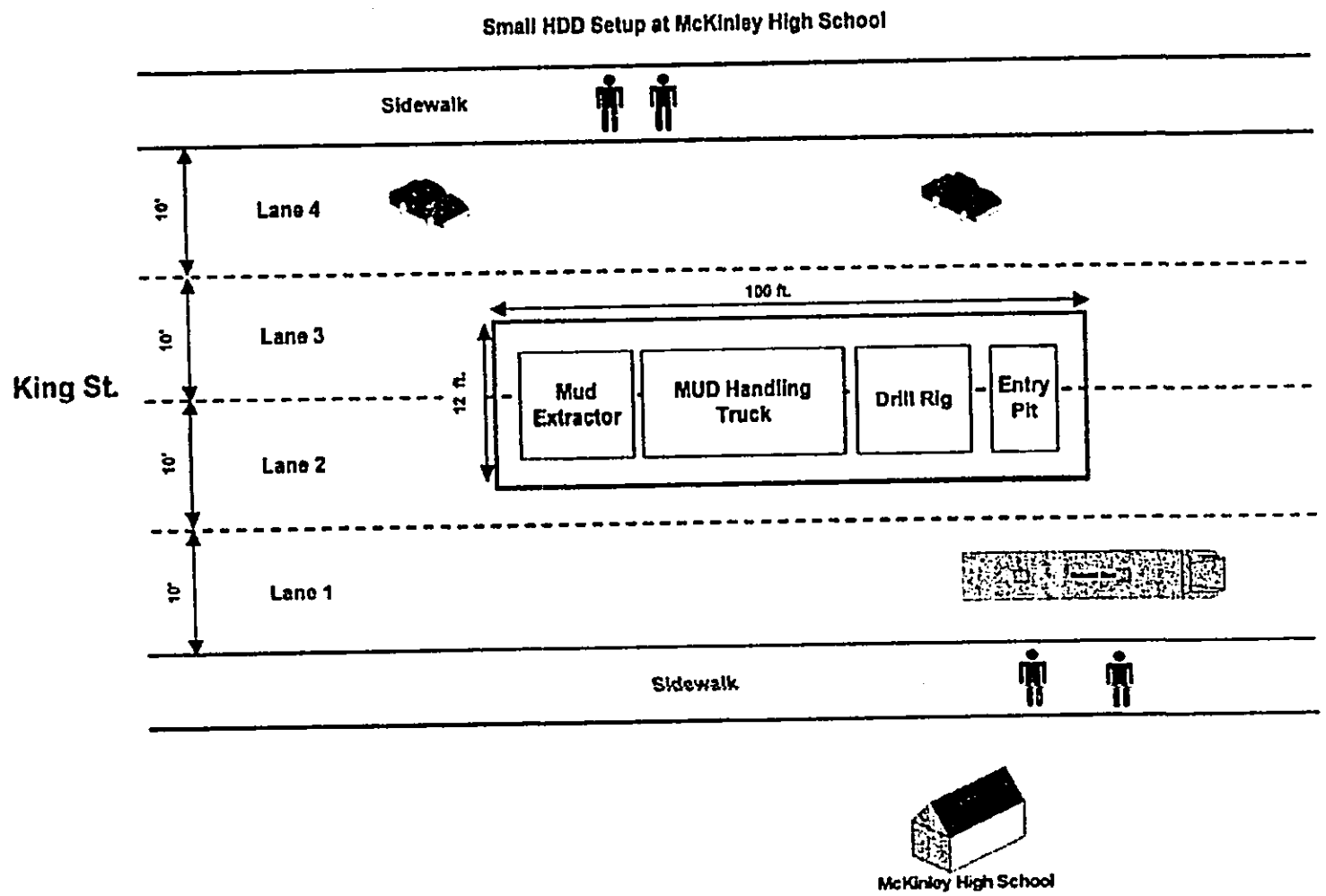

Small HDD Setup at McKinley High School
Sidewalk
10'
Lane 4
10'
Lane 3
King St.
10'
Lane 2
10'
Lane 1
100 ft.
12 ft.
Mud Extractor
MUD Handling Truck
Drill Rig
Entry Pit
Sidewalk
McKinley High School

Figure 6-3

7 *Summary Table*

A summary of the analysis is shown in the following table.

Drill Rig Size	• Large	• Large	• Large	• Small
Casing Material	• 36-inch Steel	• Three 8-inch Steel	• Three 10-inch HDPE	• Three 10-inch HDPE
Ampacity	• < 678 amps	• < 678 amps	• < 678 amps	• < 678 amps
Conductor Type	• Aluminum	• Aluminum	• Aluminum	• Aluminum
Workspace	• 100 feet x 150 feet	• 100 feet x 150 feet	• 100 feet x 150 feet	• 12 feet x 100 feet
Lay Down Area	• 10 feet x length of bore • Shorter sections of casing are possible	• 10 feet x length of bore • Shorter sections of casing are possible	• 10 feet x length of bore • Shorter sections of casing are possible	• 10 feet x length of bore • Shorter sections of casing are possible
Traffic	• Two lanes would be blocked for 35 days • Major intersections could be blocked to cross traffic for 3 days at a time	• Two lanes would be blocked for 27 days	• Two lanes would be blocked for 27 days	• Two lanes would be blocked for 152 days
Noise	• Sound barriers or deflectors will likely be needed • Noise Regulation waiver likely required	• Sound barriers or deflectors will likely be needed • Noise Regulation waiver likely required	• Sound barriers or deflectors will likely be needed • Noise Regulation waiver likely required	• Less than large HDD rig • Sound barriers or deflectors will likely be needed • Noise Regulation waiver likely required
Water Requirements	• City water hookup required	• City water hookup required	• City water hookup required	• Water truck required
Cutting & Slurry Disposal	• $1.7 million	• $0.3 million	• $0.3 million	• Minimal
Cost	• $17 to $19 million	• Not calculated	• Not calculated	$13-$15 million
Construction Duration	• Approximately 39 days	• Approximately 31 days	• Approximately 31 days	• Approximately 152 days

8 *Conclusion and Recommendations*

HECO retained POWER Engineers, Inc. (POWER) to provide a feasibility study for installing three 46kV circuits in King Street from Cooke Street to McCully Street utilizing horizontal directional drilling technology.

The study reviewed the following:

- Equipment requirements
- *Workspace requirements*
- Cable ampacity
- Casing material alternatives
- Noise and traffic impacts from construction activity
- Costs

During the initial investigation, POWER determined that the areas from Archer Substation to an area near the intersection of Cooke Street and King Street, and the area Diamond Head of Washington Middle School should be conventionally trenched. In the Archer Substation/Cooke Street area, numerous bends are required to route the cables from the substation located within HECO's Ward Avenue facility, onto Cooke Street and then around the corner onto King Street. HDD techniques require nearly straight sections. In the area Diamond Head of Washington Middle School to McCully Street, there are insufficient workspace and lay down areas to consider HDD. Additionally, due to the present electrical configuration, there is no common termination point for all three circuits; rather, each circuit is to be terminated in a different location. With no common terminus, a single borehole will not allow access to each circuit.

For the partial HDD project route, POWER identified four possible horizontal directional drill installation methodologies and reviewed the advantages and disadvantages of each method. HDD is not infeasible for King Street between Cooke Street and Washington Middle School; however there are several challenges that must be resolved before HDD can be considered a practical alternate to conventional trenching. These points of concern are discussed below.

Ampacity
In terms of ampacity, regardless of the HDD installation methodology, neither aluminum nor copper conductor met the design criteria of 678 amps. If HECO were willing to accept that these cables could be loaded for only up to six hours, then 1500 kcmil aluminum conductor would meet this limited criterion.

Traffic
Traffic lanes on King Street are 10 feet wide and therefore two lanes will have to be blocked at the drill rig site for 27 to 152 days, depending on the installation methodology selected. Equipment required for HDD cannot be removed from the roads during peak traffic hours on a daily basis. Therefore, exceptions to the requirements of the City and County of Honolulu Street Usage Permits will be necessary for HDD to be feasible.

To avoid blocking cross traffic on major cross streets, such as Keeaumoku Street and Kalakaua Avenue, it would be necessary to install the product pipeline in a shallow trench that is plated so cross traffic is not impacted. For the scenario utilizing the small to medium drill rig and short bores, nearly every cross street along King Street could be blocked at some time during pullback. The need to trench major roadway intersections, with the related traffic disruptions, would negate some of the hoped-for benefits leading to the consideration of the use of HDD technology.

Noise

Installation of an HDPE casing with a large HDD machine would generate multiple sound sources. At the drill rig, a maximum of 108 dBA can be expected. The sound from other sources, such as the mud pump, can be expected to be on the same order of magnitude. Incorporating sound barriers in close proximity to the machine may reduce noise levels to 70 dBA. Smaller drill rigs have lower power and water requirements and therefore, when properly equipped with high noise reduction mufflers, are quieter. Regardless, a special noise permit will be required for either size drill rig.

If these problems can be overcome, HDD may be feasible. However, logistics for the drilling and pullback operations along King Street between Cooke Street and McCully Street will be challenging due to the urban setting. HECO will need cooperation from the City and property owners in the area.

Appendices

A Cable Pulling Tensions

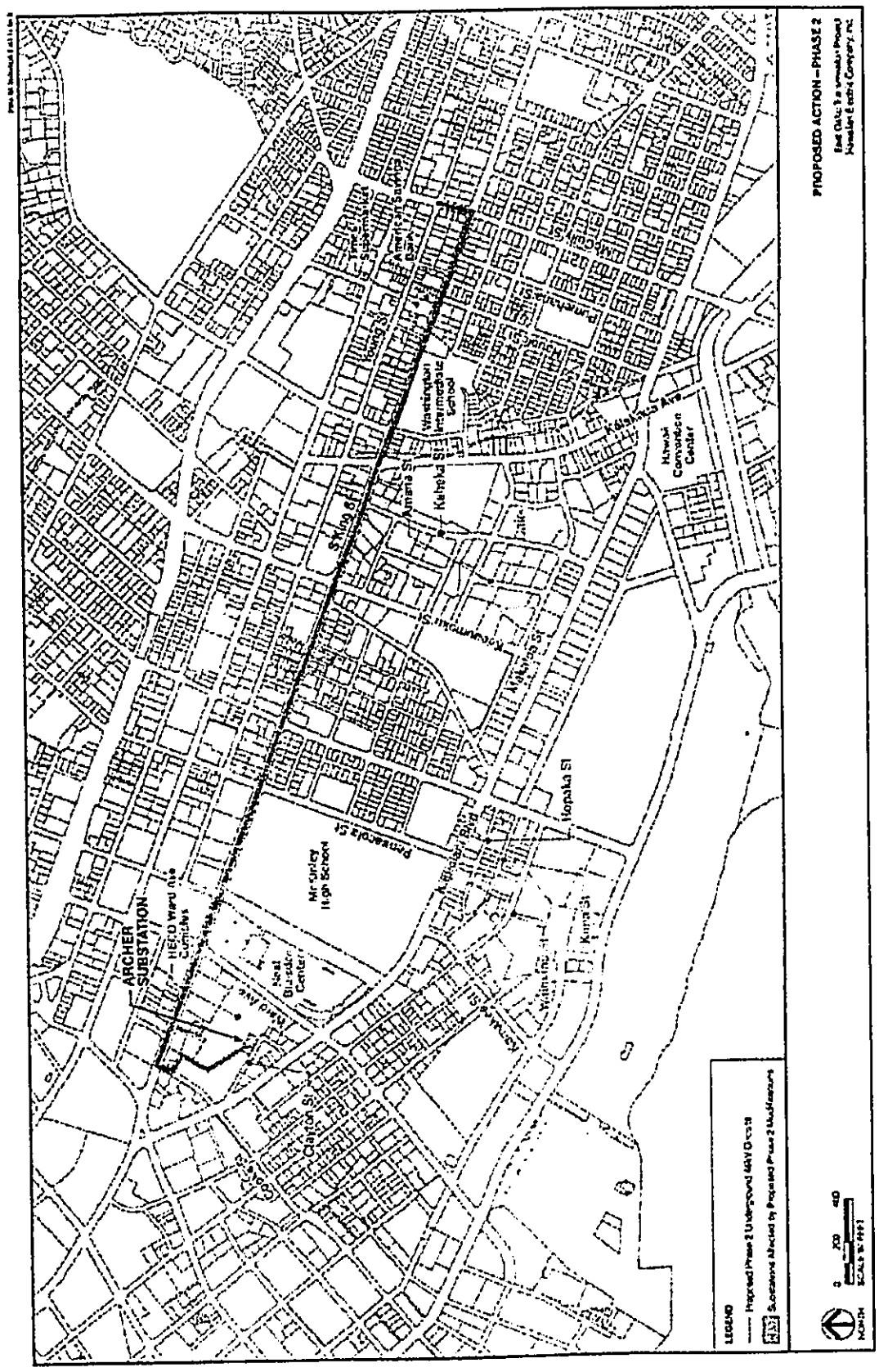
East Oahu Feasibility Study Cable Pulling Tensions

Following are the cable tensions calculations for pulling a standard HECO 46kV XLPE insulated power cable.

All cable pulls are assumed straight lengths. The HECO standard single conductor cable can withstand up to 9000 lbs. and when pulled in trefoil up to 18,000 lbs. All tension and sidewall calculations fall well within design parameters.

Cable	# Cables	Conduit	Section	Tension (lbs)
46Kv	1	HDPE	MH1-MH2	1666
46Kv	3	HDPE	M1-M2	6845
46Kv	3	Steel	M1-M2	6827
46Kv	1	HDPE	MH2-MH3	774
46Kv	3	HDPE	MH2-MH3	2711
46Kv	3	Steel	MH2-MH3	2723
46Kv	1	HDPE	MH3-MH4	774
46Kv	3	HDPE	MH3-MH4	2711
46Kv	3	Steel	MH3-MH4	2723

B Route Information



C Casing Material and Selection

Prior to installation: During hydrostatic testing, the pipeline will be full of water. Therefore, the additional weight of water must be included in these calculations. Hoop and longitudinal stresses resulting from hydrostatic testing are calculated. Using the known distance between rollers as the free spanning distance, the maximum hogging and sagging moments can be calculated. Considering the greater of these two moments, the maximum spanning stress is calculated.

During installation: Spanning stresses also occur in the installation phase. The theoretical pulling force must be calculated to determine the stresses that will result from pulling. An assumed downhole friction factor of 1.0 is recommended to provide conservative results and to include the effect of the pipeline being pulled around a curve. The maximum predicted pulling force should be used to calculate the longitudinal stress. In the case of HDPE ducts, advantages can sometimes be had by flooding the ducts with water before pullback into the hole to reduce friction.

When calculating the longitudinal curvature stresses, allowing for a 10% drilling tolerance allows the use of a radius of curvature 90% of the design radius.

External pressure from static head in the drilled hole and/or overburden pressures must be considered. It is recommended that the static head resulting from the maximum estimated drilling fluid density be used with a factor of safety of 1.5 to provide conservative estimations of the resulting hoop and longitudinal stresses.

After installation: The longitudinal curvature stresses and external pressure stresses should be calculated for conditions after installation of the pipe. These calculations are done in the same way as was done above for the conditions during installation.

Hoop and longitudinal stresses resulting from the final hydrostatic test should also be calculated.

In-service: The maximum working pressure of the pipeline is used in calculating longitudinal and hoop stresses that will be imposed during service.

In summary, the individual and combined stresses at each stage of construction and those for the in-service condition, must be compared with allowable limits.

ASME B31.8 – 1992, Table A842.22 provides the following limits:
Maximum allowable longitudinal stress: 80% SMYS.
Maximum allowable hoop stress: 72% SMYS.
Maximum allowable combined stress: 90% SMYS. (Where SMYS is the Specified Minimum Yield Strength of the pipe material).

Note that other agencies, such as the State Department of Transportation, City Public Works Departments or railroad companies may impose additional limits to those specified above. Owner companies should identify any such further constraints to ensure adequacy of the design.

D Cable Ampacity

Configuration	Conductor	Depth	Ampacity **	Transient ***
3 x 3 DB	AL	Std.	678	1344
3 x 3 DB	CU	Std.	840	*
36" Steel Casing	AL	50'	514	1207
36" Steel Casing	CU	50'	636	*
3 - 8" steel	AL	20'	515	1052
3 - 8" steel	CU	20'	627	*
3 - 10" HDPE	AL	20'	493	1226
3 - 10" HDPE	AL	20'	600	*

* No copper conductors transient ampacity calculations were done due to the fact that the aluminum conductor met all criteria and copper will perform superior to aluminum

E *Cost Estimates*

Horizontal Directional Drill Cost Estimates

Location	Casing	Conductor	Cost ($ / Mile)
MH1-MH2	36"Steel	Aluminum	$8.48M
MH2-MH3	36"Steel	Aluminum	$8.39M
MH3-MH4	36"Steel	Aluminum	$8.39M
			Total Cost **$12.52M**

Location	Casing	Conductor	Cost ($ / Mile)
MH1-MH2	3 - 10" HDPE	Aluminum	$5.91M
MH2-MH3	3 - 10" HDPE	Aluminum	$5.70M
MH3-MH4	3 - 10" HDPE	Aluminum	$5.70M
			Total Cost **$8.66M**

Location	Casing	Conductor	Cost ($ / Mile)
MH1-MH2	3 - 8" Steel	Aluminum	$6.30M
MH2-MH3	3 - 8" Steel	Aluminum	$6.29M
MH3-MH4	3 - 8" Steel	Aluminum	$6.29M
			Total Cost **$9.19M**

Location	Casing	Conductor	Cost ($ / Mile)
Short Bore Entire Route	3 - 10" HDPE	Aluminum	$5.61M
			Total Cost **$8.85M**

Notes:
Dewatering Not Included
Mob / DeMob of + $150,000 should be added to all costs except small rig short bore.
No Disposal Costs included
Copper Conductor $22 / ft. is not included above.
Aluminum Conductor $16.50 / ft.

* Cost Estimates Located in Appendix O

INTEROFFICE CORRESPONDENCE

Hawaiian Electric Co., Inc.

August 5, 2004

To: K. Wong

From: E. F. Oshiro

Subject: East Oahu Transmission Project – Phase 2
Horizontal Directional Drilling Cost

This memo describes the cost to utilize horizontal directional drilling (HDD) for the ductline construction on King Street for Phase 2 of the East Oahu Transmission Project (EOTP).

Background

HECO retained POWER Engineers, Inc. (POWER) to provide a feasibility study and to develop costs for installing three 46kV circuits in King Street from Cooke Street to McCully Street utilizing horizontal directional drilling technology.

During the initial investigation, POWER determined that the areas from Archer Substation to an area near the intersection of Cooke Street and King Street, and the area Diamond Head of Washington Middle School should be conventionally trenched.

For the partial HDD project route, POWER identified four possible horizontal directional drill installation methodologies and developed the cost for each method. The cost developed for HDD from POWER did not include the additional cost for conventional trench construction in the areas identified that could not be constructed using HDD methods. In order to make the estimates comparable to the initial installation cost for Phase 2, these costs were added.

Cost Summary

The initial installation cost for Phase 2 construction including partial construction utilizing HDD is as follows:

Rig	Casing	Material	Paving	Total
Large	36"	Steel	Minimal	$17.1 million
Large	36"	Steel	Curb to Curb	$18.7 million
Small	3-10"	HDPE	Minimal	$13.3 million
Small	3-10"	HDPE	Curb to Curb	$14.8 million

PUC Estimate with Minimal Paving:	$9.5 million
PUC Estimate with Curb to Curb Paving:	$14.1 million

Conclusion

Based on this analysis, HDD cost $0.6 to $7.6 million more than conventional trenching.

F Reference List

An Introduction to Trenchless Technology, Kramer, McDonald, Thompson, Van Nostrand Reinhold Publishing, NY

Guideline for Design and Installation of T&D Cables Using Guided Drilling Systems – EPRI TR-105850

Directional Crossings Contractors Association – Guidelines for a Successful Directional Crossing

Hawaiian Electric Company, Inc. Underground Engineering Standards

Pirelli Cable

RayChem Accessories

Laney Drill

HMS Drillers

ECI Drillers

Intercon Construction

RCI

City & County of Honolulu

Appendix B

Traffic Impact Study

EAST OAHU TRANSMISSION PROJECT

TRAFFIC IMPACT STUDY

FINAL

Honolulu, Hawaii

Prepared For:

Belt Collins Hawaii
2153 North King Street Suite 200
Honolulu, Hawaii 96819

Prepared By:

WILBUR SMITH ASSOCIATES
333 Fayetteville Street, Suite 1450
Raleigh, NC 27601
(919) 755-0583

December 2004

(WSA Project No. 512650)

Wilbur Smith Associates

Table Of Contents

EXECUTIVE SUMMARY

S.1 Overview Of Project S-1
S.2 Makaloa Street Corridor Impacts S-2
S.3 Pumehana Street Area S-10
S.4 Date Street Area S-12
S.5 Winam Avenue Area S-14
S.6 King Sreet Corridor S-16

CHAPTER 1
INTRODUCTION

1.1. Project Description 1-1
1.1.1. Phase 1 1-1
1.1.2. Phase 2 1-2
1.2. Methodology And Assumptions 1-2
1.2.1. Analysis Scnarios 1-2
1.2.2. Traffic Forecast Methodology 1-3
1.2.3. Intersection Analysis Methodology 1-3
1.2.4. Assumptions Regarding City Bus Rapid Transit (BRT) Project 1-4
1.2.5. Assumptions Regarding Street Repaving 1-5
1.3. Report Organization 1-5

CHAPTER 2
EXISTING CONDITIONS

2.1. Makaloa Street Corridor 2-1
2.1.1. Roadways and Traffic Controls 2-1
2.1.2. Public Transit Routes and Stops 2-3
2.1.3. Bicycle Facilities 2-3
2.1.4. Traffic Volumes 2-4
2.1.5. Traffic Conditions at Key Intersections 2-6
2.2. Pumehana Street Study Area 2-7
2.2.1. Roadways and Traffic Controls 2-7
2.2.2. Public Transit Routes and Stops 2-8
2.2.3. Bicycle Facilities 2-8
2.2.4. Traffic Volumes 2-8
2.2.5. Traffic Conditions 2-8
2.3. Date Street-Laau Street Area 2-9
2.3.1. Roadways and Traffic Controls 2-9
2.3.2. Public Transit Routes and Stops 2-9
2.3.3. Bicycle Facilities 2-9

2.3.4. Traffic Volumes 2-10
2.3.5. Traffic Conditions at Key Intersections 2-10
2.4. Winam Avenue Study Area 2-11
2.4.1. Roadways and Traffic Controls 2-11
2.4.2. Public Transit Routes and Stops 2-11
2.4.3. Bicycle Facilities 2-11
2.4.4. Traffic Volumes 2-12
2.4.5. Traffic Conditions 2-13
2.5. King Street Corridor 2-13
2.5.1. Roadways and Traffic Controls 2-14
2.5.2. Public Transit Routes and Stops 2-15
2.5.3. Bicycle Facilities 2-15
2.5.4. Traffic Volumes 2-16
2.5.5. Traffic Conditions at Key Intersections 2-18

CHAPTER 3
FUTURE CONDITIONS WITHOUT EOTP CONSTRUCTION WORK

3.1. BRT System 3-1
3.2. Makaloa-Kapiolani Corridor 3-1
3.2.1. Roadway and Public Transit Modifications Without the BRT Line 3-2
3.2.2. Roadway and Public Transit Modifications With BRT Line 3-2
3.2.3. Traffic Volumes 3-2
3.2.4. Traffic Conditions at Key Intersections Without BRT 3-3
3.2.5. Traffic Conditions at Key Intersections With BRT 3-4
3.3. Pumehana Street Area 3-5
3.3.1. Roadways, Public Transit, and Bicycle Facilities 3-5
3.3.2. Traffic Volumes 3-5
3.4. Date Street Area 3-5
3.4.1. Roadways, Public Transit, and Bicycle Facilities 3-5
3.4.2. Traffic Volumes 3-6
3.5. Winam Avenue Area 3-6
3.5.1. Roadways, Public Transit, and Bicycle Facilities 3-6
3.5.2. Traffic Volumes 3-6
3.6. King Street Corridor 3-7
3.6.1. Roadway and Public Transit Modifications Without the BRT Line 3-7
3.6.2. Roadway and Public Transit Modifications With BRT Line 3-8
3.6.3. Traffic Volumes 3-8
3.6.4. Traffic Conditions at Key Intersections Without BRT 3-8
3.6.5. Traffic Conditions at Key Intersections With BRT 3-9

CHAPTER 4
PHASE 1 TRAFFIC IMPACTS IN MAKALOA CORRIDOR

4.1. City BRT Project 4-1
4.2. Proposed Makaloa-Fern Alignment 4-2
4.2.1. Project Description 4-2
4.2.2. Traffic Impacts 4-4
4.2.3. Impacts on Public Transit Routes and Stops 4-6
4.2.4. Impacts on Pedestrians 4-6
4.2.5. Possible Actions to Minimize Impacts 4-6
4.2.6. Impacts with All-Daytime Construction Option 4-7
4.3. Alternative 1 (Kaheka-Kapiolani) Before BRT 4-8
4.3.1. Project Description 4-8
4.3.2. Traffic Impacts with Daytime Construction 4-10
4.3.3. Impacts on Public Transit with Daytime Construction 4-12
4.3.4. Impacts on Pedestrian Circulation with Daytime Construction 4-12
4.3.5. Possible Actions to Minimize Impacts for Daytime Construction 4-13
4.3.6. Impacts with Nighttime Construction Option 4-14
4.4. Alternative 1 (Kaheka-Kapiolani) After BRT 4-14
4.4.1. Project Description 4-14
4.4.2. Traffic Impacts with Daytime Construction 4-14
4.4.3. Impacts on Public Transit and Pedestrians with Daytime Construction 4-15
4.4.4. Possible Actions to Minimize Impacts 4-16
4.4.5. Impacts with Nighttime Construction Option 4-16
4.5. Alternative 2 (Kalauokalani-Kapiolani) Before BRT 4-16
4.5.1. Project Description 4-16
4.5.2. Traffic Impacts with Daytime Construction 4-17
4.5.3. Impacts on Public Transit With Daytime Construction 4-18
4.5.4. Impacts on Pedestrian Circulation With Daytime Construction 4-18
4.5.5. Possible Actions to Minimize Impacts 4-18
4.5.6. Impacts with Nighttime Construction Option 4-18
4.6. Alternative 2 (Kalauokalani-Kapiolani) After BRT 4-18

CHAPTER 5
PHASE 1 TRAFFIC IMPACTS IN PUMEHANA STREET AREA

5.1. Impacts With Proposed Project 5-1
5.1.1. Project Description 5-1
5.1.2. Traffic Impacts 5-2
5.1.3. Pedestrian Impacts 5-4
5.1.4. Possible Actions to Minimize Impacts 5-4
5.2. Impacts With Single-Lane Option 5-5
5.2.1. Description of Option 5-5
5.2.2. Traffic Impacts 5-6
5.2.3. Possible Actions to Minimize Impacts 5-6

CHAPTER 6
PHASE 1 TRAFFIC IMPACTS IN DATE STREET AREA

6.1. Impacts With Proposed Project 6-1
6.1.1. Project Description 6-1
6.1.2. Traffic Impacts 6-3
6.1.3. Impacts on Public Transit Routes and Stops 6-4
6.1.4. Impacts on Pedestrian Circulation 6-5
6.1.5. Possible Actions to Minimize Impacts 6-5

CHAPTER 7
PHASE 1 TRAFFIC IMPACTS IN WINAM AVENUE AREA

7.1. Impacts With Proposed Option 7-1
7.1.1. Project Description 7-1
7.1.2. Traffic Impacts 7-3
7.1.3. Impacts on Public Transit Routes and Stops 7-3
7.1.4. Impacts on Pedestrian Circulation 7-4
7.1.5. Possible Actions to Minimize Impacts 7-4
7.2. Impacts With Single Lane Option 7-4
7.2.1. Description of Option 7-4
7.2.2. Traffic Impacts 7-5

CHAPTER 8
PHASE 2 TRAFFIC IMPACTS IN KING STREET CORRIDOR

8.1. City BRT Project 8-1
8.2. Proposed Nighttime Trenching Option Before BRT Scenario 8-2
8.2.1. Project Description 8-2
8.2.2. Traffic Impacts 8-6
8.2.3. Impacts on Public Transit Routes and Stops 8-7
8.2.4. Impacts on Pedestrian Circulation 8-7
8.2.5. Possible Actions to Minimize Impacts 8-8
8.3. Proposed Nighttime Trenching Option After BRT Scenario 8-9
8.3.1. Project Description 8-9
8.3.2. Traffic Impacts 8-9
8.3.3. Impacts on Public Transit Routes and Stops 8-10
8.3.4. Impacts on Pedestrian Circulation 8-10
8.3.5. Possible Actions to Minimize Impacts 8-10
8.4. Daytime Trenching Option Before BRT 8-11
8.4.1. Project Description 8-11
8.4.2. Traffic Impacts with Daytime Construction 8-12
8.4.3. Impacts on Public Transit Routes and Stops 8-14
8.4.4. Impacts on Pedestrian Circulation 8-15
8.4.5. Possible Actions to Minimize Impacts 8-15
8.5. Daytime Trenching Option After BRT 8-16

8.5.1. Project Description 8-16
8.5.2. Traffic Impacts with Daytime Construction 8-17
8.5.3. Impacts on Public Transit Routes and Stops 8-18
8.5.4. Impacts on Pedestrian Circulation 8-18
8.5.5. Possible Actions to Minimize Impacts 8-19
8.6. Partial Horizontal Directional Drilling Option Before BRT 8-19
8.6.1. Project Description 8-19
8.6.2. Traffic Impacts 8-23
8.6.3. Impacts on Public Transit Routes and Stops 8-27
8.6.4. Impacts on Pedestrian Circulation 8-27
8.6.5. Potential Actions to Minimize Impacts 8-28
8.7. Partial Horizontal Directional Drilling Option After BRT 8-29
8.7.1. Project Description 8-29
8.7.2. Traffic Impacts 8-29
8.7.3. Impacts on Public Transit 8-31
8.7.4. Impacts on Pedestrian Circulation 8-31
8.7.5. Potential Actions to Minimize Impacts 8-31

APPENDICES

Appendix A Methodology for Analyzing Levels of Service
Appendix B Comparison of Repaving Full Street Width Versus Partial Width

ILLUSTRATIONS

Figure 1-1 Project Phase 1 ..... Follows Chapter 1
Figure 1-2 Project Phase 2
Figure 1-3 Proposed BRT Sections Potentially Affecting EOTP

Figure 2-1 Midday Roadway Lanes, Makaloa-Kapiolani Corridor ..... Follows Chapter 2
Figure 2-2 Makaloa St. Traffic Volumes by Time of Day
Figure 2-3 Kapiolani Blvd. Traffic Volumes by Time of Day
Figure 2-4 2004 Morning Peak Hour Traffic, Makaloa-Kapiolani Corridor
Figure 2-5 2004 Midday Peak Hour Traffic, Makaloa-Kapiolani Corridor
Figure 2-6 2004 Afternoon Peak Hour Traffic, Makaloa-Kapiolani Corridor
Figure 2-7 Date St. Traffic Volumes by Time of Day
Figure 2-8 Peak Hour Traffic, Date Street
Figure 2-9 Traffic Volumes by Time of Day, Winam Ave. at Mooheau Ave..
Figure 2-10 Midday Traffic Lanes, King Street Corridor
Figure 2-11 Traffic Volumes by Time of Day, King St. at Kealamakai St.
Figure 2-12 Traffic Volumes by Time of Day, King St. at Hauoli St.
Figure 2-13 2004 Peak Hour Traffic, King Street Corridor

Figure 3-1 2007 Morning Peak Hour Traffic, Makaloa-Kapiolani Corridor ..... Follows Chapter 3
Figure 3-2 2007 Midday Peak Hour Traffic, Makaloa-Kapiolani Corridor
Figure 3-3 2007 Afternoon Peak Hour Traffic, Makaloa-Kapiolani Corridor
Figure 3-4 2009 Peak Hour Traffic, King Street Corridor

Figure 8-1 Potential Work Site Locations, King Street Horizontal Direction Drilling Option ..... Follows Chapter 8

TABULATIONS

Table S-1 Overview of Traffic Impacts S-3
Table 2-1 TheBus Fixed-Route Service, Makaloa Street Corridor 2-4
Table 2-2 2004 Traffic Conditions At Key Intersections, Makaloa Street Corridor 2-6
Table 2-3 TheBus Fixed Route Service, King Street Corridor 2-16
Table 2-4 2004 Traffic Conditions At Key Intersections, King Street Corridor 2-19
Table 3-1 2007 Traffic Conditions At Key Intersections Without BRT Lanes, Makaloa Street Corridor 3-3
Table 3-2 2007 Traffic Conditions At Key Intersections With BRT, Makaloa Street Corridor 3-4
Table 3-3 2009 Traffic Conditions At Key Intersections Without BRT Lanes, King Street Corridor 3-10
Table 3-4 2009 Traffic Conditions At Key Intersections With BRT Lanes, King Street Corridor 3-10
Table 4-1 2007 Midday Peak Hour Traffic Conditions Alternative 1 Without BRT, Makaloa Street Corridor 4-11
Table 4-2 2007 Midday Peak Hour Traffic Conditions Alternative 1 With BRT, Makaloa Street Corridor 4-15
Table 8-1 2009 Traffic Conditions With Trenching Midday Peak Hour Without BRT Lanes, King Street Corridor 8-13
Table 8-2 2009 Traffic Conditions With Daytime Trenching Midday Peak Hour With BRT Lanes, King Street Corridor 8-18
Table 8-3 2009 Traffic Conditions Due To HDD Lane Closures Without BRT Lanes, King Street Corridor 8-25
Table 8-4 2009 Traffic Conditions With Directional Drilling With BRT Lanes, King Street Corridor 8-31

Table A-1 Level-of-Service Criteria for Intersections with Traffic Signal Control A-3
Table A-2 Level-of-Service Criteria for Unsignalized Intersections A-3
Table B-1 Comparison of Work Shifts to Repave Partial Versus Full Width of Streets B-6

EXECUTIVE SUMMARY

The Hawaiian Electric Company (HECO) plans to install additional transmission lines to transfer electrical loads in high demand areas. The proposed project, referred to as the East Oahu Transmission Project (EOTP), would include construction of additional or upgraded lines beneath streets within the central Honolulu area. This Traffic Impact Study assesses the potential construction impacts upon the transportation system, analyzes potential alignment or construction options, and identifies actions to minimize impacts.

S.1 OVERVIEW OF PROJECT

The EOTP includes construction work along a number of streets, with the work grouped into two phases. Phase 1 work would occur in 2006-2007 and would include activities at a number of locations, with the primary work in the Makaloa Street corridor as well as other work along Pumehana Street, along Date Street, and along Mooheau and Winam Avenues. Phase 2 work would occur in 2008-2009 along King Street between Cooke and McCully Streets, to include work along those streets.

S.1.1 Project Description

The proposed work in each corridor generally includes the provision of a new ductline by excavating an open trench, constructing the ductline and manholes, and covering the trench. The preferred work area would be two lanes (20 feet) in width and 300 feet in length. A 50 to 150-foot long section of trench would generally be open at any given time within the work area. The cable would be pulled and spliced in approximately 1,000-foot sections at every other manhole, with the work area at the manhole one lane in width and between 50 and 150 feet in length. After completion, the area of the street disturbed by the excavation work would be repaved for the length of the construction work. For utility lines, past practice has been to repave one lane-width of the street along the excavation for the ductline.

For Phase 1 work between the Makaloa and McCully Substations, existing ductline could be reused for most of the EOTP subtransmission line. For this connection, the proposed action would include the setup of work areas at manholes along the existing line to remove existing cable, if necessary, and to pull and splice the new cable.

S.1.2 Potential Options

For most of the Phase 1 locations, the work is proposed for daytime between 9:00 AM and 3:00 PM for the identified section of street. The option of nighttime work is considered for several sections. Alternative routes are considered for the Makaloa Street corridor.

For Phase 2, trenching at nighttime is the preferred option. Trenching during the daytime is also evaluated. The use of horizontal directional drilling is considered for a section of King Street.

For some narrow street sections in Phases 1 and 2, the assessment considers both the closure of the full width of the street one block at a time to expedite the work, and the closure of one lane for the work area.

S.1.3 Potential Interaction with BRT System

The EOTP could include construction along two streets where the City's Bus Rapid Transit (BRT) system is planned for implementation in the same general time frame as the HECO project:

- Two EOTP Phase 1 alignment alternatives in the Makaloa Street corridor would use sections of Kapiolani Boulevard between Kaheka Street and Atkinson Drive, which will have a BRT lane and passenger platform in the center of the roadway.
- The section of the EOTP Phase 2 line along King Street between Cooke and Pensacola Streets is planned for use by the BRT line, with a semi-exclusive BRT lane along the makai curb shared with vehicles turning right into driveways and cross streets, and the mauka curb lane as an exclusive contra-flow lane for Ewa-bound BRT buses.

The assessment of EOTP construction along these streets considers the impacts both with the ductline construction preceding the BRT lanes and with the ductline construction occurring after the BRT line is in operation.

S.1.4 Overview of Project Traffic Impacts

The streets that would be affected by the EOTP and an overview of several key characteristics and traffic impacts of the Project are presented in Table S-1. Each of the areas is further discussed in the following sections of this chapter.

S.2 MAKALOA STREET CORRIDOR IMPACTS

The EOTP would include expanded capacity between the Makaloa and McCully Substations. The proposed action is to construct a new ductline along a 1,000-foot long section of Makaloa Street and to reuse an existing ductline along Kalakaua Avenue, Fern Street, Hauoli Street, and Lime Street for most of the distance between the two substations. Two alternative alignments were evaluated that would construct a new ductline for the entire distance of about 3,400 feet between the two substations with the new construction located along sections of Makaloa Street, Kaheka Street, Kalauokalani Way, Kapiolani Boulevard, and Pumehana Street.

Table S-1
Overview of Traffic Impacts

Phase/Corridor	Affected Street	No. of Days Traffic Impacted	No. of Nights Traffic Impacted	Estimated Daily Traffic	Minimum Lanes Open to Traffic	No. Cross Streets Impacted	Problem Intersection Locations
Phase 1 Work Areas							
Makaloa-Kapiolani Corridor							
Proposed Action	Makaloa St. – Amana St. to Poni St. (Trenching)	11-14	10-13	7,000	1 with Flagman at Amana St.	3	Amana St., Kaheka St.
	Work at existing manholes along Kalakaua Ave. and Fern, Hauoli, Lime Sts.	2-3 at each manhole	0	2,000-4,000	2	1	Kalakaua Ave.
Alternative 1 Kaheka-Kapiolani Alignment	Makaloa St. – Amana St. to Kaheka St.	11-14	2+	7,000	1 with Flagman at Amana St.	2	Amana St., Kaheka St.
	Kaheka St. – Makaloa St. to Kapiolani Blvd.	3-4	1	14,000	4	0	
	Kapiolani Blvd. – Kaheka St. to Pumehana St.	37-42	2-3+	39,000	4	4	Kalakaua Ave., Atkinson Dr.
	Pumehana St. – Kapiolani Blvd. to Lime St.	4-5		2,900		0	
Alternative 2 Kalauokalani-Kapiolani Alignment	Makaloa St. – Amana St. to Kalauokalani Way.	11-14	15+	7,000	1 with Flagman at Amana St.	3	Amana St., Kaheka St.
	Kalauokalani Way – Makaloa to Kapiolani Blvd.	12-14	1	No Counts	4	0	
	Kapiolani Blvd. – Kalauokalani to Pumehana St.	17-18	1-2+	39,000	4	2	Kalakaua Ave., Atkinson Dr.
	Pumehana St. – Kapiolani Blvd. to Lime St.	4-5	1	2,900		0	
Pumehana St. Area							
Proposed Action Closure by Block	Lime St. – Substation to Pumehana St.	6-7	0	No Counts	Local only	1	
	Pumehana St. - Lime St. to Date St.	33-35	0	2,900	Local only	2	
Single-Lane Option	Lime St. – Substation to Pumehana St.	6	0	No Counts	1 with flagman	1	
	Pumehana St - Lime St. to Date St.	6 Closed 50-55 Flagman	0	2,900	1 with flagman	2	
Date St. Area			1-2				
Proposed Action	Date St. – Kapiolani Blvd. to Laau St.	22-26		16,000	2	1	Kapiolani Blvd. (limited stacking distance at signal)
Winam Ave. Area							
Proposed Action	Mooheau Ave. – Winam Ave. to Paliuli St.	9-10	0	8,200	1 with flagman	0	
	Winam Ave. Mooheau Ave. to Hoolulu St.	10-11	0	3,650	Local only	1	
Single-Lane Option	Mooheau Ave. – Winam Ave. to Paliuli St.	9-10	0	8,200	1 with flagman	0	
	Winam Ave. Mooheau Ave. to Hoolulu St.	21+	0	3,650	1 with flagman	1	

No. Days/Nights Traffic Impact = Days during which trenching, drilling, or repaving closes one or more lanes
Local Only = Street would be closed to through traffic but would allow access to driveways.

Wilbur Smith Associates: July 22, 2004

Table S-1 (Continued)
Overview of Traffic Impacts

Phase/Corridor	Affected Street	No. of Days Traffic Impacted	No. of Nights Traffic Impacted	Estimated Daily Traffic	Minimum Lanes Open to Traffic	No. Cross Streets Impacted	Problem Intersection Locations
Phase 2 Work Area							
King Street Corridor							
Proposed Action (Nighttime Trenching)	Cooke St. – Archer Substation Exit to King St.	0	10-12	6,400	Closed to through traffic	0	
	King St. – Cooke St. to Kaheka St.	0	120-131	30,000	4	7	
	King St. – Kaheka St. to McCully St.	0	61-73	31,000	4	1	
	McCully St. – King St. to Beretania St.	0	11-13	17,000	4	1	
Daytime Trenching Option	Cooke St. – Archer Substation Exit to King St.	9-11	1	6,400	1 lane with flagman	0	
	King St. – Cooke St. to Kaheka St.	114-125	6	30,000	4	7	Ward Ave., Keeaumoku St.
	King St. – Kaheka St. to McCully St.	58-70	3	31,000	4	1	McCully St.
	McCully St. – King St. to Beretania St.	10-12	1	17,000	4	1	
Partial Horizontal Directional Drilling Option	Cooke St. – Archer Substation Exit to King St.	0	10-12	6,400	Closed to through traffic	0	
	King St. – Cooke St. to Elsie Ln.	152 work days plus weekends	9-10	30,000	4	0	Ward Ave., Kalakaua Ave. Keeaumoku Ave.
	King St. – Elsie Ln. to McCully St.	0	61-73	31,000	4	1	McCully St.
	McCully St. – King St. to Beretania St.	0	11-13	17,000	4	1	

Wilbur Smith Associates; August 8, 2004

S.2.1 Proposed Makaloa-Fern Option

The proposed action would use the open trench method to construct about 1,000 feet of new ductline along Makaloa Street from the Makaloa Substation to Poni Street, and reuse an existing ductline along Makaloa Street from Poni Street, and along Kalakaua Avenue and Fern, Hauoli, and Lime Streets for the connection from Poni Street to the McCully Substation. Key features of the construction would include:

- The ductline construction from the Makaloa Substation to Kaheka Street would be done in the daytime (9 AM to 3 PM) with traffic affected for 12 to 15 days, while the work across the Kaheka Street intersection and along Makaloa Street to Poni Street would be done at night (8 PM to 5 AM) with traffic affected for 10 to 13 nights.
- During the ductline construction along Makaloa Street, on-street parking would be removed from both curbs during the work shift for about 400 feet on either side of the work area, with the restriction lasting for about 7-12 work days or nights on each block.
- One lane of traffic would be maintained in each direction for an estimated 9 to 11 days and 10 to 13 nights of ductline construction.
- A single lane with flagman operation may be needed for 3 to 4 days along Makaloa Street as the ductline construction crosses Makaloa Street at the Amana Street intersection.
- Kaheka Street would be blocked to through traffic on the mauka side of Makaloa Street intersection for 1-2 nights as ductline is constructed across intersection.
- Cable pulling and splicing would occur during nighttime at manholes along Makaloa Street, Kalakaua Avenue, Fern Street, Hauoli Street, and Lime Street.
- A 10-foot wide strip along the Makaloa Street trench line would be repaved from near Amana Street to Poni Street at nighttime. Parking would be restricted for one night to maintain a traffic lane in each direction with closure of one-half of street width along one-block at a time for the paving work.

The likely transportation impacts and potential mitigation actions include:

Potential Impacts	Possible Actions to Reduce Impacts
Delays from single-lane/flagman operation during daytime crossing Makaloa Street at Amana Street	Shift construction at this crossing to nighttime when there are lower traffic volumes, or Maintain two lanes along Makaloa St. with no-left-turn restrictions at Amana St.

Potential Impacts	Possible Actions to Reduce Impacts
Blockage of Kaheka Street to through traffic for 1-2 nights as ductline is constructed across intersection with Makaloa	Stage work to leave open one lane with flagman to allow through traffic with delays, and extend work by 2-3 nights
Disruption of TheBus service by Kaheka Street intersection nighttime construction blockage	Same as above Or work only during hours with no bus service, which may increase nights of work
Blockage of crosswalks at intersections	Stage work area to block only one crosswalk at an intersection at one time
Parking restriction and pedestrian impacts of daytime construction	Begin work at 8 AM (or 7 AM) to shorten construction by 1-2 days, or Shift all work to nighttime

S.2.2 All-Daytime Construction Option

This option would shift the construction of the ductline through the Kaheka Street intersection to Poni Street to the daytime (9 AM to 3 PM).

- The work within the Kaheka Street intersection during daytime hours could not be done by blocking Kaheka Street to through traffic, as this would divert up to 700 vehicles per hour to parallel streets. A single-lane/flagman operation could not be done at the intersection due to the high traffic volumes on the two cross streets. Therefore, two lanes would have to be left open.
- With two lanes open along Kaheka Street, the midday peak hour traffic would approximate an acceptable 62% of capacity. However, the work through the intersection would increase by 3-4 days due to the constrained work area configuration.
- The daytime ductline construction between Kaheka and Poni Streets should not cause any substantial delays.
- The blockage of the crosswalk at Poni Street during the daytime would require pedestrians to cross Makaloa Street at the Kaheka Street or Kalauokalani Way crosswalks, or the provision of a temporary crosswalk on the Koko Head side of the Poni Street intersection.

S.2.3 Alternative 1 Kaheka-Kapiolani Alignment

The alternative would construct a new ductline between the Makaloa and McCully Substations along Makaloa Street, Kaheka Street, Kapiolani Boulevard, and Pumehana Street. This would require trenching for a total distance of about 3,400 feet along these streets versus 1,000 feet for the proposed option. Both Daytime and Nighttime construction options were considered.

Daytime Construction Option Before BRT. The ductline construction work would extend from 9 AM to 3 PM on weekdays. The two-lane wide work area work area would be accomplished as follows:

- The on-street parking would be removed from both curbs between 200 feet Ewa of Amana Street and Kaheka Street during work hours for two to three weeks to allow one lane of traffic in each direction.
- The Koko Head side parking would be removed and one makai-bound lane closed along Kaheka Street between Makaloa Street and Kapiolani Boulevard during work hours for about one week.
- Kapiolani Boulevard would be reduced by two traffic lanes during work hours for eight to nine weeks as the work area progresses from Kaheka Street to Pumehana Street.
- Pumehana Street would be closed to traffic between Kapiolani Boulevard and Lime Street during midday work hours for one week for construction of the ductline.

Potential impacts and mitigative actions, if the City BRT lanes are not in operation, would be as follows:

Potential Impacts	Possible Actions to Minimize Impacts
Same impacts along Makaloa St. as described for proposed action	Same mitigative actions as described for the proposed action
Traffic at Kaheka St. intersection at 92% of capacity with increased delays	Schedule ductline construction work near this intersection for nighttime
Increase in delays at other Kapiolani Blvd. intersections	Schedule ductline construction work at night
Blockage of bus stops along mauka side of Kapiolani Blvd.	When blocked by open trench area, shift stop along Kapiolani away from trench area

Potential Impacts	Possible Actions to Minimize Impacts
Blockage of crosswalks at Atkinson Dr. and Kalakaua Ave. intersections	Construct ductline through this section at nighttime when less pedestrian activity is present and place advance signing to warn pedestrians of blockage and alternative routes

Nighttime Construction Option Before BRT – The ductline would be constructed generally the same as in the daytime, except the work would be done between 9 PM and 5:00 AM. The key difference would be the provision of the nighttime work area along Kapiolani Boulevard by restricting the on-street parking rather than by reducing two traffic lanes as in the daytime.

The work at nighttime would generally lessen the impacts to traffic operations, bus access, and pedestrian circulation due to lower levels of activity at most locations as compared to the midday hours.

The nighttime work would reduce the number of parking spaces in the area, which are fully occupied most evenings until after midnight.

Daytime Construction Option After BRT – The ductline construction would generally be the same as before the BRT. The major difference would be the work area along Kapiolani Boulevard would allow only one Ewa-bound traffic lane between Atkinson Drive through the Kaheka Street intersection.

The City BRT project would provide an additional left-turn lane on the Ewa-bound direction of Kapiolani Boulevard at Atkinson Drive which would lessen impacts on that intersection.

Potential Impacts	Possible Actions to Minimize Impacts
Same impacts along Makaloa St. as described for proposed action	Same mitigative actions as described for the proposed action
Traffic at Kaheka St. intersection with Kapiolani Blvd. at 7% above capacity with extremely long traffic delays may cause traffic to divert to parallel streets	Shift construction to nighttime through this section
Work area would block pedestrian access from mauka curb to BRT platform at Atkinson Dr.	Construct this section at nighttime to lessen impact, and/or Provide a temporary crosswalk and access from ewa end of platform, which may not be fully accessible

Nighttime Construction Option After BRT. The ductline would be constructed generally the same as in the daytime, except the work would be done between 9:00 PM and 5:00 AM.

Similar types of impacts could occur as described for the Daytime Construction Option, although the level of impact would be substantially reduced and no diversion of traffic to other streets would be expected due to lower levels of traffic, transit, and pedestrian activity in the late evening and overnight hours.

S.2.4 Alternative 2 Kalauokalani-Kapiolani Alignment

The alternative would construct a new ductline between the Makaloa and McCully Substations along Makaloa Street, Kalauokalani Way, Kapiolani Boulevard, and Pumehana Street. This would require trenching for a total distance of about 3,400 feet versus 1,000 feet for the proposed option. Both Daytime and Nighttime construction options were considered.

Daytime Construction Option. The ductline construction work would extend from 9 AM to 3 PM on weekdays. The two-lane wide work area would be accomplished as follows:

- The on-street parking would be removed from both curbs for a section two blocks long as the work area progresses from Amana Street to Kalauokalani Way with work taking five to six weeks. For most of the time, one lane of traffic would be provided in each direction.

- The mauka half of the 700-foot long block of Kalauokalani Way between Makaloa Street and Kapiolani Boulevard would first be closed to through traffic for construction of ductline. After the mauka half is completed, the makai half of block closed for construction of that section. The closures would each last for about 1 to 1½ weeks.

- Kapiolani Boulevard would be reduced by two traffic lanes for about four weeks as the work area progresses from Kalauokalani Way to Pumehana Street.

- Pumehana Street would be closed to traffic between Kapiolani Boulevard and Lime Street for one week for construction of the ductline.

This alignment would avoid the impacts to the Kapiolani Boulevard intersections with Kaheka Street and Atkinson Drive that would occur with daytime construction for the Kaheka-Kapiolani alternative alignment.

Potential impacts and mitigative actions, if the City BRT lanes are not in operation, would be as follows:

Impacts	Potential Mitigative Actions
Same impacts along Makaloa St. as described for proposed action	Same mitigative actions as described for the proposed action
Traffic delays in constructing ductline across Makaloa St. at Poni St. intersection	Construct at nighttime
Blockage of Kalauokalani Way crosswalks	Provide temporary walkways to bypass construction work area

The BRT system would have little impact on this alignment since the BRT operates in mixed use lanes from Atkinson Drive through Pumehana Street.

Nighttime Construction Option. Construction at nighttime would likely result in fewer transportation impacts due to lower traffic, transit, and pedestrian volumes.

S.3 PUMEHANA STREET AREA

A new underground subtransmission line would be constructed from the McCully Substation along Lime and Pumehana Streets to connect to an existing utility riser pole on the northeast corner of the intersection of Pumehana Street with Date Street. New manholes would be constructed within the intersections of Pumehana Street with Fern and Date Streets.

S.3.1 Proposed Street Closure Option

The proposed approach would be to close the affected sections of Lime and Pumehana Streets to through traffic one block at a time for the ductline construction. All construction work would be done during daytime shift hours (9 AM to 3 PM). The construction work and street/lane closures would be as follows:

- Lime Street would be closed to through traffic from Ewa of the McCully Substation to the Pumehana intersection for three-four days during construction of ductline.
- Lime Street construction area would be extended to include Pumehana Street intersection for about two days.
- Pumehana Street would be closed between Lime and Fern Streets, not including intersections, for six to seven work days.
- Pumehana Street would be closed from Fern to Date Streets, to include Fern Street intersection. The Fern Street intersection closure would last two to four work days.

- The section between Fern and Date Streets would remain closed for a total of an additional six work days as construction progresses the length of the block to Date Street.
- The Date Street intersection would be closed with the work area continuing to extend to Fern Street, for seven work days.
- Open street to traffic, but restrict parking for about a 100-foot long work area at Fern and Date Street intersections to pull and splice cable (four days).
- Close one-half width of streets to repave the section of Lime and Pumehana Streets included within the construction area.

Local property access would be permitted to the extent the driveway is not blocked by the short section of open trench. The streets would be closed to through traffic during the work shift hours for the following number of work days:

Pumehana Street	33 to 35 work days
Lime Street	6 to 7 work days
Fern Street	7 work days
Date Street	7 work days.

Potential transportation impacts and potential mitigative actions would include:

Potential Impacts	Possible Actions to Minimize Impacts
Closure of Pumehana St. to through traffic for 33 to 35 work days, with about 1,000 vehicles per day having to divert to other routes	Use single-lane option
Closure of Lime St. to through traffic for 6-7 work days, with 500 vehicles per day having to divert to other routes	Use single-lane option
Closure of Fern St. to through traffic for 7 work days, with 500 vehicles per day having to divert to other routes	Construct manhole and ductline across Fern St. at nighttime
Closure of Date St. to through traffic for 7 work days, with 800 vehicles per day having to divert to other routes	Construct manhole and ductline across Date St. at nighttime and/or reconfigure work area to leave open lane on Date St. with flagman
Blockage of crosswalks	Stage construction to avoid blocking both sides of intersection at same time

Potential Impacts	Possible Actions to Minimize Impacts
Impact on Lunalilo School traffic and parking	Schedule construction work when school is not in session (summer)
Restriction of on-street parking during daytime	If not being used by School, such as in summer, allow use of Lunalilo School parking lot for resident use

S.3.2 Single-Lane Option

This option would keep Pumehana Street open to through traffic by restricting the work area width to 10 to 12 feet. Through traffic would still have to be frequently stopped for short periods as materials are unloaded or as trucks and equipment are maneuvered into the single lane work area. This option would reduce the days that through traffic would be blocked on Pumehana Street. However, both Pumehana and the cross streets would still be blocked during the intersection work, with the duration of the cross street blockage increased by the constrained work area. The periods of closure to through traffic would be as follows:

Pumehana Street	6 work days
Lime Street	5 to 6 work days
Fern Street	9-10 work days
Date Street	9-10 work days.

The constrained work area would also extend the overall duration of the construction work by about one month, increasing the construction from 7 weeks for the proposed closure option to 10 to 11 weeks with one lane open along Pumehana Street.

S.4 DATE STREET AREA

A new transmission line would be constructed from the Kamoku Substation across Date Street and then in each direction along the mauka curb lane of Date Street to connect to existing utility riser poles located about 50 feet Ewa and 280 feet Koko Head of the Substation. A new manhole would be constructed in the mauka curb lane opposite the Substation and a new manhole would be constructed near the Koko Head end of the new ductline.

S.4.1 Proposed Daytime Construction Option

The construction work would be conducted with the blocking of two traffic lanes at a time, with two traffic lanes remaining open to traffic use. The two Koko Head-bound lanes would be transitioned into a single lane through the work area, with the normal lanes provided at the Date

Street approach to the Kapiolani Boulevard intersection throughout the construction process. The two Ewa-direction lanes would be transitioned into a single lane through the work area. The normal lanes would be provided at the Date Street approaches to the signal-controlled intersection at the Koko Head end of the Laau Street loop throughout the construction process.

The construction work would begin at 9 AM and all open trench areas would be covered and traffic barricades removed by 3 PM. The closure of two lanes past the work area would affect traffic about 12-16 days during the ductline construction and one day for repaving the street. A single Ewa-bound lane would be closed an additional 6-8 days for cable pulling and splicing work.

5.4.2 Transportation Impacts and Mitigation

During the midday work hours, the traffic volumes would approximate 400 to 500 vehicles per hour in each direction through about 2:00 PM. The traffic volumes increase to about 600 to 700 vehicles in each direction between 2:00-3:00 PM due in part to school traffic. A single unrestricted traffic lane in each direction should accommodate these volume levels with minimal delay. Any potential traffic delays would likely result from vehicles stopped to turn left into the cross streets and driveways blocking the single traffic lane in each direction through the construction work area and lane transition area, or the proximity of the lane reduction to the Kapiolani Boulevard intersection resulting in less efficient traffic operations and longer delays at that signal-controlled intersection for the Ewa-bound traffic on Date Street.

A section of on-street parking would be restricted along both curbs of Date Street during the construction work along the Koko Head half of the new ductline. The midday parking restriction would extend for between 100 and 300 feet along both curbs for about four to six days.

Potential Impacts	Possible Actions to Minimize Impacts
Delays to Koko Head-bound traffic by vehicles stopped to turn left into driveways or streets	Restrict left turns, with vehicles able to use Mahiai Street to access Date Street and turn right into driveways
Delays to Ewa-bound traffic by vehicles stopped to turn left into driveways or streets	Restrict left turns, with vehicles having to use alternative routes to turn right into driveways
Delays to Ewa-bound traffic flow at Kapiolani Boulevard intersection	Orient the work area to position the Ewa end of the area as far as possible from the Kapiolani Blvd. intersection throughout the construction work Provide no mauka-side row of traffic cones on the Ewa departure end of the work area to maximize the stacking area at the intersection

Potential Impacts	Possible Actions to Minimize Impacts
Separation of traffic lane from curb bus stop during construction across Koko Head-bound lanes	If feasible, position traffic cones to create a bus "pull out" to access the normal bus stop Or, relocate bus stop location
Blockage of crosswalk across Date St. at intersection with Ewa end of Laau St. loop	Stage work to maintain a crosswalk on one side or the other of the Laau St. intersection
Blockage of makai sidewalk	Provide temporary pathway around work area

S.5 WINAM AVENUE AREA

The EOTP would include construction of an underground ductline from a utility pole along Mooheau Avenue for about 100 feet makai to the Winam Avenue intersection and Koko Head along Winam Avenue for about 320 feet to the Koko Head side of the Hoolulu Street intersection. New manholes would be constructed on Mooheau Avenue about 25 feet mauka of Winam Avenue, and on Winam Avenue at the Koko Head end of the ductline.

S.5.1 Proposed Street Closure Option

The ductline would be constructed by trenching during the daytime with work starting at 9 AM and the streets reopened to traffic by 3 PM. The construction along the Koko Head side of Mooheau Avenue would use the sidewalk area and mauka-bound lane for a work area, with a flagman operation used to alternate traffic direction in the normal makai-bound lane. For Winam Avenue, the closure of the street to through traffic is proposed to expedite the construction of the ductline. Local traffic would be allowed to access properties along the closed section to the extent the property is not blocked by work in the open trench. The construction stages and traffic control would be as follows:

- The mauka-bound lane and adjacent shoulder of Mooheau Avenue would be closed between Paliuli Street and Winam Avenue for ductline construction, with a flagman operation used to alternate traffic direction in the open makai-bound lane. The 300 to 550 vehicles per hour could be accommodated by a flagman operation with delays generally of less than two minutes per vehicle.

- During the ductline construction near the intersection, the flagman operation would continue along Mooheau Avenue and the block of Winam between Mooheau and Hoolulu would be closed to through traffic.

- As the construction work moves onto Winam Avenue, the flagman operation ceases. Winam Avenue would remain closed as the work progresses to the Koko Head terminus of the ductline on the Koko Head side of Hoolulu Street.

Traffic along Mooheau Avenue would be affected by the flagman operation for 6 to 7 work days. The 1½ blocks of Winam Avenue would be closed to through traffic for 10 to 11 days, while the intersection blockage at Hoolulu Street would close that street to through traffic for 1-2 days.

The key potential transportation impacts and mitigative actions would be as follows:

Potential Impacts	Possible Actions to Minimize Impacts
Flagman delays on Mooheau Ave. affects about 2,800 vehicles per day	Do work along Mooheau Ave. at nighttime to reduce the number of vehicles delayed
Daytime closure of Winam Ave. would divert about 1,400 vehicles per day to parallel streets	See single-lane option
Flagman operation on Mooheau Ave. may block bus access to stop at Paliuli St.	Configure work area/transition zone to avoid impact or relocate bus stop
Closure of Hoolulu St. intersection diverts traffic to other routes	Configure work area to leave Hoolulu St. intersection open except when open trench is located within intersection (1-2 days)

5.5.2 Single-Lane Option

The work area on Winam Avenue would be limited to one-half of the roadway width. This option would use a flagman operation to alternate the direction of traffic flow to keep Winam Avenue open to through traffic for most of the time, with the traffic subject to frequent short delays as material and equipment is moved into position in the single-lane work zone. The traffic using the street would experience short delays as a result of the flagman operation and alternating flow direction.

The narrow work area (9 to 10 feet wide) would reduce the productivity of the ductline construction to between 10 and 20 feet of ductline per day. This approach would lengthen the period required for the construction work, with the ductline construction work estimated to require between 20 and 40 work days with blockage of only a single lane along Winam Avenue, versus 10-11 days with street closure to through traffic.

S.6 KING SREET CORRIDOR

Phase 2 includes the construction of a new ductline from the Archer Substation along Cooke Street (420 feet) and King Street (9,100 feet) to connect to a utility riser pole on McCully Street about 460 feet mauka of King Street.

- Along Cooke Street, the ductline would be constructed beneath the parking lane along the Koko Head curb.
- Along King Street, the line would be located beneath the second lane from the makai curb for most of the distance with several jogs into the third lane from the makai curb to avoid other utilities.
- Along McCully Street, the line would be constructed beneath the parking lane along the Koko Head curb.

Two ductlines would be constructed across King Street near Hauoli Street to connect to riser poles on the mauka side of the street. The Phase 2 line is planned for construction in 2008-2009 which may precede or follow after the implementation of the BRT line along King Street.

S.6.1 Proposed Nighttime Trenching Option

The proposed action would construct the ductline by trenching the entire length, with the trenching work as well as the repaving of the streets to be done at nighttime to allow more efficient work and to reduce impacts. The work would be done between 8:00 PM and 5:00 AM.

- Cooke Street would be closed to through traffic during the ductline construction. The street would be closed to through traffic for 9 to 11 nights.
- On King Street, the construction work area would occupy the #2 and #3 lanes from the makai curb. Parking would be restricted along the makai curb lane for a length of about 1,000 to 1,500 feet in the vicinity of the work area as it progresses down the street.
- Two construction crews would work on the project, with Crew A starting on Cooke Street and constructing the ductline to Kaheka Street while Crew B would start at Kaheka Street at the same time and construct the line to the McCully terminus. The Crew A work would extend for an estimated 114-125 nights, while Crew B would take about 58-70 nights to construct its section of the line.
- Along McCully Street, the work area would occupy the Koko Head side parking lane and the adjacent traffic lane, with the work area extending from King Street to the terminus mauka of Young Street, with the ductline work lasting for 10 to 12 nights.

- At the major intersections along King Street, and at the McCully Street-Young Street intersection, the work would be staged to leave one-half of the cross street lanes open in each travel direction.

- The pulling and splicing of the cable would be done at nighttime, the work taking about 4 nights on Cooke Street, 36 to 40 nights on King Street, and 4 nights on McCully Street.

- The repaving work would be done by closing off Cooke Street, and by closing two lanes of King and McCully Streets to pave a one lane wide section along the excavation area. The repaving of the entire width of the streets would require about 1 night for Cooke Street, 9 to 10 nights for King Street, and 1 night for McCully street.

Nighttime Construction Before BRT Line. The ductline construction along King Street would provide two through traffic lanes on the mauka side of the work area, with the makai curb lane open for buses, vehicles turning right into driveways or cross streets, and any through traffic that may choose to pass the work area on that side. At 8:00 PM, the traffic on King Street would average about 400 vehicles for each of the three traffic lanes available for use, which is less than the average of 500 vehicles in each normal traffic lane on King Street during the midday peak hour. For most of the nighttime period, the King Street volumes would approximate 100-200 vehicles or less in each of the three lanes past the work area. Nighttime construction should result in little traffic delays along King Street.

Potential Impacts	Possible Actions to Minimize Impacts
Closure of Cooke St. to through traffic	Place signs to reroute via Kapiolani Blvd.
Delays at major cross streets along King Street (not expected)	Restrict parking from mauka curb as work area crosses intersection to provide fourth traffic lane on King St. through the intersection and revise signal timing, or Start nighttime work at 9 PM to avoid impacts during higher 8-9 PM traffic hour
Traffic delays during special nighttime events	Coordinate construction schedule and work hours with Neal Blaisdell Center and other potential event sites to minimize impacts
Blockage of crosswalks by work area	Configure and stage movement of work area to block only one crosswalk at an intersection at one time, or Provide temporary crosswalk to replace mid-block or single crosswalks if appropriate and safety can be maintained

Nighttime Construction After BRT Line. The construction and impacts would be similar to those without the BRT for most of the ductline, with the BRT affecting primarily the section from Cooke to Pensacola Streets.

The ductline construction along King Street between Cooke and Pensacola Streets would provide only the two mauka-side through traffic lanes past the work area, with the makai curb lane open only for buses and vehicles turning right into driveways or cross streets. At 8:00 PM, the traffic on King Street would average about 500-600 vehicles for each of the two through traffic lanes available for use, which is about the same as the 500 vehicles in each normal traffic lane on King Street during the midday peak hour. For most of the nighttime period, the King Street volumes would approximate 100-300 vehicles or less in each of the two through lanes past the work area. Nighttime construction should result in little traffic delays along the section of King Street with the BRT lanes. The most likely location for delays would be at the Ward Avenue intersection, and to a lesser extent, the Pensacola Street intersection.

The list below represents additional potential impacts and mitigative actions that would occur only if the BRT line is in place prior to the EOTP construction.

Potential Impacts	Potential Mitigative Actions
Traffic delays at Ward Ave. or Pensacola St. during ductline construction	Delay start of nighttime work in these areas until lower traffic activity at 9 PM Temporary through traffic use of Koko Head-direction BRT lane during nighttime work hours (by City)
Blockage of BRT lane and bus stops by repaving work (if repaving is required for full width)	City waiver of requirement to resurface the BRT lanes, or Temporary operation of Koko Head-direction BRT in general traffic lane and re-routing the Ewa-direction BRT buses, with relocation of bus stops, or Repave only during hours BRT line not in service

S.6.2 Daytime Trenching Option

The Daytime Trenching Option would follow the same alignment and general progression of the ductline construction work as the proposed Nighttime Trenching Option, with the work scheduled between 9 AM and 3 PM. The ductline construction and cable pulling/splicing work would be done during the daytime. The repaving of the street would be done during the nighttime. Key differences in daytime work as compared to the nighttime construction work are listed below:

- The construction work across major intersections would progress at a slower pace of about one lane-width (10-12 feet per day) due to shorter work hours, more traffic conflicts, and a more constrained work area configuration, which would lengthen the time the work area is located within and blocking lanes in each intersection to six-eight days, versus two-three nights.

- The higher daytime traffic volumes would necessitate the restriction of parking along both curbs along King Street for three to four blocks around the work area during the time the work area reduces the traffic lanes at a major cross street intersection.

Daytime Construction Before BRT Line. Traffic conditions were analyzed for the major intersections along King Street based on a minimum of two through traffic lanes on the mauka side of the work area ductline construction, with the makai curb lane open for buses, vehicles turning right into driveways or cross streets, and any through traffic that may choose to pass the work area on that side. The analysis indicated that the midday peak hour traffic would amount to about 94% and 93% of the capacity at the Ward Avenue and Keeaumoku Street intersections, respectively, as well as about 88% of capacity of the Kalakaua Avenue and Punahou Street intersections as the work area is near, but not within, each of these intersections. The traffic volumes, coupled with the merging of traffic from the # 2 and #3 lanes would likely result in traffic delays and formation of traffic queues during the ductline construction work near these intersections.

The analysis indicated that the restriction of parking in the mauka curb lane to provide an additional through lane during the midday work hours should provide adequate capacity during the days the work area would be located near, but not within, each of the major cross street intersections.

As the work area is located within the major intersections, thus blocking cross street lanes as well as lanes on King Street, the midday peak hour traffic volumes would exceed the reduced capacities at the King Street intersections with Ward Avenue and with Keeaumoku Streets, and would approximate 91% of capacity at both the Punahou and McCully Street intersections.

Potential Impacts	Possible Actions to Minimize Impacts
Traffic delays as work area approaches/ departs each major cross street intersection	Restrict parking along both curbs for three-four blocks around work area
Traffic delays as work area crosses through major intersections and blocks some cross street lanes	Schedule work within major cross street intersections for nighttime hours only
Traffic impacts due to closure of Cooke Street to through traffic	Provide single lane for mauka-bound traffic

Potential Impacts	Possible Actions to Minimize Impacts
Blockage of bus stops during nighttime repaving same as for nighttime option	Same as for nighttime option
Blockage of crosswalks would affect more pedestrians during daytime than nighttime	Same as for nighttime option
Blockage of crosswalks near schools affect on *routes for children walking to schools*	Station additional crossing guards to direct children to alternative crosswalks, or Cease work early before end of school day and provide pedestrian crossing at normal crosswalk location

Daytime Construction After BRT Line. The construction and impacts would be similar to those without the BRT for most of the ductline, with the BRT affecting primarily the section from Cooke to Pensacola Streets.

The ductline construction along King Street between Cooke and Pensacola Streets would provide only the two mauka-side through traffic lanes past the work area, with the makai curb lane open only for buses and vehicles turning right into driveways or cross streets. The analysis indicates that the midday peak hour traffic would exceed capacity at the Ward Avenue intersection both as the work area is located within the intersection and as the work area approaches and departs from the intersection area. This would likely result in formation of long queues and encourage potential diversion of traffic to parallel routes. Midday traffic would approximate 95% of capacity as the work area is located within the Pensacola Street intersection.

The following potential impacts and mitigative actions could occur in addition to those identified without the BRT line.

Potential Impacts	Potential Mitigative Actions
Traffic delays at Ward Ave. and Pensacola St.	Construct section from Archer Ln. to Victoria St. or Pensacola St. at nighttime

S.6.3 Partial Horizontal Directional Drilling Option

Horizontal directional drilling (HDD) could be used to construct the section of the ductline from Cooke Street to Washington Middle School. The remaining sections of the ductline would be constructed by the open trench method.

A small directional drilling rig could be used to install the ductline for a distance of up to about 500 feet from the drill site. The drill rig could be used to first drill and install the ductline in one direction down King Street for a distance of 500 feet from the drill site, and then be turned 180 degrees within that drill site work area to drill and install a ductline for a distance of 500 feet in the opposite direction from the same work area. Additional work areas would be needed at the end point of the 500-foot drill distances for use in feeding in the ductline casing as the rig pulls the ductline casing back through the drill hole to the drill site. Thus, a series of 14 work areas would be needed approximately 500 feet apart along this section of King Street. Permanent manholes would be constructed at each of these work areas for future use to access the cables.

The work area for the drill site would occupy Lane #2 and #3 from the makai curb, with the area about 100 feet in length. The drill site work area would be in place at every second manhole location for about four weeks. The drill site work area would remain in place 24-hours a day and 7 days a week.

The work areas at the exit points would be set up in Lane #2 as the drill head approaches the terminus of that drill section. The exit point work areas would initially be one lane wide by about 100 feet in length as an area is excavated to provide access to the horizontal drill hole. The work area would likely be expanded to two lanes wide for 1 to 2 days as a manhole is constructed within the work area. The exit point work area would be lengthened to provide an additional length of about 500 feet in Lane #2 for use in assembling the 500-foot long ductline casing, with a diameter of about 10 inches, to be pulled back through the drill hole to provide the permanent lining for the ductline.

The exit point work area would need to be in place for about two weeks for each drill series to provide the three ductline casings between each pair of manholes. The casing assembly portion of the exit point work site could be opened to traffic during a small portion of this period. However, the 500-foot long casing assembly area would have to be closed to traffic 24-hours a day during the time the 10-inch diameter casing is being assembled through the time it is pulled into the ductline drill hole. The casing assembly would take about 7 to 10 hours and would be done during daytime; the casing pullback would take 10 hours and would be done in the daytime. The casing would be placed in a shallow temporary trench across any major cross streets that it would otherwise block from the time of assembly to the completion of pullback into the drill hole.

On-street parking would be restricted along the makai curb near the drill site and exit point work areas during the period each work area is in place. The restriction would extend for a distance of about 1,500 feet, from about 300 feet upstream of the one work area to about 300 feet beyond the second work area, with this section including the casing assembly area. The restriction would be in place for 24 hours a day, 7 days a week. This would allow the makai curb lane to remain open to traffic at all hours to maintain access to driveways and bus stops, and to accommodate general traffic flow pass the work area.

The other sections of the ductline would be constructed by the conventional trenching method. These would include the sections along Cooke Street (about 420 feet), King Street from near the

Washington Middle School to McCully Street, the two short lateral connections across King Street near the Times Supermarket, and the McCully Street section (460 feet).

Cable pulling and splicing would occur at the manholes. Only those sections of the streets affected by the ductline construction would be repaved.

HDD Option Before BRT. The estimated seven drill site work areas would close two King Street traffic lanes at each location with the closure occurring 24-hours a day, 7 days a week for the period of about 4 weeks at each of these sites. With on-street parking allowed along the mauka curb, the morning and midday traffic would be compressed into three traffic lanes past the drill site. This would result in about 700 to 800 vehicles in each of the lanes on the mauka side of the drill site. Some potential delays and queue formation could occur as a result of the lane-changing and merging of traffic out of lanes #2 and #3.

Because of the 24-hour a day work area, the lane blockage would affect afternoon peak hour traffic. In the afternoon peak hour, the approximately 3,300 vehicles passing a drill site would have to merge from six lanes (550 vehicles per lane) into four lanes (825 vehicles per lane). This lane-changing would likely result in slowing of traffic speeds and may lead to formation of traffic queues upstream of the lane blockage. These queues could stack to and disrupt traffic conditions at nearby intersections.

Where a drill site is located less than 200 feet from a key intersection, the work area would effectively result in the loss of two traffic lanes through the intersection during all hours of the day. With the initial location plan, this would include the following intersections:

Loss of 2 King Street lanes at Ward Avenue intersection

Loss of 2 King Street lanes at Kalakaua Avenue intersection.

Where a drill site is located about 200 to 300 feet from a key intersection, the work area would effectively reduce the traffic use in the #2 and #3 traffic lanes through the intersection during all hours of the day. For this assessment, it was assumed that the disruption to traffic flow would amount to a 50% loss of efficiency in the two blocked lanes, or the equivalent of the loss of one through lane, at the following intersection:

Loss of 1 King Street lane at Keeaumoku Street intersection.

Based on the preliminary plan for the work site locations, the key major intersections should operate at acceptable conditions during the morning and midday periods. However, the higher afternoon peak hour traffic volumes could result in severe congestion and lengthy delays at several King Street intersections:

- At Kalakaua Avenue, traffic would exceed intersection capacity by 20%
- At Ward Avenue, traffic would exceed intersection capacity by 16%
- At Keeaumoku Street, traffic would amount to 96% of intersection capacity.

The lengthy delays along King Street in the afternoon peak hour could result in traffic diverting to alternative routes during the approximately four weeks each that a drill site is present near the Kalakaua Avenue, Ward Avenue, and Keeaumoku Street intersections.

The excavation of the shallow trenches across each major cross street would be done during the nighttime work hours and should have little impact on traffic flow.

The HDD should have minimal impact on bus operations along King Street or the cross streets.

The casing assembly and pullback could impact pedestrian crossings of King Street since the 10-inch diameter casing would be located along a 500-foot section of lane #2 for about two days at a time during the assembly and pullback work. Each crosswalk would be affected three times as different casings are assembled and pulled into the drill hole.

The HDD option would reduce the impacts due to repaving if only the sections where the street is damaged at the entry and exit pits, plus the shallow casing pullback trenches across major intersections, are repaved. Only about three nights would be required for repaving on King Street, versus nine nights if one lane width the entire length of the construction were to be repaved along the trench.

The key potential transportation impacts and mitigative actions would be as follows:

Potential Impacts	Possible Actions to Minimize Impacts
Morning and midday delays for King St., traffic at the drill site work areas	Restrict on-street parking for three to four blocks at each drill site work area between 6:30 AM and 3:30 PM
Afternoon peak hour delays at Ward Ave., Kalakaua Ave., and Keeaumoku Sts.	Relocate drill site work area further from intersection, which increases number of work sites and duration of work, or Re-stripe King Street on mauka side of work area past drill site for four 9-foot wide lanes
Blockage of crosswalks across King St. during assembly and pullback of casing at each pullback work area	Construct temporary pedestrian bridge over the assembled casing Post advance warning signs to indicate alternative routes

HDD Option After BRT. The BRT would restrict through traffic from both of the curb lanes along King Street in the EOTP section from Cooke to Pensacola Streets. The afternoon peak hour King Street traffic volume of about 3,300 vehicles would be compressed from four lanes

(825 vehicles per lane) to two lanes (1,650 vehicles per lane) at the drill site work areas near Cooke Street, Ward Avenue, and Pensacola Street. The merging would likely result in slowing of traffic and formation of traffic queues and delays at each location, with the queues potentially disrupting traffic flow along cross streets. Some of the King Street traffic would attempt to divert to parallel routes such as H-1 Freeway, Kinau Street, Kapiolani Boulevard, and Ala Moana Boulevard. Traffic at the Ward Avenue intersection could exceed capacity by about 50%.

During the morning and midday peak hours, the traffic would be compressed from 500 vehicles per lane to about 1,000 vehicles per lane at the work areas. The merging maneuvers would likely result in formation of traffic queues and traffic delays.

Potential Impacts	Possible Actions to Minimize Impacts
Increased traffic delays from Cooke St. to Pensacola St.	Construct EOTP prior to BRT operation, or Temporary relocation of Ewa direction BRT buses to Kapiolani Blvd. and open mauka curb lane to Koko Head traffic for 3-month duration of work at the drill sites
Increased traffic delays at Ward Ave. intersection	Relocate drill site further from intersection, or Construct section of ductline near Ward Ave. by conventional trenching at nighttime

Chapter 1
INTRODUCTION

The Hawaiian Electric Company (HECO) plans to install additional electrical transmission lines within the central Honolulu area between Cooke Street and the Kapahulu area. The proposed project, referred to as the East Oahu Transmission Project (EOTP), would allow HECO to transfer electrical loads between substations serving high demand areas of the island, which would address existing and future transmission problems in the East Oahu area.

The EOTP would include the placement of many of the additional or upgraded electrical lines in underground duct lines to be constructed within existing streets. The construction of these underground ductlines would affect traffic flow, public transit operations, and pedestrian and bicycle circulation in the area. The purpose of the Traffic Impact Study is to assess the potential construction impacts of the EOTP upon the transportation system, analyze potential alignment alternatives or construction options for the work within the roadways, and identify possible actions to minimize impacts on transportation operations.

1.1. PROJECT DESCRIPTION

The EOTP includes construction work along a number of roadways to provide the additional electrical transmission network connections and capacity increases. These individual construction areas have been grouped within two construction phases. The key work elements with construction activities affecting transportation system are outlined in the following sections.

1.1.1. Phase 1

The work locations included in Phase 1 are depicted in Figure 1-1. The major activity in this initial phase will be construction to increase capacity between the Makaloa and McCully Substations. The proposed project includes the construction of a new 46 kV ductline under a portion of Makaloa Street and the reuse of existing ductline along Makaloa, Kalakaua, Fern, Hauoli, and Lime Streets. Two alternative alignments have been identified for assessment along the Koko Head section of this connection: 1) construction of a new ductline along Makaloa Street, Kaheka Street, Kapiolani Boulevard, and Pumehana Street; and 2) construction of a new ductline along Makaloa Street, Kalauokalani Way, Kapiolani Boulevard, and Pumehana Street.

Other elements of the Phase 1 construction, which are assessed in separate sections of this report, include:

- Construction of a new subtransmission ductline in a section of Lime and Pumehana Streets
- Construction of a new subtransmission ductline under a section of Date Street

- Construction of a new subtransmission ductline under a section of Mooheau and Winam Avenues.

The Phase 1 work is expected to extend from 2006 into 2007.

1.1.2. Phase 2

The Phase 2 work centers on construction of a new transmission ductline within King Street between Cooke and McCully Streets, as well as short connecting sections along those two streets as depicted in Figure 1-2. The proposed action would use the trenching method to construct the new ductline. The use of horizontal directional drilling was evaluated as an alternative to trenching for the section of King Street between Cooke Street and Washington Middle School.

The Phase 2 work is expected to extend from 2008 through the first quarter of 2009.

1.2. METHODOLOGY AND ASSUMPTIONS

The general methodology and assumptions used in the forecasting and analysis of traffic impacts with the EOTP are outlined in the following sections.

1.2.1. Analysis Scenarios

For the EOTP Phase 1 construction, the impact assessment reflects anticipated mid-2007 traffic conditions. For the Makaloa-McCully transmission line, an assessment was made for the proposed action (trenching along Makaloa Street and reusing existing ductlines from Poni Street to the McCully Substation). In addition, two alignment alternatives were considered:

1. Construction of new ductline along Makaloa Street, Kaheka Street, Kapiolani Boulevard, and Pumehana Street; and

2. Construction of a new ductline along Makaloa Street, Kalauokalani Way, Kapiolani Boulevard, and Pumehana Street.

The traffic analysis for the proposed action was based on construction in daytime for the Ewa section of the Makaloa Street ductline and at night for the Koko Head section, as well as the option of constructing the entire line during daytime. The alternative alignments assessed the option of daytime construction as well as for nighttime construction.

The proposed alignment for the construction along Pumehana Street was assessed for daytime construction due to the adjacent residential uses. The proposed approach is based on the closure of each street block to through traffic as construction occurs on that block; the assessment also considered the option of maintaining a traffic lane along Pumehana Street for through traffic.

Only the proposed alignment and daytime construction were assessed for the construction along Date Street and along Winam Avenue due to the residential uses in these areas.

The traffic assessment of the Phase 2 King Street project considered only the proposed alignment along King Street. An analysis was made of both the proposed conventional trenching for construction of the ductline, and the option of using horizontal directional drilling (HDD) for the section between Cooke Street and Washington Middle School near Elsie Lane. The trenching approach was analyzed as to traffic impacts of proposed nighttime work; the option of daytime trenching work was also assessed for King Street.

1.2.2. Traffic Forecast Methodology

The existing weekday and peak hour traffic counts were used as the basis for the projection traffic volumes within the EOTP Phase 1 study areas to the late 2006-early 2007 for use in assessing the project impacts, and along the King Street study area to late 2008-early 2009 to assess the Phase 2 traffic impacts. An average annual growth rate of 0.75% was used to project the existing counts to the forecast years. This growth rate was based on the average traffic growth forecast between 2000 and 2025 for the Ward Avenue Screenline in the BRT project.[1] The BRT forecasts were developed using the Oahu Metropolitan Planning Organization (OMPO) regional traffic forecasting model and the City and County of Honolulu projections of population and employment growth for Honolulu.

At an average growth rate of 0.75% per year, the 2004 traffic counts were increased by 2% to reflect late 2006-early 2007 traffic and by 4.1% to reflect traffic in late 2008-early 2009. The 0.75% annual growth rate was also used to factor older traffic counts at several locations to reflect 2004 traffic levels.

1.2.3. Intersection Analysis Methodology

Traffic conditions at intersections controlled by traffic signals or STOP signs were analyzed using the methodology set forth in the *2000 Highway Capacity Manual*, as summarized in Appendix A. The analyses of traffic signal-controlled intersections were based on the following operational assumptions:

- Use of 4-second yellow clearances for each signal phase and a 1-second all-red interval for the main street through traffic phase.
- Left-turns generally allowed only with protected left-turn phases.
- No Right Turn on Red used in analysis for all intersections.

[1] *Primary Corridor Transportation Project Final EIS*, prepared by the City and County of Honolulu, July 2003.

1.2.4. Assumptions Regarding City Bus Rapid Transit (BRT) Project

The City and County of Honolulu is proceeding with the development of a Bus Rapid Transit (BRT) system to serve as the public transit spine connecting the various areas within central Honolulu and the outlying areas Ewa of the central Honolulu area. The In-Town elements of the BRT network will include construction of the BRT facilities along several routes:

1. An initial route, referred to as the initial operating system (IOS) that will extend from Aala Park through Downtown Honolulu and continue to Waikiki through the Kakaako Makai area and along Ala Moana Boulevard.

2. A Kalihi route that will extend from Aala Park along Dillingham Boulevard to the Middle Street area.

3. A Downtown to UH-Manoa route that will extend from Downtown along King Street to Pensacola Street, along Pensacola Street to Kapiolani Boulevard, along Kapiolani Boulevard to University Avenue, and along University Avenue to UH-Manoa.

4. A Kakaako Mauka route that will extend from Downtown Honolulu along Halekauwila and Pohukaina Streets to connect to the IOS at Ward Avenue.

The Regional BRT route portion of the network will extend from Middle Street along the H-1 Freeway to Kapolei.

The Downtown to UH-Manoa route will extend along a section of King Street, from Cooke Street to Pensacola Street, which is proposed for construction of the Phase 2 ductline, and along a section of Kapiolani Boulevard, from Kaheka Street to McCully Street that is being considered as an alternative route for a Phase 1 ductline.

BRT Schedule. The plan is to begin construction on the IOS in 2004 and open that route for service in 2005. The City plans to proceed with construction of the other routes in the order presented above, but the timing is uncertain as it will be influenced by the availability of funding.

The BRT work along King Street and Kapiolani Boulevard could begin by 2006, the year the EOTP Phase 1 work is planned to begin for the Makaloa-Kapiolani corridor, and before the start of work on King Street in EOTP Phase 2.

BRT Schedule Assumptions for the EOTP Analysis. HECO would not perform construction work on either the Phase 1 Kapiolani Boulevard alternatives or the Phase 2 King Street section at the same time the City has BRT construction on those street segments. Therefore, the EOTP construction on King Street would either precede or follow the BRT construction on the King Street segment, and EOTP construction along one of the Kapiolani route alternatives would either precede or follow the BRT construction on that segment of street. The traffic analysis of the EOTP construction assesses the impacts on both King Street and Kapiolani Boulevard both with and without the BRT system in place along those streets.

Descriptions of the BRT system along those two streets, as it would affect the EOTP, are further discussed in Chapter 3.

1.2.5. Assumptions Regarding Street Repaving

Present ordinances of the City and County of Honolulu require that utility companies repave the area of the street disturbed by excavation and trenching work, with paved area extending at least six inches beyond the disturbed area. Past practice has been to resurface the width of one traffic lane. The City and County of Honolulu has recently set forth a policy that utility companies repave the entire width of the street for the length of the excavation work.

The traffic assessments presented in Chapters 4 through 8 reflect the past practice of repaving the width of one traffic lane for the length of the excavation work. Appendix B summarizes the primary differences that would occur in the traffic impacts with repaving the full-width rather than the partial width of the streets. Appendix B includes estimates of the number of work shifts needed to repave the full width as compared to partial width.

The estimates of the time needed to repave the excavation areas (one lane width) were based on the following rates of pavement work along the roadways:

Makaloa, Kaheka, Kalauokalani Way	600-800 feet per work shift
Kapiolani Boulevard	1,000
Pumehana Street	600
Date Street	600
Winam, Mooheau Avenue	600
Cooke Street	600
King, McCully Street	1,000

1.3. REPORT ORGANIZATION

This traffic impact analyses for the HECO EOTP construction has been organized into the following chapters:

1. **Introduction**

2. **Existing Conditions.** Describes the existing roadway facilities, public transportation services, traffic volumes, and traffic conditions in each of the construction areas.

3. **Future Traffic Conditions Without the Project.** Describes the traffic increases on area roadways and traffic conditions at key intersections in year 2006 for the Phase 1 areas and for 2008 in the Phase 2 area. The assessment for the Makaloa-Kapiolani area and King Street consider conditions both without and with the planned BRT facility along these streets.

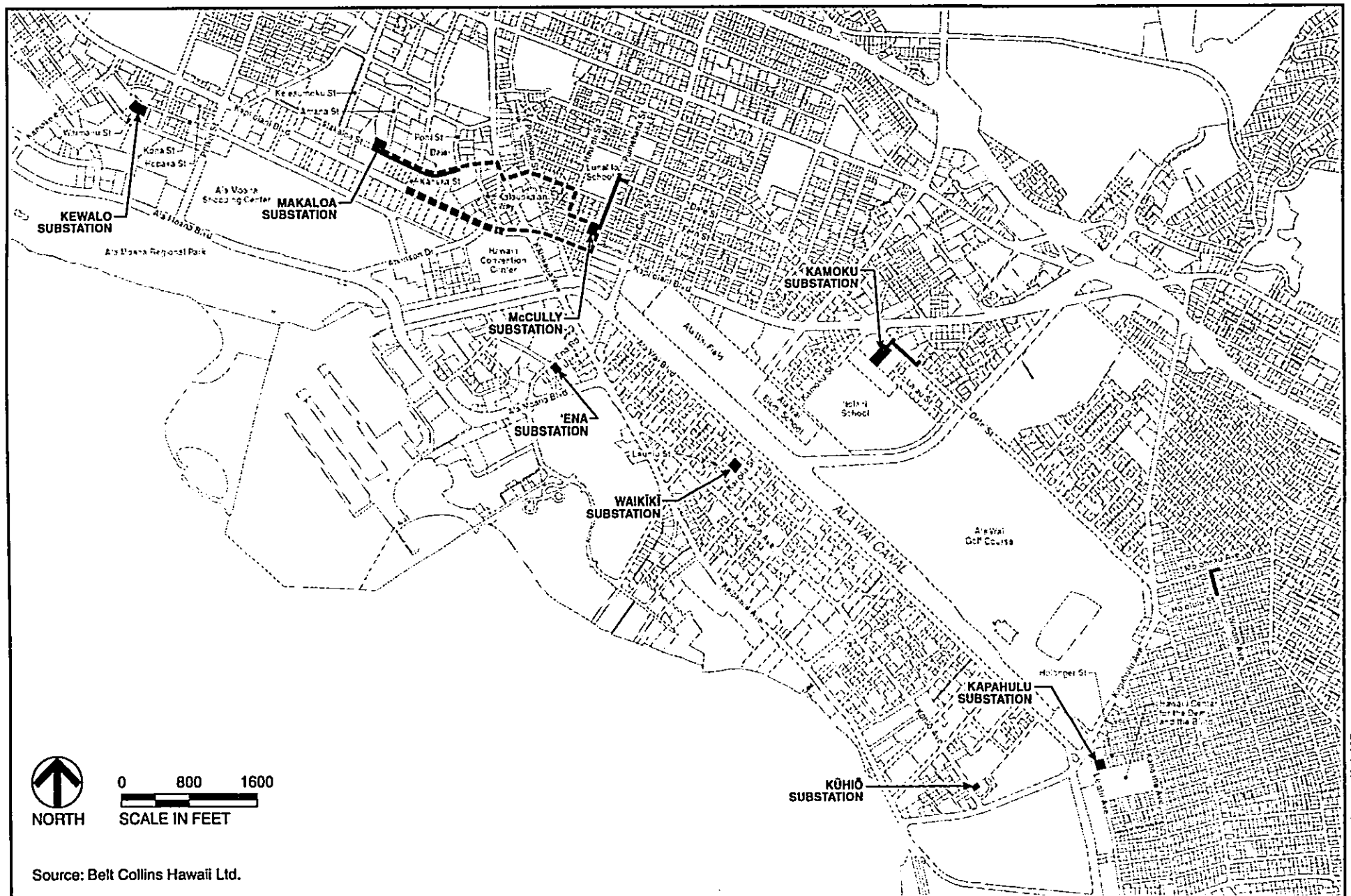
4. **Phase 1 Traffic Impacts in Makaloa-Kapiolani Corridor.** Describes the traffic conditions at key intersections for the different construction alignments, with the Kapiolani alignment alternatives considered both with and without the BRT project

5. **Phase 1 Traffic Impacts in Pumehana Street Area.** Describes the traffic effects on area roadways with the EOTP construction with the traffic control options.

6. **Phase 1 Traffic Impacts in Date Street Area.** Describes the traffic effects on area roadways with the EOTP construction.

7. **Phase 1 Traffic Impacts in Winam Avenue Area.** Describes the traffic effects on area roadways with two traffic control options.

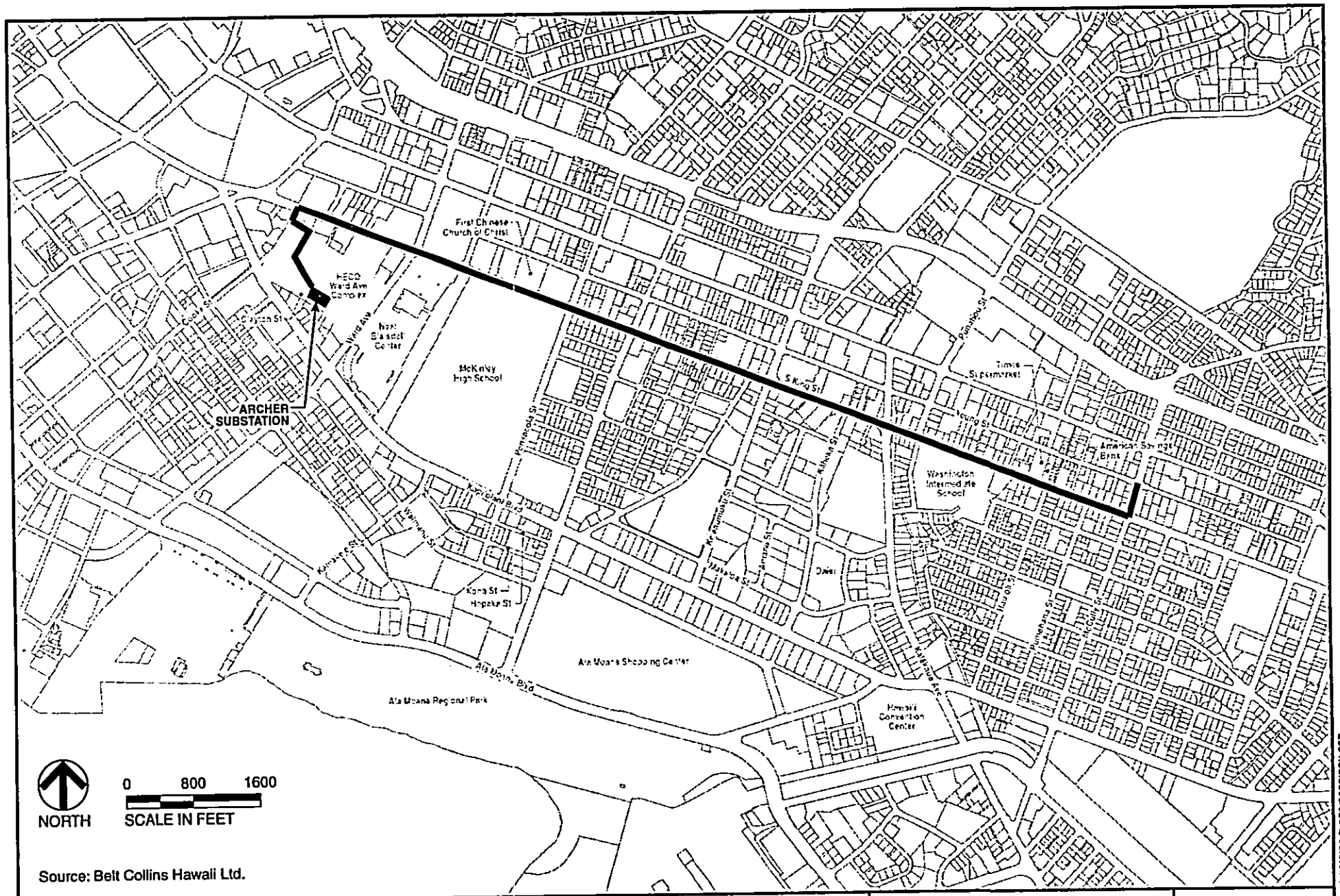
8. **Phase 2 Traffic Impacts in King Street Corridor.** Describes the traffic effects on area roadways with the proposed trenching construction method, both for the preferred nighttime work and for daytime work, and with the horizontal directional drilling option.



Source: Belt Collins Hawaii Ltd.

2004.33.0800/026-1 k11.02.04 2

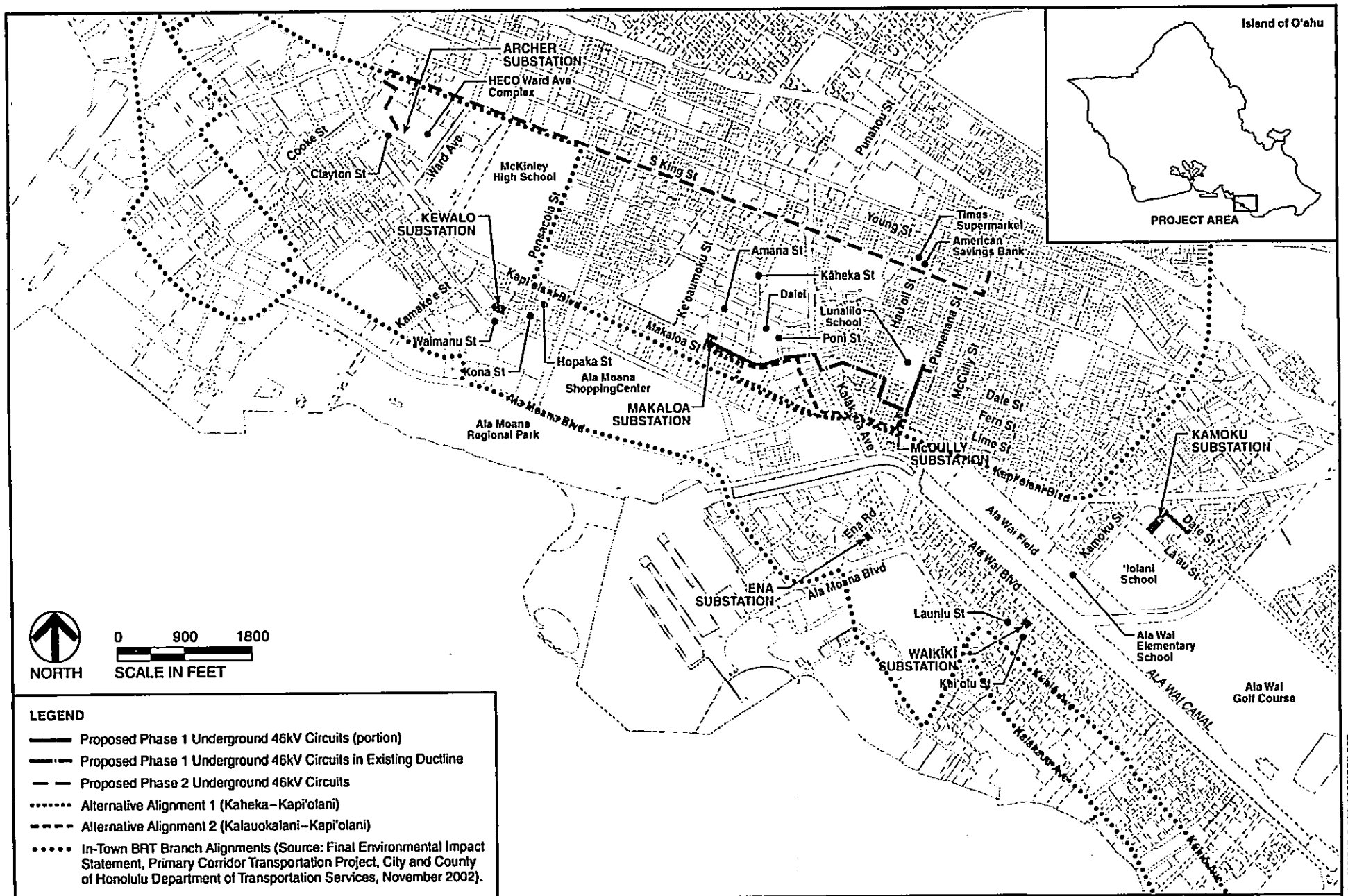
Wilbur Smith Associates — ENGINEERS PLANNERS ECONOMISTS	333 FAYETTEVILLE ST, SUITE 1450 RALEIGH, NORTH CAROLINA 27601 TELE : (919) 755-0583 FAX : (919) 832-8798	EOTP TRAFFIC IMPACT STUDY HONOLULU, HAWAII	PROJECT PHASE 1	FIGURE: 1-1



Source: Belt Collins Hawaii Ltd.

2004.33.0800/026-2 d8.8.04 1

Wilbur Smith Associates (ENGINEERS PLANNERS ECONOMISTS) 333 FAYETTEVILLE ST, SUITE 1450 RALEIGH, NORTH CAROLINA 27601 TELE : (919) 755-0583 FAX : (919) 832-8798	EOTP TRAFFIC IMPACT STUDY HONOLULU, HAWAII	PROJECT PHASE 2	FIGURE: 1-2



LEGEND

- Proposed Phase 1 Underground 46kV Circuits (portion)
- Proposed Phase 1 Underground 46kV Circuits in Existing Ductline
- Proposed Phase 2 Underground 46kV Circuits
- Alternative Alignment 1 (Kaheka–Kapi'olani)
- Alternative Alignment 2 (Kalauokalani–Kapi'olani)
- In-Town BRT Branch Alignments (Source: Final Environmental Impact Statement, Primary Corridor Transportation Project, City and County of Honolulu Department of Transportation Services, November 2002).

2004.33.0800/028-5 d12.9.04 1

Wilbur Smith Associates
ENGINEERS PLANNERS ECONOMISTS
333 FAYETTEVILLE ST, SUITE 1450
RALEIGH, NORTH CAROLINA 27601
TELE : (919) 755-0583
FAX : (919) 832-8798

EOTP TRAFFIC IMPACT STUDY

HONOLULU, HAWAII

PROPOSED BRT SECTIONS POTENTIALLY AFFECTING EOTP

FIGURE: 1-3

Chapter 2
EXISTING CONDITIONS

The EOTP construction is planned along roadways ranging from narrow collector streets within residential areas to major six-lane arterial roadways bordered by mostly commercial uses. Many of these roadways accommodate both regional and local traffic, with most of the major streets also accommodating public transit routes.

2.1. MAKALOA STREET CORRIDOR

The EOTP Phase 1 construction work is planned along the section of Makaloa Street between the Makaloa Substation, located at the intersection with Amana Street, and Poni Street, with limited work at existing manholes to access an existing ductline along Kalakaua Avenue to Fern Street, and along Fern, Hauoli, and Lime Streets to the McCully Substation. Alignment alternatives could involve construction along either Kaheka Street or Kalauokalani Way to Kapiolani Boulevard, and along Kapiolani Boulevard to Pumehana Street.

Makaloa Street and the section of Kapiolani Boulevard on the Ewa side of Atkinson Drive are mostly lined with a mix of high-rise and low-rise commercial buildings, and several high-rise residential buildings. Kalauokalani Way is lined mostly with low-rise commercial buildings, with several low-rise residential buildings. The commercial buildings on each street include retail stores, restaurants, and entertainment venues. The Daiei store is located mauka of Makaloa Street between Kaheka and Poni Streets. The Hawaii Convention Center (HCC) is located on the makai side of Kapiolani Boulevard between Atkinson Drive and Kalakaua Avenue.

The blocks Koko Head of Kalakaua Avenue are mostly developed with a mix of low-rise commercial buildings along Kapiolani Boulevard, Kalakaua Avenue, and McCully Street, with low-rise residential buildings along many of the minor streets. The Lunalilo Elementary School is located on the northeast corner of Fern and Hauoli Streets.

The Makaloa Substation is located on the southwest corner of the intersection of Makaloa and Amana Streets. The McCully Substation is located on the southeast corner of the intersection of Pumehana and Lime Streets.

2.1.1. Roadways and Traffic Controls

The area roadway network is depicted in Figure 2-1, which indicates the number of midday traffic lanes at key intersections within the study area for the new transmission line between the Makaloa and McCully Substations.

Makaloa Street – The 40-foot curb-to-curb width of Makaloa Street is generally used to provide one travel lane in each direction, with parallel parking provided along both sides of the street.

Sidewalks are provided along both sides of the street. Traffic signal controls are located at the intersections with Keeaumoku Street, Kaheka Street, and Kalakaua Avenue, with these intersections functioning as the constraints to traffic capacity along this section of Makaloa Street.

Makaloa Street has a large number of closely-spaced driveways to the commercial businesses located along both sides of the street. A Fire Station is located on the mauka side of Makaloa Street immediately Koko Head of Kaheka Street, with the driveway for the emergency equipment located about 60 feet Koko Head of Kaheka Street.

Kapiolani Boulevard – This major east-west arterial street is generally striped for three travel lanes in each direction, with separate turn lanes provided only at a few intersections. On-street parking is permitted in the curb lane along each side of the street on the blocks Ewa of Atkinson Drive during the evenings, weekends, and holidays. The on-street parking is restricted during midday as well as the commute peak traffic periods on weekdays when the curb lanes are needed to provide traffic capacity.

The City and County of Honolulu Department of Transportation Services (City DTS) provides a reversible-lane operation on weekdays to accommodate the high volume of Ewa-direction traffic in the morning peak commute period and Koko Head-direction traffic in the afternoon peak commute period. The City sets out a line of traffic cones to shift the street centerline and provide a fourth Ewa-bound traffic lane in the morning from about 6:00 and 8:30 AM. In the afternoon, a fourth Koko Head-bound lane is provided from about 3:30 to 6:00 PM. During the morning peak period, left turns are prohibited in the two-lane Koko Head-bound direction at most intersections, while left turns are prohibited in the two-lane Ewa-bound direction in the afternoon peak period.

The typical constraint on traffic capacity along this section of Kapiolani Boulevard is the intersection with Kalakaua Avenue, and its proximity to the Atkinson Drive intersection. Left turns are not permitted from either of the Kapiolani Boulevard approaches, or from makai-bound approach of Kalakaua Avenue. Left turns are also been restricted from the mauka-bound approach of Kalakaua Avenue in the afternoon peak hour to increase capacity for the high volumes of through traffic.

Fern, Lime, and Hauoli Streets – These three streets provide access and circulation within the residential area mauka of Kapiolani Boulevard and Koko Head of Kalakaua Avenue, as well as provide access to the Lunalilo School. Fern Street has a curb-to-curb width of about 35 feet in the block near Kalakaua Avenue with parking allowed along both sides, with the other blocks having a 24-foot width. The curb-to-curb widths on Hauoli and Lime Streets generally range between 20 and 28 feet, with most around 24 feet. Several sections of these streets are operated as one-way streets due to the narrow widths, with these including one-way Koko Head-bound traffic on the section of Fern Street between Hauoli and McCully Streets, and one-way makai-bound traffic on Hauoli Street between Algaroba Street and Kapiolani Boulevard. Curb parking is allowed along one side of most of the blocks.

Kaheka Street – This street has a 40-foot curb-to-curb width for most of its length, but widens to 60 feet between Makaloa Street and Kapiolani Boulevard. Parking is permitted along both sides of the street mauka of the Makaloa Street intersection, and along the Koko Head side curb between Makaloa Street and Kapiolani Boulevard. Kaheka Street is used by both traffic traveling to/from the commercial uses and high-rise residential buildings located along the street, and by traffic traveling between the Ala Moana Center/Kapiolani Boulevard area and the King Street corridor.

Kalauokalani Way – This one-block long street provides one travel lane in each direction. Most of the street length has neither curb-and-gutter nor improved sidewalks. Informal parking occurs along several of the sections without curbs. Left turns are prohibited into or out of Kalauokalani Way at its intersection with Kapiolani Boulevard.

Pumehana Street – Pumehana Street operates as the mauka-bound street as part of a one-way couplet with Hauoli Street. The street has a curb-to-curb width of 24 feet, with parking allowed along the Koko Head curb. The McCully Shopping Center has a driveway connection to Pumehana Street in the block mauka of Kapiolani Boulevard. The exit for one of the Lunalilo School parking lots connects to Pumehana Street just mauka of the intersection with Fern Street.

2.1.2. Public Transit Routes and Stops

Both Kapiolani Boulevard and Kalakaua Avenue are used by a number of TheBus major trunk routes, with a combined high frequency of buses along each street. Kaheka Street is also served by several collector bus routes that connect the Ala Moana Center, as well as the Transit Center there, to the residential and business areas extending mauka from Kapiolani Boulevard to the Makiki and Manoa areas. TheBus routes that currently operate along the study area sections of Kapiolani Boulevard, Kalakaua Avenue, Makaloa Street, and McCully Street are described in Table 2-1.

The approximate locations of the bus stops along the study area streets are depicted in Figure 2-1. Among the more heavily-used bus stops are those at the intersection of Kapiolani Boulevard and Kalakaua Avenue as these are used for transfers between the routes operating along the two streets. The bus stops at the intersection of Kalakaua Avenue with Makaloa Street also receive high levels of use by patrons of the nearby Daiei store as well as residents and employees from the surrounding blocks.

2.1.3. Bicycle Facilities

McCully Street is designated as a bicycle route from Kapiolani Boulevard to Wilder Avenue. Makai of Kapiolani Boulevard, a bicycle/pedestrian path is provided along the mauka side of the Ala Wai Canal to the Manoa-Palolo Drainage Channel and along the Channel to Date Street.

2.1.4. Traffic Volumes

Available 24-hour machine counts and peak period manual turning movement counts were obtained from City DTS for the past four years. Additional turning movement counts were made in March-April 2004 by Belt Collins Hawaii at the Kaheka Street intersections with Makaloa Street and with Kapiolani Boulevard, and at the intersection of Kapiolani Boulevard with Kalakaua Avenue.

Table 2-1
TheBus Fixed-Route Service,
Makaloa Street Corridor

No.	Route Name	Type of Route	Approximate Hours of Operation	Typical Buses/Hour Each Way
Along Kapiolani Boulevard				
A	City Express	Limited Stops	5 AM-10 PM	4
3	Kaimuki-Salt Lake	Trunk	4:30 AM-1 AM	6
9	Palolo Valley-Pearl Harbor	Trunk	6 AM-11 PM	2-4
Along Kalakaua Avenue				
B	City Express	Limited Stops	5:30 AM-10 PM	4
2	Waikiki-School Street	Trunk	5 AM-1 AM	5
13	Waikiki-Liliha	Trunk	5 AM-1 AM	4
Along Kaheka Street				
5	Ala Moana-Manoa (NB only)	Urban Collector	6 AM-9 PM	1-2
6	Pauoa/Woodlawn (NB only)	Urban Collector	5:30 AM-11 PM	2-3
17	Makiki-Ala Moana (NB only)	Urban Collector	6 AM-9:30 PM	1-2
18	University-Ala Moana (NB only)	Urban Collector	7 AM-9 PM	1-2
Along McCully Street				
4	Nuuanu-Punahou (SB only)	Urban Collector	5 AM-11 PM	3-4

NB Only = Street is used by the route only in the northbound travel direction.
SB Only = Street is used by the route only in the southbound travel direction.
Wilbur Smith Associates; May 5, 2004

Weekday Traffic Characteristics – The highest weekday traffic volumes occur along Kapiolani Boulevard and Kalakaua Avenue. The recent traffic counts along the study area roadways, or estimates of daily volumes by WSA (as indicated by an *), are listed on the following page.

Kapiolani Boulevard, at Hauoli Street	39,000 vehicles per day
Kalakaua Avenue, mauka of Kapiolani Boulevard	35,000
Kaheka Street	14,000
Makaloa Street *	7,000
Hauoli Street, at Kapiolani Boulevard	3,500
Fern Street, at Kalakaua Avenue *	2,000

The variation of traffic volumes through the day along Makaloa Street at Poni Street is depicted in Figure 2-2. The weekday traffic volumes are indicated for each 15-minute increment from early morning until late night for each direction of travel. The traffic volumes remain very low through the morning until around noon, when the numbers of vehicles in each 15-minute period double those of the morning commute hours. The Makaloa Street volumes remain at a high level from around noon through the afternoon and evening hours, with the traffic volumes declining around midnight.

The variation of traffic volumes along Kapiolani Boulevard are depicted in Figure 2-3. The Ewa-bound traffic has a very high peak flow in the morning peak commute hour, with peak hour volumes approximating 600 to 700 vehicles each 15-minute interval. The Ewa-bound traffic flow remains at about 300 vehicles per 15 minutes through the midday and afternoon. The Koko Head-direction traffic flow increases from about 100 vehicles each 15 minutes in the morning commute period to about 300 vehicles per period around noon. The Koko Head direction peak flow occurs between around 4:00 PM to 6:30 PM with around 400 to 500 vehicles each 15 minutes. The combined volumes remain in a comparatively narrow range of between 600 and 800 vehicles per 15 minutes from the morning commute period through the afternoon commute period, with the directional split in traffic volumes shifting through the day.

Peak Hour Traffic Volumes – Traffic volumes are indicated for the key intersections and along roadway segments, where available, in Figure 2-4 for the morning commute peak hour. The highest traffic volumes occur along Kapiolani Boulevard with Ewa-bound volumes of about 3,400 vehicles on the Koko Head side of Atkinson Drive. Total volumes in both directions along Kapiolani Boulevard average about 600 vehicles per lane between Atkinson Drive and McCully Street, and 400 to 500 vehicles per lane Ewa of Atkinson Drive. Traffic volumes along Makaloa Street average about 175 to 225 vehicles per lane.

Traffic volumes are indicated for the key intersections and along roadway segments, where available, in Figure 2-5 for the midday peak hour, which occurred from about Noon to 1:00 PM. The two-way volumes along Kapiolani Boulevard total about 2,800 and 2,100 vehicles on the Koko Head and Ewa side of Atkinson Drive, respectively. Total volumes in both directions along Kapiolani Boulevard average about 400 to 650 vehicles per lane between Atkinson Drive and McCully Street, and 500 vehicles per lane Ewa of Atkinson Drive. Traffic volumes along Makaloa Street average about 300 vehicles per lane.

Traffic volumes are indicated for the key intersections and along roadway segments, where available, in Figure 2-6 for the afternoon peak hour, which occurred from about 4:30 to 5:30 PM.

The two-way volumes along Kapiolani Boulevard total about 3,200 and 4,100 vehicles on the Koko Head and Ewa side of Atkinson Drive, respectively. Total volumes in both directions along Kapiolani Boulevard average about 500 to 600 vehicles per lane between Atkinson Drive and McCully Street, and 500 vehicles per lane Ewa of Atkinson Drive. Traffic volumes along Makaloa Street average about 400 vehicles per lane.

2.1.5. Traffic Conditions at Key Intersections

Traffic conditions at the key intersections for the morning, midday, and afternoon peak hours are summarized in Table 2-2. The general analysis methodology and use of levels of service are described in Appendix A.

Existing traffic volumes at the Makaloa Street intersection with Kaheka Street utilize relatively low portions of the estimated available intersection capacity, with the afternoon peak hour traffic amounting to 66% of the intersection capacity. Morning peak hour traffic approximates a very low 27% of capacity while the midday peak hour traffic amounts to 39% of capacity.

Table 2-2
2004 Traffic Conditions At Key Intersections,
Makaloa Street Corridor

Intersections	Morning Peak Hour			Midday Peak Hour			Afternoon Peak Hour		
	V/C	ADPV	LOS	V/C	ADPV	LOS	V/C	ADPV	LOS
Makaloa St.-Kaheka St.	0.27	18.1	B	0.39	19.8	B	0.66	25.3	C
Kapiolani Blvd.-Kaheka St.	0.49	14.2	B	0.69	25.8	C	0.86	43.1	D
Kapiolani Blvd.-Atkinson Dr.	0.99	23.6	C	0.62	20.2	C	0.63	24.5	C
Kapiolani Blvd.-Kalakaua Ave.	0.93	49.2	D	0.80	39.0	D	0.90	43.0	D
Kapiolani Blvd.-McCully St.	0.82	40.7	D		NA		0.96	57.3	E

V/C = Ratio of the traffic volume to the theoretical capacity of the intersection.
ADPV = Average delay per vehicle, in seconds.
LOS = Level of service.
NA = Not Available

Wilbur Smith Associates; July 26, 2004.

Congested conditions currently occur at several key intersections along the McCully-to-Kaheka Street section of Kapiolani Boulevard during both the morning and afternoon peak commute periods. The morning peak hour traffic volumes approximate 99% of the estimated capacity at the intersection with Atkinson Drive and 93% of the Kalakaua Avenue intersection capacity. In the afternoon peak hour, the most congested conditions occur at the intersection of Kapiolani Boulevard with McCully Street where the traffic volumes amounting to 96% of the estimated intersection capacity. Traffic uses about 90% of the estimated capacity of the Kalakaua Avenue intersection.

The midday peak hour traffic approximates 62% to 80% of the capacity at the key intersections along this section of Kapiolani Boulevard.

2.2. PUMEHANA STREET STUDY AREA

Pumehana Street extends mauka-makai through the McCully community between Kapiolani Boulevard and King Street. The middle blocks of the street, where the new HECO subtransmission line is planned, are occupied primarily by a mix of single- and multi-family residences, with the Lunalilo Elementary School located on the Ewa side between Fern and Citron Streets. The block at the makai end of Pumehana Street is largely occupied by commercial uses and the McCully Substation, while much of the blocks mauka of Citron Street are occupied by commercial uses.

2.2.1. Roadways and Traffic Controls

Pumehana Street functions as a collector street that provides circulation within the McCully community. Because of the narrow street widths, Pumehana and Hauoli Streets are operated as a one-way street couplet with Pumehana Street serving traffic flow in the mauka-bound direction. The 24-foot curb-to-curb width of Pumehana Street provides a single mauka-bound traffic lane and an on-street parking lane along the Koko Head curb.

Lime Street is a two-way street with a 24-foot curb-to-curb street width. The blocks of Fern Street on either side of Pumehana Street are operated as a one-way street in the Koko Head-bound direction, with the 24-foot curb-to-curb width used to provide one traffic lane and a parking lane. The 36-foot curb-to-curb width of Date Street is used to provide a traffic lane in each direction, with parking allowed along both curbs. The blocks of Citron Street on either side of Pumehana Street are operated as a one-way street in the Ewa direction.

One of the Lunalilo Elementary School parking lots is located on the northwest corner of the Pumehana Street intersection with Fern Street. The lot has a single mauka-direction circulation aisle with angle stalls on both sides of the aisle; all vehicles must enter the lot from Fern Street and exit onto Pumehana Street.

Although there are marked crosswalks at the intersections, many of the blocks along Pumehana Street do not have paved sidewalks.

The Pumehana Street intersection with Fern Street is controlled by all-way STOP signs, while the Lime and Date Street approaches to Pumehana Street are controlled by STOP signs.

Of the east-west cross streets, Fern, Date, and Citron Streets have signal-controlled intersections with McCully Street.

2.2.2. Public Transit Routes and Stops

There is no scheduled public bus route along Pumehana Street or along the adjacent sections of the streets that cross the section of Pumehana Street planned for the construction work.

2.2.3. Bicycle Facilities

Neither Pumehana Street nor the sections of the streets crossing Pumehana Street are marked with bicycle lanes nor signed as bicycle routes.

2.2.4. Traffic Volumes

The most recent traffic counts available along Pumehana Street were made by City DTS in October 1990. These counts, made on either side of the Lime Street intersection, were increased by 0.75% per year to provide an estimate current year 2004 traffic levels along Pumehana Street. The City DTS counts and the estimated 2004 volumes are as follows:

Location and Time Period	1990 Traffic	2004 Traffic
Approaching Fern Street		
24-hour Volume	2,330	2,700
Morning Peak Hour (7:30-8:30 AM)	105	120
Afternoon Peak Hour (4:00-5:00 PM)	195	225
Approaching Lime Street		
24-hour Volume	2,537	2,900
Morning Peak Hour (7:30-8:30 AM)	64	75
Afternoon Peak Hour (4:00-5:00 PM)	216	250

2.2.5. Traffic Conditions

A section of one-way street within an urban area, without traffic signal controls, should be able to accommodate up to about 8,000 to 9,000 vehicles per lane per day, or up to about 700 to 800 vehicles per lane in a one-hour period, at traffic conditions reflective of Level of Service (LOS) D. The estimated traffic volumes along the single-lane Pumehana Street are well below these volume levels.

2.3. DATE STREET-LAAU STREET AREA

The EOTP Phase 1 plans includes the construction work within Date Street for a distance of about 330 feet from about midway between the Kapiolani Boulevard and Laau Street Ewa-end intersections, to about midway between the Laau Street Ewa-end and Mahiai Place intersections.

This section of Date Street is bordered by a mix of high-rise and mid-rise residential buildings, with access to many of these provided by driveway connections to Date Street. The Koko Head intersection of the Laau Street loop is one of the access points to Iolani School.

2.3.1. Roadways and Traffic Controls

This section of Date Street provides two traffic lanes in each travel direction, without any separate turn lanes, within the 40-foot curb-to-curb width. On-street parking is not permitted along either curb on the Ewa side of Laau Street. On-street parking is permitted along both curbs Ewa of the Laau Street intersection, with parking restricted along the makai curb 6:30-8:30 AM and along the mauka curb 3:30-6:30 PM. Sidewalks are provided along both sides of Date Street.

Laau Street is a private roadway loop that connects to Date Street at both ends of the loop. The Koko Head end of the loop provides access to Iolani School. The Ewa end of Laau Street is one-way in the Koko Head-bound direction, with marked parking spaces along both curbs.

No traffic signal controls are located along the section of Date Street proposed for the construction work, although there are traffic signal controls at the Kapiolani Boulevard intersection Ewa of the construction area, and at the Koko Head end of the Laau Street loop about two blocks Koko Head of the construction area.

2.3.2. Public Transit Routes and Stops

TheBus Route 3 (Kaimuki-Salt Lake) provides transit service along Date Street between Kapahulu Avenue and Kaipolani Boulevard. Route 3 provides service seven days a week, with the weekday service beginning about 4:15 AM and continuing until around 1:30 AM. The frequency of service during most of the day varies from 10 to 20 minutes between buses in each direction.

There is a bus stop for the Koko Head-bound travel direction located on Date Street near Laau Street Ewa-end intersection; the bus stop for the Ewa-bound direction is located on Date Street near the Kapiolani Boulevard intersection.

2.3.3. Bicycle Facilities

There are no special provisions for bicycle travel along the section of Date Street between Kapiolani Boulevard and the Koko Head intersection of Laau Street. Bicycle lanes are provided

along Date Street from Kapahulu Avenue to the Manoa-Palolo Drainage Channel, where the lanes follow the Channel to the Ala Wai Canal and then parallel the Ala Wai Canal.

2.3.4. Traffic Volumes

Available 24-hour machine counts were obtained from City DTS. Turning movement counts were obtained from Julian Ng, Inc. for the Date Street intersections with Kapiolani Boulevard and the Koko Head end of Laau Street. The turning movement counts were made in July 1999 as part of a traffic study for Iolani School.

Daily Traffic Characteristics – The City DTS had recorded 24-hour traffic volumes along Date Street Ewa of Lukepane Avenue, located about two blocks Koko Head of Laau Street. The counts were made on October 8-9, 2002. The City DTS had made counts for the Koko Head-bound direction of Date Street at both intersections with Laau Street on October 9-10, 1996.

The 1996 counts indicated Koko Head-bound traffic of over 10,000 vehicles per day at the Laau Street intersection. The counts at Lukepane Avenue indicated a total daily volume of 8,462 in the Koko Head direction and 7,165 in the Ewa direction. Therefore, the traffic volumes along the construction area may be about 20% or more higher than the counts at Lukepane Avenue.

The variation of Date Street traffic volumes through the day at Lukepane Avenue is depicted in Figure 2-7. The Ewa-bound traffic volumes peak in the morning peak commute period and then continue at 15-minute flow rates of about 100 vehicles until around 3:00 PM when school traffic and commute traffic increases the Ewa-bound flow rate. The traffic flow rate decreases after 6:30 PM. The Koko Head-direction traffic has a minor peak during the morning commute/school traffic period and remains at about the same flow rate through the midday as the Ewa-bound traffic (about 100 to 120 vehicles per 15 minutes). The afternoon commute peak begins to build at 3:00 PM with school traffic. The peak afternoon traffic flow rates extend from about 4:00 to 6:30 PM. The combined volumes of about 400 vehicles each 15 minutes in the afternoon commute peak period exceed the morning and midday flow rates of 200 to 300 vehicles.

Peak Hour Traffic Volumes – The 1999 peak hour traffic volumes for Date Street between the Kapiolani Boulevard and Laau Street intersections are depicted in Figure 2-8. The Ewa-bound traffic in the planned construction area is about 100 to 150 vehicles more than the Koko Head-bound traffic in the morning peak hour. In the midday and afternoon peak hours, the Koko Head-bound traffic volumes exceed the Ewa-bound traffic by about 150 vehicles.

2.3.5. Traffic Conditions at Key Intersections

The midday peak hour traffic volumes at the Date Street intersection with Kapiolani Boulevard and Kamoku Street approximates 74% of the intersection capacity with average traffic delays at LOS D.

The midday peak hour traffic volumes at the signal-controlled intersection of Date Street with the Koko Head end of the Laau Street loop roadway use 45% of the intersection capacity. The average vehicle delays are at LOS A during the midday period.

2.4. WINAM AVENUE STUDY AREA

The EOTP Phase 1 plans include construction work within Winam Avenue between Mooheau Avenue and Martha Street, with the construction also extending onto Mooheau Avenue. These adjacent blocks and the surrounding area are primarily occupied by single-family residences.

2.4.1. Roadways and Traffic Controls

Winam Avenue functions as a collector street for the surrounding residential area, connecting the adjacent blocks to Mooheau Avenue and to Kapahulu Avenue. The block between Mooheau Avenue and Hoolulu Street has a 17 to 20-foot pavement width and provides one travel lane in each direction. The narrow section extends from Mooheau Avenue to about 50 feet on the Koko Head side of Hoolulu Street, where Winam Avenue widens to a 36-foot wide roadway. The Winam Avenue approach to Mooheau Avenue is controlled by a STOP sign.

The section of Mooheau Avenue near Winam Avenue provides one traffic lane in each direction within a pavement width of about 24 feet.

There are some sections of paved sidewalks along of Winam Avenue within the proposed construction area. During the field reconnaissance, pedestrians were observed to walk within the traffic lanes. Mooheau Avenue has sidewalks along both sides of the roadway.

2.4.2. Public Transit Routes and Stops

TheBus Route 3 provides service along Mooheau Avenue from about 5:00 AM until 1:00 AM. There are no fixed-route public transit buses operating on the section of Winam Avenue between Mooheau Avenue and Hoolulu Street.

The bus stop for Koko Head bound travel is located on Mooheau Avenue across from Paliuli Street. Bus stops for Ewa-bound travel are located on Mooheau Avenue near Mokihana Street and near Kapahulu Avenue.

2.4.3. Bicycle Facilities

Mooheau Avenue and Winam Avenue are neither marked with bicycle lanes nor signed as a bicycle route.

2.4.4. Traffic Volumes

The City DTS made a 24-hour traffic count at the Winam Avenue-Mooheau Avenue intersection on February 6-7, 1992. The count of Ewa-direction traffic was made on the Koko Head side of Mooheau Street, the same side as the proposed EOTP construction work. The count of the Koko Head-direction traffic was made on the Ewa side of Mooheau Street. On Mooheau Avenue, the mauka-bound and makai-bound traffic was counted on the makai and mauka sides of the intersection, respectively.

Daily Traffic Characteristics – The 1992 count recorded a total weekday volume of 3,239 vehicles on Winam Avenue with 1,279 vehicles traveling in the Ewa direction and 1,960 in the Koko Head direction. The higher Koko Head-direction traffic may result from the count location Ewa of Mooheau Street and not reflect an imbalance in directional flow on Winam Avenue.

The 1992 count recorded a weekday volume of 7,290 vehicles on Mooheau Avenue, with 4,013 on the mauka-bound approach to the intersection and 3,277 on the makai-bound approach.

The traffic variations through the day for each travel direction on Winam Avenue, as indicated in the 1992 count, are depicted in Figure 2-9. The highest volumes occur in the Koko Head-bound travel direction during the lunchtime and afternoon commute peak hours, with the midday volumes higher than the morning volumes. The Ewa-bound volumes fluctuate without any distinctive peaking period.

Peak Hour Traffic Volumes – The 1992 traffic volumes were increased by 0.75% per year to estimate the traffic volumes in 2004.

Year and Time Period	Koko Head Direction Traffic	Ewa Direction Traffic	Both Directions
WINAM AVENUE			
1992 Traffic Count			
24-hour Volume	1,960	1,279	3,239
Morning Peak Hour (7:00-8:00 AM)	93	80	173
Midday Peak Hour (11:15 AM-12:15 PM)	161	88	249
Afternoon Peak Hour (5:45-6:45 PM)	159	85	244
Estimated 2004 Traffic			
24-hour Volume	2,200	1,450	3,650
Morning Peak Hour (7:00-8:00 AM)	105	90	195
Midday Peak Hour (11:15 AM-12:15 PM)	180	100	280
Afternoon Peak Hour (5:45-6:45 PM)	180	100	280

Year and Time Period	Koko Head Direction Traffic	Ewa Direction Traffic	Both Directions
MOOHEAU AVENUE			
1992 Traffic Counts			
24-hour Volume	3277	4013	7290
Morning Peak Hour (7:00-8:00 AM)	16	257	273
Midday Peak Hour (11:15 AM-12:15 PM)	223	231	454
Afternoon Peak Hour (5:45-6:45 PM)	344	402	746
Estimated 2004 Traffic			
24-hour Volume	3695	4525	8220
Morning Peak Hour (7:00-8:00 AM)	20	290	310
Midday Peak Hour (11:15 AM-12:15 PM)	255	260	515
Afternoon Peak Hour (5:45-6:45 PM)	390	455	845

2.4.5. Traffic Conditions

A two-lane street should be able to accommodate a total two-way volume of about 1,000 vehicles in a one-hour period at LOS D conditions or better. The estimated 2004 peak one-hour traffic volumes along Winam Avenue are well below this level. The estimated 2004 afternoon peak one-hour volumes along Mooheau Avenue are near this level.

2.5. KING STREET CORRIDOR

The proposed HECO EOTP Phase 2 construction would be located within the section of King Street extending from Cooke Street to McCully Street. The construction project would also extend onto the block of Cooke Street makai of King Street and onto the two blocks of McCully Street mauka of King Street.

The properties fronting onto King Street are mostly a mix of low-rise and mid-rise office buildings, and low-rise commercial buildings containing retail shops, restaurants, and service establishments. The access for most of these businesses is provided by driveway connections to King Street. Some of the larger properties extend through to Young Street on the mauka side or to one of several parallel streets on the makai side, and have primary or secondary driveway access from the parallel streets.

Straub Hospital is located on the northwest corner of the Ward Avenue intersection with King Street. Access to the Hospital is available from Hotel Street as well as King Street. The emergency entrance is located on Hotel Street.

The Neal Blaisdell Center conference and performance venue is located on the southeast corner of the Ward Avenue intersection with King Street, with the Center extending makai to Kapiolani Boulevard. The main vehicle entrance/exit is located on King Street at the Victoria Street intersection. A secondary entrance/exit is located on Kapiolani Boulevard.

McKinley High School is located along the makai side of King Street between the Neal Blaisdell Center and Pensacola Street. The School "fronts" onto King Street and has a tree-lined U-shaped driveway connecting to King Street. This driveway is used for student drop-off and pick-up. The School parking lot is accessed from Pensacola Street.

Washington Middle School is located on the makai side of King Street on the Koko Head side of Punahou Street. Several of its parking areas are accessed from King Street.

2.5.1. Roadways and Traffic Controls

Figure 2-10 indicates the number of midday traffic lanes at key intersections along the section of King Street between Cooke and McCully Streets, which would be the location of the construction work for the new transmission line.

King Street - King Street and Beretania Street form a one-way major arterial street couplet, with King Street serving Koko Head-bound traffic and Beretania Street serving Ewa-bound traffic. King Street has a curb-to-curb width of about 64 to 66 feet, with the street striped to provide six traffic lanes. During most of the day, parking is permitted in the curb lane along both sides of the street for most of Cooke-to-McCully Street section, with parking restricted along several areas to provide separate turn lanes at intersections with major cross streets, as well as in front of the Neal Blaisdell Center.

During the afternoon peak commute traffic hours, the on-street parking is restricted along both curbs to provide six traffic lanes through this section of King Street. The afternoon parking restriction extends from 3:30 PM to 6:30 PM.

Cooke Street – The block of Cooke Street between King Street and Kapiolani Boulevard is striped for one traffic lane in each direction, with on-street parking allowed along the Koko Head curb. The street is 32 feet wide, curb-to-curb, for most of the block with the street widening to 36 feet for a distance of about 100 feet to King Street. The Cooke Street approach to King Street is controlled by a STOP sign.

McCully Street – The two blocks of McCully Street between King and Beretania Streets have a curb-to-curb width of 64 feet, with sidewalks along both sides of the street. Both blocks are striped for two travel lanes in each direction with a center left-turn lane and on-street parking along the Koko Head side curb. The McCully Street intersections with King Street, Young Street, and Beretania Street are controlled by traffic signals.

2.5.2. Public Transit Routes and Stops

King Street is used by a number of TheBus major trunk routes and collector routes, with key features of these routes summarized in Table 2-3. The Koko Head-direction service of Route 1 is the only route that continues the entire length between Cooke and McCully Streets, as it links the East Honolulu, Kahala, and Kaimuki areas to the central area of Honolulu, as well as the Kalihi area. Route 1 is one of the most heavily-patronized bus routes in Honolulu.

The City Express Route B uses King Street from Downtown Honolulu to Kalakaua Avenue, where it turns makai to serve the Waikiki area. The Ewa-direction Route B buses travel mauka on Kalakaua Avenue across King Street to use Beretania Street to continue to Downtown Honolulu. The Route 2 and Route 13 buses follow the same route through the area as Route B. While Routes 2 and 13 may stop at any bus stop to pick up and drop off passengers, the Route B buses operate as a faster "limited stop" service that stops only at cross streets with bus service to allow transfers and at a few designated stops at major traffic generators.

Route 5 travels on King Street only from Kaheka Street to Punahou Street, where the route turns mauka to service the Manoa Valley area. Route 6 uses King Street from Kaheka Street to University Avenue, which is located about eight blocks beyond McCully Street.

The locations of the bus stops along King Street are depicted in Figure 2-10. Table 2-3 also lists the bus routes that cross King Street. Most of these routes service bus stops at King Street.

2.5.3. Bicycle Facilities

This section of King Street is not striped with bicycle lanes nor signed as a bicycle route. Young Street, which is located parallel to and one block mauka of King Street, is designated as a bicycle route from Victoria Street to Isenberg Street.

The section of McCully Street crossing King Street is designated as a bicycle route, with the route designation extending from Kapiolani Boulevard to Wilder Avenue.

Table 2-3
TheBus Fixed Route Service,
King Street Corridor

No.	Route Name	Type of Service	Approximate Hours of Operation	Typical Buses/Hour Each Way
Along King Street				
B	City Express	Limited Stops	5 AM-10 PM	4
1	Kalihi-Kaimuki	Trunk	4 AM-1 AM	6-8
2	Waikiki-School Street	Trunk	5 AM-1 AM	5
5	Ala Moana-Manoa	Urban Collector	6 AM-9 PM	1-2
6	Pauoa/Woodlawn	Urban Collector	5:30 AM-11 PM	2-3
13	Waikiki-Liliha	Trunk	5 AM-1 AM	4
Along Pensacola Street				
17	Makiki-Ala Moana	Urban Collector	6 AM-9:30 PM	1-2
18	University-Ala Moana	Urban Collector	7 AM-9 PM	1-2
Along Keeaumoku Street				
5	Ala Moana-Manoa (SB only)	Urban Collector	6 AM-9 PM	1-2
6	Pauoa/Woodlawn (SB only)	Urban Collector	5:30 AM-11 PM	2-3
17	Makiki-Ala Moana (NB only)	Urban Collector	6 AM-9:30 PM	1-2
18	University-Ala Moana (NB only)	Urban Collector	7 AM-9 PM	1-2
Along Kaheka Street				
5	Ala Moana-Manoa (NB only)	Urban Collector	6 AM-9 PM	1-2
6	Pauoa/Woodlawn (NB only)	Urban Collector	5:30 AM-11 PM	2-3
Along Kalakaua Avenue				
B	City Express	Limited Stops	5 AM-10 PM	4
2	Waikiki-School Street	Trunk	5 AM-1 AM	5
13	Waikiki-Liliha	Trunk	5 AM-1 AM	4

Wilbur Smith Associates; May 5, 2004

2.5.4. Traffic Volumes

Available 24-hour machine counts and peak period manual turning movement counts were obtained from City DTS for the intersection of King Street and Punahou Street. Additional turning movement counts were made in March-April 2004 by Belt Collins Hawaii at other intersections of King Street with major cross streets and at the McCully Street intersection with Young Street.

Daily Traffic Characteristics – City DTS machine counts of daily traffic volumes along King Street were available for several locations between Cooke Street and Ward Avenue, at Punahou Street, and at Hauoli Street. Daily traffic counts were also available for Punahou Street and Cooke Street near King Street.

King Street, at Cooke Street	29,000 vehicles per day
King Street, Ewa of Punahou Street	28,000
King Street, Ewa of Hauoli Street	31,000
Ward Avenue, south of King Street	28,000
Kalakaua Avenue, north of King Street	23,000
Punahou Street, mauka of King Street	21,500
Cooke Street, at Kapiolani Boulevard	6,400

The counts indicate that the weekday traffic volumes are similar along the length of the proposed construction work on King Street, with the daily traffic ranging between 28,000 and 31,000 vehicles per day.

The variation of King Street traffic by hour of the day is depicted in Figure 2-11 at Kealamakai Street, located a block Koko Head of Cooke Street, and in Figure 2-12 at Hauoli Street near the Koko Head end of the proposed construction project. The traffic near the Cooke Street end of the Project area reaches a slightly higher volume level during the morning peak commute period, with 400 to 500 vehicles during each 15-minute period, as compared to 300 to 400 vehicles each 15 minutes at Hauoli Street. The 15-minute volumes vary from 400 to 500 vehicles during the midday period, and begin increasing around 2;30 PM to reach a high of about 700 to 800 vehicles each 15 minutes between 4:00 and 6:00 PM.

The counts indicate that traffic volumes on King Street are the same or lower in the morning peak commute period than in the midday period. Thus, construction work may be no more disruptive during the morning commute peak period than during the midday hours and even less disruptive during the morning peak period at the Koko Head end of the construction project.

Peak Hour Traffic Volumes – The traffic movements at the major intersections along King Street are depicted for the morning, midday and afternoon peak hours in Figure 2-13.

The traffic volumes along King Street are similar during the morning and midday peak hours from Cooke Street to Punahou Street. Koko Head of Punahou Street the volumes are much higher in the midday period than in the morning peak hour. The afternoon peak hour volumes along King Street are generally 50% higher than either the morning or midday peak hour volumes.

Traffic volumes along the cross streets indicate similar patterns with the midday volumes similar to or higher than the morning peak hour volumes, and with the afternoon peak hour traffic generally higher than the other two periods.

The highest volumes of turn movements from King Street occur at Pensacola Street (right turn in midday peak hour), Piikoi Street (left turn in midday and afternoon peak hours), Keeaumoku Street (left turn in afternoon peak hour), and Punahou Street (left turn in afternoon peak hour). During the counts, traffic along Keeaumoku Street was affected by midday lane closures for construction work, which may have decreased the number of vehicles turning right onto Keeaumoku Street during the midday peak hour and increased the number turning right onto Pensacola Street.

2.5.5. Traffic Conditions at Key Intersections

Traffic conditions at the key intersections for the morning, midday, and afternoon peak hours are summarized in Table 2-4. The general analysis methodology and use of levels of service are described in Appendix A.

The highest level of capacity use occurs at each of the intersections along the Project corridor during the afternoon peak hour, even with the restriction of the on-street parking along King Street during this period to provide additional traffic capacity. The highest levels of capacity use occur at the Punahou Street intersection with afternoon peak hour traffic amounting to 96% of capacity. Afternoon peak hour traffic approximates 85% of capacity at the Kalakaua Avenue intersection and 84% at the Ward Avenue and Keeaumoku Street intersections.

The midday traffic at most of the King Street intersections uses a higher proportion of the estimated capacity than does the morning peak hour volumes. Intersections with the highest level of midday capacity use are Punahou Street (75%), Keeaumoku Street (72%), and Kalakaua Avenue (71%).

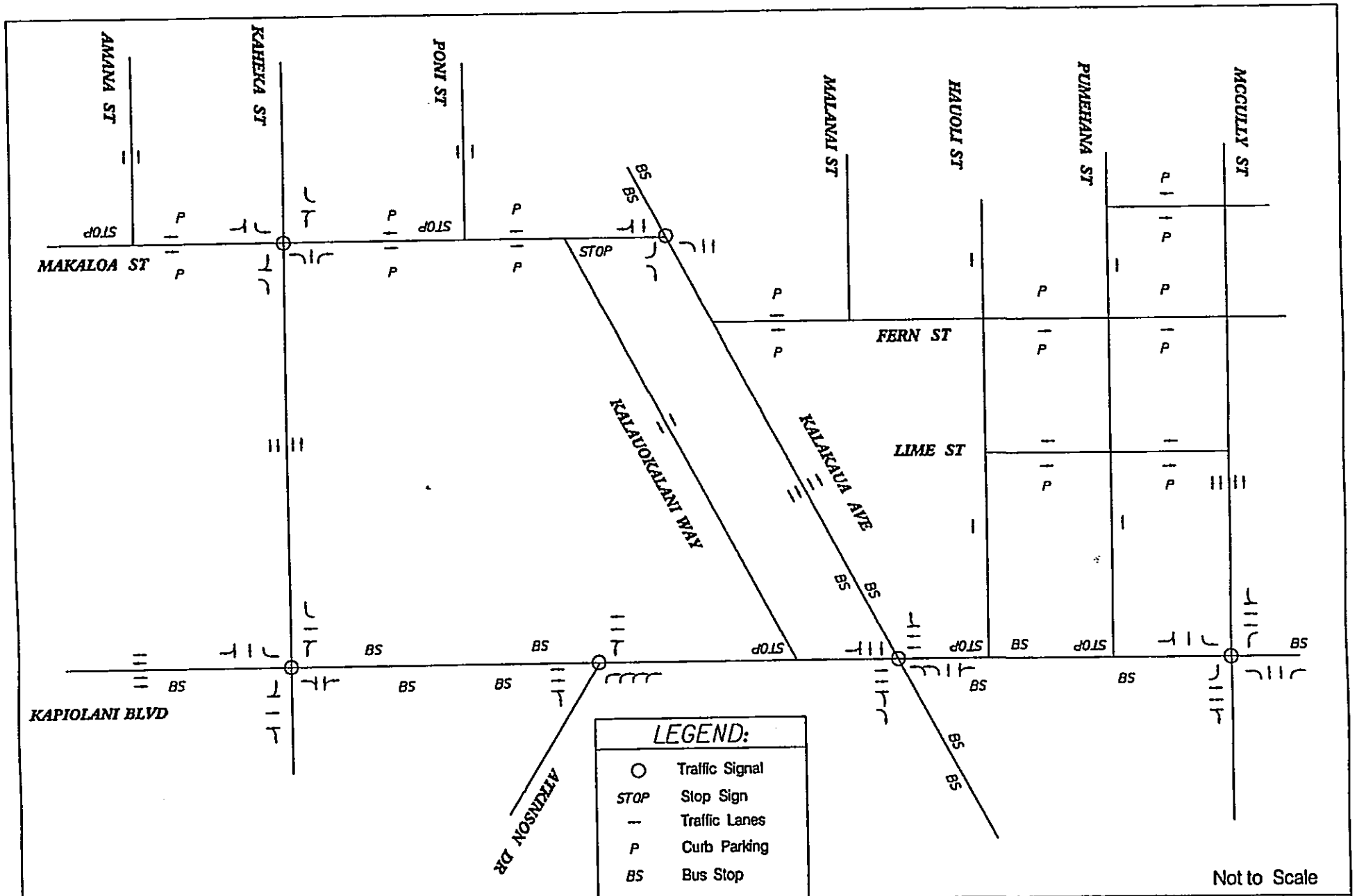
The highest estimated levels of capacity use in the morning peak hour occur at the Punahou Street (75%), Kalakaua Avenue (69%), and Ward Avenue (68%) intersections.

Table 2-4
2004 Traffic Conditions At Key Intersections, King Street Corridor

Intersections	Morning Peak Hour			Midday Peak Hour			Afternoon Peak Hour		
	V/C	ADPV	LOS	V/C	ADPV	LOS	V/C	ADPV	LOS
King St.-Ward Ave.	0.68	20.7	C	0.64	20.2	C	0.84	26.1	C
King St.-Pensacola St.	0.51	18.4	B	0.60	19.5	B	0.61	17.3	B
King St.-Piikoi St.	0.46	17.6	B	0.56	18.7	B	0.73	20.2	C
King St.-Keeaumoku St.	0.60	26.0	C	0.72	31.4	C	0.84	30.0	C
King St.-Kalakaua Ave.	0.69	24.7	C	0.71	23.5	C	0.85	27.7	C
King St.-Punahou St.	0.75	37.2	D	0.75	33.7	C	0.96	47.8	D
King St.-McCully St.	0.58	24.5	C	0.74	23.3	C	0.81	29.5	C
McCully St.-Young St.	0.56	20.2	C	0.54	19.4	B	0.66	23.1	C

V/C = Ratio of the traffic volume to the theoretical capacity of the intersection.
ADPV = Average delay per vehicle, in seconds.
LOS = Level of service.

Wilbur Smith Associates; May 10, 2004.



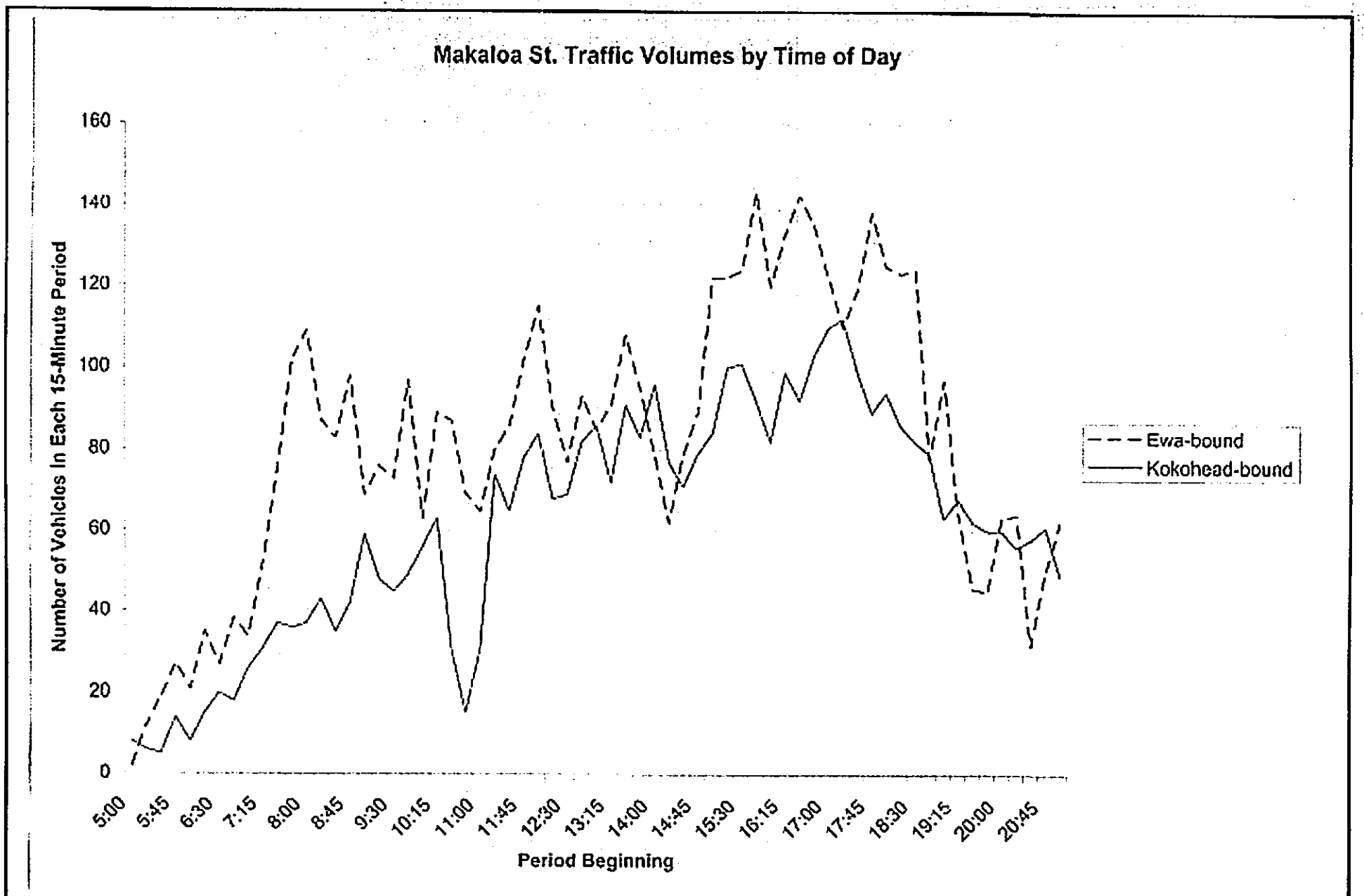
Wilbur Smith Associates
ENGINEERS PLANNERS ECONOMISTS
333 FAYETTEVILLE ST, SUITE 1450
RALEIGH, NORTH CAROLINA 27601
TELE : (919) 755-0583
FAX : (919) 832-8798

EOTP TRAFFIC IMPACT STUDY

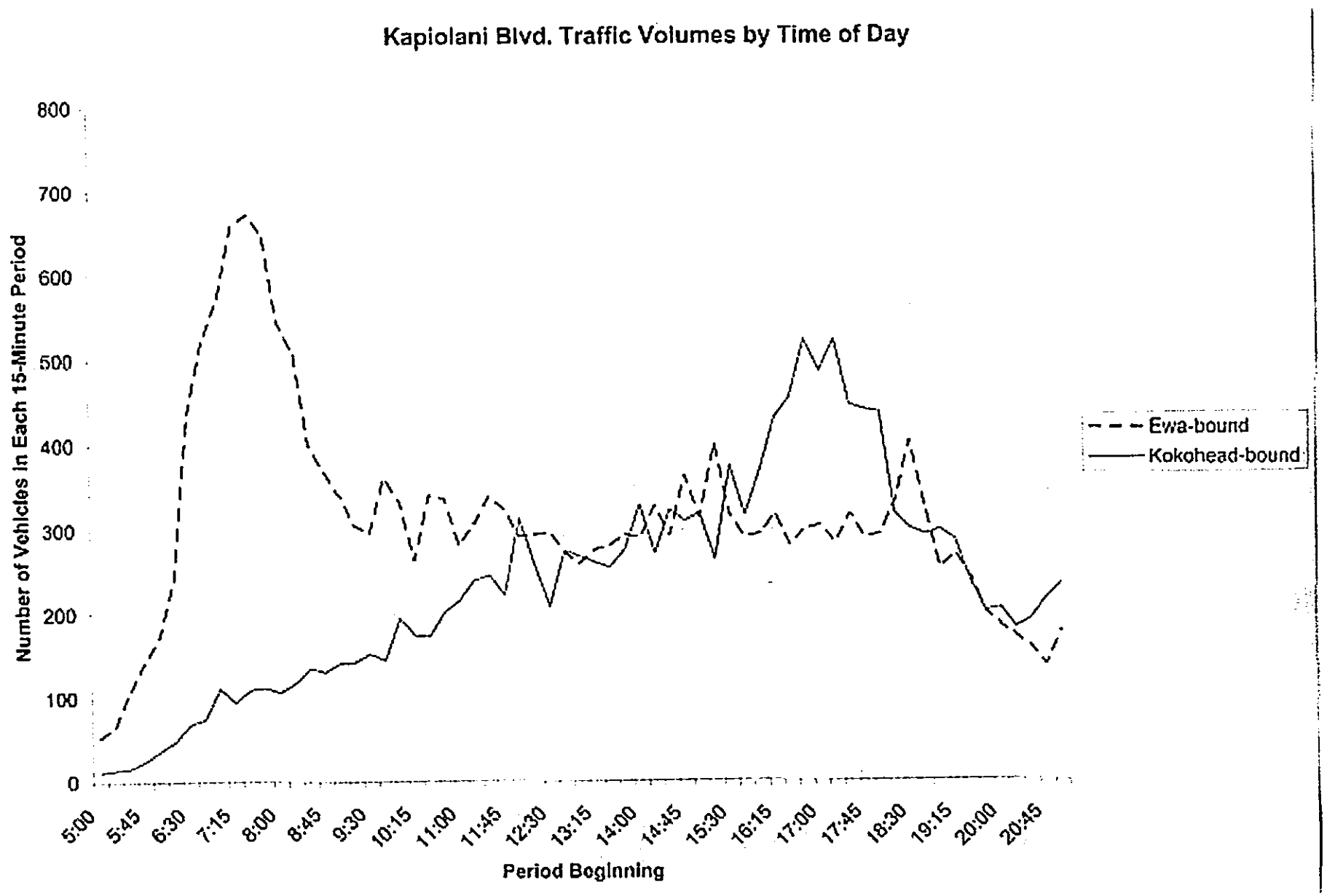
HONOLULU, HAWAII

MIDDAY ROADWAY LANES
MAKALOA – KAPIOLANI
CORRIDOR

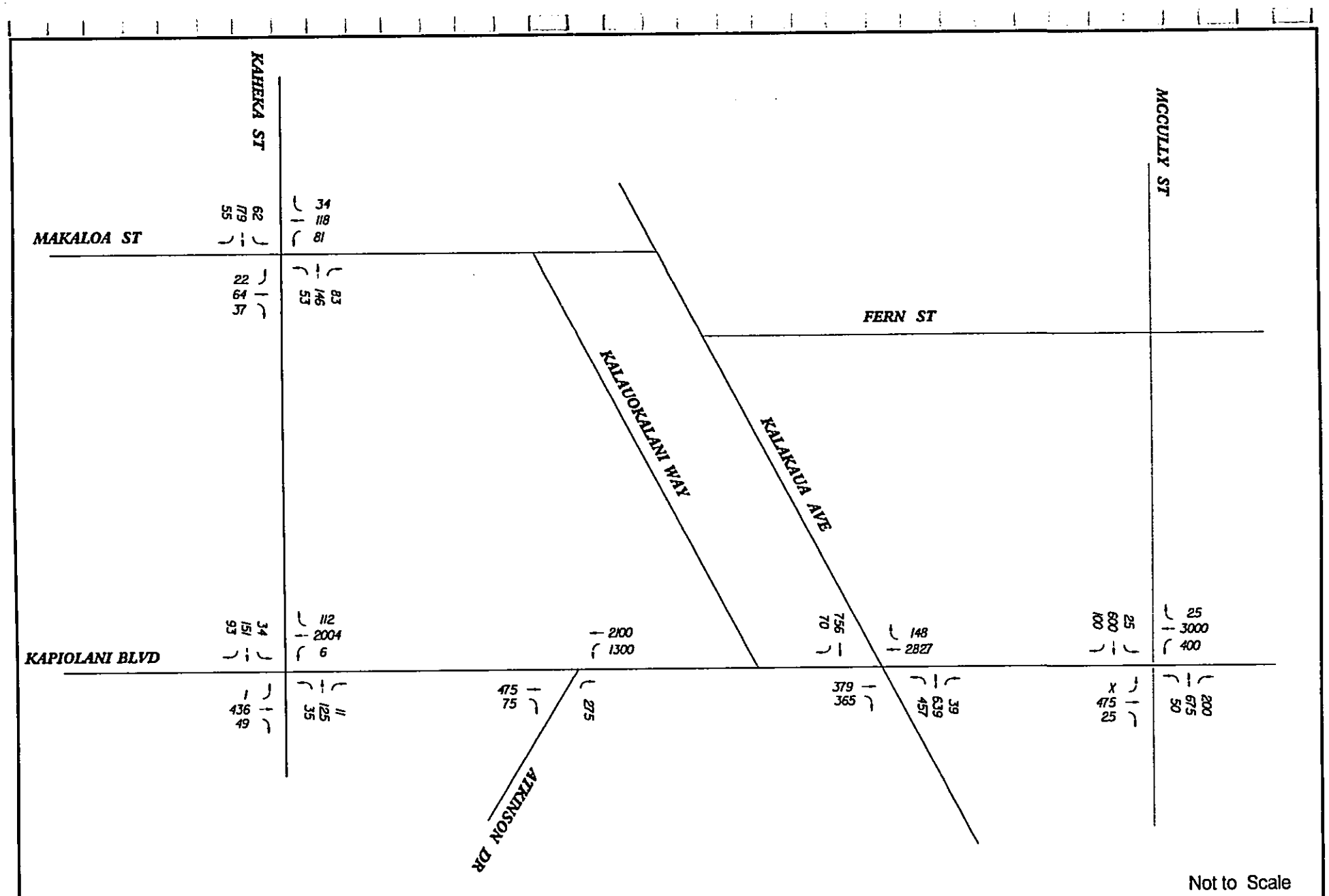
FIGURE: 2-1



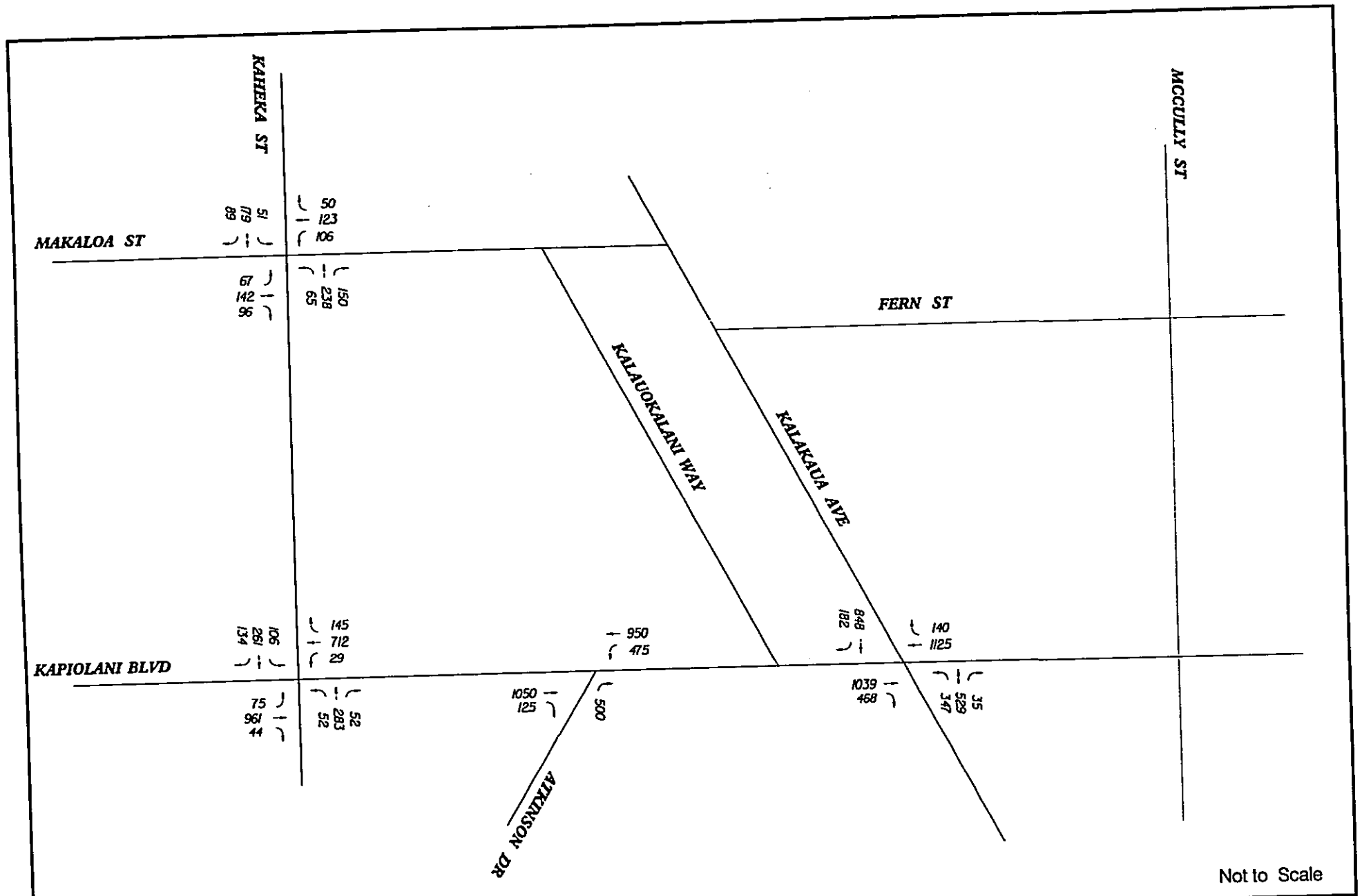
Wilbur Smith Associates ENGINEERS PLANNERS ECONOMISTS	333 FAYETTEVILLE ST, SUITE 1450 RALEIGH, NORTH CAROLINA 27601 TELE : (919) 755-0583 FAX : (919) 832-8793	EOTP TRAFFIC IMPACT STUDY HONOLULU, HAWAII	MAKALOA ST. TRAFFIC VOLUMES BY TIME OF DAY	FIGURE: 2-2



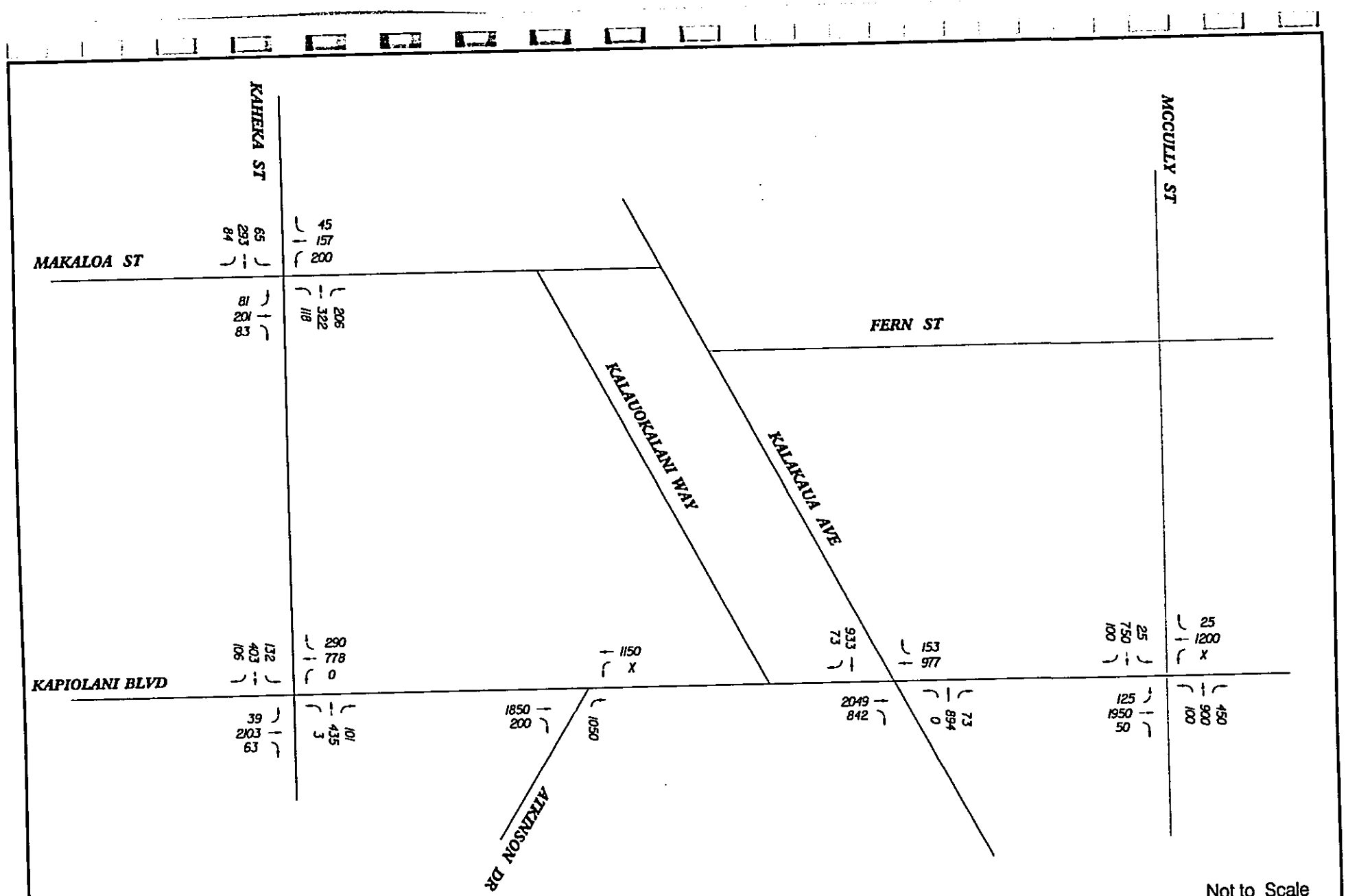
Wilbur Smith Associates ENGINEERS PLANNERS ECONOMISTS	333 FAYETTEVILLE ST, SUITE 1450 RALEIGH, NORTH CAROLINA 27601 TELE : (919) 755-0583 FAX : (919) 832-8798	EOTP TRAFFIC IMPACT STUDY HONOLULU, HAWAII	KAPIOLANI BLVD. TRAFFIC VOLUMES BY TIME OF DAY	FIGURE: 2-3



Wilbur Smith Associates (Engineers Planners Economists)	333 FAYETTEVILLE ST, SUITE 1450 RALEIGH, NORTH CAROLINA 27601 TELE : (919) 755-0583 FAX : (919) 832-8798	EOTP TRAFFIC IMPACT STUDY HONOLULU, HAWAII	2004 MORNING PEAK HOUR TRAFFIC MAKALOA – KAPIOLANI CORRIDOR	FIGURE: 2-4

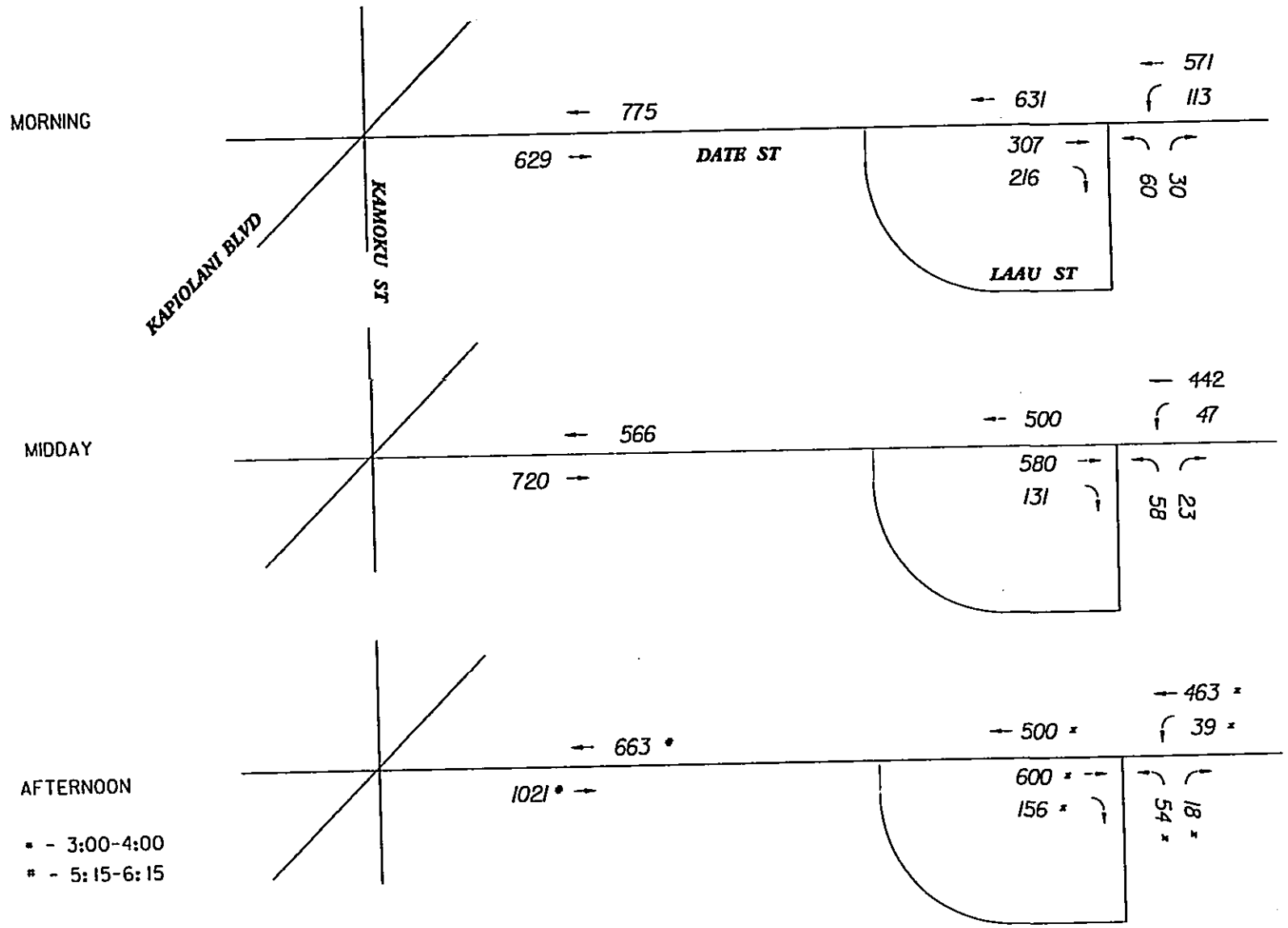


Wilbur Smith Associates (ENGINEERS PLANNERS ECONOMISTS)	333 FAYETTEVILLE ST, SUITE 1450 RALEIGH, NORTH CAROLINA 27601 TELE : (919) 755-0583 FAX : (919) 832-8798	EOTP TRAFFIC IMPACT STUDY HONOLULU, HAWAII	2004 MIDDAY PEAK HOUR TRAFFIC MAKALOA – KAPIOLANI CORRIDOR	FIGURE: 2-5



Wilbur Smith Associates (Engineers Planners Economists)	333 FAYETTEVILLE ST, SUITE 1450 RALEIGH, NORTH CAROLINA 27601 TELE : (919) 755-0583 FAX : (919) 832-8798	EOTP TRAFFIC IMPACT STUDY HONOLULU, HAWAII	2004 AFTERNOON PEAK HOUR TRAFFIC MAKALOA – KAPIOLANI CORRIDOR	FIGURE: 2-6

Wilbur Smith Associates ENGINEERS PLANNERS ECONOMISTS	333 FAYETTEVILLE ST, SUITE 1450 RALEIGH, NORTH CAROLINA 27601 TELE : (919) 755-0583 FAX : (919) 832-8798	EOTP TRAFFIC IMPACT STUDY HONOLULU, HAWAII	DATE ST. TRAFFIC VOLUMES BY TIME OF DAY	FIGURE: 2-7



Wilbur Smith Associates
ENGINEERS PLANNERS ECONOMISTS
333 FAYETTEVILLE ST, SUITE 1450
RALEIGH, NORTH CAROLINA 27601
TELE : (919) 755-0583
FAX : (919) 832-8798

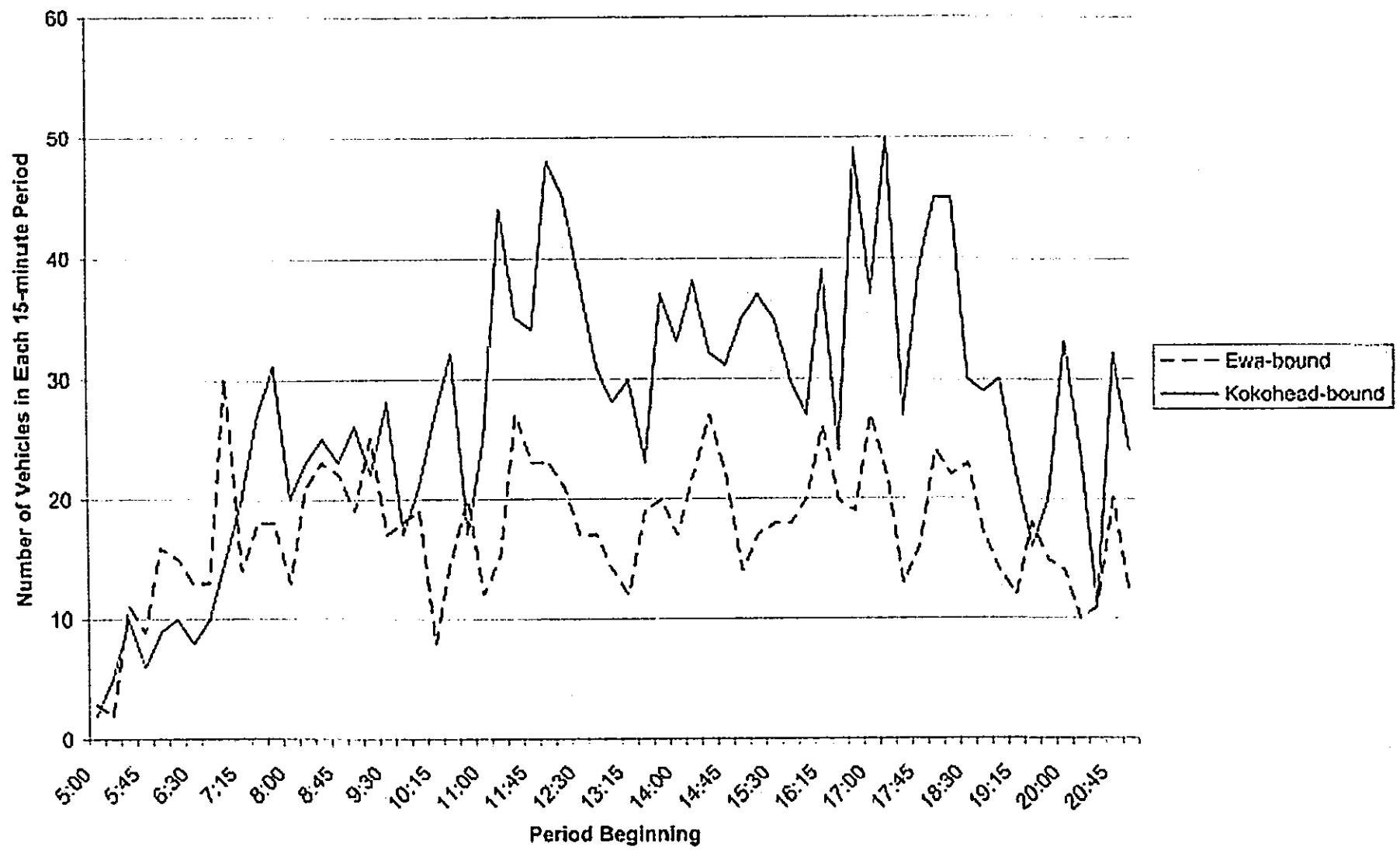
EOTP TRAFFIC IMPACT STUDY

HONOLULU, HAWAII

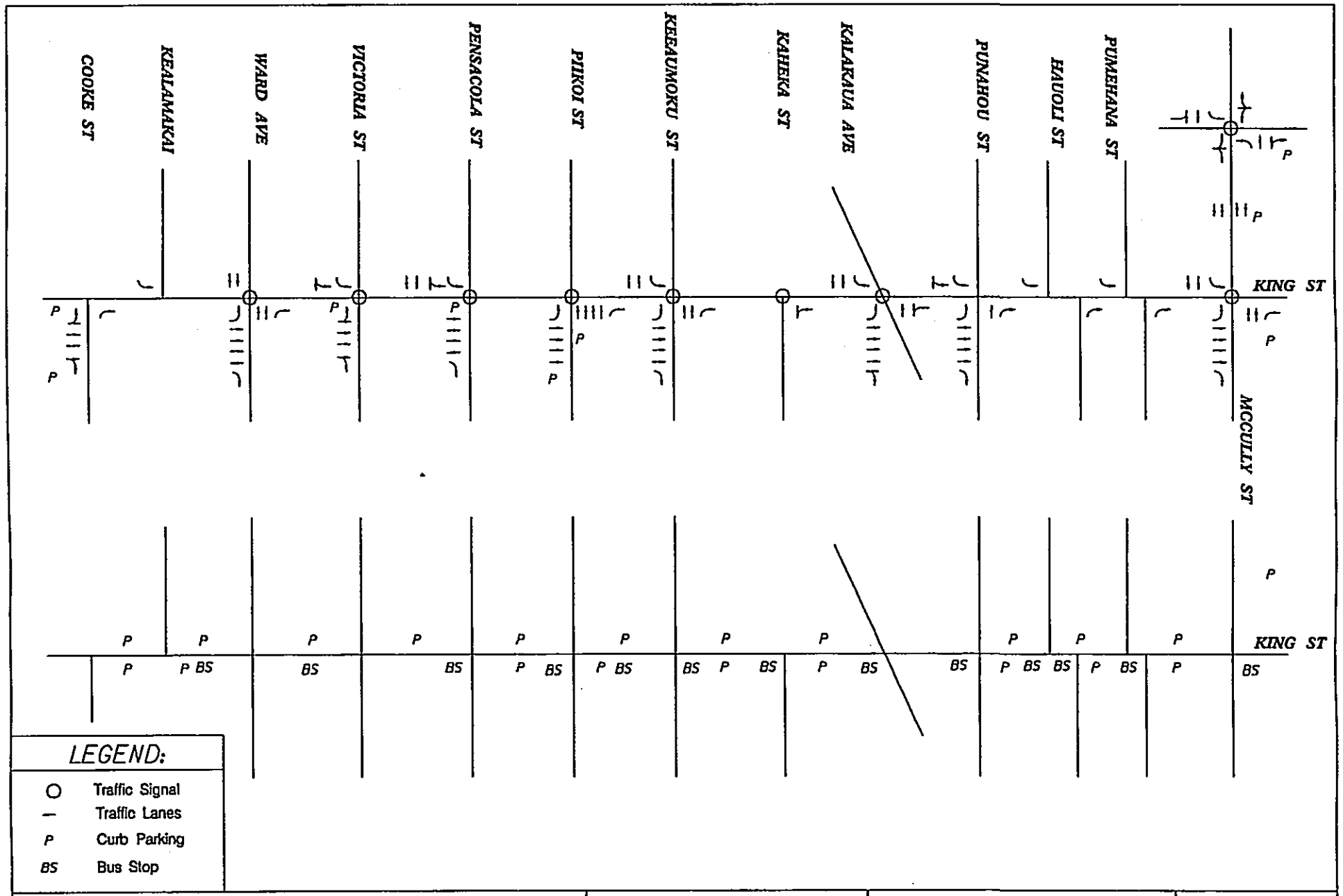
PEAK HOUR TRAFFIC

DATE STREET

FIGURE: 2-8



Wilbur Smith Associates ENGINEERS PLANNERS ECONOMISTS	333 FAYETTEVILLE ST. SUITE 1450 RALEIGH, NORTH CAROLINA 27601 TELE : (919) 755-0563 FAX : (919) 832-8796	EOTP TRAFFIC IMPACT STUDY HONOLULU, HAWAII	TRAFFIC VOLUMES BY TIME OF DAY – WINAM AVE. AT MOOHEAU AVE.	FIGURE: 2-9



Wilbur Smith Associates
ENGINEERS PLANNERS ECONOMISTS
333 FAYETTEVILLE ST, SUITE 1450
RALEIGH, NORTH CAROLINA 27601
TELE : (919) 755-0583
FAX : (919) 832-8798

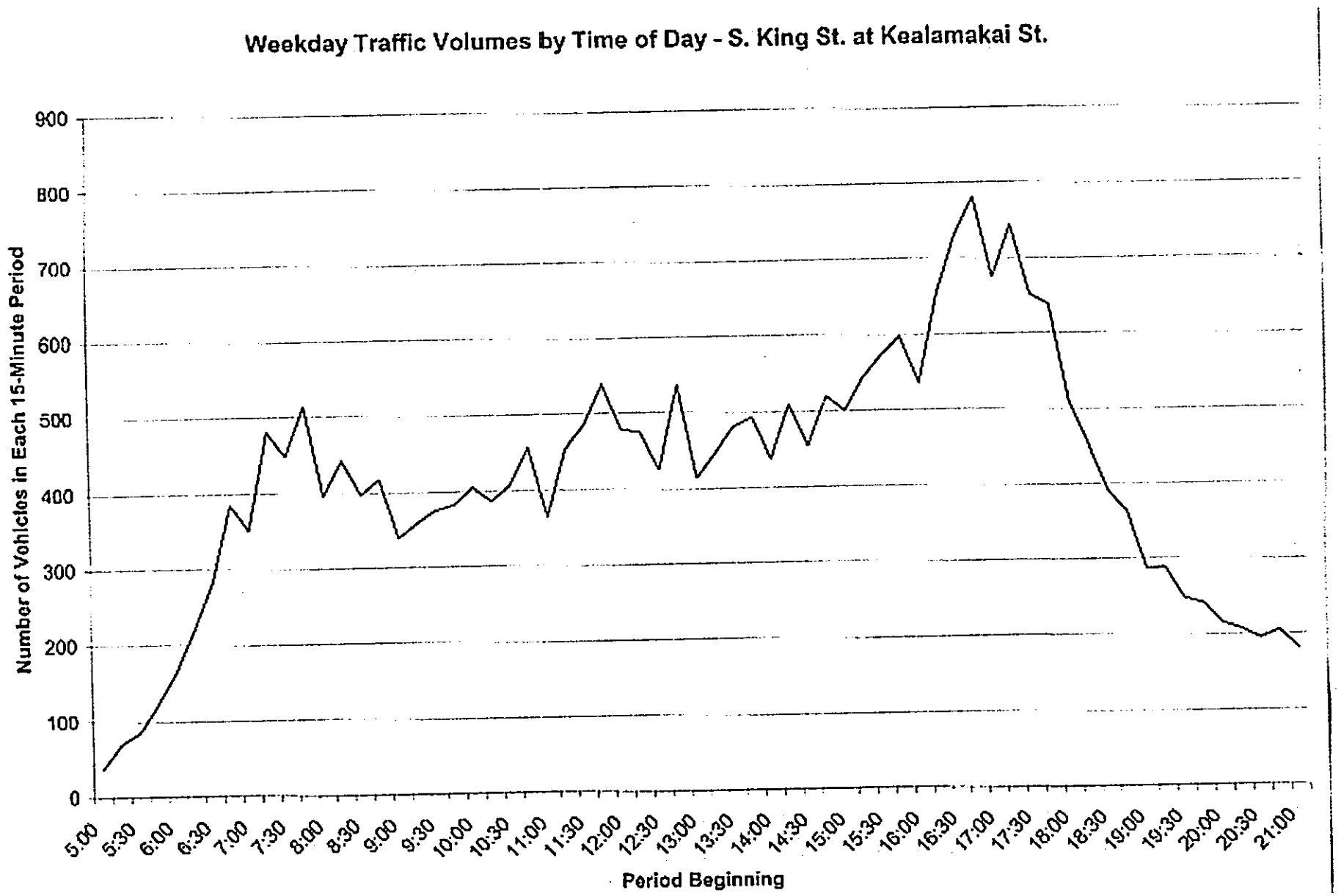
EOTP TRAFFIC IMPACT STUDY

HONOLULU, HAWAII

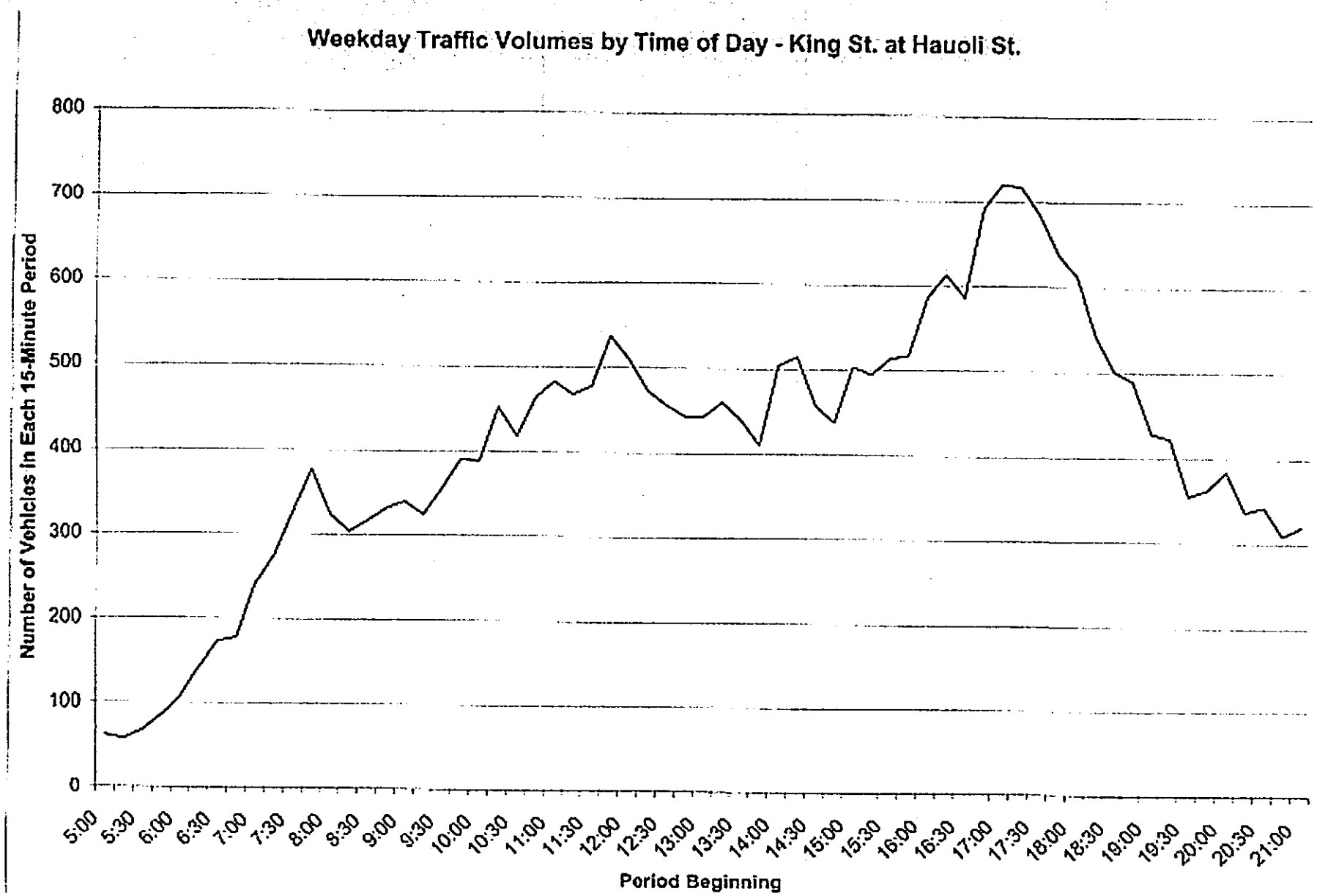
MIDDAY TRAFFIC LANES

KING STREET CORRIDOR

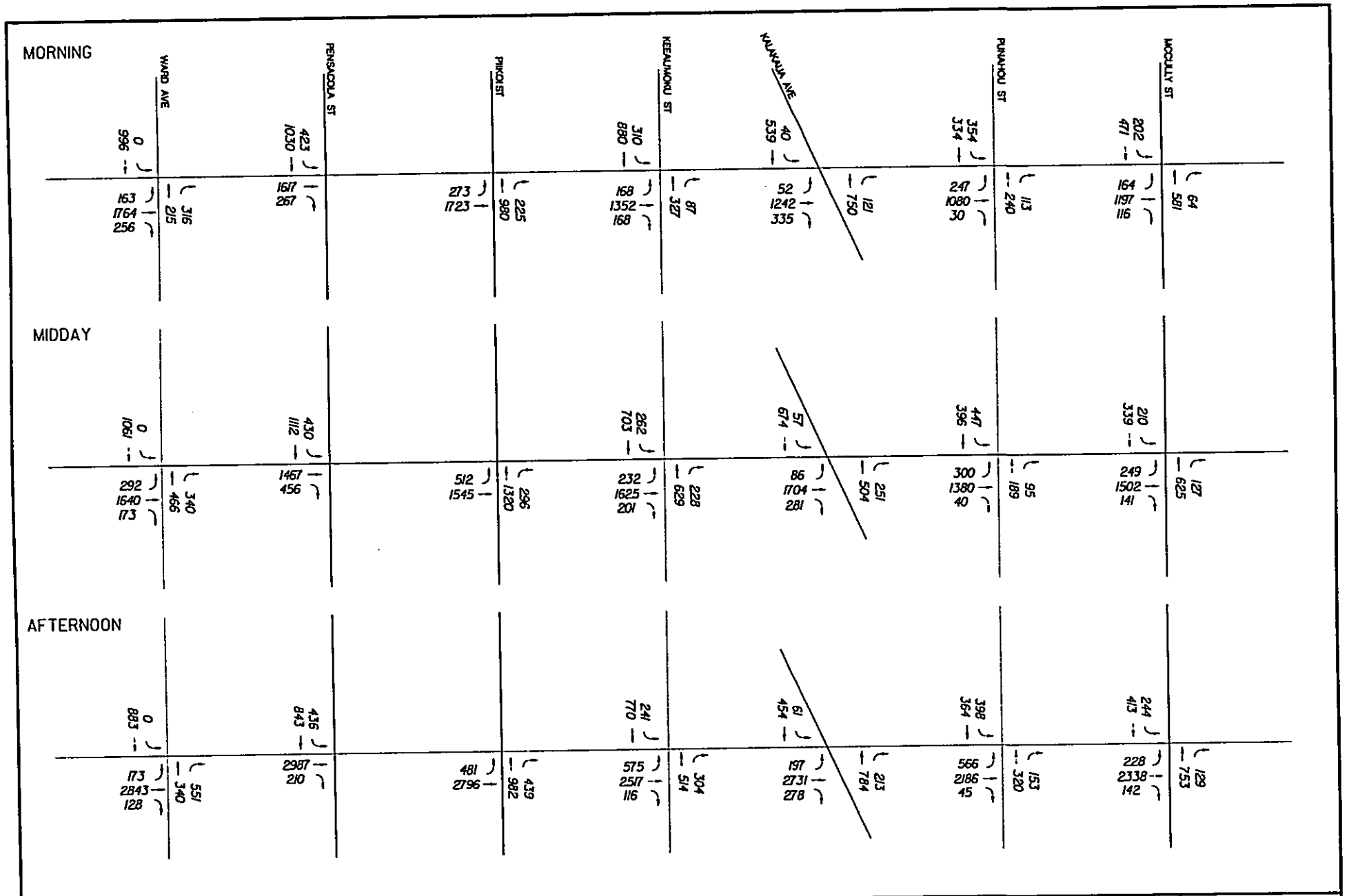
FIGURE: 2-10



Wilbur Smith Associates ENGINEERS PLANNERS ECONOMISTS	333 FAYETTEVILLE ST, SUITE 1450 RALEIGH, NORTH CAROLINA 27601 TELE : (919) 755-0583 FAX : (919) 832-8798	EOTP TRAFFIC IMPACT STUDY HONOLULU, HAWAII	TRAFFIC VOLUMES BY TIME OF DAY – KING ST. AT KEALAMAKAI ST.	FIGURE: 2-11



Wilbur Smith Associates ENGINEERS PLANNERS ECONOMISTS	333 FAYETTEVILLE ST. SUITE 1450 RALEIGH, NORTH CAROLINA 27601 TELE : (919) 755-0583 FAX : (919) 832-8798	EOTP TRAFFIC IMPACT STUDY HONOLULU, HAWAII	TRAFFIC VOLUMES BY TIME OF DAY – KING ST. AT HAUOLI ST.	FIGURE: 2-12



Wilbur Smith Associates
ENGINEERS PLANNERS ECONOMISTS
333 FAYETTEVILLE ST, SUITE 1450
RALEIGH, NORTH CAROLINA 27601
TELE : (919) 755-0583
FAX : (919) 832-8798

EOTP TRAFFIC IMPACT STUDY

HONOLULU, HAWAII

2004 PEAK HOUR TRAFFIC

KING STREET CORRIDOR

FIGURE: 2-13

Chapter 3
FUTURE CONDITIONS WITHOUT EOTP CONSTRUCTION WORK

The transportation facilities and conditions were projected for yearend 2006-early 2007 for the Phase 1 construction areas and late 2008–early 2009 for the Phase 2 corridor. These conditions were used as a baseline for use in assessing the impacts of the EOTP construction work.

3.1. BRT SYSTEM

The planned BRT UH-Manoa line will extend along that portion of Kapiolani Boulevard being considered as an alternative to the proposed alignment of the Phase 1 transmission line along Makaloa, Fern, Hauoli, and Lime Streets. The BRT project will modify Kapiolani Boulevard from Atkinson Drive through the Kaheka Street intersection to provide a special BRT lane, while the BRT buses will operate in the general traffic lanes in the section between Atkinson Drive and Pumehana Street.

The planned BRT UH-Manoa line will also extend along a portion of King Street that would be affected by the proposed EOTP construction. Between Cooke and Pensacola Streets, the BRT will convert the makai curb lane to a semi-exclusive transit lane and change the mauka curb lane to a contra-flow lane for exclusive use by BRT buses operating in the Ewa-bound travel direction.

The implementation of the BRT modifications and start of service along each of these sections could either precede or follow the EOTP construction work. Therefore, the future conditions for the EOTP assessment have been made both without and with the prior implementation of the BRT service along these streets.

3.2. MAKALOA-KAPIOLANI CORRIDOR

The roadway and traffic conditions were projected for this corridor for year 2007, the year in which most of the EOTP construction is expected to occur. The proposed action includes construction of a new ductline beneath a section of Makaloa Street and the reuse of an existing ductline along Kalakaua Avenue, Fern, Hauoli, and Lime Streets. Alternative alignments would include construction of a new ductline beneath Kapiolani Boulevard.

The EOTP construction would likely precede the construction of the BRT UH-Manoa line planned along this section of Kapiolani Boulevard. However, an assessment was made of traffic conditions along Kapiolani Boulevard with the BRT line in the event that it is in place by the time of the EOTP construction.

3.2.1. Roadway and Public Transit Modifications Without the BRT Line

No roadway modifications are anticipated along this corridor by 2006 that would substantially change the number of traffic lanes or intersection capacities.

TheBus services are expected to remain similar to the current routes and frequencies of service using the area roadways, with stop locations at present locations.

3.2.2. Roadway and Public Transit Modifications With BRT Line

The BRT line, as depicted in the Final EIS for the Primary Corridor Project,[1] will primarily affect the Kapiolani Boulevard intersections with Kaheka Street and with Atkinson Drive. Between Pensacola Street and Keeaumoku Street, the BRT would operate in two exclusive lanes located in the center of Kapiolani Boulevard, with one lane for BRT buses in each travel direction. The exclusive lane for Koko Head-direction BRT buses will extend through the Kaheka Street intersection and end at the Atkinson Drive intersection. At Atkinson Drive, the Koko Head-direction BRT buses would continue to University Avenue in the curb lanes with mixed traffic. The Ewa-direction BRT buses will travel along the curb lane in mixed traffic from University Avenue through the Kaheka Street intersection. The exclusive BRT bus lane in the center of the street will begin midway between the Kaheka and Keeaumoku Street intersections and continue to Pensacola Street. Parking will be restricted along the curb lanes of the blocks with the exclusive BRT lane(s).

With the BRT lane, the Kapiolani Boulevard approaches to the Kaheka Street intersection will be re-striped to provide two through lanes and a left-turn-only lane in each direction throughout the day. At the Atkinson Drive intersection, the Kapiolani Boulevard approach for Koko Head direction traffic will provide two travel lanes plus the exclusive BRT lane next to the centerline of the roadway. The Ewa-bound approach of Kapiolani Boulevard will be marked for two left-turn only lanes and two through lanes. The existing reversible lane operation would continue in the morning and afternoon peak commute periods on the Koko Head side of the Atkinson Drive intersection, but will not extend Ewa of Atkinson Drive.

3.2.3. Traffic Volumes

The Wal-Mart development along Keeaumoku Street, now under construction, would increase traffic along both Makaloa Street and Kapiolani Boulevard. The 2004 weekday peak hour traffic volumes were increased by the 2% growth for use in estimating the 2007 traffic volumes, plus the traffic projected by the new Wal-Mart development[2] was added to the reflect the opening of that project in the next year. These forecasts were used both without and with the BRT line. The

1 *Final Environmental Impact Statement, Primary Corridor Transportation Project*, City and County of Honolulu Department of Transportation Services, July 2003.

2 *Traffic Impact Report for Proposed Wal-Mart and Sam's Club*, prepared by Austin, Tsutsumi & Associates, Inc., February 2003.

resultant peak hour traffic volumes are depicted in Figures 3-1, 3-2, and 3-3 for the morning, midday, and afternoon peak traffic hours, respectively.

The same traffic forecasts were used with the BRT system in place along Kapiolani Boulevard. The BRT system could potentially reduce traffic along Kapiolani Boulevard through either the shift of some trips made by automobile to use of public transportation, or by encouraging traffic to use alternative routes through the area to avoid increased congestion at several locations where the BRT will reduce the capacity for the general traffic lanes.

3.2.4. Traffic Conditions at Key Intersections Without BRT

Traffic conditions at the key intersections for the 2007 morning, midday, and afternoon peak traffic hours are summarized in Table 3-1.

The 2007 peak hour traffic would amount to low levels of capacity use at the Makaloa Street intersection with Kaheka Street, particularly in the morning peak hour (28%) and in the midday peak hour (40%). These low levels of capacity use indicate that one or more traffic lanes could likely be closed at this intersection during these periods while maintaining reasonable traffic flow through the intersection.

The estimated 2007 traffic volumes would approximate capacity at the Kapiolani Boulevard intersection with Atkinson Drive, and approach capacity at the Kalakaua Avenue intersection in the morning peak hour, and at McCully Street in the afternoon peak hour.

Table 3-1
2007 Traffic Conditions At Key Intersections Without BRT Lanes, Makaloa Street Corridor

Intersections	Morning Peak Hour			Midday Peak Hour			Afternoon Peak Hour		
	V/C	ADPV	LOS	V/C	ADPV	LOS	V/C	ADPV	LOS
Makaloa St.-Kaheka St.	0.28	18.1	B	0.40	20.0	C	0.68	25.8	C
Kapiolani Blvd.-Kaheka St.	0.51	14.4	B	0.61	24.5	C	0.92	48.0	D
Kapiolani Blvd.-Atkinson Dr.	1.00	28.2	C	0.67	20.4	C	0.64	24.9	C
Kapiolani Blvd.-Kalakaua Ave.	0.96	56.4	E	0.85	40.8	D	0.93	45.3	D
Kapiolani Blvd.-McCully St.	0.84	41.6	D		NA		0.98	61.5	E

V/C = Ratio of the traffic volume to the theoretical capacity of the intersection.
ADPV = Average delay per vehicle, in seconds.
LOS = Level of service.
NA = Not Available

Wilbur Smith Associates; July 26, 2004.

The estimated midday peak hour traffic volumes would amount to 85% or less of capacity at each of the Kapiolani Boulevard intersections.

3.2.5. Traffic Conditions at Key Intersections With BRT

The modifications with the BRT system would directly affect traffic conditions at the Kapiolani Boulevard intersections with Kaheka Street and with Atkinson Drive. As summarized in Table 3-2, the loss of a through lane in each direction, as well as loss of the reversible lane operation, would worsen conditions during the afternoon commute peak hour. The estimated 2007 afternoon peak hour would exceed the capacity at both the Kaheka Street and Atkinson Drive intersections by 2% to 6%, with resultant long delays (LOS E or F) at each intersection. The BRT project would provide two dedicated left-turn lanes for the left-turn from Kapiolani Boulevard onto Atkinson Drive, which would improve conditions in the morning and midday peak traffic hours over those without the BRT project. Similarly, the BRT project would add separate left-turn lanes at the intersection with Kaheka Street, which would offset the reduction in general traffic lanes and avoid any worsening of midday conditions .

The traffic conditions at the Kapiolani Boulevard intersections with both Kalakaua Avenue and McCully Street would be similar to the conditions without the BRT system in place.

Table 3-2
2007 Traffic Conditions At Key Intersections With BRT, Makaloa Street Corridor

Intersections	Morning Peak Hour			Midday Peak Hour			Afternoon Peak Hour		
	V/C	ADPV	LOS	V/C	ADPV	LOS	V/C	ADPV	LOS
Kapiolani Blvd.-Kaheka St.	0.83	22.4	C	0.61	24.9	C	1.06	133.6	F
Kapiolani Blvd.-Atkinson Dr.	0.82	24.5	C	0.61	26.7	C	1.02	75.2	E
Kapiolani Blvd.-Kalakaua Ave.	0.96	56.4	E	0.85	44.7	D	0.93	45.3	D
Kapiolani Blvd.-McCully St.	0.84	41.6	D		NA		0.98	61.5	E

V/C = Ratio of the traffic volume to the theoretical capacity of the intersection.
ADPV = Average delay per vehicle, in seconds.
LOS = Level of service.
NA = Not Available.

Wilbur Smith Associates; July 23, 2004.

3.3. PUMEHANA STREET AREA

No substantial changes are anticipated along Pumehana Street or the adjacent blocks between 2004 and the planned 2007 construction of the EOTP along the street.

3.3.1. Roadways, Public Transit, and Bicycle Facilities

There are no changes expected to the roadways and traffic controls along Pumehana Street that would substantially affect traffic capacity or operations by 2007. There are no plans to add public bus service or bicycle lanes along the street by 2007.

3.3.2. Traffic Volumes

The estimated 2004 traffic volumes were increased by 2% to provide an estimate of daily and peak hour traffic volumes along Pumehana Street. The estimated 2004 and 2007 traffic volumes are as follows:

Location and Time Period	2004 Traffic	2007 Traffic
Approaching Fern Street		
24-hour Volume	2,700	2,750
Morning Peak Hour (7:30-8:30 AM)	120	125
Afternoon Peak Hour (4:00-5:00 PM)	225	230
Approaching Lime Street		
24-hour Volume	2,900	2,960
Morning Peak Hour (7:30-8:30 AM)	75	80
Afternoon Peak Hour (4:00-5:00 PM)	50	255

3.4. DATE STREET AREA

No substantial changes are anticipated along Date Street or the adjacent blocks between Kapiolani Boulevard and Laau Street by the time of the planned construction of the EOTP along this section of street in 2007.

3.4.1. Roadways, Public Transit, and Bicycle Facilities

There are no changes expected to the roadways and traffic controls along Date Street that would substantially affect traffic capacity or operations by 2007. There are no plans to substantially increase public bus service or add bicycle lanes along this section of Date Street by 2007.

3.4.2. Traffic Volumes

The estimated 2007 traffic volumes were increased by 2% to provide an estimate of daily and peak hour traffic volumes along Date Street. The estimated 2007 traffic volumes along Date Street at the vicinity of the EOTP construction site are as follows:

2007 Time Period	Koko Head Direction Traffic	Ewa Direction Traffic	Both Directions
24-hour Volume	11,000	9,500	20,500
Morning Peak Hour	680	830	1,510
Midday Peak Hour	790	620	1,410
Afternoon Peak Hour	1,050	730	1,780

3.5. WINAM AVENUE AREA

No substantial changes are anticipated along Winam Avenue or the adjacent blocks between 2004 and the planned 2007 construction of the EOTP along the street.

3.5.1. Roadways, Public Transit, and Bicycle Facilities

There are no changes expected to the roadways and traffic controls along Winam Avenue that would substantially affect traffic capacity or operations by 2007. There are no plans to add public bus service or bicycle lanes along the street by 2007.

3.5.2. Traffic Volumes

The estimated 2004 traffic volumes were increased by 2% to provide an estimate of daily and peak hour traffic volumes along Winam Avenue and Mooheau Avenue. The estimated 2007 traffic volumes are as follows:

2007 Street and Time Period	Koko Head Direction Traffic	Ewa Direction Traffic	Both Directions
WINAM AVENUE			
24-hour Volume	2,250	1,480	3,730
Morning Peak Hour (7:00-8:00 AM)	110	95	205
Midday Peak Hour (11:15 AM-12:15 PM)	185	105	290
Afternoon Peak Hour (5:45-6:45 PM)	185	105	290
MOOHEAU AVENUE			
24-hour Volume	3770	4615	8385
Morning Peak Hour (7:00-8:00 AM)	20	300	320
Midday Peak Hour (11:15 AM-12:15 PM)	260	265	525
Afternoon Peak Hour (5:45-6:45 PM)	400	465	865

3.6. KING STREET CORRIDOR

The roadway and traffic conditions were projected for this corridor for late 2008-early 2009, during the later stages of the EOTP construction work, which is expected to extend from late 2007 to early 2009. The Proposed Project would include construction of a new ductline between Cooke and McCully Streets as well as on the block of Cooke Street makai of King Street and on the two blocks of McCully Street mauka of King Street.

The EOTP construction may precede or follow the construction of the BRT UH-Manoa line planned along the section of King Street between Downtown and Pensacola Street. Therefore, an assessment was made of traffic conditions along King Street both without and with the BRT line in place by the time of the EOTP construction.

3.6.1. Roadway and Public Transit Modifications Without the BRT Line

No roadway modifications are anticipated along this corridor by 2009 that would substantially change the number of traffic lanes or intersection capacities.

TheBus services are expected to remain similar to the current routes and frequencies of service using the area roadways, with bus stops at present locations.

3.6.2. Roadway and Public Transit Modifications With BRT Line

The BRT line, as depicted in the Final EIS for the Primary Corridor Project, would primarily affect the King Street EOTP construction between Cooke and Pensacola Streets. This would directly affect traffic capacity and operations at the intersections with Ward Avenue and with Pensacola Street.

The Koko Head direction BRT lane will be located in the makai curb lane from Ewa of Cooke Street to the Pensacola Street intersection. The makai BRT lane will function as a "semi-exclusive" lane and will permit use only by BRT buses, other public transit vehicles, and by those non-transit vehicles turning right at cross streets or into driveways along the BRT lane. King Street will also be used for the Ewa-direction BRT lane, with the mauka curb lane converted to a contra-flow Ewa-bound lane for exclusive use by Ewa-bound BRT buses. On-street parking will be prohibited along both curbs of King Street from Ewa of Cooke Street to Pensacola Street.

On Pensacola Street, the BRT will operate in two exclusive lanes located along the Ewa side of the street, with one lane for BRT buses in each travel direction. All BRT buses will turn between King and Pensacola Streets.

With the BRT lane, the section of King Street between Cooke Street and Pensacola Street will provide four general traffic lanes in the Koko Head direction. Left-turns will be made from the mauka lane of these four lanes, with the left turns into both cross streets and driveways made across the opposing BRT Ewa-bound bus lane. The semi-exclusive makai curb lane will be used for right turns by non-transit vehicles. King Street will retain its present lane configuration Koko Head of Pensacola Street.

3.6.3. Traffic Volumes

The 2004 weekday peak hour traffic volumes were increased by 4.1% for use as the 2009 traffic volumes, both without and with the BRT line. For this analysis, the BRT line was not assumed to reduce the number of vehicles operating along King Street or the cross streets in 2009. The resultant peak hour volumes are depicted in Figures 3-4 for the morning, midday, and afternoon peak traffic hours.

3.6.4. Traffic Conditions at Key Intersections Without BRT

The 2009 peak hour traffic conditions at the key intersections along King Street, without the BRT project, are summarized in Table 3-3. The projected traffic at the Punahou Street intersection with King Street approximates the intersection capacity in the afternoon peak hour. Afternoon peak hour traffic at several of the other intersections (Ward Avenue, Keeaumoku Street, and Kalakaua Avenue) amount to 88% to 89% of capacity.

The morning and midday peak hour traffic at the Punahou Street intersection would approximate 78% of the intersection capacity. Other intersections with either the morning and midday peak hour traffic volumes at 70% or more of capacity include the King Street intersections with Ward Avenue, Keeaumoku Street, and Kalakaua Avenue.

3.6.5. Traffic Conditions at Key Intersections With BRT

Of the key study intersections along King Street, the BRT project will directly affect the intersections with Ward Avenue and with Pensacola Street. The conditions at these two intersections with the BRT system in place by 2009 are summarized in Table 3-4.

The conditions at the Ward Avenue intersection would be little changed in the morning and midday peak hours from those without the BRT. The BRT does not reduce the number of through lanes along King Street in these two periods since it displaces the on-street parking allowed in each curb lane. The BRT would shift the traffic turning left onto Ward Avenue from the mauka curb lane to the second lane from the mauka curb, which would be shared with the through traffic. With the BRT, the afternoon peak hour traffic would amount to 96% of the intersection capacity versus 88% without the BRT.

Capacity utilization at the Pensacola Street intersection would be 60% and 66% during the morning and midday peak hours, respectively. During the afternoon peak hour, traffic would approximate 86% of capacity with the BRT project versus 64% without the BRT lanes.

Table 3-3
2009 Traffic Conditions At Key Intersections Without BRT Lanes, King Street Corridor

Intersections	Morning Peak Hour			Midday Peak Hour			Afternoon Peak Hour		
	V/C	ADPV	LOS	V/C	ADPV	LOS	V/C	ADPV	LOS
King St.-Ward Ave.	0.71	21.2	C	0.67	20.5	C	0.88	30.1	C
King St.-Pensacola St.	0.53	18.7	B	0.63	20.0	B	0.64	17.8	B
King St.-Piikoi St.	0.48	17.9	B	0.59	19.0	B	0.76	21.3	C
King St.-Keeaumoku St.	0.63	28.3	C	0.75	34.8	C	0.88	33.2	C
King St.-Kalakaua Ave.	0.73	26.5	C	0.74	24.4	C	0.89	29.9	C
King St.-Punahou St.	0.78	40.9	D	0.78	36.9	D	1.00	59.6	E
King St.-McCully St.	0.61	25.3	C	0.80	29.5	C	0.84	31.4	C
McCully St.-Young St.	0.58	20.6	C	0.57	19.8	B	0.70	24.3	C

V/C = Ratio of the traffic volume to the theoretical capacity of the intersection.
ADPV = Average delay per vehicle, in seconds.
LOS = Level of service.

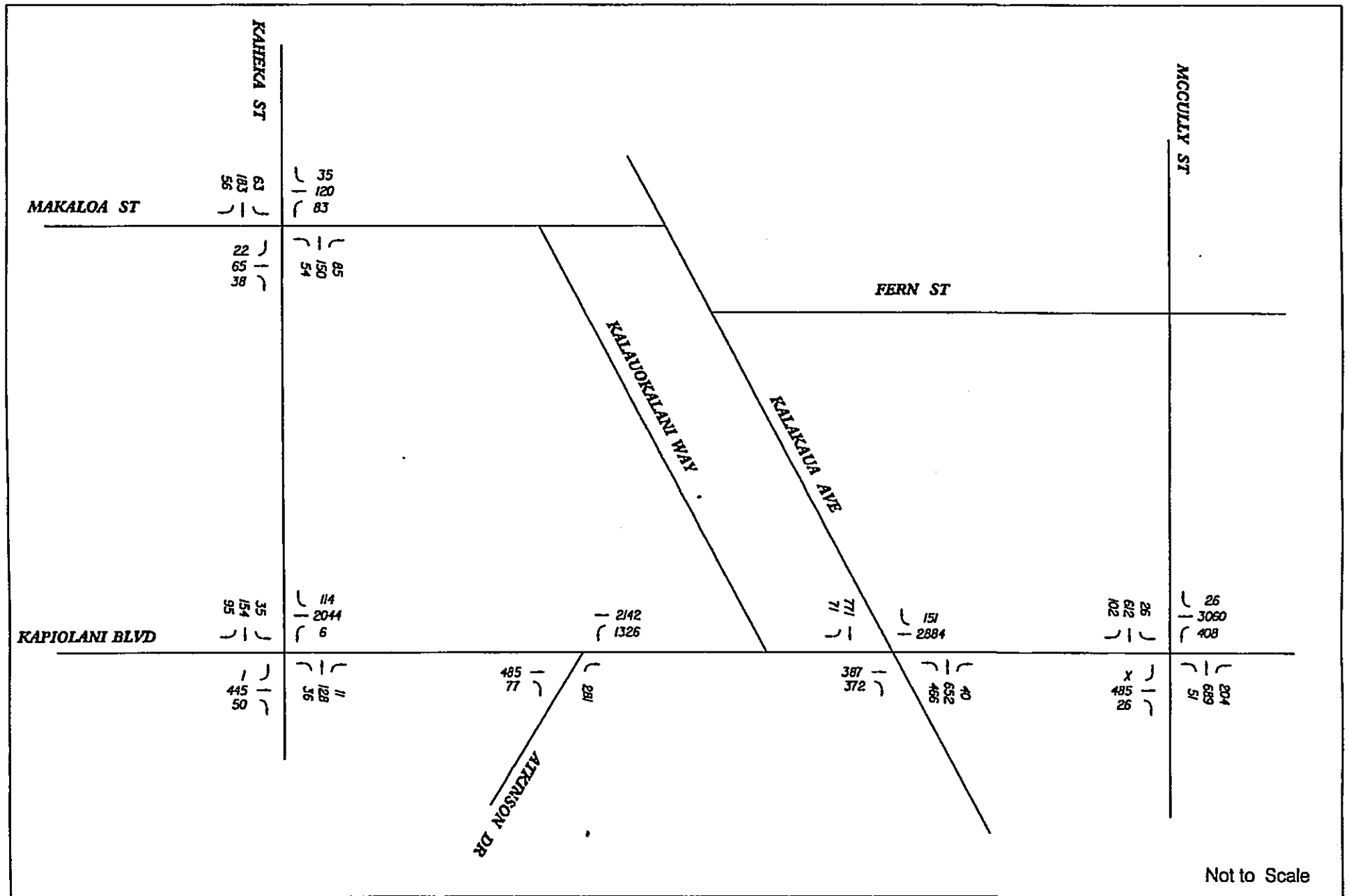
Wilbur Smith Associates; May 10, 2004.

Table 3-4
2009 Traffic Conditions At Key Intersections With BRT Lanes, King Street Corridor

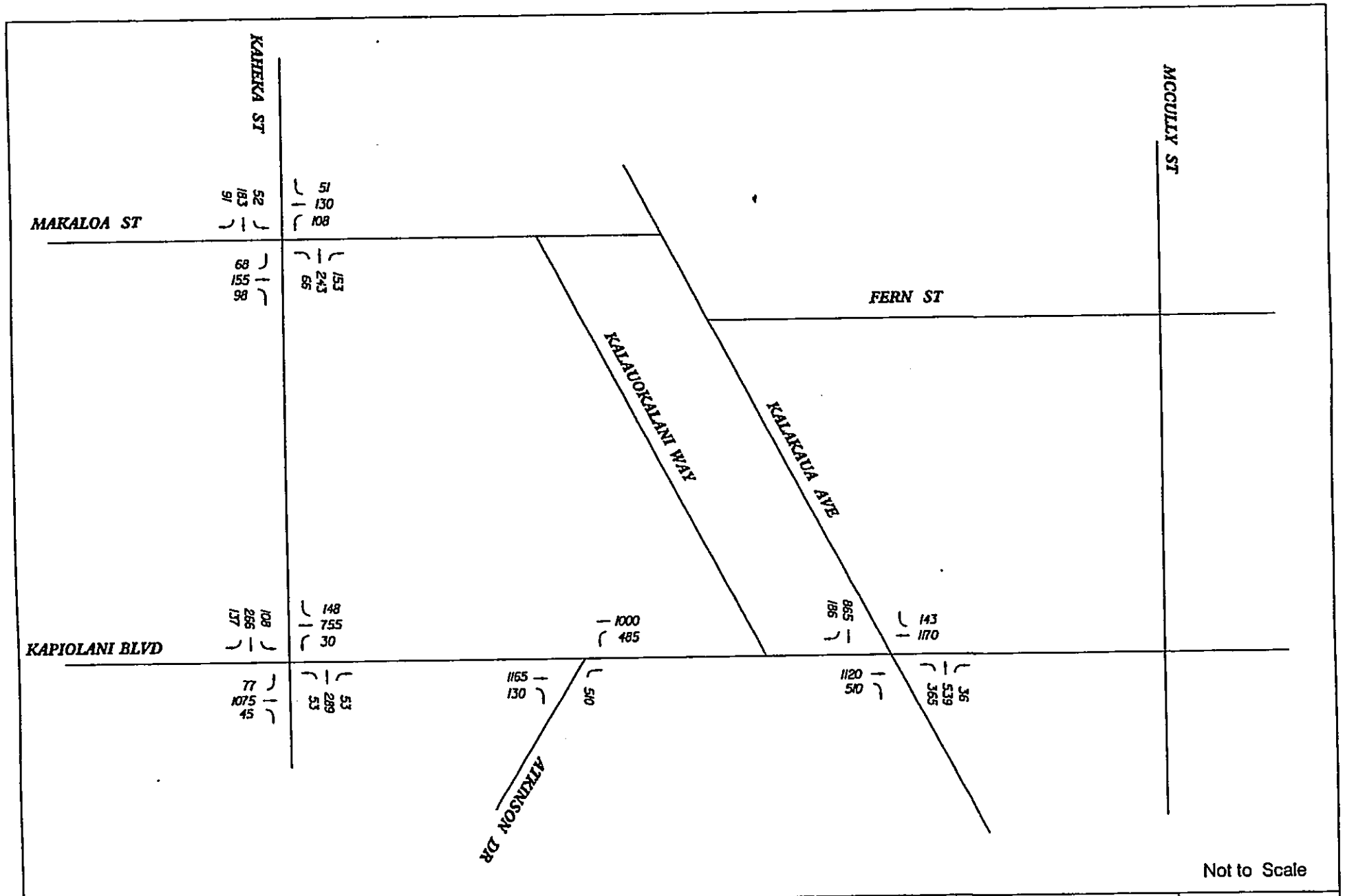
Intersections	Morning Peak Hour			Midday Peak Hour			Afternoon Peak Hour		
	V/C	ADPV	LOS	V/C	ADPV	LOS	V/C	ADPV	LOS
King St.-Ward Ave.	0.68	20.5	C	0.68	20.7	C	0.96	33.2	C
King St.-Pensacola St.	0.60	19.0	B	0.66	19.8	B	0.86	22.5	C

V/C = Ratio of the traffic volume to the theoretical capacity of the intersection.
ADPV = Average delay per vehicle, in seconds.
LOS = Level of service.

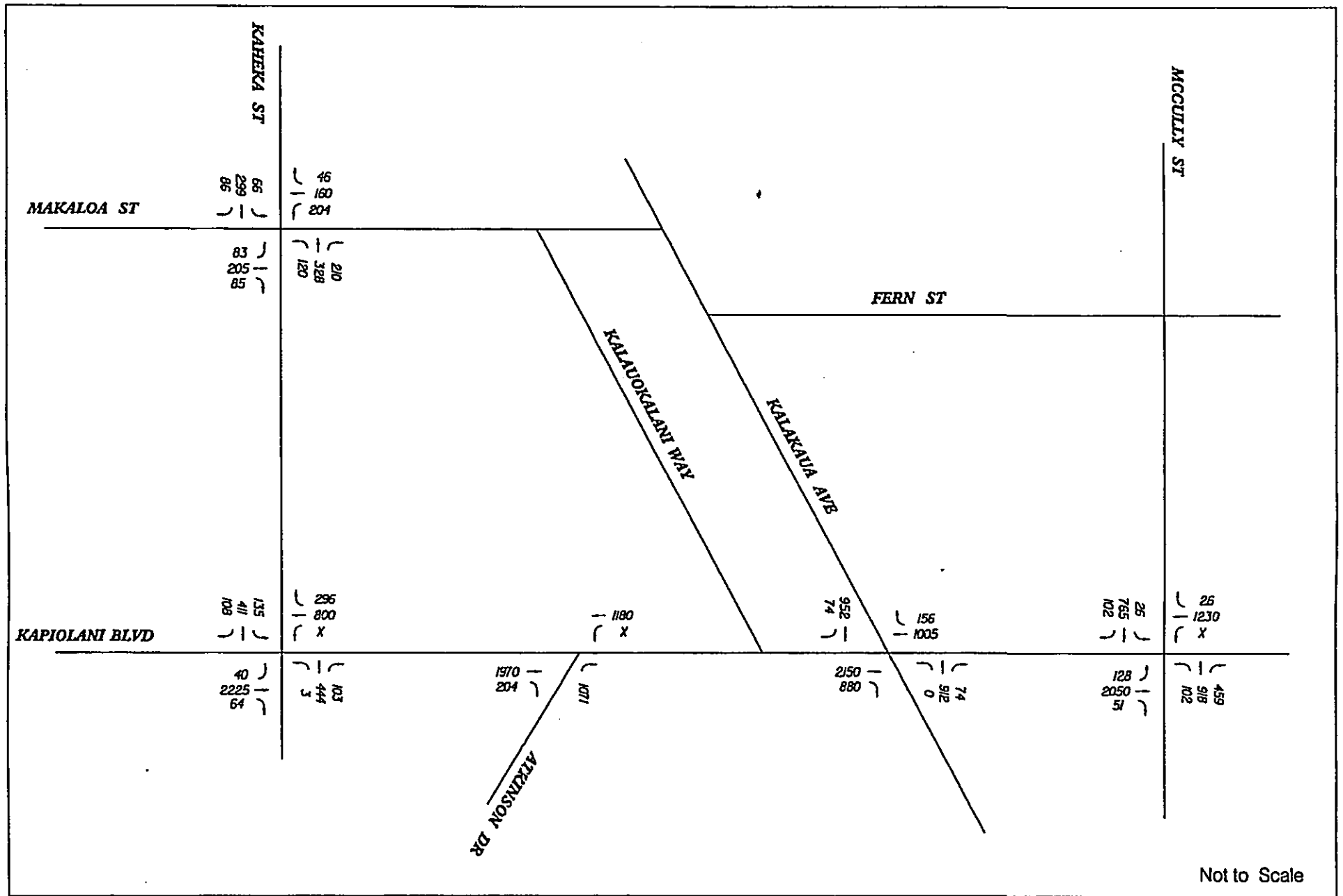
Wilbur Smith Associates; May 11, 2004.



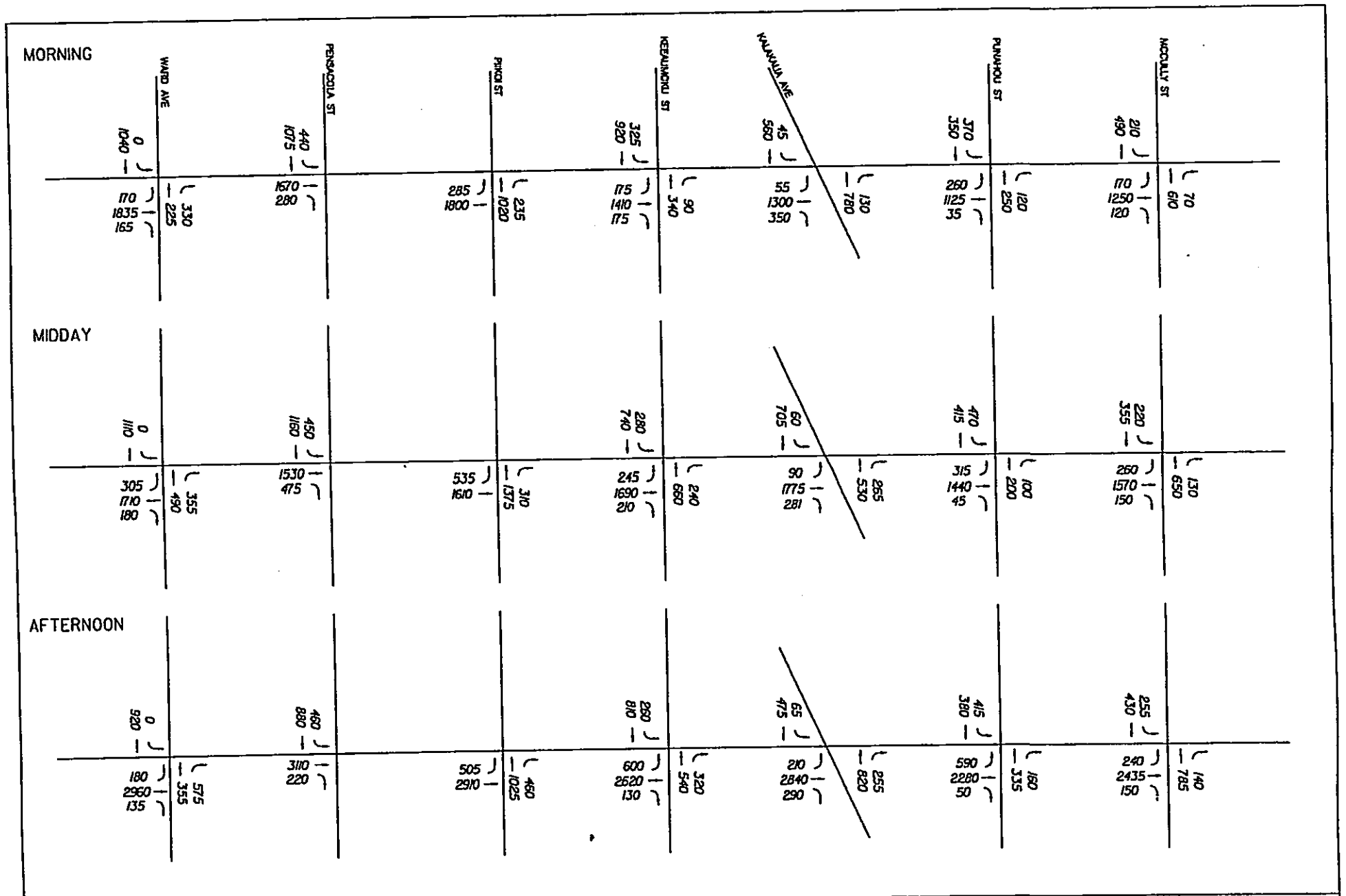
Wilbur Smith Associates (Engineers Planners Economists)	333 FAYETTEVILLE ST, SUITE 1450 RALEIGH, NORTH CAROLINA 27601 TELE : (919) 755-0583 FAX : (919) 832-8798	EOTP TRAFFIC IMPACT STUDY HONOLULU, HAWAII	2007 MORNING PEAK HOUR TRAFFIC MAKALOA – KAPIOLANI CORRIDOR	FIGURE: 3-1



Wilbur Smith Associates (Engineers Planners Economists)	333 FAYETTEVILLE ST, SUITE 1450 RALEIGH, NORTH CAROLINA 27601 TELE : (919) 755-0583 FAX : (919) 832-8798	EOTP TRAFFIC IMPACT STUDY HONOLULU, HAWAII	2007 MIDDAY PEAK HOUR TRAFFIC MAKALOA – KAPIOLANI CORRIDOR	FIGURE: 3-2



Wilbur Smith Associates (ENGINEERS PLANNERS ECONOMISTS)	333 FAYETTEVILLE ST, SUITE 1450 RALEIGH, NORTH CAROLINA 27601 TELE : (919) 755-0583 FAX : (919) 832-8798	EOTP TRAFFIC IMPACT STUDY HONOLULU, HAWAII	2007 AFTERNOON PEAK HOUR TRAFFIC MAKALOA – KAPIOLANI CORRIDOR	FIGURE: 3-3



Wilbur Smith Associates
ENGINEERS PLANNERS ECONOMISTS
333 FAYETTEVILLE ST, SUITE 1450
RALEIGH, NORTH CAROLINA 27601
TELE : (919) 755-0583
FAX : (919) 832-8798

EOTP TRAFFIC IMPACT STUDY

HONOLULU, HAWAII

2009 PEAK HOUR TRAFFIC

KING STREET CORRIDOR

FIGURE: 3-4

Chapter 4
PHASE 1 TRAFFIC IMPACTS IN MAKALOA CORRIDOR

The EOTP would include expanded electrical subtransmission line capacity between the Makaloa Substation, located on the northwest corner of the intersection of Makaloa and Amana Streets, and the McCully Substation located on Lime Street between Hauoli and Pumehana Streets. The proposed action would construct a new ductline along Makaloa Street between the Substation and Poni Street, about 1,000 feet in length, and would reuse an existing ductline for the remaining 2,400 feet between Poni Street and the McCully Substation. The reuse of the existing ductline for most of the route would require work at existing manholes along Kalakaua Avenue, Fern, Hauoli, and Lime Streets to pull and splice the new subtransmission line.

Two alternative routes have been identified for the connection between the two substations, with both requiring construction of a new ductline for the entire distance between the two substations. Alternative 1, also referred to as the Kaheka Street alternative, would follow Kaheka Street, Kapiolani Boulevard, and Pumehana Street for the new connection (Figure 4-1). Alternative 2, also referred to as the Kalauokalani Way alternative, would follow Makaloa Street, Kalauokalani Way, Kapiolani Boulevard, and Pumehana Street for the new connection.

The proposed Phase 1 construction is planned for 2006-2007.

4.1. CITY BRT PROJECT

The construction of the UH-Manoa BRT line along Kapiolani Boulevard could occur as early as 2006-2007, although it may occur after the EOTP construction work.

If it appears that the EOTP work in this corridor would occur at the same time as the BRT construction work along this section of Kapiolani Boulevard, then HECO would likely delay the EOTP work between the Makaloa and McCully substations until the completion of the BRT construction through this section. Therefore, the assessment of the EOTP impacts have been organized as follows:

Proposed Makaloa-Fern Alignment – The assessment of this route is considered independent of the BRT line since the BRT would not directly affect the streets along the route. However, the reduction of general traffic lanes along Kapiolani Boulevard by the BRT could encourage the diversion of some traffic from Kapiolani Boulevard to Makaloa Street and result in slightly higher traffic volumes along Makaloa Street than those considered in this assessment.

Alternative 1 (Kaheka-Kapiolani). The BRT project will change the number of traffic lanes and the traffic operations along this section of Kapiolani Boulevard between Kaheka Street and Atkinson Drive. Therefore, the EOTP construction along this

alternative is assessed for a scenario with the existing street (Pre-BRT scenario) and for a scenario if the EOTP construction follows the BRT construction (Post-BRT scenario).

Alternative 2 (Kalauokalani-Kapiolani). The BRT project will not significantly change the roadway or traffic operations along Kapiolani Boulevard between Kalauokalani Way and Pumehana Street. The BRT buses will operate in the general traffic lanes along this section.

4.2. PROPOSED MAKALOA-FERN ALIGNMENT

The new ductline along Makaloa Street would be constructed by the trenching method. HECO proposes to construct the section of the new ductline near the Makaloa Substation and Amana Street in the daytime because of the nearby residential uses. The sections of the new ductline along Makaloa Street near Kaheka Street and Poni Street could be constructed in either the daytime or nighttime. Nighttime work is preferred by HECO to allow longer work shifts, gain greater work efficiency, and reduce traffic impacts. Nighttime work is assessed as the proposed action for the Kaheka-Poni Street segment, with daytime work on this segment assessed as an option.

4.2.1. Project Description

The new ductline between the Makaloa Substation and Poni Street would be constructed by excavation of an open trench. As sections of the ductline are constructed, the sections of the trench will be filled, with the section of open trench ranging between 50 to 150 feet in length at any given time. With a large efficiently laid out work activity area, the preparation, trenching, ductline construction, and covering of the ductline could progress at an average of about 60 feet per day within Makaloa Street. This desired work activity area would be two lanes wide and about 350 feet in length, which would be protected by barricades. With a more compact and less efficient work area, such as an area only one lane wide, the construction would progress at a slower rate, possibly 20 feet per day or less, with the construction requiring several additional weeks.

After the ductline has been constructed, crews would establish work areas at every other manhole location for pulling and splicing the new transmission line. The work area at each manhole would be one lane wide by about 100 to 150 feet in length for pulling of cable and one lane wide by 50 to 100 feet long for splicing of the cable. This activity would include the manholes along the new ductline as well as those along the section of reused ductline. About one day is needed for pulling and three days for splicing the cable at every other manhole.

In addition to the work activity area, a transition zone would be needed to accomplish any shift of the traffic path from the normal lanes on the approach to the construction work area and again on the departure from the section of street with the lane shift to return to the normal traffic lanes. The shift of the traffic paths through the construction area would typically be defined by rows of

traffic cones to mark the temporary path for vehicles through the work area. On low-speed urban streets, these shifts of the vehicle path are typically laid out on a 15 to 1 ratio, meaning that a distance of about 150 to 180 feet is needed to shift the traffic path by the width of one lane (10-12 feet), and at least double that to shift the path by the width of two lanes. The overall length of the work activity area and the lane shift on either end of the work area could total about 950 feet or more. The traffic would be shifted from its normal path for this distance.

Street closures for day shift work would extend from 9:00 AM until 3:00 PM. Night shift work would extend from 7:00 PM until 5:30 AM.

The construction stages that would most affect traffic operations, and the schedule and estimated duration for each, would be as follows:

Stage	Work Element	Traffic Provisions	Shift	Duration (Days)
1	Construct ductline from Substation to manhole in center of Makaloa St.	Restrict parking both curbs for 600 to 800 feet Cone one lane in each direction along makai side of street	Day	2-3
2	Construct ductline from manhole to makai side of road	Restrict parking along both curbs for about 600 to 800 feet Single traffic lane along mauka curb with flagman	Day	3-4
3	Construct ductline along makai parking lane from Amana to Ewa of Kaheka St.	Restrict parking along both curbs from Amana St. to Kaheka St. Cone one lane in each direction along mauka side of street	Day	7-8
4	Construct ductline from makai parking lane to manhole in center of street on Ewa side of Kaheka St.	Restrict parking along both curbs from Amana St. to Kaheka St. Single Makaloa St. traffic lane on Ewa side of Kaheka intersection along mauka curb with flagman	Night	1-2
5	Construct ductline from manhole in center of Kaheka St. across intersection to mauka side parking lane	Restrict parking along both curbs of Makaloa for ½ block on both sides of Kaheka St. Cone traffic lane in each direction along makai side of Makaloa St. Close Kaheka St. with barricade on mauka side of Makaloa St.	Night	1-2

Stage	Work Element	Traffic Provisions	Shift	Duration (Days)
6	Construct ductline along mauka parking lane from Kaheka St. to Ewa side of Poni St.	Restrict parking along both curbs from Kaheka St. to Poni St. Cone traffic lane in each direction along makai side of street	Night	7-8
7	Construct ductline from mauka parking lane to manhole in center of street on Ewa side of Poni St. intersection	Restrict parking along both curbs of Makaloa St. for ½ block on both sides of Poni Single traffic lane along makai curb with flagman	Night	1

The construction would extend across the driveway of the fire station on the northeast corner of the Makaloa Street intersection with Kaheka Street. The construction would be coordinated with the Fire Department to maintain the response capability of the equipment during the construction work.

The preliminary surveying and utility location work would also require the set up of work areas that could also affect traffic and parking. Most of these work areas would typically be small in size and would be in place for several hours. Some larger work areas, requiring closure of one or two lanes during the midday work hours, could be needed to excavate down to underground utilities that would be crossed by the ductline. These work areas would be used to construct concrete collars to provide support to the utility line that is being crossed by the ductline. However, the number and location of these excavations would not be known until the beginning of the design and field work.

The pulling and splicing of the transmission cable would occur at every other manhole for the three manholes along the new ductline on Makaloa Street and six manholes along existing ductline. The existing manholes are located at the Makaloa Street intersection with Kalakaua Avenue, Kalakaua Avenue at Fern Street, Fern Street at Punahou Street, Hauoli Street at Fern street, Hauoli Street at Lime Street, and Lime Street at the McCully Substation. In addition, the Project would include the replacement of several poles and removal of transmission lines from ducts in the existing ductline.

The width of one traffic lane would be repaved along the length of the ductline construction. Paving would occur at night. At major cross street intersections, one-half of the cross-street width would be paved at a time to maintain traffic flow on the cross street.

4.2.2. Traffic Impacts

The ductline construction would last approximately two months. During this period, the traffic would be affected by daytime work and shifts of traffic lanes during ductline construction along

Makaloa Street for about 12-15 days, while the nighttime closure of streets or shift of traffic lanes would occur during 10-13 days.

During the Makaloa Street construction work, the restriction of on-street parking near the work area to maintain a travel lane in each direction would provide through traffic with conditions during most of the daytime construction that would be comparable to those without construction. The principal impacts would be the temporary reduction in the parking supply along the section of street affected by the work area and traffic transition zones (lane shifts), and some disruption of access to driveways in the area of the open trench.

The most critical stage of the proposed ductline construction along Makaloa Street, as outlined in the list of stages that affect traffic operations on page 4-3, would be Stage 2 as the ductline is constructed on a diagonal alignment from the manhole in the normal mauka traffic lane of the centerline through the Amana Street intersection to the makai parking lane at the Koko Head side of the intersection, with this work scheduled for the daytime. As the trench work progresses diagonally across the intersection, there would be a two-day long work period when there is not adequate width on either the mauka or makai side of the street to maintain two traffic lanes side-by-side. During this period, one of three options may be necessary:

1. Provide one lane in each direction, but with the Ewa-bound lane located on the mauka side of the work area and the Koko Head direction lane located makai of the work area; or

2. Provide a single lane on the mauka side of the work area, with traffic restricted to the Ewa-bound direction; or

3. Provide a single lane on the mauka side of the work area, with flagmen to provide for alternating traffic flow in each direction.

Each of these three approaches would be complicated by the traffic desiring to turn into or out of Amana Street. Approach #1 would limit Amana Street to right turns in/out, and the shift of the work area would be disruptive to the traffic flow and to overall construction efficiency. Option #2 would require Koko Head-bound traffic wanting to use Makaloa Street to circulate on either Kapiolani Boulevard or Kanunu Street to bypass the work area.

The midday traffic volumes along Makaloa Street, with 350 to 600 vehicles per hour, could be accommodated by the Option #3 flagman operation. Since it would allow all movements, this option is favored for this stage of construction although it would result in some delay to virtually all through traffic due to the alternating traffic flow. It would also require the use of a third flagman to control traffic turning out of Amana Street.

The nighttime construction work may block Kaheka Street on the mauka side of the intersection as the ductline is constructed across the intersection. The barricaded work area could require through traffic to use Poni or Amana Streets, or other parallel streets, to bypass the barricade across Kaheka Street. Access would be maintained to the properties along the Kaheka Street

block between Makaloa and Kanunu Streets via Kanunu Street. This blockage of Kaheka Street to through traffic could last for 2 to 4 nights.

During the ductline construction, there would be frequent movement of trucks removing excavated material and delivering construction materials to the work area. These movements could result in frequent disruption to traffic flow in the lane adjacent to the work area.

Approximately two nights would be needed to repave a lane-width of the street along the trenchline for the entire 1,000-foot long section. During the nighttime repaving work, the on-street parking would be restricted along both parking lanes of Makaloa Street for one night on the Amana-Kaheka section and one night on the Kaheka-Poni section.

4.2.3. Impacts on Public Transit Routes and Stops

The closure of the block of Kaheka Street to through traffic during the nighttime construction at the intersection with Makaloa Street could affect the TheBus routes that operate along Kaheka Street, depending upon the work hours at the intersection. Routes 5, 6, 17, and 18 provide service in the mauka-bound direction. The first trip of Routes 5, 17, and 18 passes through the intersection around 6:00 AM, with the last trip at around 9:00-9:30 PM. Route 6 services extend from about 5:30 AM until about 11:00 PM. The routes serve a bus stop next to the Daiei store on the mauka side of Makaloa Street.

4.2.4. Impacts on Pedestrians

Pedestrian crosswalks are provided across Makaloa Street on both sides of the Amana and Kaheka Street intersections, and on the Ewa side of the Poni Street intersection. The construction work through these intersections would close each of these crosswalks for a period of one work shift or more. The closure of each crosswalk would require pedestrians to use alternative crossing points and lengthen their trip distances and walk times. The ductline connection to the Substation would cross and block the sidewalk on the mauka side of Makaloa Street.

4.2.5. Possible Actions to Minimize Impacts

Since the morning commute period traffic volumes are lower than the midday volumes, the traffic impacts could be reduced if the daytime construction period were to begin earlier and end earlier. The work start time could be shifted to 7:00 AM or 8:00 AM and the afternoon work ended earlier.

If the daytime work were to start at 7:00 AM or 8:00 AM and the afternoon end of the work period kept at 3:00 PM, this would provide a longer work day, allow more productive use of the work day, and shorten the number of days needed for the daytime work. The longer work day could reduce the estimated 12-15 days of daytime construction by 2-3 days.

The traffic impacts from the construction work across the Amana Street intersection could be lessened if done on the nighttime work shift. The traffic volumes during the night time hours range from 50 to 300 vehicles per hour, substantially less than the midday volumes of 500 to 700 vehicles per hour. If the ductline work is done at this intersection in the daytime, the impact on through traffic could be reduced by the coning of the Ewa-bound lane on the mauka side and the Koko Head-bound lane on makai side of the work area, which would limit Amana Street traffic to right-turns in-out, rather than using a flagman operation as discussed in Section 4.2.2 to serve all traffic movements.

The construction work at the Kaheka Street intersection should be coordinated with TheBus and City DTS to minimize any disruption to TheBus service along Kaheka Street. This could include the delay in the start of the nighttime work that requires a barricade across the Kaheka Street intersection until after the last bus trip along Kaheka Street. Alternatively, the nighttime work across the intersection could be staged so that two mauka-makai lanes are open on Kaheka Street across the intersection, or one lane with a flagman operation. Each of these approaches would result in a less efficient work area and would likely extend the construction work in the intersection by 2-3 nights.

At intersections, the work area should be reconfigured and the construction work staged to maintain use of one mauka-makai crosswalk at each intersection for as much of the construction period as possible. If there is a period when there is no mauka-makai crosswalk open across Makaloa Street at an intersection, advance warning signs should be placed at each end of the Makaloa Street blocks to warn pedestrians of the closure.

During the blockage of the sidewalk at the Makaloa Substation, an alternative pathway should be provided or advance warning signs should be placed at each end of the block to warn pedestrians of the closure and alternative routes.

4.2.6. Impacts with All-Daytime Construction Option

The section of the ductline from the Ewa side of Kaheka Street to Poni Street could be constructed during the daytime, as proposed for the Ewa segments of the new ductline.

The section from the Koko Head side of Kaheka Street to Poni Street could be constructed as described for the Proposed Project with minimal effect to traffic flow. The daytime construction would restrict parking along this section at a time that may be of more importance to area businesses.

The closure of Kaheka Street to through traffic on the mauka side of the Makaloa Street intersection would have significant impacts on area traffic during the daytime, as the midday traffic that must be diverted range up to 700 vehicles per hour. The diversion of these vehicles to Poni and Amana Streets would result in severe congestion along these streets. The diversion to Kalakaua Avenue would likely result in congested conditions at the intersection with Makaloa Street, while diversion to Keeaumoku Street may result in congestion at the Keeaumoku Street

intersections with Kapiolani Boulevard and Makaloa Street. The closure would also require the re-routing of TheBus routes that operate along Kaheka Street.

Therefore the work within the Kaheka Street intersection would have to be staged to maintain traffic flow along Kaheka Street. Because of the traffic signal operations, a flagman operation may not be feasible with the daytime volume of Kaheka Street traffic, thus requiring one lane be provided in each direction on Kaheka Street through the intersection. The need to maintain traffic would also be reinforced by the use of the street by four TheBus routes, with 7 to 9 buses per hour through the intersection during the daytime work hours. This would provide acceptable conditions for the midday traffic, with traffic at about 62% of intersection capacity. However, the reconfigured work area may result in very low productivity which would increase the time in which the intersection is impacted by the construction work by an additional 3 to 4 days.

4.3. ALTERNATIVE 1 (KAHEKA-KAPIOLANI) BEFORE BRT

Both daytime and nighttime construction was considered in the traffic assessment for the Alternative 1 Kaheka-Kapiolani alignment with daytime construction as the preferred option.

4.3.1. Project Description

The new ductline between the Makaloa and McCully Substations would be constructed by trenching along sections of Makaloa, Kaheka, Kapiolani, and Pumehana Street. This would require trenching for a total distance of about 3,400 feet versus trenching for about 1,000 feet with the proposed Makaloa-Fern alignment. For the purpose of the traffic assessment, the ductline was assumed to be located within the cross section of each street along the alignment that would result in the least disruption to traffic flow:

- The new ductline would follow the same alignment as the proposed alignment from the Makaloa Substation to the manhole at Kaheka Street.
- From the Kaheka Street manhole, the ductline would extend Koko Head across Kaheka Street and then makai along Kaheka Street to Kapiolani Boulevard in either the parking lane or the traffic lane closest to the Koko Head side curb.
- The ductline would be located under either the mauka curb lane or the adjacent lane along Kapiolani Boulevard from Kaheka Street to Pumehana Street.
- On Pumehana Street, the ductline would be located along the Ewa side of the street.

The location of the ductline is proposed along the mauka side of Kapiolani Boulevard for two traffic-related reasons:

1. With the planned BRT line, Kapiolani Boulevard will have three Ewa-bound lanes, but only two Koko Head-bound lanes between Kaheka Street and Atkinson Drive. Therefore, future closure of a traffic lane to access a ductline manhole for future repair or servicing work would be less disruptive if it is located in the Ewa-bound lanes.

2. The ductline would have to cross Kapiolani Boulevard twice, with the additional traffic impacts, if located along the makai side of the street, as well as cross Atkinson Drive and the higher-volume side of the Kalakaua Avenue intersection.

   The construction process and work area size would be the same as described for the proposed alignment. The work would be done primarily in the daytime with the work hours from 9:00 AM until 3:00 PM. The major phases in the ductline construction and the estimated duration of each are outlined in the following table.

Approximately six new manholes would be constructed along Kapiolani Boulevard, including manholes near the Kaheka Street and Pumehana Street intersections.

In addition to the ductline construction, work would occur at every other manhole along the new line to pull and splice the new transmission line. Approximately one day would be needed at each manhole for cable pulling with the work area one lane wide and 100-150 feet in length. Approximately three days would be needed at each manhole for cable splicing with the work area one lane wide and 50-100 feet in length.

The ductline construction stages for Alternative 1 that would most affect traffic operations, and the schedule and estimated duration for each, would be as follows:

Stage	Work Element	Traffic Provisions	Shift	Duration (Days)
1,2, 3	Construct ductline from Makaloa Substation to manhole at Kaheka St. (Same as proposed alignment)	Restrict parking along both curbs for 600 feet Cone one lane in each direction along makai side of street	Day	12-15
4	Construct ductline across Kaheka St. intersection	Restrict parking along both curbs of Makaloa St. for ½ block on both sides of Kaheka St. Cone traffic lane in each direction along makai side of Makaloa St. Close Kaheka St. with barricade on mauka side of Makaloa St.	Night	2
5	Construct ductline along Koko Head side of Kaheka St. to Kapiolani Blvd.	Restrict parking along the curb from Kaheka St. to Kapiolani Blvd. Cone 2 traffic lanes in each direction along Kaheka St.	Day	3-4

Stage	Work Element	Traffic Provisions	Shift	Duration (Days)
6	Construct ductline along mauka side of Kapiolani Blvd. from Kaheka St. to Kalakaua Ave. intersection	Cone traffic into 2 lanes in each direction	Day	25-28
7	Construct ductline across Kalakaua Ave. intersection	Cone traffic into 2 lanes in each direction along Kapiolani Blvd. Cone traffic into 1 lane in each direction along Kalakaua Ave. Work on one-half of Kalakaua Ave. at a time	Night	2-3
8	Construct ductline along mauka side of Kapiolani Blvd. from Kalakaua Ave. to Pumehana St.	Cone traffic into 2 lanes in each direction along Kapiolani Blvd.	Day	12-14
9	Construct ductline along Ewa side of Pumehana St. from Kapiolani Blvd. to Lime St.	Close Pumehana St. between Kapiolani Blvd. & Lime St. to through traffic	Day	4-5

The entire length of the 3,400-foot long trenchline along Makaloa Street, Kaheka Street, Kapiolani Boulevard, and Pumehana Street would be repaved at nighttime. The repaving would be one-lane in width. Approximately nine nights would be needed to repave the trenchline, with about five nights needed along Kapiolani Boulevard.

4.3.2. Traffic Impacts with Daytime Construction

The traffic impacts during the construction phases along Makaloa Street would be the same as those described for that same phase of the Proposed Project.

Alternative 1 would have significant impacts along Kapiolani Boulevard, as well as Kaheka Street. The ductline construction work area would occupy two traffic lanes, extending for about 900 to 1,000 feet, along this section of Kapiolani Boulevard each weekday for a period of 8 to 9 weeks. The ductline construction would also reduce the traffic lanes along Kaheka Street for 1 week and close the block of Pumehana Street between Kapiolani Boulevard and Lime Street for about 1 week.

This alignment alternative would impact the midday traffic conditions at the signal-controlled Makaloa-Kaheka Streets intersection and the Kapiolani Boulevard intersections at Kaheka Street, Atkinson Drive, and Kalakaua Avenue, as summarized in Table 4-1 for the midday peak traffic hour.

Table 4-1
2007 Midday Peak Hour Traffic Conditions Alternative 1 Without BRT, Makaloa Street Corridor

Intersection	Without EOTP Construction Work			With EOTP Construction Work		
	V/C	ADPV	LOS	V/C	ADPV	LOS
Makaloa St.-Kaheka St.	0.40	20.0	C	0.59	23.1	C
Kapiolani Blvd.-Kaheka St.	0.61	24.5	C	0.92	39.6	C
Kapiolani Blvd.-Atkinson Dr.	0.67	20.4	C	0.80	30.5	C
Kapiolani Blvd.-Kalakaua Ave.	0.85	40.8	D	0.90	46.8	D

V/C = Ratio of the traffic volume to the theoretical capacity of the intersection.
ADPV = Average delay per vehicle, in seconds.
LOS = Level of service.

Wilbur Smith Associates; July 26, 2004.

The reduction of traffic lanes on the makai and Ewa legs of the Makaloa Street intersection with Kaheka Street would worsen conditions at the intersection, but the midday peak hour traffic would amount to a low 59% of intersection capacity, with estimated average delay per vehicle for the entire intersection at an acceptable LOS C. The ductline construction work area and traffic transition zones could affect traffic conditions at this intersection for 2-3 weeks as the work area is shifted along the alignment.

With the reduction of lanes on the mauka leg of Kaheka Street and the Koko Head leg of Kapiolani Boulevard, the 2007 midday peak hour traffic would approximate 92% of capacity versus 61% without the construction impacts. Average delays would increase by about 60% per vehicle but remain within reasonable levels. The ductline construction work area and traffic transition zones would affect traffic conditions at this intersection for 2-3 weeks as the work area is shifted along the alignment.

With the reduction in traffic lanes at the Kapiolani Boulevard intersection with Atkinson Drive, the midday peak hour traffic would approximate 80% of the intersection capacity, versus 67% without the construction work. The analyses indicate reasonable levels of vehicle delay (LOS C) based on the assumptions of optimized signal timing as the construction work proceeds through the intersection. The ductline construction work area and traffic transition zones would affect traffic conditions at this intersection for 2-3 weeks as the work area is shifted along the alignment.

With the reduction in traffic lanes, the midday traffic at the Kalakaua Avenue intersection would amount to 90% of capacity, versus 85% without the construction work. Average traffic delay would increase by about 15%.

During the nighttime repaving of the trenchline, the on-street parking would have to be restricted for one night along the curb lane affected by the excavation for the ductline. This would include the makai curb parking along Makaloa Street between the Substation and Kaheka Street, the parking on Kaheka Street between Makaloa Street and Kapiolani Boulevard, and the parking along the mauka curb of Kapiolani Boulevard from Kaheka Street to Pumehana Street.

During the ductline construction, there would be frequent movement of trucks removing excavated material and delivering construction materials to the work area. These movements could result in frequent disruption to traffic flow in the lanes adjacent to the work area, with these disruptions likely to affect more traffic during daytime construction than during the nighttime.

4.3.3. Impacts on Public Transit with Daytime Construction

There are four TheBus stops located along the mauka curb between Kaheka and Pumehana Streets with these located:

- Koko Head side of Kaheka Street
- Ewa side of Atkinson Drive
- Ewa side of Kalakaua Avenue
- Midway between Hauoli and Pumehana Streets.

Access would be maintained for each of these bus stops. As the construction work area separates each of these stops from the active traffic lane being used by the buses, a pathway would be provided by traffic cones and marked by a sign to a location adjacent to the active traffic lane. The buses would stop at this marked location; the passengers waiting to board may wait at the normal curb location until they see the bus approach and then they would walk to the location where the bus would actually stop.

As the most active portion of the work area around the open trench section approaches each stop location, the bus stop would be relocated along the street to a location where there would be little conflict with the construction activities. Once the active construction work area has shifted past the normal stop location, the bus stop would be returned to the normal location.

4.3.4. Impacts on Pedestrian Circulation with Daytime Construction

Crosswalks are provided at each of the intersections controlled by traffic signals, with the crosswalks used by moderate numbers of pedestrians from the morning commute period through

the early evening hours. The ductline construction work area would cross and disrupt use of one or more crosswalks at each intersection.

At the Kaheka Street intersection, the ductline would block both the mauka crosswalk across Kaheka Street and the crosswalk across the Koko Head-side leg of Kapiolani Boulevard. Persons walking along the sidewalk on the mauka side of Kapiolani Boulevard would have to detour mauka to the Makaloa Street intersection to cross Kaheka Street. Alternatively, they could cross Kapiolani Boulevard and use the makai sidewalk between Kaheka Street and Atkinson Drive.

At Atkinson Drive, the construction work would block the crosswalk across Kapiolani Boulevard which is located on the Ewa side of Atkinson Drive. Since there is no crosswalk on the Koko Head side of the intersection, persons desiring to cross Kapiolani Boulevard would have to cross at either the Kalakaua Avenue or Kaheka Street intersections.

The ductline construction would cross the crosswalks across Kapiolani Boulevard on both the Koko Head and Ewa sides of the Kalakaua Avenue intersection. There is no crosswalk across Kalakaua Avenue on the makai side of the intersection. The closest signal-controlled intersections with crosswalks are at Atkinson Drive or at McCully Street. Persons on the Ewa side would likely use the crosswalk at Atkinson Drive to cross Kapiolani Boulevard. However, the long distance to the McCully Street signal would likely encourage those pedestrians who are trying to cross the Koko Head side of the intersection to jaywalk or cross Kapiolani Boulevard at the un-signalized intersection with Hauoli Street.

4.3.5. Possible Actions to Minimize Impacts for Daytime Construction

The traffic impacts, as well as the pedestrian impacts, at the Kapiolani Boulevard intersection with Kaheka Street could be reduced by constructing the section through this intersection at nighttime.

The pedestrian impacts at the Atkinson Drive and Kalakaua Avenue intersections could be minimized by constructing the ductline through this intersection at nighttime. Nighttime construction would also reduce traffic congestion and delays at the Kalakaua Avenue intersection.

Advance signs should be placed at adjacent intersections warning sidewalk users of the blockage of any crosswalks and guiding them to cross at the adjacent intersections.

Locations of the bus stops could be temporarily relocated outside of the street section affected by the work in the open trench.

The construction project should be coordinated with the Hawaii Convention Center staff to avoid construction work along the Kalakaua Avenue-Atkinson Drive section during any medium- to large-size events at the HCC.

4.3.6. Impacts with Nighttime Construction Option

The lower volumes of traffic, pedestrians, and transit users in the late evening and overnight hours would substantially reduce the impacts as compared to the daytime construction work. Traffic volumes along Kapiolani Boulevard in the evening range from about 1,400 vehicles between 9:00 PM and 10:00 PM, which is less than half of the midday volumes, to 150 vehicles per hour around 3:00 AM.

The evening work would impact parking availability since the parking would be removed from both curbs. The parking is heavily used through the late evening due to the numbers of restaurants, entertainment venues, and other establishments that operate into the evening.

4.4. ALTERNATIVE 1 (KAHEKA-KAPIOLANI) AFTER BRT

Both daytime and nighttime construction was considered in the traffic assessment for the Alternative 1 Kaheka-Kapiolani alignment with daytime construction preferred.

4.4.1. Project Description

The ductline construction would follow the same alignment and use the same work area sizes as used in the pre-BRT assessment.

The BRT lane between Kaheka Street and Atkinson Drive would preclude the coning of two traffic lanes in each direction as proposed for the Pre-BRT construction option. The Ewa-bound traffic direction would be limited to a single lane between Atkinson Drive and Kaheka Street. At the Atkinson Drive intersection, the construction work area would occupy the two regular through lanes and the single Ewa-bound traffic lane would use the striped buffer area at the BRT platform between the bus lane and Ewa-bound traffic lanes, and the left-turn lane from the platform area to the Kaheka Street intersection.

4.4.2. Traffic Impacts with Daytime Construction

The traffic impacts during the construction phases along Makaloa Street would be the same as those described for that same phase of the Proposed Project.

With the BRT project in place, the Kaheka Street Alternative would impact the midday traffic conditions at the Kapiolani Boulevard intersections at Kaheka Street, Atkinson Drive, and Kalakaua Avenue, as summarized in Table 4-2.

The ductline construction would have the most impact on the Kapiolani Boulevard intersection with Kaheka Street, where the midday traffic would exceed the intersection capacity by 7% with the loss of lanes on the mauka and Koko Head legs of the intersection. The average delay per vehicle would increase by over 80 seconds as compared to the delays without the construction

project. These delays and resultant traffic queues could result in diversion of 200 or more vehicles in the midday peak hour to King Street or other parallel routes.

Table 4-2
2007 Midday Peak Hour Traffic Conditions Alternative 1 With BRT, Makaloa Street Corridor

Intersection	Without EOTP Construction Work			With EOTP Construction Work		
	V/C	ADPV	LOS	V/C	ADPV	LOS
Makaloa St.-Kaheka St.	0.40	20.0	B	0.59	23.1	C
Kapiolani Blvd.-Kaheka St.	0.61	24.9	C	1.07	106.0	F
Kapiolani Blvd.-Atkinson Dr.	0.61	26.7	C	0.61	36.7	C
Kapiolani Blvd.-Kalakaua Ave.	0.85	44.7	D	0.90	47.3	D

V/C = Ratio of the traffic volume to the theoretical capacity of the intersection.
ADPV = Average delay per vehicle, in seconds.
LOS = Level of service.

Wilbur Smith Associates; July 26, 2004.

At the Atkinson Drive intersection, the midday traffic volumes would amount to about 61% of capacity without or with the lane loss during the EOTP construction. The critical conflicting movements in the midday peak hour that determine the overall level of intersection capacity use are the Koko Head-bound through traffic and the traffic turning right from Atkinson Drive. The construction project would not reduce capacity for either of these two traffic movements.

The BRT line would have little effect on traffic operations at the intersection of Kapiolani Boulevard with Kalakaua Avenue. Therefore the traffic conditions with the Kaheka-Kapiolani Alternative 1 alignment would be the approximately the same with the BRT as without the BRT (Table 4-1).

4.4.3. Impacts on Public Transit and Pedestrians with Daytime Construction

The impacts identified for the Before-BRT construction option would also occur with BRT in place along Kapiolani Boulevard.

The impacts on pedestrians would likely worsen at the crosswalk on the Ewa side of Atkinson Drive since the BRT platform/stop in the center of the street will be accessed via this crosswalk. This would increase the number of pedestrians affected by the blockage of this crosswalk.

4.4.4. Possible Actions to Minimize Impacts

The construction impacts on pedestrian access to the BRT platform and curb bus stop could be reduced by construction through this area at nighttime. Also, a temporary crosswalk could potentially be provided to access the Ewa end of the platform, although this may not be fully accessible.

The other mitigative actions identified for the Before-BRT scenario would also be appropriate with the BRT in place. Nighttime construction minimize the congestion and delays estimated for the Kapiolani Boulevard intersection with Kaheka Street.

4.4.5. Impacts with Nighttime Construction Option

The impacts with nighttime construction would be similar to those identified with nighttime construction of the Pre-BRT scenario.

4.5. ALTERNATIVE 2 (KALAUOKALANI-KAPIOLANI) BEFORE BRT

Both daytime and nighttime construction was considered in the traffic assessment for the Alternative 2 Kalauokalani-Kapiolani alignment with daytime construction preferred for this alternative.

4.5.1. Project Description

The new ductline between the Makaloa and McCully Substations would be constructed by trenching along sections of Makaloa, Kalauokalani, Kapiolani, and Pumehana Street. This would require trenching for a total distance of about 3,400 feet versus trenching for about 1,000 feet with the proposed Makaloa-Fern alignment. For the purpose of the traffic assessment, the ductline was assumed to be located within the cross section of each street along the alignment that would result in the least disruption to traffic flow.

The alignment alternative would continue the ductline Koko Head of the Poni Street intersection along Makaloa Street for one additional block to Kalauokalani Way. The ductline would extend the length of Kalauokalani Way to Kapiolani Boulevard where it would continue Koko Head along Kapiolani Boulevard and Pumehana Street to the McCully Substation.

The ductline would be extended Koko Head from the Poni Street manhole along the makai side of Makaloa Street. The section along the approximately 700-foot long Kalauokalani Way would be constructed by closure of both traffic lanes in two stages, with the first closing the mauka half of the block and the second the makai half of the block in order to shorten the time each section of the street is closed. Local property access would be maintained during work hours by allowing resident and visitor vehicles to enter the construction area to the extent the driveway is not

blocked by the open trench. At about 3:00 PM, the open trench would be covered with metal plates and the street opened to traffic until 9:00 AM the following weekday.

The section from Kalauokalani Way to the McCully Substation would follow the same alignment and construction procedures as described for that section in the Kaheka Street alternative.

The duration of the ductline construction work along each street is estimated as follows:

Makaloa Street	27-30 days
Kalauokalani Way	12-14
Kapiolani Boulevard	19-21
Pumehana Street	4-5

Approximately two new manholes would be constructed along Kalauokalani Way and three or four along Kapiolani Boulevard. During the pulling of the new transmission cable, a single traffic lane would be blocked at every other manhole for a distance of about 100-150 feet, with the blockage lasting about 1 day each. During the splicing of the cable, a single traffic lane would be blocked at each manhole for a distance of about 50-100 feet for about 3 days each.

The entire length of the 3,400-foot long trenchline along Makaloa Street, Kaheka Street, Kapiolani Boulevard, and Pumehana Street would be repaved at nighttime. The repaving would be one-lane in width. Approximately 11-12 nights would be needed to repave the trenchline, with about 3 nights needed along Kapiolani Boulevard.

4.5.2. Traffic Impacts with Daytime Construction

This alternative would have the same impact upon the Makaloa Street-Kaheka Street intersection as the proposed Makaloa-Fern alignment, and the same impact on the Kapiolani Boulevard-Kalakaua Avenue intersection as the Kaheka-Kapiolani Alternative.

The construction of the ductline across Makaloa Street through the Poni Street intersection would have similar impacts to those discussed for the Amana Street crossing.

The closure of Kalauokalani Way to through traffic should not affect many vehicles since the majority of the traffic along the street is likely traveling to/from properties along the street. Access to driveways would be allowed during the work hours except where prevented by the open trench. The trench area would be covered by metal plates at about 3:00 PM and traffic flow permitted until 9:00 AM the following weekday. During the work hours, through traffic could use Kalakaua Avenue or Kaheka Street as an alternative route.

4.5.3. Impacts on Public Transit With Daytime Construction

This alternative alignment would impact the bus stops along the mauka side of Kapiolani Boulevard on the Ewa side of the Kalakaua Avenue intersection and midway between Hauoli and Pumehana Streets.

The procedure for maintaining access to these two bus stops would be the same as described for the Kaheka-Kapiolani Alternative Alignment.

4.5.4. Impacts on Pedestrian Circulation With Daytime Construction

The construction would impact pedestrian circulation at the Kapiolani Boulevard intersections with Kalakaua Avenue and Pumehana Street the same as for the Kaheka-Kapiolani Alternative Alignment.

In addition, construction work along the Kalauokalani Way section would block the makai crosswalk at the Makaloa Street end and the mauka crosswalk at the Kapiolani Boulevard end.

4.5.5. Possible Actions to Minimize Impacts

The mitigative actions would be similar to those identified for the Kaheka-Kapiolani Alternative Alignment.

The impact on traffic at the Poni Street intersection could be reduced by the construction of the ductline across the intersection during the nighttime.

During the blockage of the Kalauokalani Way crosswalks at Makaloa Street and Kapiolani Boulevard, either a temporary pathway should be provided or advance signing should be provided at the ends of the blocks to direct pedestrians to use alternative routes.

4.5.6. Impacts with Nighttime Construction Option

Construction at nighttime would likely result in fewer impacts due to the lower traffic, transit, and pedestrian volumes that during the midday hours.

4.6. ALTERNATIVE 2 (KALAUOKALANI-KAPIOLANI) AFTER BRT

The impacts and potential mitigative actions would be similar to those for the Before BRT scenario.

Chapter 5
PHASE 1 TRAFFIC IMPACTS IN PUMEHANA STREET AREA

The EOTP would include the construction of a new underground ductline from the McCully Substation to connect to an existing circuit at the intersection of Pumehana and Date Streets. The underground line would extend beneath Lime Street for about 125 feet from the Substation to the Koko Head side of Pumehana Street and along the Koko Head side of Pumehana Street for two blocks (about 600 feet) to the mauka side of Date Street. New manholes would be constructed along the Pumehana Street line in the center of Fern Street and on the northeast corner of the Date Street intersection. An underground connection would also be constructed from the new Date Street manhole to the southeast corner of the intersection.

The ductline would be constructed by excavation of an open trench. As sections of the ductline are constructed, those sections of the trench would be filled so that the section of open trench would not exceed about 50 to 150 feet in length at any given time. With a large efficiently laid out work activity area, the preparation, trenching, construction of the ductline, and covering can progress at an average of about 40 feet per day within the narrow streets of this area. With a more compact and less efficient work area, the construction would likely progress at a much slower rate. The desired work activity area is two lanes wide and about 350 feet in length.

After the ductline has been constructed, crews would establish work areas at every other manhole for pulling and splicing the new transmission line. The work area at each manhole would be one lane wide by about 100 feet in length for pulling of cable and one lane wide by 50 feet long for splicing of the cable.

After the completion of the construction work one lane, or about one-half the street width, of Lime and Pumehana Streets will be repaved for the length of the construction project.

5.1. IMPACTS WITH PROPOSED PROJECT

HECO proposes to construct the line along Pumehana Street by closing the street to through traffic one block at a time to provide an optimum-sized work area to minimize the number of work days needed for the connection.

5.1.1. Project Description

All construction work would be done during the daytime hours, with street closures set to start at 9:00 AM and the street to reopen to traffic by 3:00 PM. During the 9:00 AM -3:00 PM period, local access would be allowed within the block to the extent that individual's driveway is not blocked by the work crew actively working in an open trench at that driveway. The open trench area would be covered by 3:00 PM and the street opened to traffic until 9:00 AM the next weekday morning.

The general phasing and duration of street closures for the construction of the ductline and manholes is anticipated as follows:

Stage	Street Section Closed	Anticipated Duration (Work Days)
1	Close Lime St. from Ewa side of Substation to Pumehana St.	3-4
2	Extend Lime St closure to include Pumehana St. intersection; Pumehana St. will be closed to through traffic	2
3	Close Pumehana St. from mauka side of Lime St. to makai side of Fern St.	6-7
4	Close Pumehana St. from makai side of Fern St. to makai side of Date St., includes new manhole	7
5	Open Fern St. intersection and retain closure from mauka side of Fern St. to makai side of Date St.	6
6	Extend closure to mauka side of Date St., includes new manhole	7
7	Repave Pumehana and Lime Streets one-half width at a time	2-3

The work area for pulling/splicing at the Fern Street manhole would likely extend along the Koko Head side of Pumehana Street and close off the Koko Head leg of Fern Street. The work area for pulling/splicing at the Date Street manhole would likely extend along the Koko Head side of Pumehana Street mauka from the center of Date Street.

The construction work requiring street closure would be scheduled for weekdays, unless special circumstances require work on a weekend. Otherwise the streets would be open to traffic circulation on weekends and holidays, as well as in the evenings.

The repaving work would be done between 9:00 AM and 3:00 PM. On Pumehana Street, the traffic lane would be open as the excavated area and repaving work would generally be located in the parking lane.

5.1.2. Traffic Impacts

Local traffic access would be maintained to/from properties along the closed sections of Pumehana Street and the cross streets during work hours to the extent the driveways are not blocked by the work in the open trench on the Koko Head side of the street. Local vehicles would be permitted to drive within the closed block to access or depart from the properties along that block. Vehicles would be allowed to exit from the Lunalilo Elementary School parking lot onto Pumehana Street during the construction. At about 3:00 PM, the open trench would be covered with metal plates and the street opened to traffic until 9:00 AM the next weekday.

The street closure during the construction of the ductline would affect through traffic along Pumehana Street, as well as along Lime, Fern, and Date Streets as each of that street's intersections with Pumehana Street is blocked by the construction work. The closure between 9:00 AM and 3:00 PM will affect about 35% to 40% of the daily traffic volume on each street. The estimated closures for ductline construction are as follows:

Street	Work Phases	Estimated Volume 9 AM-3 PM	Estimated Weekdays Closed to Thru Traffic
Pumehana	2-6	1,200	33-35
Lime	1,2	500	6-7
Fern	4	500	7
Date	6	800	7

Through traffic would be restricted along Pumehana Street for about 7 weeks of the construction period. Through traffic along each of the cross streets would be restricted for approximately 1½ weeks.

The Pumehana Street traffic would likely have to use McCully Street instead of Pumehana Street to bypass the portion of the street that is closed. This may increase left turns from mauka-bound McCully Street at the Date and Citron Street intersections. Some traffic may access Fern or Phillip Streets from Kalakaua Avenue.

The street closures could create a one-way dead end for the block of Pumehana Street makai of the closed section and the block of Fern Street Ewa of the closure. This "dead end" would affect the residences along these blocks as well as any traffic exiting the McCully Shopping Center to travel mauka on Pumehana Street.

The construction would also restrict the parking along each block of Pumehana Street during the daytime work hours as the ductline is installed along that block, or about one to two weeks for each block.

During the repaving work, both local and through traffic would be allowed to use Lime and Pumehana Streets. However, equipment maneuvering and positioning may frequently block the traffic lane for short periods. On-street parking would be restricted during the one day needed to repave the streets.

5.1.3. Pedestrian Impacts

The ductline would block the crosswalks at three intersections along Pumehana Street as the construction occurs on that segment. This could affect the routes of children walking to/from Lunalilo Elementary School.

5.1.4. Possible Actions to Minimize Impacts

During the initial Stages 1 and 2 closure of Lime Street, signs should be placed at the Lime Street intersections with McCully Street and Hauoli Street to warn drivers that Lime Street is closed to through traffic.

During the Stage 2 work within the Lime Street-Pumehana Street intersection, one or a combination of the following actions should be implemented to avoid the one-way street dead end, especially as it may affect the traffic exiting the McCully Shopping Center:

1. Place the barricades for the work area so as to allow a right turn from mauka-bound Pumehana Street onto the Koko Head leg of Lime Street to avoid a one-way dead end.

2. Place signs to allow two-way traffic on the block of Pumehana Street makai of the closure to allow the Shopping Center and resident traffic to exit onto Kapiolani Boulevard. A Traffic Control Officer (TCO) should be stationed at the intersection with Kapiolani Boulevard with this option.

3. Close the McCully Shopping Center exit onto Pumehana Street.

The placement of a manhole in the center of Fern Street along the new ductline during the Stage 4 ductline work would require 2-3 days closure of traffic along Fern Street. One or both of the following modifications could be used to lessen the traffic impacts:

1. Excavate and/or place and backfill the manhole at nighttime

2. Reconfigure the work area to use Fern Street and the parking lane on Pumehana Street without blocking the traffic lane on Pumehana Street.

The new manhole to be constructed at Date Street is positioned on the mauka side of the intersection, with the new ductline crossing Date Street twice. To minimize the traffic disruption, one or a combination of the following actions should be considered:

1. Excavate and/or place and backfill the manhole at nighttime

2. Reconfigure the work area to use one-half of Date Street and the parking lane on Pumehana Street without blocking the traffic lane on Pumehana Street.. A 12-foot wide traffic lane could be kept open along Date Street with use of a flagman operation to allow traffic flow in both directions.

As the construction work area shifts mauka along Pumehana Street, any "dead end" blocks should be temporarily signed for two-way traffic during the work hours, and a traffic control officer used to monitor traffic.

To the extent possible, the construction work should be staged and work area reconfigured to avoid closing both the mauka and makai crosswalks across Pumehana Street at an intersection at the same time. If both crosswalks at an intersection are closed at the same time, a school crossing guard should be posted at that intersection to direct school children to the alternative crossing locations.

The construction work along Lime and Pumehana Streets could be scheduled in the summer months when the Lunalilo Elementary School is not in session to reduce impacts on School traffic and parking. Overall traffic, parking, and pedestrian use should also be lower along Pumehana Street when the School is not in session, thus reducing the impacts of the construction work.

If the construction work is done when the Lunalilo Elementary School is not in session, the School parking lot at the corner of Pumehana and Fern Streets could potentially be used by residents while the on-street parking is restricted by the ductline construction along Pumehana Street.

5.2. IMPACTS WITH SINGLE-LANE OPTION

This option would keep a travel lane open along Pumehana Street by restricting the work zone to a width of about 12 feet.

5.2.1. Description of Option

The option would require the trenching activity to be carried out with the excavating equipment and the dump trucks positioned in a line rather than side-by-side. This would slow down the excavation work. Placement of the ductline and the covering of the ductline would mostly be done with a 12-foot wide work zone.

Certain tasks would still require the closure of the traffic lane for short periods as the lane is blocked by trucks or equipment during the unloading and positioning of material, as well as the maneuvering of trucks and equipment into the single lane work zone.

The inefficiencies would be expected to reduce the productivity to average 10 to 20 feet of ductline installation per day.

5.2.2. Traffic Impacts

This option would keep Pumehana Street open to through traffic for most of the time, with the traffic subject to frequent short delays as material and equipment is moved into position in the single-lane work zone. This approach would lengthen the period required for the construction work, including the length of time that the cross streets would be blocked by construction. Pumehana Street would still be closed to through traffic during the construction of the ductline across the intersection with Lime Street.

The estimated time for closure of the streets with this option would be as follows:

Street	Work Stages	Estimated Volume 9 AM-3 PM	Number of Days Closed to Through Traffic
Pumehana	2-6	1,200	6
Lime	1, 2	500	5-6
Fern	4	500	9-10
Date	6	800	9-10

With this approach, through traffic would be restricted along Pumehana Street for only about 6 days of the construction period. Through traffic along each of the cross streets would be restricted for approximately 1½ to 2½ weeks. However, the duration of the ductline construction (excavation, placement, and covering) along Pumehana Street would increase to about 10 to 11 weeks versus 7 weeks with street closure to through traffic.

This construction option would restrict the parking along all three blocks of Pumehana Street work area during the daytime work hours for the entire duration of the ductline installation, or about eight to nine weeks.

5.2.3. Possible Actions to Minimize Impacts

During the initial Stages 1 and 2 closure of Lime Street, signs should be placed at the Lime Street intersections with McCully Street and Hauoli Street to warn drivers that Lime Street is closed to through traffic.

To the extent possible, the construction work should be staged and work area reconfigured to avoid closing both the mauka and makai crosswalks across Pumehana Street at an intersection at the same time. If both crosswalks at an intersection are closed at the same time, a school crossing guard should be posted at that intersection to direct school children to the alternative crossing locations.

The construction work along Lime and Pumehana Streets could be scheduled in the summer months when the Lunalilo Elementary School is not in session to reduce impacts on School traffic and parking. Overall traffic, parking, and pedestrian use should also be lower along Pumehana Street when the School is not in session, thus reducing the impacts of the construction work.

If the construction work is done when the Lunalilo Elementary School is not in session, the School parking lot at the corner of Pumehana and Fern Streets could potentially be used by residents while the on-street parking is restricted by the ductline construction along Pumehana Street.

Chapter 6
PHASE 1 TRAFFIC IMPACTS IN DATE STREET AREA

The EOTP would include the construction of a new underground ductline from the Kamoku Substation on the makai side of Date Street to a new manhole within the Date Street traffic lane near the mauka curb, and the construction of a new ductline along Date Street for a distance of about 330 feet. A second manhole would be constructed near the Koko Head end of the new ductline.

The ductline would be constructed by excavation of an open trench. As sections of the ductline are constructed, those sections of the trench would be filled so that the section of open trench would not exceed about 50 to 150 feet in length at any given time. With a large efficiently laid out work activity area, the preparation, trenching, construction, and covering of the ductline can progress at an average of up to about 60 feet per day with an efficiently-sized work area. The desired work activity area is two lanes wide and about 350 feet in length. With a more compact and less efficient work area, the construction would likely progress at a slower rate.

After the ductline has been constructed, crews would establish work areas at each of the manhole locations for pulling and splicing the new transmission line. The work area at each manhole would be one lane wide by about 100-150 feet in length for pulling of the cable and one lane wide by 50-100 feet long for splicing of the cable.

After the completion of the construction work, the mauka lane on Date Street would be repaved for the length of the construction project and the trenchline across Date Street would be repaved to a 12-foot width.

6.1. IMPACTS WITH PROPOSED PROJECT

HECO proposes to construct the ductline and manholes along Date Street during the daytime hours since the work site is surrounded by a residential area.

6.1.1. Project Description

The new ductline from the Kamoku Substation would cross Date Street about midway between the Kapiolani Boulevard intersection and the intersection with the Ewa end of the Laau Street loop roadway. A new manhole would be constructed in the mauka curb lane opposite the Substation. The new ductline along Date Street would extend along the lane closest to the mauka curb for a distance of about 50 feet Ewa of the manhole to tie to an existing utility riser pole, and a distance of about 280 feet Koko Head of the manhole to tie to a utility riser pole. A second new manhole would be located along the ductline about 50 feet Koko Head of the Laau Street intersection.

All construction work would be done during the daytime hours, with street closures set to start at 9:00 AM and end by 3:00 PM. During the 9:00 AM-3:00 PM period, local access would be allowed to driveways along the mauka side to the extent that individual's driveway is not blocked by the work crew actively working in an open trench at that driveway. At about 3:00 PM, the open trench area would be covered and the street opened to traffic until 9:00 AM the next weekday morning.

The general phasing and duration of street closures for the construction of the ductline and manholes is anticipated as follows:

Stage	Work Element	Traffic Provisions	Shift	Duration (Days)
1	Block makai two lanes to construct ductline from Substation to centerline of Date St.	Restrict parking both curbs for 700 feet centered on work area Cone one lane in each direction along mauka half of street	Day	1-2
2	Block mauka two lanes to construct ductline from centerline to new manhole on mauka curb lane	Restrict parking both curbs for 700 feet centered on work area Cone one lane in each direction along makai half of street	Day	3-5
3	Block mauka two lanes to construct ductline along mauka curb lane from manhole to pole 50 feet Ewa of manhole	Restrict parking both curbs for 700 feet centered on work area Cone one lane in each direction along makai half of street	Day	1
4	Block mauka two lanes to construct ductline along mauka curb lane from manhole to pole 280 feet Koko Head of manhole, including new manhole near Koko Head end	Restrict parking both curbs for 700 feet centered on work area Cone one lane in each direction along makai half of street	Day	7-8
5	Block mauka lane to pull cable at both new manholes	Restrict any parking and cone work area along mauka curb for a 350-foot long work area including both manholes	Day	2
6	Block mauka lane to splice cable at both new manholes	Restrict parking and cone work area along mauka curb for 350-foot long work area including both manholes	Day	6
7	Block one-half of street at a time to repave Date Street the ductline construction area	Restrict parking both curbs for length of work area and transition Cone one lane in each direction along half of street not being paved	Day	1-2

Preliminary surveying and utility location work would also require the set up of work areas that could also affect traffic and parking. Most of these work areas would typically be small in size and would be in place for several hours. Some larger work areas, requiring closure of one or two lanes during the midday work hours, could be needed to excavate down to underground utilities that would be crossed by the ductline. These work areas would be used to construct concrete collars to provide support to the utility line that is being crossed by the ductline. However, the number and location of these excavations would not be known until the beginning of the design and field work.

There would also be delivery of large equipment for installation within the Kamoku Substation, with the large size requiring that the equipment be off-loaded from the truck within the makai curb lane of Date Street adjacent to the station. The delivery of equipment could occur on three to five work days.

The construction work requiring street closure would be scheduled for weekdays, unless special circumstances require work on a weekend. Otherwise the street lanes would be open to normal parking and traffic circulation on weekends and holidays, as well as in the evenings.

6.1.2. Traffic Impacts

Local traffic access would be maintained to/from properties along the section of Date Street to the extent feasible without disrupting traffic flow along Date Street. Local vehicles would be permitted to access or depart from the properties by crossing the lane transition zone on either end of the work activity area and to cross those portions of the work activity area not blocked by the open trench area and related active work area. Of the approximately 700-foot long work activity area and lane transition zone, property access would be blocked on the mauka side of Date Street for about 150-200 feet in length around the trench area.

The traffic management plan would provide one lane of traffic flow in each direction during the 9:00 AM to 3:00 PM work hours each weekday throughout the ductline construction period. Any open trench section would be covered and the normal traffic lanes provided during the peak commute hours as well as evenings and weekends. During the cable pulling and splicing work, three lanes would be available for traffic use during the midday hours, with all lanes available in the peak commute hours and during evenings and weekends.

During the midday work period, the traffic volumes would approximate 400 to 500 vehicles per hour in each direction through about 2:00 PM. The traffic volumes increase to about 600 to 700 vehicles in each direction in the 2:00-3:00 PM hour due in part to school traffic. A single unrestricted traffic lane in each direction should accommodate these volume levels with minimal delay. Any potential traffic delays would likely result from one of two sources:

1. Vehicles stopped to turn left into the cross streets and driveways blocking the single traffic lane in each direction through the construction work area and lane transition area; or

2. The proximity of the lane reduction to the Kapiolani Boulevard intersection resulting in less efficient traffic operations at that signal-controlled intersection and longer delays at the signal for the Ewa-bound traffic on Date Street.

The locations where left-turn vehicles could block the single through lane include the Ewa intersection of the Laau Street loop, Mahiai Street, and the driveways for the major condominiums and apartment buildings along this section.

At its closest, the work area would be located about 200 feet from the stop bar for the Kapiolani Boulevard intersection and over 100 feet from the entry to the right-turn lane. This would permit two stacking lanes for use by about eight or more vehicles (four per lane) between the stop bar and where the lane reduction ends, or about one-half of the waiting queues typical for the midday period. Other vehicles would be queued in single file within the lane transition and work area sections. This could result in less efficient use of the signal green time for the Date Street approach and increase traffic delays

The blockage of the two traffic lanes would occur for about 13 to 18 work days, while the blocking of a single traffic lanes would occur on about 8 work days.

During the ductline construction, there would be frequent movement of trucks removing excavated material and delivering construction materials to the work area. These movements could result in frequent disruption to traffic flow in the lanes adjacent to the work area.

Approximately 6,000 vehicles would pass through the section of Date Street with the EOTP work area during the midday work hours each work day, or about 30% of the daily traffic.

The parking restriction during the construction of the Koko Head end of the ductline would extend along both curbs of Date Street for a distance of up to about 300 feet Koko Head from the Ewa intersection with the Laau Street loop. A portion or all of this parking would be restricted between 9 AM and 3 PM for about four to six work days.

6.1.3. Impacts on Public Transit Routes and Stops

The bus stop for the Koko Head-direction buses, located just Ewa of the Laau Street intersection would be affected by the initial closure of the makai-side lanes for construction of the ductline across Date Street. The bus stop would be located near the end of the section enclosed for the work activity area, but would be about 100 feet from the trench and active work area. Thus the traffic lane would be separated from the curbside bus stop for about two work days. The bus stop would be relocated next to the active traffic lane and marked by a sign. Buses would continue to stop at this location and a pathway would be marked from the curb area stop to the edge of the work area. Passengers would likely wait at the normal curb location until they see the bus approach and then they would walk to the location adjacent to the active traffic lane where they would board the bus.

The bus stop for the Ewa direction buses is located near the Kapiolani Boulevard intersection and would not be blocked by the construction.

6.1.4. Impacts on Pedestrian Circulation

The construction of the new ductline from the Substation across Date Street would involve trenching across the sidewalk along the makai side of Date Street. A temporary detour would be provided around the excavation area to maintain pedestrian circulation.

The construction of the ductline along the mauka curb lane would block the pedestrian crossing of Date Street located on the Koko Head side of the intersection with the Ewa end of Laau Street.

6.1.5. Possible Actions to Minimize Impacts

The periodic blockage of the single traffic lane in each direction along Date Street by vehicles waiting to turn left could be minimized by one or more of the following actions during the ductline construction phases:

- The left turns from the single Koko Head-bound travel direction lane could be temporarily restricted during the construction hours. Vehicles desiring to turn left into the driveways on the mauka side of the street would travel mauka on Kapiolani Boulevard and turn onto Mahiai Place/Street and use Mahiai Street to travel to Date Street. The vehicles would turn right onto Date Street and then right into the driveway at their destination.

- Left turns could be restricted into the Ewa end of Laau Street and all driveways along the makai side of the lane-reduction section of Date Street. Drivers would have to modify their routes to approach from the Ewa side to turn right into these driveways.

The impact on traffic operations on the Date Street approach to the Kapiolani Boulevard intersection could be minimized by one or more of the following actions:

- At all times the work activity area closed off to traffic should be configured and positioned to remain as far as feasible from the Kapiolani Boulevard to maximize the length of street with two storage lanes available for the Ewa-direction traffic waiting at the intersection.

- No row of traffic cones should be provided on the mauka side of the Ewa-direction traffic lane at the Ewa end of the work area for use in transitioning traffic back into the normal lanes. This would allow traffic to use the entire distance between the work activity area and intersection for stacking in both of the Ewa-bound traffic lanes.

The delivery and unloading of switching equipment within the makai lane of Date Street should be scheduled outside the peak traffic hours. In particular, the makai curb lane should be clear to accommodate the pick-up of peak Koko Head direction traffic around 3:00 PM.

During the construction of the ductline, a pedestrian crossing of Date Street should be maintained at the intersection with the Ewa end of Laau Street. The work should be staged so that a temporary crossing location could be provided on the Ewa side of the intersection when the crossing of the Koko Head side is blocked by the construction.

During the work days when only a single lane is blocked for pulling and splicing the cable, the additional (third) traffic lane could be used as follows:

1. Second Koko Head-bound lane – This option would require the least change from the normal lanes and minimize the temporary lane shifts. However, it would have the most adverse effects on traffic operations at the Kapiolani Boulevard intersection.

2. Second Ewa-bound lane – This would benefit traffic operations at the Kapiolani Boulevard intersection. It may also be less disruptive to restrict traffic from turning left into the mauka-side driveways from the single Koko Head-bound lane and reroute this traffic via to Mahiai Street to turn right into these driveways.

3. Center two-way left-turn lane – This would allow direct left-turns in each direction without delay to through traffic. However, it would be difficult to clearly communicate the use of the lane to drivers to ensure safe traffic use, and it may not alleviate any stacking problems at the Kapiolani Boulevard intersection.

Option #2 would likely have the most beneficial effects on area traffic circulation.

Chapter 7
PHASE 1 TRAFFIC IMPACTS IN WINAM AVENUE AREA

The EOTP would include the construction of a new underground ductline for a distance of 420 feet along Mooheau Avenue and Winam Avenue near the intersection of these two streets. The ductline would extend from an existing utility pole located along Mooheau Avenue for a distance of 100 feet makai along Mooheau Avenue to the Winam Avenue intersection and then for a distance of about 320 feet in the Koko Head direction along Winam Avenue to tie to an existing utility riser pole. A new manhole would be constructed along the Mooheau Avenue section of the line and at the Winam Avenue end of the new underground ductline.

The ductline would be constructed by excavation of an open trench. As sections of the ductline are constructed, those sections of the trench would be filled so that the section of open trench would not exceed about 50 to 150 feet in length at any given time. With a large efficiently laid out work activity area, the preparation, trenching, construction, and covering of the ductline can progress at an average of about 40 feet per day within the narrow streets of this area. With a more compact and less efficient work area, the construction would likely progress at a rate of 10 to 20 feet per day. The desired work activity area is two lanes wide and about 350 feet in length.

7.1. IMPACTS WITH PROPOSED OPTION

The new ductline would begin at a utility pole located along the Koko Head side of Mooheau Avenue about 100 feet mauka of Winam Avenue and extend makai along the Koko Head edge of the roadway to the Winam Avenue intersection. The new ductline would extend along the mauka edge of Winam Avenue to end at a utility pole about 80 feet on the Koko Head side of Hoolulu Street. The new manholes would be located within Mooheau Avenue approximately 25 feet mauka of Winam Avenue and at the Koko Head end of the line along Winam Avenue.

7.1.1. Project Description

HECO proposes to construct the ductline along this narrow section of Winam Avenue by closing the street to through traffic to provide an optimum-sized work area to minimize the number of work days needed for the connection. HECO plans to maintain local traffic access to/from properties along the closed section of Winam Avenue. Local vehicles would be permitted to drive within the closed block(s) to access or depart from the properties along that block(s).

For the ductline construction along Mooheau Avenue, the work area would include the mauka-bound traffic lane and the adjacent Koko Head-side sidewalk area of the road, with the work area extending onto Winam Avenue for positioning of equipment and materials. During the ductline construction along Mooheau Avenue, one lane of traffic would be maintained adjacent to the construction work area. A flagman operation would be used to alternate the direction of traffic flow through the single-lane section.

After the ductline has been constructed, crews would establish work areas at each of the manholes for pulling and splicing the new transmission cable. The work area at each manhole would be one lane wide by about 100-150 feet in length for pulling of cable and one lane wide by 50-100 feet long for splicing of the cable.

After the completion of the construction work, a one-lane width of Winam and Mooheau Avenues would be repaved for the length of the construction project.

The general phasing and duration of street closures for the construction of the ductline and manholes is anticipated as follows:

Stage	Work Element	Traffic Provisions	Shift	Duration (Days)
1	Construct ductline and manhole along Mooheau Ave.	Close 200-foot section of mauka-bound lane of Mooheau Ave. Provide flagman operation to alternate traffic flow direction in the open makai-bound lane	Day	6-7
2	Construct ductline from Mooheau Ave. onto Winam Ave.	Close mauka-bound lane of Mooheau Ave. Provide flagman operation to alternate traffic flow direction in the open makai-bound lane Close Winam Ave. between Mooheau Ave. and Hoolulu St.	Day	2
3	Construct ductline along Winam Ave. between Mooheau Ave. & Hoolulu St.	Close Winam Ave. between Mooheau Ave. and Hoolulu St.	Day	4-5
4	Construct ductline across Hoolulu St. to end with new manhole	Close Winam Ave. between Mooheau Ave. and Martha St.	Day	4-5
5	Block mauka-bound lane on Mooheau Ave. and Ewa-bound lane on Winam Ave. to pull & splice cable at both new manholes	Provide flagman operation to alternate traffic flow direction in the single open lane past each of the two manholes	Day	4
6	Block one-half of street at a time to repave Mooheau and Winam Avenues the length of the construction area	Provide flagman operation to alternate traffic flow direction in the single open lane	Day	1

All construction work would be done during the daytime hours, with street closures set to start at 9:00 AM and extend until 3:00 PM. During the 9:00 AM-3:00 PM period, local access would be

allowed to driveways to the extent that individual's driveway is not blocked by the work crew actively working in an open trench at that driveway. The open trench area would be covered by 3:00 PM and the street opened to traffic until 9:00 AM the next weekday morning.

The construction work requiring street closure would be scheduled for weekdays, unless special circumstances require work on a weekend. Otherwise the street lanes would be open to normal parking and traffic circulation on weekends and holidays, as well as in the evenings.

7.1.2. Traffic Impacts

The single-lane/flagman traffic operation along Mooheau Avenue would last for about 8 to 9 work days during the ductline construction, 4 work days during the pulling and splicing of the cable, and 1 day during the repaving of Mooheau Avenue. The traffic volumes along this section of Mooheau Avenue during the midday work hours would range between about 300 and 550 vehicles per hour. Although virtually all of these vehicles would have to stop for the flag operation, the midday traffic levels should be accommodated by a single-lane flagman operation for this short distance with delays of no more than two minutes. Approximately 2,800 vehicles a day, or about 33% of the daily traffic, would be affected by the flagman operation.

The street closure along Winam Avenue would extend for about 12 to 13 days during the ductline construction. The closure to through traffic would affect most of the estimated 1,400 vehicles per day that travel this section during the midday construction hours. Most of these vehicles would likely use either 6th Avenue or Campbell Avenue to bypass the closed section of Winam Avenue, which would result in increases to traffic flow on these streets.

The closure of one lane and use of a flagman operation along Winam Avenue would occur for about 4 days during the pulling and splicing of the cable. There should be only short delay, if any, to the approximately 180 to 290 vehicles traveling along this section of Winam Avenue during each midday hour.

The construction work would also restrict the on-street parking along these work areas during the midday hours.

7.1.3. Impacts on Public Transit Routes and Stops

The traffic lane-shift section at the mauka end of the single-lane/flagman operation on Mooheau Avenue may extend beyond the bus stop across from Paliuli Street and affect Koko Head-bound bus access to that stop.

The single-lane/flagman operation along Mooheau Avenue would also result in short delays to buses and bus passengers in both directions during each trip through the construction area.

7.1.4. Impacts on Pedestrian Circulation

The use of the Koko Head side shoulder area of Mooheau Avenue as part of the work area would block pedestrian use of this section. Pedestrians would have to cross to the Ewa side of the roadway to pass by the work area.

Sidewalks are present along the front of some properties along Winam Avenue, while others have no provision for pedestrians. Some pedestrians currently walk within the traffic lanes. During the construction work, pedestrians would be restricted from walking within the traffic lanes.

7.1.5. Possible Actions to Minimize Impacts

The ductline and manhole construction along Mooheau Avenue could be done at nighttime to reduce the number of vehicles delayed by the flagman operation, as well as reduce impacts to bus users and pedestrians.

The impacts to through traffic along Winam Avenue could be reduced with the use of the single-lane option along Winam Street (Section 7.2).

The work area should be configured so as to not block the Hoolulu Street intersection except when required by the actual trenching and ductline construction within the intersection with Winam Avenue. This would minimize disruption to traffic flow along Hoolulu Street.

Advance detour signs should be placed on the Ewa-bound Winam Avenue approach to Martha Street to indicate that street as a possible detour route for Ewa-direction traffic along Winam Avenue that wants to turn makai on Kapahulu Avenue. Martha Street intersects with Campbell Avenue on the Koko Head side of Kapahulu Avenue and traffic using Martha Street would be able to turn onto Kapahulu Avenue at the signal-controlled Campbell Avenue intersection.

If feasible, the work area, traffic transition zone, and the flagman operation should be located to avoid impacting the bus stop location opposite Paliuli Street. If the traffic transition zone does affect access to the bus stop, the bus stop could be temporarily relocated mauka of the transition zone.

7.2. IMPACTS WITH SINGLE LANE OPTION

This option would keep a travel lane open along Winam Avenue by restricting the work zone to a width of about 9 to 10 feet.

7.2.1. Description of Option

The option would require the trenching activity to be carried out with the excavating equipment and the dump trucks positioned in a line rather than side-by-side. This would slow down the

excavation work. Most of the placement of the ductline and the covering of the ductline would have to be done within an 8 to 10-foot wide work zone.

Certain tasks would still require the closure of the traffic lane for short periods as the lane is blocked by trucks or equipment during the unloading and positioning of material, as well as the maneuvering of trucks and equipment into the single lane work zone.

The inefficiencies would be expected to reduce the productivity to average 10 to 20 feet of ductline installation per day.

Through traffic would be maintained in a single traffic lane with use of a flagman operation to alternate the direction of traffic flow.

7.2.2. Traffic Impacts

This option would keep Winam Avenue open to through traffic for most of the time, with the traffic subject to frequent short delays as material and equipment is moved into position in the single-lane work zone. The traffic using the street would experience short delays as a result of the flagman operation and alternating flow direction

This approach would lengthen the period required for the construction work, with the ductline construction work estimated to require between 20 and 40 work days with blockage of only a single lane along Winam Avenue, versus 12 to 13 days with street closure.

Chapter 8
PHASE 2 TRAFFIC IMPACTS IN KING STREET CORRIDOR

The EOTP includes the construction of a ductline along King Street to increase transmission capacity between the Archer Substation, located along Cooke Street, and the McCully area. The proposed Phase 2 work would use the open trench construction method to construct the new ductline from the Archer Substation along Cooke Street to King Street (420 feet), along King Street for a distance of about 9,100 feet to McCully Street, and mauka on McCully Street for a distance of about 460 feet to connect to a utility riser pole. The Phase 2 work would also include two ductlines across King Street to connect to utility poles in the vicinity of Hauoli Street. New manholes would be constructed about 500 feet apart along the new ductline.

Nighttime construction is proposed for the Phase 2 ductline construction work and repaving of the streets. Cable installation could be done in daytime or nighttime. Daytime construction is considered as an option for the proposed trenching method for ductline construction.

Horizontal directional drilling (HDD) was considered as an option for constructing a section of the new ductline along King Street. HDD would be limited to the section between Cooke Street and Washington Middle School due to the requirements for large work support areas at each end of the drilled section. With the HDD option, about 1,800 feet of the King Street ductline between Washington Middle School and McCully Street, and the Cooke and McCully Street segments of the new ductline would be constructed by the conventional trenching method.

The construction of the Proposed Project could begin in late 2007 and end in early 2009. Most of the construction work would likely occur in 2008 and early 2009.

8.1. CITY BRT PROJECT

The UH-Manoa BRT line is planned to extend along King Street from Downtown Honolulu to Pensacola Street with the line extending makai along Pensacola Street. This BRT line could be constructed either prior to or after the EOTP Phase 2 construction work. The BRT, if in place by late 2007, could affect the construction of the section of the EOTP Phase 2 line along King Street between Cooke Street and Pensacola Street. Accordingly, the assessment of the EOTP impacts has considered the following scenarios:

Proposed EOTP open trench construction before the BRT project

Proposed EOTP open trench construction after the BRT project

EOTP HDD Option before the BRT project

EOTP HDD Option after the BRT project

The post-BRT assessments focus on the transportation conditions along the Cooke-Pensacola Streets section of King Street that would be directly affected by the BRT line.

8.2. PROPOSED NIGHTTIME TRENCHING OPTION BEFORE BRT SCENARIO

Nighttime construction is proposed for the King Street ductline line. Nighttime construction would allow a longer work shift and more productive use of the work hours. Nighttime work would also be expected to result in fewer impacts on most area businesses and would occur in hours with lower levels of traffic, transit and pedestrian activity in most areas.

8.2.1. Project Description

The initial weeks of work would include survey work, location of underground utilities, and the reinforcing of underground utilities that would cross the planned ductline. The preliminary surveying and utility location work would set up work areas that would typically be small in size and would be in place for several hours. Some larger work areas, requiring closure of one or two lanes during the midday work hours, could be needed to excavate down to underground utilities that would be crossed by the ductline. These work areas would be used to construct concrete collars to provide support to the utility line that is being crossed by the ductline. However, the number and location of these excavations would not be known until the beginning of the design and field work.

The ductline would be constructed by excavation of an open trench. As sections of the ductline are constructed, those sections of the trench would be filled so that the section of open trench would not exceed about 50 to 150 feet in length at any given time. With a large efficiently laid out work activity area, the preparation, trenching, construction, and covering of the ductline can progress at an average of about 60 feet per day. The desired work activity area is two lanes wide and about 300 feet in length. Where a more compact or less efficiently-shaped work area is required, the construction would progress at a slower rate. For nighttime construction, the slower rates would primarily occur at the two lines crossing the King Street lanes to tie to mauka-side riser poles near Hauoli Street, and for the crossing through the McCully Street intersection. At these locations, the construction is likely to cross only one lane per night due to the inefficient configuration of the work area during these crossings. The other intersections would be crossed in two nights, one half of the cross street each night.

After the ductline has been constructed, crews would establish work areas at every other manhole for pulling and splicing the new cable. The work area at each manhole would be one lane wide by about 100 feet in length for pulling of cable and one lane wide by 50 feet long for splicing of the cable.

The width of one traffic lane would be repaved along the length of the ductline construction. At major cross street intersections, one-half of the cross-street width would be paved at a time to maintain traffic flow on the cross street.

The ductline construction and paving work would be done during nighttime work shifts, with the work occurring between 8:00 PM and 5:00 AM. The cable pulling and splicing could be done either during daytime or nighttime; for this assessment these tasks are assumed to be done during the nighttime.

Cooke Street Ductline – Along Cooke Street, the new ductline would be located adjacent to the Koko Head side curb, with most of the length under the present parking lane. The entire length of the Cooke Street ductline would be used as the work area during the trenching work along the street. Traffic could be controlled through one of the following approaches during the ductline construction:

1. Close this section of Cooke Street to through traffic. Local traffic access to/from the properties along the block would be accommodated to the extent the driveway is not blocked by the section of open trench.

2. Use the parking lane and the normal mauka-bound lane as the work area. Traffic flow would be allowed in the normal makai-bound lane, with traffic flow allowed to alternate between makai- and mauka-bound directions by use of a flagman operation.

3. Use the parking lane and the normal mauka-bound lane as the work area. Traffic flow would be allowed in the normal makai-bound lane, with flow in the makai-bound direction.

4. Use the parking lane and the normal mauka-bound lane as the work area. Traffic flow would be allowed in the normal makai-bound lane, with flow in the mauka-bound direction.

With the relatively low traffic volumes at night, the closure of this block of Cooke Street would be the preferred option for the ductline construction, as well as the repaving of the street.

Only one manhole is planned along Cooke Street, approximately 25 feet makai of King Street. For the pulling and splicing of the cable, the curb parking lane area would be used as the work area with normal traffic flow allowed in both of the striped lanes.

King Street Ductline – Present plans are to locate the ductline about 20 feet from the makai curb for most of the length from Cooke to McCully Street. This would place it in the second traffic lane from the makai curb. The trenching work area would use this second lane and the third lane from the makai curb as the protected work area. In addition to the 300-foot long work area, there would be a transition section upstream of the work area to shift vehicles out of the blocked lanes. The transition section would be 150 to 300 feet in length and would be defined by traffic cones and signing to direct traffic out of the two blocked lanes. Parking would be restricted along the makai curb lane so it would be open for use by public transit buses and to provide access into/out of driveways along the makai side of the street, as well as traffic turning right at cross streets (i.e. all right turns would be made from the curb lane. Traffic passing by the work area would also have the option of using the curb lane.

There would be a 300-foot long section across Piikoi Street to Alder Street where the line is planned "jog" into the third lane from the curb, but remain within the two-lane wide work area. A similar 100-foot long jog section is planned at the Punahou Street intersection.

Two feeder ductlines are planned to connect the main lateral ductline to utility riser poles on the mauka sidewalk area. One is located at the Hauoli Street intersection and the second is located 125 feet Ewa of Hauoli Street near the Times Supermarket driveway. The construction of these two lines would begin after the main ductline construction has been completed and the lateral work area removed from along King Street. The construction of these lines across the King Street lanes would begin at the mauka curb and would close two lanes at a time until the work reaches the main ductline in the second lane from the makai curb. Each of these two lines would be constructed sequentially.

At McCully Street, the line is planned to diagonally cross the King Street traffic lanes at the intersection to reach the Koko Head curb on the mauka side of King Street. The work area for the line would close two King Street lanes at a time. McCully Street would be coned to provide one traffic lane in each direction with both lanes initially on the Koko Head side of the street, and then shifted to the Ewa side of the street as the construction work area progresses across McCully Street.

McCully Street Ductline – The ductline on McCully Street would be located beneath the parking lane on the Koko Head side of the street. The work area would use the parking lane and the adjacent mauka-bound traffic lane, and would extend the length of the ductline section, with the exception that Young Street would not be blocked except during the actual trenching and construction of the line across the intersection. The construction across Young Street would block only one-half of the street at one time, with one traffic lane provided in each travel direction. Parking would be restricted along the curb of McCully Street during the construction.

Cable Pulling and Splicing – A work crew would pull cable through the new ductline at the rate of about two manholes (1,000 feet) per work shift. Typically, the crew would work at every other manhole to pull the cable, or at one location each work shift. The work area would block a single traffic lane at the manhole for a distance of 100 to 150 feet.

A second crew would splice cable, with that work starting about one week after the start of cable pulling. The cable splicing would occur at every other manhole. The work area would block a single traffic lane at the manhole for a distance of 50 to 100 feet.

Repaving – The full length of the excavation for the ductline construction would be repaved to the width of one lane. The paving would close Lanes #2 and #3 as the work area and pave one lane width for about two to three blocks at a time. Paving would occur at night. At major cross street intersections, one-half of the cross street width would be paved at a time to maintain traffic flow on the cross street.

Duration of Work – The overall Phase 2 construction work would extend over a period of about 18 months, with major lane closures occurring for about 3 to 4 weeks along Cooke Street, 30 to

35 weeks along King Street, and 3 to 4 weeks along McCully Street. The major work elements and duration of the work involving closure of traffic lanes or restriction of on-street parking would be as follows:

Work Stage	Work Element	Traffic Provisions	Shift	Duration (Work Days)
1	Close Cooke St. from Substation to King St. to construct ductline	Restrict parking for length of work area Close block to through traffic	Night	9-11
2	Block two lanes as ductline construction proceeds along King Street	Restrict makai curb parking for 1,000 to 1,500 feet length of traffic control area Use 300-foot long work area plus 300-450 feet for traffic lane shifts	Night	114-125 (Crew A) & 58-70 (Crew B)
3	Block parking lane and adjacent mauka-bound lane on McCully St. to construct ductline	Restrict parking along curb between King and Beretania Sts. Cone one lane in each direction along makai half of street	Night	10-12
4	Pull and splice cable at Cooke St. manhole (1 location)	Restrict parking for 100 feet at manhole near King St.	Night	4
5	Pull and splice cable at King St. manholes (9 to10 locations)	Cone one lane for 100-150 foot long work area at manholes	Night	36-40
6	Pull and splice cable at McCully St. manhole (1 location)	Restrict parking and cone work area along Koko Head curb for 150-foot long work area at manhole	Night	4
7	Repave Cooke Street the length of the construction area	Restrict parking Block street to through traffic	Night	1
8	Block Lanes #2 and #3 for 2-3 blocks at a time to repave one lane width of King Street the length of the ductline	Restrict parking along makai side of 2 to 3 blocks long repaving area Provide 2 to 3 lanes along mauka half of street	Night	9-10
9	Repave parking lane along McCully Street for the length of the construction area	Restrict parking between King and Beretania Streets Provide one lane each direction plus left-turn lanes	Night	1

Two work crews would begin work at the same time on the trenching and installation of the ductline. One crew would begin at Archer Substation and construct the line to Kaheka Street. The second crew would begin at Kaheka Street and construct the section to the McCully Street end. The first crew would be working an estimated 114 to 125 evenings; the second crew would finish in an estimated 58 to 70 evenings.

8.2.2. Traffic Impacts

During the ductline construction work along King Street, the traffic plan would provide a minimum of two through lanes on the mauka side of the work area and the makai curb lane would be open for use by buses, right-turn vehicles, and other vehicles that may choose to pass on that side. Construction work would start at 8:00 PM and continue until about 5:00 AM. Traffic volumes along King Street in the early evening hours range between 900 and 1,200 vehicles per hour with volumes declining to about 500 vehicles per hour after 10:00 PM and to 100 to 200 vehicles per hour after midnight.

The three traffic lanes would result in similar or lower traffic volumes per lane during each evening hour (about 400 per lane at 8:00 PM) than with the regular lanes in the midday peak hour (about 500 per lane). There should be little to no delay in traveling past the construction work area on King Street, either mid-block or at signal-controlled intersections. Should queues and delays develop during the higher volume early evening hours, parking could be restricted along the mauka curb to provide an additional traffic lane.

As the open trench portion of the construction work area crosses through the major signal-controlled intersections, the work would be phased to block about one-half of the intersection width at one time. About one-half of the lanes on the cross street would be blocked with traffic cones and signing used to direct the remaining traffic lanes around the enclosed work area. The reduced number of traffic lanes could result in traffic delays on the cross streets as each is partially blocked by the work area, which would extend for 2 to 3 nights at each major cross street intersection. The delays would most likely occur on the cross streets with two-way traffic where only one-lane is provided in a travel direction.

Traffic entering King Street from minor cross streets and from driveways as each is blocked by the work area would be forced to turn onto and travel along King Street past the work area and traffic transition zones before the vehicle would be able to access a cross street or driveway on the opposite side of the street. Although access would be maintained to all driveways, some drivers may have to reroute their travel path to enter or exit those side streets and driveways along the approximately 600-foot long section of King Street occupied by the work area and transition zones.

During the ductline construction and paving work on Cooke Street, the block between Kapiolani Boulevard and King Street would be blocked to through traffic. Vehicles desiring to travel makai-bound on Cooke Street would have to turn from King onto Kapiolani Boulevard or

continue on King Street and turn onto Ward Avenue to travel makai. Vehicles desiring to travel mauka on Cooke Street would have to turn left onto Kapiolani Boulevard to access King Street.

During the McCully ductline construction, McCully Street traffic would be provided with only a single through lane in the mauka-bound direction at the King Street and Young Street intersections, plus a mauka-bound left-turn lane at Young Street. The traffic volumes during the evening hours should be accommodated without lengthy delays.

During the paving work on McCully Street, both the mauka- and makai-bound traffic would be provided with a single through lane, plus turn lanes at the King Street and Young Street intersections. The traffic volumes during the evening hours should be accommodated without major delays.

During the ductline construction, there would be frequent movement of trucks removing excavated material and delivering construction materials to the work area. These movements could result in frequent disruption to traffic flow in the lanes adjacent to the work area.

8.2.3. Impacts on Public Transit Routes and Stops

The ductline construction and cable pulling/splicing work should not significantly affect public transit routes or stops. Access would be maintained to all bus stops since the ductline construction work would not occur in the curb lane used to access the bus stops.

With the repaving of only one lane-width along King Street, if parking is restricted along the makai curb lane, then bus access to each bus stop should be permitted as the excavation area in Lane #2 or #3 is repaved on each block of King Street.

In general there should be fewer bus passengers desiring to access the bus stops during the nighttime construction hours than if the work were to be done in the daytime, and therefore fewer persons that could be potentially impacted during the nighttime construction.

8.2.4. Impacts on Pedestrian Circulation

The ductline construction work would cross and block each crosswalk along the affected blocks of Cooke, King, and McCully Streets. The construction at each intersection, and the movement of the work area, would usually be staged to block only one crosswalk at a time at a signal-controlled intersection.

As the ductline construction proceeds from Cooke Street onto King Street, the construction work area would block the Cooke Street crosswalk along the makai side of King Street and affect pedestrian circulation along the makai sidewalk through this area.

There is a signal-controlled crosswalk adjacent to the entrance driveway at McKinley High School that is used for pedestrian crossings. With nighttime construction there should be little or

no use of this crosswalk. There are signal-protected crosswalks 400 feet Ewa at Victoria Street and 600 feet makai at Pensacola Street that could be used during the time this crosswalk is blocked by the work area.

There are a number of minor streets with only a single crosswalk across King Street, as well as several mid-block crosswalks. Many of these are closely spaced at 200 to 400 feet apart and temporary closure of one at a time should not result in a substantial increase in the pedestrian trip distance and time (1-2 minutes). The closure of the Kaheka Street crosswalk would leave the longest gap at about 1,100 feet between adjacent crosswalks which could result in a potential increase of up to 5 minutes in walk time.

8.2.5. Possible Actions to Minimize Impacts

The schedule for construction work should be coordinated with events at Neal Blaisdell Center to avoid any blockage of lanes along King Street, Ward Avenue, and Victoria Street adjacent to the Center on evenings with a major event at the Center.

Additional traffic capacity could be provided during the construction work within or near major intersections by restriction of parking along the mauka curb lane for one to two blocks on either side of the intersection as the work area impacts traffic operations at that intersection. This would provide an additional lane for through traffic. Signal timing may need to be adjusted to provide more green time to the major cross street as the construction work blocks lanes on the cross street.

The nighttime work that requires lane closures could start later in the evening, about 9:00 PM, after traffic volumes decline to lower levels in order to minimize any traffic delays and business impacts due to parking restrictions. However, a later start time would require either that the work extends into the early morning hours (5:00 AM), or the fewer work hours each evening would increase the time needed to complete the work by about 15 work nights (3 weeks).

Paving plans should be reviewed with TheBus operations staff to identify if any bus stops may have access blocked by the repaving work to the extent that would warrant temporary relocation of the stop.

At intersections with two crosswalks across King Street, the work area should be configured and work staged to block only one of the crosswalks at a time, thus keeping the one crosswalk open at all times for pedestrians to cross King Street at the intersection.

The City DTS and Neighborhood Boards should be consulted to identify any locations with single crosswalks that should be temporarily relocated during its blockage by the construction work, to the extent that a safe alternate crossing point can be provided nearby.

8.3. PROPOSED NIGHTTIME TRENCHING OPTION AFTER BRT SCENARIO

The EOTP King Street construction work along the blocks from Cooke to Pensacola Streets would occur along the section that will be used for the BRT UH-Manoa line. Most of the nighttime construction work and the construction impacts would be very similar with the BRT line as those discussed in the preceding section without the BRT line. This section focuses on those locations and issues where the presence of the BRT line would alter the construction impacts or mitigative actions from the nighttime scenario without the BRT.

8.3.1. *Project Description*

The construction work area and procedures would generally be the same as without the BRT line. With the BRT line, general through traffic would be restricted from the two curb lanes, with the four lanes in the center of the street available for general traffic. The makai curb lane would be a semi-exclusive lane for use by BRT and other transit vehicles, as well as vehicles turning right at cross streets or into driveways. Through vehicles would not be allowed to use the makai-side BRT lane to pass by the construction work area.

8.3.2. Traffic Impacts

The ductline construction along King Street between Cooke and Pensacola Streets would provide only the two mauka-side through traffic lanes past the work area, with the makai curb lane open only for buses and vehicles turning right into driveways or cross streets. At 8:00 PM, the traffic on King Street would average about 500-600 vehicles for each of the two through traffic lanes available for use, which is about the same as the 500 vehicles in each normal traffic lane on King Street during the midday peak hour. For most of the nighttime period, the King Street volumes would approximate 100-300 vehicles or less in each of the two through lanes past the work area. Nighttime construction should result in little traffic delays along the section of King Street with the BRT lanes. The most likely location for any delays would be at the Ward Avenue intersection, and to a lesser extent, the Pensacola Street intersection.

The exclusive use of mauka curb lane for the Ewa-bound travel direction for BRT buses would preclude the use of this lane to increase Koko Head-bound traffic lanes and capacity past the work area.

If general through traffic cannot pass on the makai side in the semi-exclusive BRT lane, the traffic transition area upstream of the work area would need to be twice as long (minimum of 300 feet versus 150 feet) to shift all through vehicles in the second (#2) and third (#3) lanes from the makai curb to the general traffic lanes mauka of the work area. This would lengthen the section of the street where traffic maneuvering and circulation is constrained by the work area.

During the repaving work, access to about a 1,000-foot length of the makai curb lane would be possible only at the Ewa end of the paving section. Any vehicles desiring to turn into a makai-

side driveway or minor side street along that section would have to enter the makai curl lane at the beginning of the work area. This could result in driver confusion and additional travel.

8.3.3. Impacts on Public Transit Routes and Stops

If only one-lane width of the street is repaved (past practice), there should be little impact on bus operations or access to bus stops.

If the entire width of King Street is repaved, with one-half of the street width for 1-3 blocks closed at a time, the repaving work would affect both BRT lanes, especially the contra-flow Ewa-bound BRT buses in the mauka curb lane:

- During the paving of the makai half of the street, the BRT buses and other transit buses could operate in the lane adjacent to the paving activity. Any bus stops along the block being paved would have service temporarily ceased at that stop during the one or two nights bus access to that stop is affected. The BRT bus stop at Neal Blaisdell Center could be relocated temporarily to an adjacent block.

- During the paving of the mauka half of the King Street, the contra-flow direction BRT lane would have to be relocated to a different street. The repaving of the mauka half of this 2,800-foot long section of King Street could require up to about 9 nights of work. This relocation may require persons desiring to use BRT to travel to or from this area to transfer to local bus routes and/or to walk further to the BRT stops for the relocated line section.

8.3.4. Impacts on Pedestrian Circulation

The location and type of impacts on pedestrian circulation would be the same as described for the Pre-BRT scenario. The presence of the BRT service would likely increase the pedestrian volumes near the Neal Blaisdell Center and Pensacola Street BRT stops, with some of these pedestrians affected by the blockage of the crosswalks.

8.3.5. Possible Actions to Minimize Impacts

If only a one-lane width area along Lanes #2 and #3 is repaved, then there should be little impact or need for mitigative actions as a result of the BRT facilities and operations.

If the repaving of the full street width were to be required, then the following actions could be undertaken to reduce impacts of the repaving work:

- The impacts on the BRT bus line for about two weeks during the repaving of the mauka half of King Street could be avoided by the City not requiring that the concrete BRT lane be included in the resurfacing work for the street.

- If the repaving of the BRT lanes are required, the Ewa-bound direction of the BRT line would need to be relocated from the mauka curb lane during evening hours for the two weeks of the repaving work. The Ewa-bound service could be continued along Kapiolani Boulevard in normal traffic lanes and reenter the King Street BRT lane at the King-South Street intersection. Special temporary signing, traffic cones, and traffic control officers would likely be needed at the King-South Street intersection to facilitate the awkward bus turning maneuver from South Street into the BRT lane on the mauka side of King Street.

- Alternatively, the repaving work could be done in the late night/early morning hours when the BRT service is not operational. However, the shorter work shift could extend the duration of the repaving work on the mauka BRT lane by two additional weeks.

The repaving of the trenchline across the makai-side BRT lane at Cooke Street should be done during the nighttime hours when the BRT is not in service

8.4. DAYTIME TRENCHING OPTION BEFORE BRT

The Daytime Trenching Option would follow the same alignment and general progression of the work as the proposed Nighttime Trenching Option. The ductline construction and cable pulling/splicing work would be done during the daytime. The repaving of the street would be done during the nighttime.

8.4.1. Project Description

The ductline construction would be done during a daytime work shift that begins with set-up of the work area barriers and traffic cones at 9:00 AM. All of the work activities in the traffic lanes would be completed, any open trench section covered, and the barriers removed by 3:00 PM each weekday.

The work area and transition area for the ductline would be the same as described for the proposed Nighttime Trenching Option Before-BRT scenario. As the ductline construction work area progresses through the major signal-controlled intersections, the work area would be reconfigured so that the intersection would remain open to the cross-street traffic. The assessment was based on closing off one-half of the cross-street intersection width at one time for the construction, with one-half of the lanes on the cross street closed and one-half open to traffic. With a smaller, inefficiently-configured construction work area and shorter work shift, the daytime construction work would progress at about 10 feet or one lane-width per day.

The cable pulling and splicing work would also be done between 9:00 AM and 3:00 PM, with work occurring at every other manhole along the line.

The repaving of the streets would be done at night between the hours of 8:00 PM and 5:00 AM. The streets would generally be repaved one to two blocks at a time, with one-half of the street closed for paving and one-half left open to traffic.

8.4.2. Traffic Impacts with Daytime Construction

Traffic conditions were analyzed for the midday peak hour traffic at the major intersections along King Street as the two-lane wide construction work area/lane shift transition area advances through each intersection. The conditions for three construction stage/traffic control scenarios are presented in Table 8-1. These are:

1. Approach/departure scenario with three traffic lanes – This scenario reflects traffic conditions at the intersection as the leading and trailing lane shift transition areas cross the intersection, which represent about two-thirds the length of the combined work activity area/lane transition area. For this scenario, it is assumed that two through lanes are open to traffic on the mauka side of the work area, general traffic is allowed to use the makai curb lane, and the on-street parking is allowed to remain in the mauka curb lane through the midday construction hours.

2. Approach/departure scenario with four traffic lanes – This scenario restricts parking along the mauka curb lane for three to four blocks around the work activity area to allow general traffic use of the makai curb lane to provide three traffic lanes on the mauka side of the construction area.

3. Crossing scenario with four traffic lanes – This scenario reflects conditions as the open trench area blocks a portion of the cross street at the intersection. One-half of the cross-street traffic lanes in each direction would be closed at a time. Parking would be restricted along the mauka curb and general traffic would be allowed to use the mauka lane on King Street for about 2 to 3 blocks on either side of the intersection.

With construction advancing about 60 feet per day, the lane modifications and traffic conditions for the advance/departure scenarios 1 and 2 would affect each intersection for approximately 6 to 8 work days (3 to 4 during approach and 3 to 4 during departure of work zone to intersection). The conditions with Scenario 3 would extend for about 6 to 8 work days at each major intersection as the number of cross street lanes through the intersection must be reduced due to construction work. Because of the constraints within the reconfigured work activity area and the shorter work shift, the excavation and ductline placement work would proceed across the intersection at the rate of about one lane width, or about 10 feet, per work day.

Scenario 1, with three lanes on King Street as the work area blocks lanes on King Street but not the cross street, would result in midday traffic conditions at most intersections that are similar to or slightly worse than afternoon peak hour conditions without the construction work. With the work area lane reduction, the 2009 midday traffic volumes would amount to 94% of the reduced Ward Avenue intersection capacity and 93% of the Keeaumoku Street intersection capacity. The traffic volumes would approximate 88% of the capacity of the Kalakaua Avenue and Punahou Street intersections. These midday conditions, with some likely queuing and delays of traffic, would last for about 6 to 8 work days at each of these intersections.

In Scenario 2, the mauka curb parking would be restricted during the midday work hours to provide a fourth lane for through traffic at each intersection as the King Street lanes are blocked by the construction work near that intersection. The additional through traffic lane would result in acceptable conditions at each intersection, with the midday volumes at 85% or less of each intersection's reduced capacity during the approach and departure of the work area. Some traffic queuing and delays could still result from the traffic lane-changing to pass around the work area when it is at an intersection.

Table 8-1
2009 Traffic Conditions With Trenching Midday Peak Hour Without BRT Lanes, King Street Corridor

Intersections	3 King St. Lanes with No Cross Street Lanes Closed			4 King St. Lanes with No Cross Street Lanes Closed			4 King St. Lanes with Half of Cross Street Lanes Closed		
	V/C	ADPV	LOS	V/C	ADPV	LOS	V/C	ADPV	LOS
King St.-Ward Ave.	0.94	32.9	C	0.81	24.0	C	1.10	120.2	F
King St.-Pensacola St.	0.79	23.6	C	0.64	20.3	C	0.78	24.3	C
King St.-Piikoi St.	0.73	22.3	C	0.61	19.8	B	0.77	23.6	C
King St.-Keeaumoku St.	0.93	38.2	D	0.85	31.5	C	1.06	103.3	F
King St.-Kalakaua Ave.	0.88	30.6	C	0.76	25.2	C	0.87	32.9	C
King St.-Punahou St.	0.88	39.5	D	0.85	38.8	D	0.91	50.7	D
King St.-McCully St.	0.84	35.5	C	0.78	31.0	C	0.91	31.7	C
McCully St.-Young St.	0.83	27.6	C	0.83	27.6	C	0.85	27.7	C

V/C = Ratio of the traffic volume to the theoretical capacity of the intersection.
ADPV = Average delay per vehicle, in seconds.
LOS = Level of service.
NA = Not Analyzed

Wilbur Smith Associates; May 26, 2004.

As the ductline construction blocks lanes on the cross street as well as on King Street (Scenario 3), the midday peak hour traffic volumes would exceed the capacity of the intersections at Ward

Avenue and at Keeaumoku Street. The midday traffic would exceed 90% of capacity at the Punahou and McCully Street intersections. The formation of traffic queues and long delays would be expected during the midday hours for about 6 to 8 work days as the construction work progresses across each of these intersections. The lengthy delays could result in some traffic diverting to parallel routes such as Kapiolani Boulevard, Kinau Street, and the H-1 Freeway. Approximately 200 to 400 vehicles per hour would likely to divert to parallel routes to avoid delays at the work area.

Traffic entering King Street from minor cross streets and from driveways as each is blocked by the work area would be forced to turn onto and travel along King Street past the work area and traffic transition zones before the vehicle would be able to access a cross street or driveway on the opposite side of the street. Although access would be maintained to all driveways, some drivers may have to reroute their travel path in order to enter or exit side streets and driveways along King Street. Higher traffic volumes would be expected on most cross streets and driveways during the daytime than in the evening hours, therefore more vehicles would likely be affected than with nighttime construction.

During the ductline construction and paving work on Cooke Street, the block between Kapiolani Boulevard and King Street would be blocked to through traffic. The small number of vehicles desiring to travel makai-bound on Cooke Street would have to turn from King onto Kapiolani Boulevard or continue on King Street and turn onto Ward Avenue to travel makai. The several hundred through vehicles per hour desiring to travel mauka on Cooke Street would have to turn left onto Kapiolani Boulevard to access King Street. This would affect traffic operations at the Kapiolani Boulevard intersections with Cooke Street and with South Street from 9:00 AM to 3:00 PM for about 9 to 11 days and at night time for one night during repaving.

During the paving work on McCully Street, the mauka-bound traffic would be provided with a single through lane, plus turn lanes at the King Street and Young Street intersections. The traffic volumes during the evening hours should be accommodated without major delays.

8.4.3. Impacts on Public Transit Routes and Stops

The ductline construction and cable pulling/splicing work stages would not directly affect public transit routes or stops. Access would be maintained to all bus stops since construction would not occur in the curb lane used to access the bus stops. The increased traffic volume in the makai curb lane in the vicinity of the construction work, as a result of the reduced number of traffic lanes, could result in additional delay and increased travel time for the buses.

If only a single lane-width is repaved along the ductline, the nighttime repaving should have minimal effect on bus service. If the entire width of King Street were to be repaved, then bus access to each bus stop would be halted as the makai lane is repaved on that block of King Street. Since this activity is proposed for the evening hours, there should be fewer bus passengers desiring to access the bus stops than if the work were to be done in the daytime, and therefore fewer persons that could be potentially impacted by the paving work at nighttime.

8.4.4. Impacts on Pedestrian Circulation

The locations and types of impacts on pedestrian circulation would be similar to those described for the proposed Nighttime Trenching Option.

Pedestrian activity at the crosswalks would likely be higher during the daytime construction hours than in the nighttime hours. If the construction work occurs near McKinley High School and Washington Middle School when school is in session, the blockage of the crosswalks near the schools would likely affect the normal routes used by neighborhood children to walk to these schools.

8.4.5. Possible Actions to Minimize Impacts

The ductline construction work could begin at 8:00 AM (or 8:30 AM) instead of 9:00 AM, with the additional one hour (one-half hour) allowing both an additional hour of work per day and more productive work during the work shift since a greater percentage of the shift time would be spent on construction and a lesser proportion would be spent on set-up and take-down of traffic controls and construction equipment. The traffic counts along King Street indicate that traffic during the 8:00-9:00 AM hour is lower than the volumes during most of the 9:00 AM-3:00 PM midday shift. The longer work day should reduce the number of work days by 15 to 20 and the period during which the construction impacts the area by 3 to 4 weeks.

The impact of the ductline construction on traffic conditions at the major signal-controlled intersections could be significantly reduced if the construction work within each of these intersections is done in the evening hours. Nighttime construction would be most needed at the King Street intersections with Ward Avenue and Keeaumoku Street. Evening construction would also be appropriate to reduce impacts at the Kalakaua Avenue, Punahou Street, and McCully Street intersections.

The impacts on traffic circulation during the ductline construction along Cooke Street could potentially be reduced if one lane is left open for traffic use. The alternative approaches to the single-lane operation would be as follows:

1. If a flagman operation is used to alternate traffic directions along this single lane, the vehicles waiting on the makai end to travel mauka would likely stack into the Kapiolani Boulevard intersection and disrupt traffic operations at that intersection. At the mauka end, this option would require the removal of parking along the makai curb of King Street to provide a stacking area for vehicles waiting to travel makai on Cooke Street.

2. If the lane is operated one-way makai (normal direction), traffic approaching from Kapiolani Boulevard and the makai section of Cooke Street could travel to King Street via Kapiolani Boulevard and South Street. This route could also be used for local access to properties along the block of Cooke Street.

3. If the lane is operated one-way mauka bound, the lane would best serve traffic from the Kakaako area that desires to travel Koko Head on King Street and should result in least impacts at Kapiolani Boulevard intersections. The makai-bound traffic would have to turn from King Street onto Kapiolani Boulevard or turn onto Ward Avenue to travel makai.

Option 3 would appear to minimize circulation and the potential for traffic problems. Option 1 should be avoided during the daytime hours because of potential disruption during higher-volume hours.

If the crosswalks near McKinley High School and Washington Middle School are blocked during days when these schools are in session, crossing guards could be placed at the blocked crosswalks during the student arrival/departure hours to direct students to alternative crossing locations.

The size and/or layout of the ductline installation work area should be modified as appropriate to avoid simultaneously blocking two adjacent King Street crosswalks as the work progresses down the street. Alternatively, the work hours could be ended at 2:00 PM to minimize impacts on school traffic and pedestrians when the work area is located in front of McKinley High School and Washington Middle School.

The impact on bus stops could be avoided by not repaving the makai curb lane, or by temporary relocation of the bus stop to an adjacent block if there is not a nearby stop.

8.5. DAYTIME TRENCHING OPTION AFTER BRT

The EOTP King Street construction work along the blocks from Cooke to Pensacola Streets would occur along the section that will be used by the BRT UH-Manoa line. The daytime construction work and the construction impacts would be very similar with the BRT line as those discussed in the preceding section without the BRT line. This section focuses on those locations and issues where the presence of the BRT line would alter the construction impacts or mitigative actions from the daytime scenario without the BRT.

8.5.1. Project Description

The construction work area and procedures would generally be the same as without the BRT line. With the BRT line, general through traffic would be restricted from the two curb lanes, with the four lanes in the center of the street available for general traffic. With the BRT line, the makai curb lane would be a semi-exclusive lane for use by BRT and other transit vehicles, as well as vehicles turning right at cross streets or into driveways. Through vehicles would not be allowed to use the makai-side BRT lane to pass by the construction work area unless permitted by the City. The mauka curb lane would be operated as contra-flow lane for BRT buses only and would not be available for general traffic use to bypass the construction area.

8.5.2. Traffic Impacts with Daytime Construction

The BRT would primarily affect traffic operations during the construction work along King Street between Cooke and Pensacola Streets. The traffic impacts along King Street from the Koko Head side of Pensacola Street to McCully Street with the BRT would be similar to those described for the Daytime Option without the BRT.

If general through traffic cannot pass on the makai side in the semi-exclusive BRT lane, the traffic transition area upstream of the work area would need to be at least twice as long (minimum of 300 feet versus 150 feet) to shift all through vehicles in the two blocked lanes (second and third lanes from the makai curb) to the lanes mauka of the work area. This would lengthen the section of the street where traffic maneuvering and circulation is constrained by the work area and lane transitions.

The ductline construction through the section with BRT lanes would likely result in traffic queuing and delays on the upstream side of the work area. The two-lane wide work area would require the 2,100 to 2,200 vehicles per hour in the four traffic lanes on King Street to merge from into two lanes to pass by the work site, with about 1,100 vehicles per lane at the work area.

The presence of the BRT lanes would affect the traffic conditions during the trenching and ductline construction work through the intersections of King Street with Ward Avenue and with Pensacola Street (Table 8-2).

During the approach/departure of the work area at the Ward Avenue intersection, the midday peak hour traffic would exceed the capacity of the intersection by an estimated 4%, with long traffic delays (LOS F). These conditions could result in the some King Street traffic seeking alternative routes, most likely using Kapiolani Boulevard, Kinau Street, or the H-1 Freeway. This diversion could amount to 100 to 200 vehicles per hour during the midday hours for 3-4 days as the work area approaches the intersection and a similar number as it departs from the intersection. About half would likely use the H-1 Freeway while the rest would use parallel surface streets.

For 6 to 8 work days as the work area progresses through the Ward Avenue intersection, the blockage of two of the lanes on Ward Avenue at a time would further reduce capacity, with the midday peak hour traffic exceeding this reduced capacity by about 38%, with extremely long delays and formation of multi-block long traffic queues. These conditions would likely lead to a large number of vehicles diverting from King Street to parallel streets and the H-1 Freeway, with the diversion amounting to 800 or more vehicles per hour diverting from King Street to other routes during the midday peak traffic hours. Of these diverted vehicles, approximately 400 of these vehicles would likely use the H-1 Freeway to bypass the work area, which would increase midday Koko Head direction traffic volumes on the freeway by about 5%. Some traffic that would normally use Ward Avenue would likely divert to Pensacola and Piikoi Streets or other alternative routes to bypass the intersection.

As the ductline construction work area closes two King Street lanes as it approaches and departs from the Pensacola Street intersection, the midday peak hour would approximate 83% of the reduced intersection capacity. As two lanes are blocked on the Pensacola Street makai-bound approach during the work within the intersection, the midday peak hour traffic would amount to 95% of the intersection capacity with traffic delays at LOS E. During the 6 to 8 days of work within the intersection, traffic queues would likely form on both the King and Pensacola Street approaches at the intersection with increased delays due to traffic changing lanes to pass by the work area.

Table 8-2
2009 Traffic Conditions With Daytime Trenching Midday Peak Hour With BRT Lanes, King Street Corridor

Intersections	Without Construction Project			2 King St. Lanes with No Cross Street Lanes Closed			2 King St. Lanes with Half of Cross Street Lanes Closed		
	V/C	ADPV	LOS	V/C	ADPV	LOS	V/C	ADPV	LOS
King St.-Ward Ave.	0.68	20.7	C	1.04	99.3	F	1.38	511.2	F
King St.-Pensacola St.	.66	19.8	B	0.83	24.6	C	0.95	72.2	E

V/C = Ratio of the traffic volume to the theoretical capacity of the intersection.
ADPV = Average delay per vehicle, in seconds.
LOS = Level of service.
NA = Not Analyzed

Wilbur Smith Associates; May 26, 2004.

8.5.3. Impacts on Public Transit Routes and Stops

The type of impacts would be the same as those described for the Nighttime Option with BRT. The higher volumes of buses and bus passengers during the daytime hours would increase the number of persons affected by the construction as compared to the nighttime.

8.5.4. Impacts on Pedestrian Circulation

The type of impacts would be the same as those described for the Nighttime Option with BRT. The higher volumes of pedestrians during the daytime hours would increase the number of persons affected by the construction as compared to the nighttime.

8.5.5. Possible Actions to Minimize Impacts

The impacts on the transportation system could be reduced by constructing the ductline between Cooke and Pensacola Streets at nighttime when there are lower levels of vehicles, buses, and pedestrians in the area. In particular, the section of ductline from Archer Lane through the Ward Avenue intersection to around Victoria Street should be constructed at nighttime to avoid the severe congestion anticipated for work in the Ward Avenue intersection with the BRT in operation.

The repaving of the trenchline across the makai-side BRT lane at Cooke Street should be done during the nighttime hours when the BRT is not in service.

8.6. PARTIAL HORIZONTAL DIRECTIONAL DRILLING OPTION BEFORE BRT

The horizontal directional drilling (HDD) feasibility study by Powers Engineers, Inc. has indicated that HDD could be used for construction of that portion of the ductline along King Street between Cooke Street and Washington Middle School. This section contains all of the major cross streets, with the exception of McCully Street, and has soil conditions that are conducive to directional drilling.

The other sections would be constructed through the conventional trenching approach. These would include the section of King Street between Washington Middle School and McCully Street, the ductlines across King Street near the Times supermarket, the ductline along Cooke Street, and the ductline along McCully Street.

8.6.1. Project Description

A small directional drilling rig could be used to install the ductline for a distance of up to about 500 feet from the drill site. The drill rig could be used to first drill and install the ductline in one direction down King Street for a distance of 500 feet from the drill site, and then be turned 180 degrees within that drill site work area to drill and install a ductline for a distance of 500 feet in the opposite direction from the same work area. A drill site work area would be needed about every 1,000 feet of ductline installed through this procedure. Additional work areas would be needed at the end point of the 500-foot drill distances for use in assembling and feeding in the ductline casing as the rig pulls the ductline casing back through the drill hole to the drill site. Thus, at any given time during the HDD work, two work areas would be needed approximately 500 feet apart along this section of King Street. Permanent manholes would be constructed in Lane #2 within each of these work areas for future use to access the cables for maintenance and servicing purposes.

Ductline Construction Work Area Size and Locations. The small horizontal drilling rig could be set up within the width of two traffic lanes. The work area for the drill site would be two lanes wide and about 100 feet in length. As discussed in the "Ductline Construction" section, the drill site work area would be in place at each location for about four weeks. The drill site work area

would remain in place 24-hours a day and 7 days a week for the duration of the drilling activity and the ductline casing pulling activity.

The work areas at the exit points would be set up as the drill head approaches the terminus of that drill section. The exit point work areas would initially be one lane wide by about 100 feet in length as an area is excavated to provide access to the horizontal drill hole. The exit point work area would be expanded to provide an additional length of about 500 feet for use in assembling the 500-foot long ductline casing to be pulled back through the drill hole to provide the permanent lining for the ductline. At the end of work at an exit point work area, the work area would likely be widened to two lanes (#2 and #3) for 1 to 2 days as a manhole is constructed within the work area.

The smaller exit point work area would need to be in place for about two weeks for each drill series to provide the three ductline casings between each pair of manholes. Each exit point work area would be used during two different drills: once as the exit end of the three drills from the Ewa direction, and secondly, as an exit point for the three drills from the Koko Head direction. The exit point work site could be opened to traffic during non-work hours during a portion of this period. However, the longer casing assembly area would have to be closed to traffic 24-hours a day during the time the casing is being assembled through the time it is pulled into the ductline drill hole.

Traffic transition areas would be provided upstream (Ewa side) of both the drill site and exit point work areas to facilitate the shift of traffic out of the blocked Lane #2. The line of traffic cones would extend approximately 150 feet Ewa of the work area.

On-street parking would be restricted along the makai curb near the drill site and exit point work areas during the period each work area is in place. At the drill site work area, the restriction would extend for a distance of about 700 feet, from about 300 feet upstream of the work area to about 300 feet beyond the work area. The restriction would be in place for 24 hours a day, 7 days a week. At the exit point/casing assembly work area, the parking restriction would need to extend about 1,100 to 1,200 feet from the time that each casing is being assembled to the time that it has been pulled into the hole.

Powers Engineers, Inc. has estimated that a series of 14 work areas would be needed for the section between Cooke Street and Washington Middle School. Seven would be used as drill sites and seven as exit point/pullback areas work areas. Their preliminary plan for the locations of these 14 sites is depicted in Figure 8-1.

The ductline would be located in the second lane from the makai curb for reasons similar to those discussed for the proposed trenching method. The work areas for the drill site would occupy the second and third lanes from the makai curb. The makai curb lane would remain open to traffic at all hours to maintain access to driveways and bus stops, and to accommodate general traffic flow pass the work area.

The other sections of the ductline would be constructed by the trenching method. These would include the sections along Cooke Street (about 420 feet), King Street from the Washington Middle School to McCully Street, the two short lateral connections across King Street near the Times Supermarket, and the McCully Street section (460 feet).

Location of Ductline Casing Assembly. The 500-foot long ductline casing for each of the three circuits between each pair of manholes would be assembled by welding together a series of short sections, probably in 40-foot lengths. The 500-foot long casing must be assembled near to the pullback work area. The 500-foot long casing would likely be assembled in the #2 traffic lane, thus using/blocking the same lane as the drill site and exit point/pullback work areas. It would be unlikely that the sidewalk area or curb lane would be used since the ductline would block access to driveways and cross streets for the 500-foot length of the casing, as well as interfere with pedestrian access to and use of bus stops.

Ductline Construction Process and Duration. Three 46kV circuits would be provided along the King Street corridor. With the small to medium directional drilling rig, each of the three circuits would be placed within a separate 10-inch diameter ductline casing, thus requiring three separate parallel drillings between each pair of manholes/work areas along the ductline. Therefore, there would be a total of six drills done from each of the seven drill site work areas, as well as separate assembly and pullback of the six individual ductline casings. The overall process and timing requirements for construction of the ductline at one of the seven drill sites, using Manhole 3 (MH3) as an example, would be as follows:

Day 1	• Dig entry pit at MH3 • Set up drill rig in lanes 2 and 3 at MH3 • Begin drilling pilot hole 1 towards MH2
Day 2	• Complete pilot hole 1 to MH2 • Back-ream drill hole from MH2 to MH3 • Assemble casing in 500-foot long section of lane 2 between MH 2 and MH 1, with completion at end of shift
Day 3	• Pullback casing from MH2 to MH3 (10 hours)
Day 4	• Drill pilot hole 2 to MH2 • Assemble casing in 500-foot long section of lane 2 between MH 2 and MH 1
Day 5	• Backream drill hole 2 from MH2 to MH3
Day 6	• Pullback casing from MH2 to MH3 (10 hours)
Day 7	• Drill pilot hole 3 to MH2 • Assemble casing in 500-foot long section of lane 2 between MH 2 and MH 1
Day 8	• Backream drill hole 3 from MH2 to MH3
Day 9	• Pullback casing from MH2 to MH3 (10 hours)

Day 10	• Turn rig around towards MH4 • Drill pilot hole 1 to MH4 • Assemble casing in 500-foot long section of lane 2 between MH 4 and MH 5
Day 11	• Backream drill hole 1 from MH4 to MH3
Day 12	• Pullback casing from MH4 to MH3 (10 hours)
Day 13	• Drill pilot hole 2 to MH4 • Assemble casing in 500-foot long section of lane 2 between MH 4 and MH 5
Day 14	• Backream drill hole 2 from MH4 to MH3
Day 15	• Pullback casing from MH4 to MH3 (10 hours)
Day 16	• Drill pilot hole 3 to MH4 • Assemble casing in 500-foot long section of lane 2 between MH 4 and MH 5
Day 17	• Backream drill hole 3 from MH4 to MH3
Day 18	• Pullback casing from MH4 to MH3 (10 hours)
Day 19	• Demobilize drill rig at MH3 • Move drill rig to MH5 to start drill work there • Install MH2
Day 20	• Install MH3 • Complete ductline to manhole connections at MH 2 and MH3
Day 21	• Pull cable MH2 to MH3
Day 22	• Pull cable MH3 to MH4
Day 23	• Contingency day for MH3 work

The ductline construction work at each of the seven drill sites would require about four weeks if no major problems are encountered. The drilling rig would be operating along King Street for a total of about seven months.

The assembly of each 500-foot length of casing/pipe is estimated by Powers Engineers, Inc. to take 7 to 10 hours. If the assembly starts at 9:00 AM, the work would be complete at about 4:00 PM to 7:00 PM if done in one day, or the work could be split between two days.

The pullback of the casing into the drill hole is estimated by Powers Engineers, Inc. to require approximately 10 hours. If the work starts at 9:00 AM, the pullback would extend until 7:00 PM. The pullback of a casing should continue nonstop until it has been completely pulled into the drill hole.

The 500-foot long section of assembled casing, with an outside diameter of about 10 inches, would be present in Lane #2 during the time it is assembled until the time it is pulled into the drill hole. Therefore, traffic would be restricted from use of or crossing of that section of Lane #2

until the casing is pulled into the drill hole. The casing would normally be in the lane for about two days except for a weekend and/or holiday when the casing could be present in the traffic lane for 3 to 4 days.

Where the assembled casing stretches across one of the major mauka-makai cross streets, a shallow trench would be excavated across the intersection in Lane #2, the assembled casing placed into trench, and the trench covered with metal plates to allow the cross-street traffic to cross over the casing until the time the casing is pulled into the drill hole. The shallow trench would be excavated at nighttime with closure of one-half of the cross street at a time, with the excavation of each trench occurring at the beginning of the work on that section of the ductline. The shallow trench would be filled in once all of the casings for that assembly area have been pulled into the drill hole.

Cooke Street Ductline. The ductline from the HECO property to the Ewa exit point manhole on King Street would be constructed by trenching as described for the proposed nighttime trenching option.

Washington Middle School to McCully Street Ductline. The approximately 1,800 feet of ductline between the HDD exit point manhole (MH14) and McCully Street would be constructed by trenching as described for the proposed nighttime trenching option.

McCully Street Ductline. The ductline along McCully Street would be constructed by trenching as described for the proposed nighttime trenching option.

Cable Pulling and Splicing. A work crew would pull cable through the new ductlines at every other manhole at the rate of about 1,000 feet per work shift.

Repaving. The width of a single traffic lane would be repaved within each of the HDD work areas within the King Street, and along those sections of Cooke, King, and McCully Streets affected by the trenching work. This would include the shallow trenches across the cross streets used during the casing assembly work. The paving work would be done at night.

8.6.2. Traffic Impacts

The drill site work area would close two King Street traffic lanes at the location of the odd-numbered manhole locations depicted in Figure 8-1, with the closure occurring 24-hours a day, 7 days a week for the period of about 4 weeks at each of these manholes. Because of the 24-hour a day work area, the lane blockage would affect commute peak hour traffic as well as traffic in the off-peak hours. In the afternoon peak hour, the approximately 3,300 vehicles passing the drill site would have to merge from six lanes (550 vehicles per lane) into four lanes (825 vehicles per lane). This lane-changing would likely result in slowing of traffic speeds and may lead to formation of traffic queues upstream of the lane blockage. These queues could stack to and disrupt traffic conditions at nearby intersections.

With on-street parking allowed along the mauka curb, the morning and midday traffic would be compressed into three traffic lanes past the drill site. This would result in about 700 to 800 vehicles in each of the lanes on the mauka side of the drill site with potential delays and queue formation.

Where a drill site is located less than 200 feet from a key intersection, the work area would effectively result in the loss of two traffic lanes through the intersection during all hours of the day. This would include the following drill sites and affected intersections:

MH3 loss of 2 King Street lanes at Ward Avenue intersection

MH13 loss of 2 King Street lanes at Kalakaua Avenue intersection.

Where a drill site is located about 200 to 300 feet from a key intersection, the work area would reduce the traffic use in the #2 and #3 traffic lanes through the intersection during all hours of the day. For this assessment, it was assumed that the disruption to traffic flow would amount to a 50% loss of efficiency in the two blocked lanes, or the equivalent of the loss of one through lane, at the following intersection:

MH11 loss of 1 King Street lane at Keeaumoku Street intersection.

The estimated 2009 peak hour traffic conditions during the weekdays when each intersection would be affected by the drilling and casing pullback activities are summarized in Table 8-3. The conditions would be impacted for a period of about four weeks at each intersection.

Each of the key intersections would operate at acceptable levels during the morning and midday peak hour traffic periods with the loss of traffic lanes while the drill sites and pullback work areas are set up at the location nearest to each of the intersections along King Street. However, the loss of traffic lanes during the afternoon peak period would result in severe traffic congestion and lengthy delays at several of the intersections during the afternoon peak period.

Table 8-3
2009 Traffic Conditions Due To HDD Lane Closures Without BRT Lanes, King Street Corridor

Intersections	Morning Peak Hour			Midday Peak Hour			Afternoon Peak Hour		
	V/C	ADPV	LOS	V/C	ADPV	LOS	V/C	ADPV	LOS
King St.-Ward Ave. *	0.87	36.4	D	0.81	25.1	C	1.16	249.8	F
King St.-Pensacola St. **	0.58	19.7	B	0.64	20.9	B	0.79	24.6	C
King St.-Piikoi St. **	0.59	19.9	B	0.60	20.1	C	0.86	23.6	C
King St.-Keeaumoku St. *	0.67	26.3	C	0.80	30.4	C	0.96	44.1	D
King St.-Kalakaua Ave. *	0.84	28.9	C	0.88	31.4	C	1.20	402.2	F
King St.-Punahou St.	0.78	40.9	D	0.78	36.9	D	1.00	59.6	E

V/C = Ratio of the traffic volume to the theoretical capacity of the intersection.
ADPV = Average delay per vehicle, in seconds.
LOS = Level of service.
* = Intersection affected by drill site.
** = Intersection affected by casing assembly.

Wilbur Smith Associates; July 21, 2004.

The most severe problem location would be the Kalakaua Avenue intersection. The location of a drill site just Ewa of the intersection would result in loss of two King Street traffic lanes through the intersection. The afternoon peak hour traffic would exceed the reduced intersection capacity by an estimated 20%, with average delays for each vehicle passing through the intersection estimated at almost 7 minutes. These conditions would result in the formation of extremely long traffic queues that could stack through and affect operation of other intersections and cross streets. The long delays could result in as many as 600 to 800 vehicles changing their routes to use other parallel roadways in the afternoon commute period, including the H-1 Freeway, Wilder Avenue, and Kapiolani Boulevard. Of the diverted traffic, an estimated 400 or more vehicles may use the H-1 Freeway to bypass the work area in the afternoon peak hour. These conditions would last for about four weeks while a drill site is located adjacent to this intersection.

The estimated afternoon peak hour traffic along King Street would exceed the capacity of the Ward Avenue intersection by16% as a result of the drill site located just Ewa of that intersection. The estimated delay would average 6 minutes per vehicle passing through the intersection. The traffic queues along King Street and Ward Avenue could affect access to the Straub Hospital facilities during the afternoon commute period. The long delays could result in about 500 or more vehicles diverting to parallel routes during the afternoon peak hours. About 200 to 300 vehicles would likely use the H-1 Freeway in the peak hour to bypass the work site. The long queues and delays during the construction work at this intersection would last for about four weeks the drill site work area is located near the intersection.

The drill site at MH11 near Keeaumoku Street intersection, with the traffic transitioning out of Lanes #2 and #3 as vehicles cross the intersection, would effectively reduce capacity by about one traffic lane along King Street. The capacity of this intersection would also be reduced by one lane during the assembly and pullback of the casing to be installed between MH9 and MH10. The estimated afternoon peak hour traffic volumes would approximate 96% of the reduced intersection capacity. This would likely result in formation of long traffic queues along King Street. These conditions would last for about two weeks during the casing work for MH9 and an additional four weeks when the drill rig work area is set up at MH11.

The casing assembly and pullback work at the Pensacola and Piikoi Street intersections would displace one traffic lane along King Street. The two intersections would operate at acceptable levels with afternoon peak hour traffic amounting to 86% of capacity at Piikoi Street intersection and 79% of capacity at the Pensacola Street intersection.

The manhole near Punahou Street (MH14) would be used only for pullback of the casing for the section between MH13 and MH14. Thus, the Punahou Street intersection would be directly affected by neither drill work nor casing assembly work.

Neither the drill site work areas nor the casing assembly work areas should restrict access into/out of the side streets and driveways along the work areas since the makai curb lane would be open for traffic circulation. The presence of the long work area could result in extra traffic circulation if the driver does not realize that he must be in the curb lane to access a driveway until he is past the beginning of the work area.

The sections of King, Cooke, and McCully Streets with ductline constructed by the trenching method would experience traffic impacts similar to those described for the Trenching Option.

The ductline construction would affect availability of on-street parking in the area near the drill site and exit point work areas. Typically, on-street parking would be restricted for a total length of about 1,500 feet along the makai curb along King Street. The restriction would extend from about 300 feet upstream of the drill site work area to about 700 feet downstream of the exit site manhole work area, with this section including the 500-foot long casing layout area.

Traffic and parking would be affected by the cable pulling and splicing work that would occur at every other manhole along the constructed ductline. The work areas would be in place only during the off-peak traffic periods and would affect a 400 to 500-foot section at each manhole.

The HDD would limit the traffic impacts due to repaving King Street. Repaving may only be needed for about a 100-foot long section at each drill site, each exit point, and each shallow trench at major cross streets, plus about 1,800 feet from Washington Middle School to McCully Street. This would require about three nights the King Street HDD work areas, two nights for the Washington-McCully section, one night for paving at the Cooke Street, and one night for McCully Street.

8.6.3. Impacts on Public Transit Routes and Stops

The drilling work should not directly impact the bus stops near the drill site or exit site work areas since these would be located in the #2 and #3 lanes. Likewise, the assembly and pulling of casing/pipe for ductline should not affect bus service along King Street.

The assembled casing for the ductline should not affect bus service along the mauka-makai cross streets since the casing should be located within the shallow trench for those major cross streets with bus service.

The bus routes along Kaheka Street should not be affected if the casing is located far enough away from Lane #1 to allow the buses to make the right turn onto King Street.

The trenching work for the section of the ductline between Washington Middle School and McCully Street should not affect bus stops or bus service along that section.

The HDD option should have less impact during the repaving work than the trenching option since the drilling option would affect a more limited length of King Street around the work areas for the drill sites and the exit sites. Therefore, repaving may only be needed for about 3,200 feet of the length on King Street for the HDD option versus 9,100 for the trenching option.

8.6.4. Impacts on Pedestrian Circulation

The drill site work areas should not require the closure of any crosswalk across King Street or the cross streets. Several crosswalks may be located within the lane transition areas, but this may assist pedestrian crossings by providing a mid-street refuge section of crosswalk.

The crosswalks across King Street at the key intersections should be unrestricted for most of the time since the casing would be located within a shallow, covered trench.

The casing/pipe assembly and pullback near the exit site work areas could severely affect use of many of the other crosswalks across King Street for about 5-6 work days at each location during the time that one of the three casings is present within that section of the #2 traffic lane. The 10-

inch diameter casing located along Lane #2 would serve as an impediment to pedestrian crossings within the 500-foot long section of street the casing occupies for the approximately two days during assembly and pullback on each section of King Street between Cooke Street and Washington Middle School. This interference with pedestrian crossings would occur only along those sections (every second 500-foot section) used as the casing assembly area, with the interference occurring during two separate months on each of these sections as that section is first used for pullback in the Ewa direction (5-6 work days) and later for pullback in the Koko Head direction (5-6 work days)..

The impacts of the construction of the sections of the ductline by trenching along Cooke Street, McCully Street, and along King Street from Washington Middle School to McCully Street would be the same as described for the trenching option.

8.6.5. Potential Actions to Minimize Impacts

One or more additional manholes could be installed to shift the problem manhole locations near Ward Avenue (MH3), Keeaumoku Street (MH11), and Kalakaua Avenue (MH13) to locations further from these intersections. Such shifts could reduce the capacity reduction to one lane and reduce the delays and potential diversion of King Street traffic to parallel routes. However, the additional manholes would result in additional drill sites and increase the overall duration of the HDD work along King Street, as well as increase the number of days the travel corridor is affected by the lane reductions.

The drill site work area for the Ward Avenue and Kalakaua Avenue sites could be reduced to a 15-foot width, thus using only one-half the width of Lane #3. The resulting 36-foot street width mauka of the reduced work area could be re-striped as four 9-foot wide traffic lanes to increase the capacity past the work areas. This increased capacity would result in traffic amounting to about 98% of capacity through the Ward Avenue intersection and to 92% of capacity through the Kalakaua Avenue intersection. This could greatly shorten the delays and traffic queues at these two locations.

The drill site work areas and exit point work areas could be located in the makai (#1) lane from the makai curb, thus locating the ductline under the #1 lane. This would provide general traffic four contiguous lanes on the mauka side of the work areas. However, this would require buses to merge into the general traffic lanes to pass by the work areas, which would increase delay to the buses and passengers. Also, this would place the manholes in the makai curb lane, which could disrupt use of the parking near the manhole during future servicing and repair activities at that manhole.

To reduce the time the casing is located within the street and affecting pedestrian crossings and traffic circulation, the casing assembly could be done the night before the pull back operation, or the day prior to the pullback operation.

Short moveable walkways, less than a lane-width in length, could be constructed to allow pedestrians to cross the casing in Lane #2. The walkways could be used at those crosswalks not at the key signal-controlled intersections where the casing would be placed in a shallow, covered trench to avoid blocking the crosswalk. The short portable walkways could be either a step or ramp design, although neither of these would be fully accessible to all pedestrians. The moveable walkways would be relocated as the work area shifts along the route. Also, advance signs should be placed to warn pedestrians of the affected crosswalks and direct them to alternative routes.

8.7. PARTIAL HORIZONTAL DIRECTIONAL DRILLING OPTION AFTER BRT

For the HDD construction option, the manhole work areas between Cooke Street and Pensacola Street would be located within the section of King Street used for the UH-Manoa BRT line. This section of King Street would contain three drill site work areas (MH1, MH3, and MH5) and three exit point/pullback work areas (MH2, MH4, and MH6).

This section focuses on these and other locations and issues where the presence of the BRT line would alter the construction impacts or possible modifications from those for the HDD scenario without the BRT.

8.7.1. Project Description

The construction work areas and procedures would generally be the same as without the BRT line (Section 8.6.1).

With the HDD construction option, the ductline along Cooke Street to the King Street MH1 drill site work area located in the #2 lane from the makai curb would be constructed by trenching and would cross the BRT line for the Koko Head travel direction located in the makai curb lane.

With the BRT lane, general through traffic would be restricted from the two curb lanes, with the four lanes in the center of the street available for general traffic. The makai curb lane would be a semi-exclusive lane for use by BRT and other transit vehicles, as well as vehicles turning right at cross streets or into driveways. Through vehicles would not be allowed to use the makai-side BRT lane to pass by the six HDD work areas unless permitted by the City. The mauka curb lane would be operated as contra-flow lane for BRT buses only and would not be available for general traffic use to pass by the six work areas.

8.7.2. Traffic Impacts

Traffic impacts would worsen at the six drill site and exit point work areas as compared to the scenario without the BRT due to the reduced number of general traffic lanes and capacity. In the afternoon peak hour, traffic use of the two remaining general traffic lanes along King Street past the drill site work areas at MH1 (Cooke Street), MH3 (near Ward Avenue), and MH5 (McKinley High School) would increase to about 1,600 vehicles per lane past the work areas. The lane-

changing and merging activity would likely result in long traffic queues at each location that extend back to and interfere with traffic operations of the cross streets.

At the three exit point work areas, the 3,300 afternoon peak hour vehicles would be compressed from four lanes into the three general use lanes past the work area, which would amount to about 1,100 vehicles per lane. The merging and lane-changing activity would also result in slowing of traffic and formation of traffic queues.

Each of the key intersections would operate at acceptable levels during the morning and midday peak hour traffic periods with the loss of traffic lanes while the drill sites and pullback work areas are set up at the location nearest to each of the intersections along King Street. However, the loss of traffic lanes during the afternoon peak period would result in severe traffic congestion and lengthy delays at several of the intersections during the afternoon peak period.

The traffic passing through the Ward Avenue intersection, with traffic limited to two lanes on King Street, would exceed the estimated intersection capacity during all three peak traffic periods. In the afternoon peak hour, the estimated traffic would amount to about 53% above the estimated capacity of the intersection (Table 8-4). The estimated delay averages over 13 minutes per vehicle passing through the intersection, which indicates that long queues would likely form on both streets. The substantial delays would result in diversion of traffic to alternative routes. The diversion could amount to about 1,000 or more vehicles per hour in the afternoon peak period, with the diversion amounting to 300 to 500 vehicles per hour in the morning and midday periods. These vehicles would likely seek alternative routes along the H-1 Freeway, Wilder Avenue, Kapiolani Avenue, and Ala Moana Boulevard. Approximately one-half of these vehicles would likely use the H-1 Freeway to bypass the work area on King Street with the remainder using one of the parallel surface streets. These conditions would occur on weekdays for the four weeks that the work area is in place at Ward Avenue.

The analysis of traffic conditions at the Pensacola Street intersection with use of one traffic lane blocked by the exit point site and with the BRT line indicates the afternoon peak hour volumes with amount to 93% of intersection capacity.

Table 8-4
2009 Traffic Conditions With Directional Drilling With BRT Lanes, King Street Corridor

Intersections	Morning Peak Hour			Midday Peak Hour			Afternoon Peak Hour		
	V/C	ADPV	LOS	V/C	ADPV	LOS	V/C	ADPV	LOS
King St.-Ward Ave.	1.16	307.9	F	1.11	202.0	F	1.53	796.2	F
King St.-Pensacola St.	0.63	20.6	C	66.0	21.8	C	0.93	31.4	C

V/C = Ratio of the traffic volume to the theoretical capacity of the intersection.
ADPV = Average delay per vehicle, in seconds.
LOS = Level of service.

Wilbur Smith Associates; July 21, 2004.

8.7.3. Impacts on Public Transit

The impact of the HDD option on public transit would include those identified for the scenario without the BRT.

With the BRT line in place, the trenching of the ductline from Cooke Street to the MH1 drill site work area would require the BRT buses to merge into the general traffic lanes to pass on the mauka side of the work area. To the extent that this nighttime activity was to overlap with the service hours of the BRT line, this would delay the BRT buses and affect schedule reliability for the two days of this activity.

8.7.4. Impacts on Pedestrian Circulation

The location and types of impact of the HDD option on pedestrian circulation would be similar to those identified for the scenario without the BRT. However, the BRT would likely increase pedestrian activity near the Neal Blaisdell Center and Pensacola Street BRT stops, which could increase the numbers of pedestrians affected by the construction.

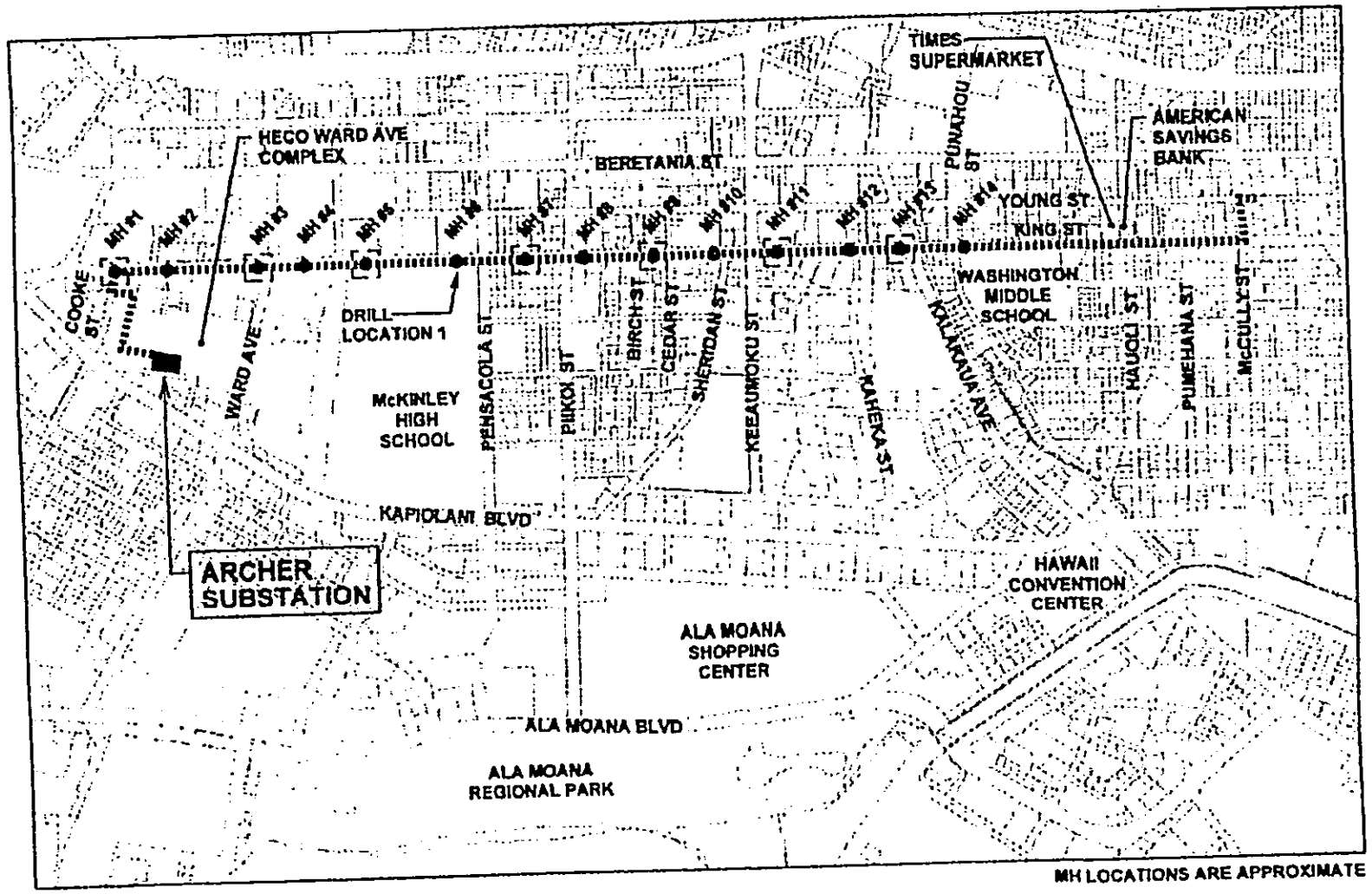
8.7.5. Potential Actions to Minimize Impacts

The most effective mitigative action would be to complete the construction of the EOTP ductline through the Cooke Street-Pensacola Street section prior to the beginning of BRT operation along King Street.

The Ewa-bound BRT lane could be relocated from King Street between Pensacola and South Streets to provide an additional traffic lane during the 4 weeks that the drill site work area is blocking two traffic lanes through the Ward Avenue intersection. The BRT buses could be rerouted via Kapiolani Boulevard-South Street to King Street. If the buses cannot turn into the King Street BRT lane from South Street the buses could continue on Beretania and Richards Streets to rejoin the BRT lane in Downtown.

The traffic impacts could be lessened by the construction of the section of the ductline between Archer Lane and Victoria Street by trenching at nighttime. This would greatly reduce the impacts to King Street and Ward Avenue traffic during the construction of the ductline within or near the intersection of these two streets.

Other potential mitigative actions would be similar to those identified for the HDD option without the BRT line on King Street. However, the removal of on-street parking would not be a potential action since the BRT service along each curb lane would have already eliminated this parking.



2004.33.0800/026-1 d8.8.04 1

Source: Power Engineers, August 2004

Wilbur Smith Associates (Engineers Planners Economists)	333 FAYETTEVILLE ST, SUITE 1450 RALEIGH, NORTH CAROLINA 27601 TELE : (919) 755-0583 FAX : (919) 832-8798	EOTP TRAFFIC IMPACT STUDY HONOLULU, HAWAII	POTENTIAL WORK SITE LOCATIONS, KING STREET HORIZONTAL DIRECTIONAL DRILLING OPTION	FIGURE: 8-1

APPENDIX A
METHODOLOGY FOR ANALYZING INTERSECTION CONDITIONS

The Transportation Research Board (TRB), a division of the National Science Foundation, has developed standardized methods for use in evaluating the effectiveness and quality of service for roadways and streets. Different methodologies are available for analyzing traffic signal-controlled intersections and other types of roadways.

The TRB evaluation methods use concepts referred to as volume-to-capacity ratio and level-of-service (LOS). The volume-to-capacity ratio (V/C) compares the existing or projected traffic volumes on a facility to the facility's theoretical capacity and, as such, indicates the relative adequacy of the facility to accommodate the traffic volumes. Capacity is estimated primarily from the facility's physical characteristics (e.g. number and widths of lanes), and to a lesser extent by the traffic characteristics (e.g. types of vehicles) and type of traffic controls. The level of service concept describes facility traffic conditions in terms of travel delays or travel speeds, with the service quality expressed on a letter basis from A to F, which signify excellent to unacceptable conditions, respectively.

Signal-Controlled Intersections. Traffic conditions at traffic signal-controlled intersections were evaluated using the Operations Analysis methodology described in the *2000 Highway Capacity Manual (HCM).*[1] The methodology calculates a ratio of actual or estimated peak hour traffic volumes to the theoretical capacity of the intersection. This volume-to-capacity ratio (V/C) reflects the physical characteristics of the intersection and the traffic characteristics, and is somewhat independent of the efficiency of the traffic signal phasing/timing. This ratio indicates the proportion of available capacity being used by traffic volumes and where there is unused capacity available for future traffic increases.

With the 2000 HCM method, the level-of-service is based on the average delay per vehicle for the various movements within the intersection as a result of the traffic signal control. This total delay is the difference between the travel time experienced with the traffic signal and the reference travel time that would result under ideal conditions, in the absence of the traffic control and geometric delay. This delay, referred to as control delay, includes initial deceleration delay, stop delay, queue move-up delay, and final acceleration delay. Average delay time and level-of-service is estimated for the entire intersection, for each roadway approach, and for each traffic movement or lane group. A description of the criteria associated with LOS A through LOS F is provided in Table A-1.

In the assessment of traffic signal-controlled intersections, it is usually most appropriate to relate the adequacy of the geometric design features (such as numbers and use of lanes, lane widths, etc.) to the V/C. Delay and LOS are most relevant to assessing modifications to the traffic signal

[1] *2000 Highway Capacity Manual,* Transportation Research Board, October 2000.

controls, since these are most directly related to the signal design features, such as cycle length, number and arrangement of phases, and allocation of green time.

Unsignalized Intersections. At intersections with STOP sign controls, the level of service was calculated using the 2000 HCM procedures for intersections with STOP or YIELD signs. In this methodology, the six levels of service, A through F, are used to describe traffic conditions for those movements that must yield to other movements:

- Left-turn out of the side street or driveway;
- Through movement from the side street,
- Right-turn out of the side street or driveway; and
- Left-turn into the side street.

Through vehicles on the major streets are not required to yield to other movements at two-way STOP controlled intersections.

The general indicator of intersection delay is determined by calculating the one-hour capacity for each key movement, based on the conflicting traffic volumes, and then comparing the number of vehicles making that maneuver to the calculated capacity. The unused or "reserve" capacity for the movement is then used to identify a delay time and a level-of-service for that movement. Unlike analysis at signalized intersections, an overall intersection level-of-service is not calculated, but a level-of-service is calculated for each lane group subject to the STOP or YIELD condition.

The level-of-service criteria for unsignalized intersections with STOP or YIELD controls are defined in Table A-2.

Table A-1

LEVEL-OF-SERVICE CRITERIA FOR INTERSECTIONS WITH TRAFFIC SIGNAL CONTROL

LOS	Average Stopped Delay (seconds/vehicle)
A	<10.0
B	10.1 - 20.0
C	20.1 - 35.0
D	35.1 - 55.0
E	55.1 - 80.0
F	>80

Source: 2000 Highway Capacity Manual, Transportation Research Board, Chapter 16, 2000.

Table A-2

LEVEL-OF-SERVICE CRITERIA FOR UNSIGNALIZED INTERSECTIONS

LOS	Average Stopped Delay (seconds/vehicle)
A	<10.0
B	10.1 - 15.0
C	15.1 - 25.0
D	20.1 - 35.0
E	35.1 - 50.0
F	>50

Source: 2000 Highway Capacity Manual, Transportation Research Board, Chapter 17, 2000.

APPENDIX B
COMPARISON OF REPAVING
FULL STREET WIDTH VERSUS PARTIAL WIDTH

Present ordinances of the City of County of Honolulu require that utility companies repave the area of the street disturbed by their work, with the paved area to extend at least six inches beyond the disturbed area. Typically, the width of the entire lane has been resurfaced.

The City and County of Honolulu has recently set forth a policy that "all trenching work by utility companies on City Streets is to repave the street the length of the trench but no less than 12 feet in length from curb to curb." This would indicate that the entire width of the street should be repaved for the length of the excavation work.

The EOTP work in each area would include the repaving of the streets affected by the construction of the new ductlines. The assessments of traffic impacts in the individual report sections have been based on the present City Ordinance requirements rather than the new policy direction. The following presents a brief comparison of the differences that would occur if the policy of full-width repaving is applied to the EOTP.

Assumptions Used In Comparison

The area included in the repaving under each approach is outlined in the following sections.

Partial Width Repaving

The impact assessments included in the individual report sections (Chapters 4 through 8) have reflected partial width repaving. In each area this has been assumed to provide repaving of the width of one traffic lane along the street section(s) that have been disturbed by excavation work. The excavations for the new ductlines would typically be about 5 feet of width or less. The excavation area to install new manholes would be about 8 feet in width by about 12 to 14 feet in length. Therefore, resurfacing of a normal lane width, usually between 10 and 12 feet, would be adequate to resurface the excavation area and an area extending several feet beyond the excavated pavement.

The repaving work would be done at night for most of the work areas:

- Makaloa-Kapiolani Corridor – All streets in each alternative would be paved at nighttime.
- Pumehana Street Area – All repaving would be done in daytime.
- Date Street Area – The repaving would be done at nighttime.

- Winam Avenue Area – Mooheau and Winam Avenues would be repaved in daytime.
- King Street Corridor – All streets would be repaved at nighttime.

Full Width Repaving

Full-width repaving would indicate the resurfacing of the entire curb-to-curb street width for the length of the area disturbed by the excavation work. This would include resurfacing of the transit stops and BRT lanes.

The streets would be repaved in the daytime or nighttime as indicated for Partial Width Repaving.

For most of the streets, it was assumed that one-half of the street width would be used as the paving work area with the area protected by traffic cones and signing. On-street parking on at least one side of each street would be restricted during the repaving hours.

Impact Upon Traffic And Parking

The following sections summarize the impacts for full width repaving as it differs from the impacts of the partial width repaving described in Chapters 4-8. The differences primarily center around the effects on the duration of the paving work (how long the impacts continue), parking displacement, and bus operations.

The numbers of days/nights that each street would be affected by the repaving work are summarized in Appendix Table B-1.

Makaloa-Kapiolani Corridor

The changes in impacts for the proposed alignment and two alternative alignments are outlined in the following paragraphs.

Proposed Makaloa-Fern Alignment. The excavation work would extend 1,000 feet along Makaloa Street from the Makaloa Substation to Poni Street. Paving full width at nighttime would have the following effects:

- The paving work would extend for 5 nights versus only 2 nights for partial width.
- Parking would be restricted along both sides of the street each night versus only one side for partial width repaving.

Kapiolani-Kaheka Alternative. The excavation would extend for about 3,400 feet along Makaloa, Kaheka, Kapiolani, and Pumehana Street.

- Parking would be restricted along both sides of Makaloa Street each night versus only one side for partial width repaving.
- Bus stops would be affected along both sides of Kapiolani Boulevard versus only the mauka side with partial width.
- Driveway access would be affected along both sides of Makaloa Street and Kapiolani Boulevard rather than one side (partial width).
- The paving work would extend a total of about 9 nights versus 4-5 nights for partial width, with a corresponding increase on impacts to pedestrian crossings, access to bus stops, driveway access, and parking restrictions.

Kapiolani-Kalauokalani Alternative. The excavation would extend for about 3,400 feet along Makaloa, Kalauokalani, Kapiolani, and Pumehana Street.

- Parking would be restricted along both sides of Makaloa Street each night versus only one side for partial width repaving.
- Bus stops would be affected along both sides of Kapiolani Boulevard versus only the mauka side with partial width.
- Driveway access would be affected along both sides of Makaloa Street, Kalauokalani Way, and Kapiolani Boulevard rather than one side (partial width).
- The paving work would extend a total of about 11-12 nights versus 5-6 nights for partial width, with a corresponding increase on impacts to pedestrian crossings, access to bus stops, driveway access, and parking restrictions.

Pumehana Street Area

The excavation work would extend along Lime Street from McCully Substation to Pumehana Street and along Pumehana Street to Date Street, a distance of 720 feet.

- Driveway access would be affected along both sides of Pumehana Street versus only the Koko Head side with partial width repaving. This would impact the Lunalilo School parking lot on the northwest corner of Fern Street.
- The paving work would extend a total of about 2 days versus 1.3 days for partial width, with a corresponding increase on impacts to pedestrian crossings, driveway access, and parking restrictions.

Date Street Area

The excavation would extend for 380 feet along Date Street from just Ewa of the Kamoku Substation to Koko Head of the Ewa end of Laau Street. Paving would be done at nighttime.

- Access to Laau Street and driveways along the makai side of the street would be affected by full width repaving, in addition to the mauka-side driveways that would be affected by partial width.
- TheBus stops would be affected along both sides of Date Street versus only the mauka side with partial width repaving.
- The curb parking stalls would be affected on both sides of Date Street versus partial width paving restricting use of parking only on mauka side.
- The paving work would extend a total of about 2 nights versus less than 1 night for partial width, with a corresponding increase on impacts to pedestrian crossings, driveway access, bus stop relocations, and parking restrictions.

Winam Avenue Area

The excavation work would extend along Mooheau Avenue and along Winam Avenue for a total distance of 420 feet. The paving work would be done in the daytime.

- Driveway access would be affected along both sides of Winam and Mooheau Avenues versus only one side with partial width repaving.
- TheBus stop on the Ewa side of Mooheau Avenue would be affected while no bus stops would be affected with partial width repaving.
- The paving work would extend a total of about 1.1 days versus 0.7 days for partial width repaving, with a corresponding increase on impacts to pedestrian crossings, driveway access, and bus stop access.

King Street Corridor

The excavation requirements and the repaving would differ between the trenching and horizontal directional drilling (HHD) options for the work in the King Street corridor. Paving work would be done at nighttime.

Trenching Option. The entire length of the ductline would be constructed by trenching, with about 420 feet along Cooke Street, 7,500 feet along King Street, and 420 feet along McCully Street. Paving the full street width would have the following impacts:

- Driveway access would be affected along both sides of Cooke and McCully Streets versus only the Koko Head side with partial width repaving.
- Driveway access would be affected along both sides of King Street while the partial width repaving would not affect either side.
- Parking along the mauka curb would also be restricted while that half of King Street is being repaved, while the partial width repaving would affect only the on-street parking along the makai curb.
- TheBus stops along King Street would have to be relocated while no bus stops would be relocated with partial width repaving.
- If the BRT lanes on King Street are in service, the Ewa-bound contra-flow BRT lane would have to be relocated during the repaving of the mauka curb lane of the street.
- The paving work would extend a total of about 20-21 nights versus 10-11 nights for partial width repaving, with a corresponding increase on impacts to pedestrian crossings, driveway access, on-street parking, and bus stop access.

Partial HHD Option. Approximately 6,500 feet of the ductline along King Street would be constructed by HHD. Trenching would be used for the remainder which would include about 420 feet along Cooke Street, 1,800 feet along King Street, and 420 feet along McCully Street. Paving the full street width would have the following impacts:

- Driveway access would be affected along both sides of Cooke and McCully Streets versus only the Koko Head side with partial width repaving.
- Driveway access would be affected along both sides of King Street while the partial width repaving would not affect either side.
- Parking along the mauka curb would also be restricted while that half of King Street is being repaved, while the partial width repaving would affect only the on-street parking along the makai curb.
- TheBus stops along King Street would have to be relocated while no bus stops would be relocated with partial width repaving.
- The paving work would extend a total of about 15-16 nights versus 6-7 nights for partial width repaving, with a corresponding increase on impacts to pedestrian crossings, driveway access, on-street parking, and bus stop access.

Table B-1
Comparison of Number of Work Shifts (Days)
Needed to Repave Partial versus Full Width

Corridor & Alternative or Option	Street Section	Partial Width		Full Width	
		Width of Repaving (feet)	Work Shifts	Width of Repaving (feet)	Work Shifts
Makaloa-Kapiolani Corridor					
Proposed Action Makaloa-Fern	Makaloa St. from Amana St. to Poni St.	10.	2	40t.	5
Kaheka-Kapiolani Alternative	Makaloa St. from Amana St. to Kaheka St.	10.	0.9	40	2.8
	Kaheka St.	11	0.5	64	0.6
	Kapiolani Blvd.	11	2.3	64	4.6
	Pumehana St.	12	0.5	24	0.8
	Totals		4.2		8.8
Kalauokalani-Kapiolani Alternative	Makaloa St. from Amana St. to Kalauokalani	10	2.2	40	6.5
	Kalauokalani Way	12	1.3	24	1.9
	Kapiolani Blvd.	11	1.2	64	2.3
	Pumehana St.	12	0.5	24	0.8
	Totals		5.2		11.5
Pumehana Street Area					
Proposed Plan	Lime St.	12	0.3	24	0.4
	Pumehana St.	12	1.0	24	1.5
Single-Lane Option	Lime St.	12	0.3	24	0.4
	Pumehana St.	12	1.0	24	1.5
Date Street Area					
Proposed Action	Date St.	10	0.7	40	1.9
Winam Avenue Area					
Proposed Action	Mooheau Ave.	12	0.2	24	0.3
	Winam Ave.	10	0.5	17-20	0.8
Single-Lane Option	Mooheau Ave.	12	0.2	24	0.3
	Winam Ave.	10	0.5	17-20	0.8

Wilbur Smith Associates; July 22, 2004

Table B-1 (Continued)
Comparison of Number of Work Shifts (Days)
Needed to Repave Partial versus Full Width

Corridor & Alternative or Option	Street Section	Partial Width		Full Width	
		Width of Repaving	Work Shifts	Width of Repaving	Work Shifts
King Street Corridor					
Proposed Action (Trenching)	Cooke St.	10	0.7	32-36	1.6
	King St.	11	9.3	64	18.3
	McCully St.	10	0.5	64	0.8
	Totals		10.5		20.7
Horizontal Directional Drilling Option	Cooke St.	10	0.7	32-36	1.6
	King St. HDD Section	11	2.3	64	8.4
	King St. Trenching Sections	11	2.8	64	5.3
	McCully St.	10	0.5	64	0.5
	Totals		6.3		15.8

Wilbur Smith Associates; July 22, 2004

Appendix C1

Archaeological Assessment

Pacific Legacy Incorporated

Pacific Basin Division
332 Uluniu Street
Kailua, Hawaii 96734

Phone: 808 263-4800
Fax: 808 263-4300
www.pacificlegacy.com

17 December 2004

Lesley Matsumoto
Belt Collins Hawaii, Ltd.
2153 North King Street, Suite 200
Honolulu, Hawaii 96819

Re: Recent archaeological discoveries at the HECO Ward Avenue facility

Dear Ms. Matsumoto:

I have reviewed the enclosed letter from David Shideler of Cultural Surveys Hawai`i regarding the two human burials identified during archaeological investigations in November at the HECO Ward Avenue facility adjacent to and *makai* of the Catholic Cemetery located on South King Street. I have discussed these investigations with Mr. Shideler and he indicted that Cultural Surveys Hawai`i did not find any other archaeological resources in the area other than the two reported burials. It seems clear that these burials are a *makai* extension of the Catholic Cemetery.

After considering this additional information, the conclusion in my report entitled "Archaeological Assessment for the Hawaiian Electric Company, Inc.: East Oahu Transmission Project – 46kV Phased Project" remains unchanged. I still recommend that "any subsurface features encountered during construction and any inadvertent burials found will need to be treated appropriately and in accordance with governmental requirements."

Please do not hesitate to contact me if you have any questions or concerns.

Sincerely,

Paul L. Cleghorn
Senior Archaeologist
Pacific Basin Division

Enclosure: Letter from David Shideler dated 30 November 2004

CULTURAL SURVEYS HAWAI'I
Archaeological and Cultural Impact Studies
Hallett H. Hammatt, Ph.D.
P. O. Box 1114
Kailua, Hawai'i 96734
Bus: (808) 262-9972; Fax: (808) 262-4950
e-mail dshideler@culturalsurveys.com

November 30 2004

Mr. Nathan Napoka,
Culture and History Branch Chief
State Historic Preservation Division
Room 555 Kākuhihewa Bldg Room 555
601 Kamōkila Blvd.
Kapolei Hawai'i 96707

Subject: Human remains at the Hawaiian Electric Company Kewalo Dispatch Center Project, Kewalo, Kona District, O'ahu

Dear Mr. Nathan Napoka:

Thank you for making a second site inspection on the morning of Tuesday November 30 2004 following the second discovery of human remains on the project the previous afternoon.

It is our professional opinion that the two burials encountered most likely relate to the Roman Catholic King Street Cemetery that lies less than two meters inland of the newly discovered burials. In our interpretation, the following facts support cemetery association: 1) the burials are extended in coffins, 2) they are buried at a depth of 6 feet below the cemetery ground surface, 3) they are oriented *mauka/makai* like the cemetery graves, 4) that the heads are towards the sea like the cemetery graves, 5) that the two burials may be in an 'Ewa/Diamondhead row like the cemetery graves, 6) the general absence of any cultural deposits in the vicinity of the graves, 7) the similarity of the circumstance to the Archer Lane burials that appear to have been an extension of the cemetery, and 8) that adjacent burials of the cemetery are particularly poorly marked (4 of the 7 closest burials have no associated information on the deceased).

The closest burials in the cemetery that have any biographical data are given below.

Margaret K. wife of An Soon Sur 1892-1921 [followed by Chinese characters]

Catherine Hookano Akana 1916-1917

John Ponte 55 years of age

Emma Leialoha Valpoon 1876-1920

John J. Dominici 1925-1927

Juana Monte 1886-1922

Vivian Mendonca 1898-1922

Jacintho T. Carrita 1919 62 years old

Manoel DaSilva 1863-1917

William Chock 1919-1928

Lucia Figuero 1926-1927

---idas Aberon [n.d.]

Manuel Cordeiro 1871-1917

Neighboring burials appear to be mostly Portuguese, although Chinese (An Soon Sur, Chock) and Hawaiian (Akana, E. Leialoha Valpoon) appear to be present as well. The ethnicity of the two burials identified in the current project area is uncertain. It appears most likely the burials are European Catholics who died in the time span c. 1917-1927.

It would appear to us that under these circumstances that the State Historic Preservation Division has sole jurisdiction over the disposition of these remains. It is our understanding that there is no compelling reason to disinter these sets of human remains at this time. We look to the SHPD for guidance regarding the disposition of these remains and guidance regarding any appropriate actions either HECO or Cultural Surveys should undertake at this time.

Sincerely,

David W. Shideler
O'ahu Office Director
Cultural Surveys Hawai'i

cc. Dr. Sara Collins, SHPD archaeology branch chief
Mr. Van Horn Diamond, chair O'ahu Island Burial Council
Ms. Lori Hoo, HECO

ARCHAEOLOGICAL ASSESSMENT FOR THE HAWAIIAN ELECTRIC COMPANY, INC.: EAST O'AHU TRANSMISSION PROJECT – 46kV PHASED PROJECT

Prepared by

C. Celeste LeSuer, B.A.
and
Paul Cleghorn, Ph.D.

Pacific Legacy, Inc.
332 Uluniu Street
Kailua, Hawai'i 96734
(808) 263-4800

Prepared for

Belt Collins Hawai'i, Ltd.
2153 North King Street, Suite 200
Honolulu, Hawai'i 96819

4 August 2004

ABSTRACT

Pacific Legacy, Inc., at the request of Belt Collins Hawai'i, Ltd., conducted an archaeological assessment to be included in an Environmental Assessment (EA) for the Hawaiian Electric Company (HECO). The EA being prepared concerns land areas related to proposed routes for the HECO East O'ahu Transmission Project—46kV Phased Project in Honolulu, O'ahu, Hawai'i.

The purpose of this archaeological assessment is to determine the potential for archaeological resources to be located within the proposed project areas. This assessment will predict the types of archaeological resources that may be present. Finally, this assessment recommends development of appropriate plans for the proper treatment of archaeological and cultural resources.

The current project areas are located on the Honolulu and Waikīkī plains, which include land areas of Kalua`ōlohe and Kapahulu. Early historic accounts describe the land area as having habitation sites, wet and dry land agricultural areas, freshwater artesian wells, salt making ponds, marsh lands, and various types of fish ponds. Following the early contact years (European Contact is dated to the arrival of Captain James Cook in 1778) much of the cultivated land was left fallow. Disuse of this land area was due to Native population migration into the busy Honolulu port and town area, and an overall decrease in population due to the introduction of foreign disease. As the years passed, land use in the areas was increasingly characterized by livestock, grazing land, and residential and business lots. Fish and duck ponds and some marshland agriculture continued. During the years of the Great Māhele much of the land was awarded or sold to foreign persons and Hawaiian *ali'i* who had in recent years been gifted, sold, or mortgaged parcels by the king, other *ali'i*, or the Hawaiian Government. As immigration increased into the 1900s, most of this land was resold in parcels diminishing in size leaving the entire Kewalo and Waikīkī Plains characterized today by dense urbanization.

Six noted sites near the project area routes include three State and National Registered Historic Sites, a Catholic Cemetery, and two buried Hawaiian traditional fishponds. Only two of the three registered historic sites border the project route and none of the three sites will be impacted by the project. In addition, inadvertent discoveries of human remains have been made in several locations in the general vicinity of the project areas.

There are three areas that may require further archaeological investigations. There is a possibility that burials will be encountered on King Street fronting the Catholic Cemetery, because the cemetery boundaries may have been compromised during past widening of King Street. Two traditional fishponds may be encountered during excavations—Loko Opu and a fishpond complex of unknown name. These ponds have not been documented archaeologically. Generally, any subsurface archaeological features encountered during construction and any inadvertent burials found will need to be treated appropriately and in accordance with governmental requirements.

TABLE OF CONTENTS

1.0 INTRODUCTION **1**

1.1 Archaeological Assessment Purpose 1

2.0 PROJECT AREA SETTING **4**

2.1 Phase 1 4

2.2 Phase 2 5

3.0 METHODS **7**

3.1 Scope Of Work 7

4.0 TRADITIONAL AND HISTORIC BACKGROUND **8**

4.1 Summary 9

5.0 SITES ON THE NATIONAL AND STATE REGISTERS OF HISTORIC PLACES **10**

5.1 Thomas Square 10

5.2 Linekona School 10

5.3 McKinley High School 11

6.0 ARCHAEOLOGICAL BACKGROUND **13**

6.1 Soils 13

6.2 Previous Archaeological Investigations 14

6.3 On-going Archaeological Investigations 21

7.0 SUMMARY AND DISCUSSION **22**

8.0 REFERENCES CITED **24**

LIST OF FIGURES

Figure 1: Map of Island of O`ahu with *Moku* (Districts) and *Ahupua`a* 2

Figure 2: Location of the Proposed Action: Phase 1 and Phase 2 3

Figure 3: A Portion of Phase 1 of the Proposed Action, Including Alternate Routes 6

Figure 4: Locations of NRHP Sites 12

Figure5: Archaeological Sites Identified by Historical Maps or Archaeological Investigations 15

Figure 6: Areas of Archaeological Potential 23

1.0 INTRODUCTION

Pacific Legacy, Inc., under contract to Belt Collins Hawai'i, Ltd. conducted an archaeological assessment to be included in an Environmental Assessment concerning areas related to the proposed routes for the Hawaiian Electric Company, Inc. (HECO), East O'ahu Transmission Project—46kV Phased Project in Honolulu, O'ahu, Hawai'i. This project is located within the traditional land divisions or *ahupua'a* of Honolulu and Waikīkī in the district or *moku* of Kona (Figure 1).

The East Oahu Transmission Project is comprised of two independent phases of work, Phase 1 and Phase 2, collectively the "Proposed Action." (Figure 2). Phase 1 involves the installation of 0.5 mile of new underground ductline for 46kV subtransmission lines and related work at eight existing substations. Underground 46kV lines would be installed in the Ala Moana, McCully, Moiliili, and Kapahulu areas in the new ductline and in approximately 0.4 mile of existing underground ductline. Existing 46kV and 12 kV lines would be removed from the existing ductline. Phase 2 involves the installation of 1.9 miles of new underground ductline for 46kV subtransmission lines and related work at one substation. Three underground 46kV lines would be installed in the new ductline in the Kakaako, Makiki, and McCully areas, predominantly along King Street.

1.1 Archaeological Assessment Purpose

The purpose of this archaeological assessment is to determine the potential of encountering archaeological sites or deposits during the course of construction. This potential is assessed by conducting research into the land use history of the area and the results of previous archaeological investigations in the area. The results of these lines of inquiry will be used to determine if there is a potential for encountering subsurface archaeological resources. Resources could consist of cultural deposits, subsurface features such as buried fishponds, pits, pavements, earth ovens, or human remains. One of the goals of this research is to determine the relative sensitivity of different portions of the project areas. It is possible that some areas will have an extremely low potential of containing subsurface resources, while other areas may have a higher potential of containing subsurface resources.

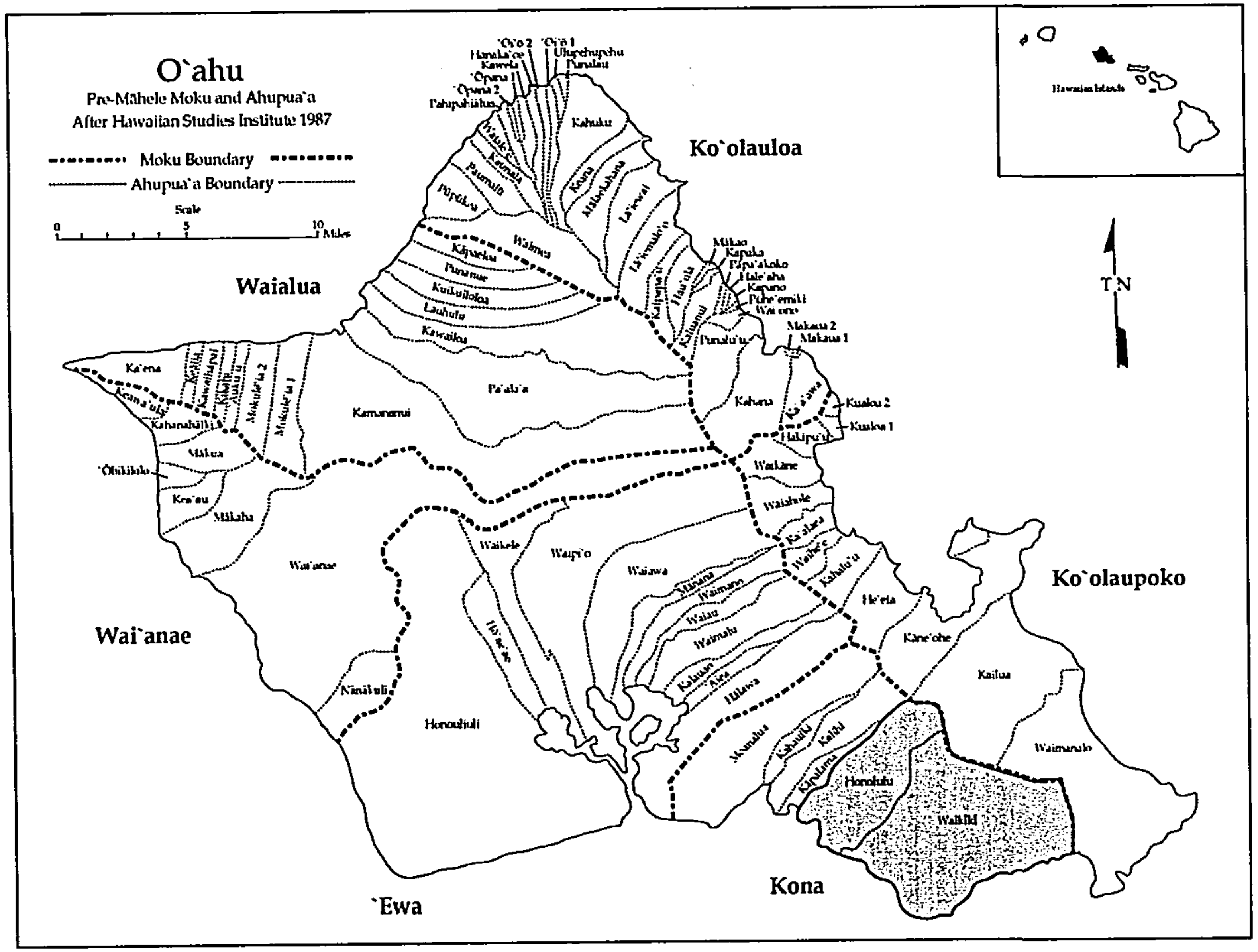


Figure 1: Map of Island of O'ahu with *Moku* (Districts) and *Ahupua'a*

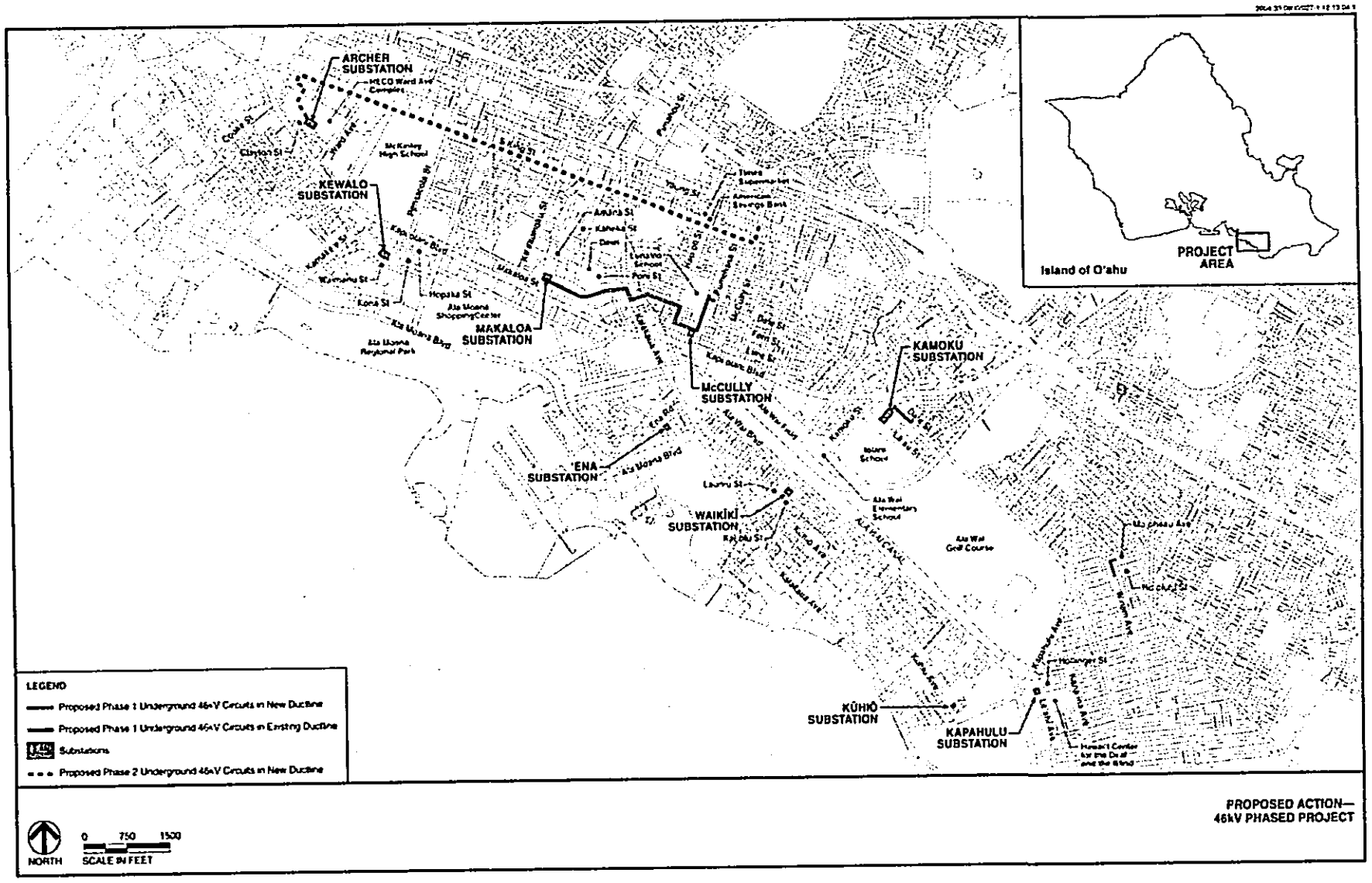


Figure 2: Location of the Proposed Action: Phase 1 and Phase 2 (New 46kV Circuits and Affected Substations)

2.0 PROJECT AREA SETTING

The Proposed Action is located in the southern leeward district of Kona on the island of O'ahu, Hawai'i. Project routes are located within the *ahupua'a* of Honolulu and Waikīkī on the Honolulu and Waikīkī plains and in the land areas of Kaluaolohe and Kapahulu, which all lie between the base of the Ko'olau Mountains and Valleys and the seaward coastline to the south (Figure 1). Downtown Honolulu is to the west and Koko Head is to the southeast. Today the entire project area landscape is urbanized, and the project routes are located on existing public streets, with a small portion on HECO private property (Figure 2).

For the purpose of this report, specific description of the project's multiple area locations will be divided into two sections: Phase 1, including the area from Makaloa Substation to Pumehana Street, Kamoku Substation, a portion of Date Street, and the area near the the intersection of Mo'oheau Avenue and Winam Avenue in Kapahulu; and Phase 2 on and near King Street.

2.1 PHASE 1

Phase 1 of the Proposed Action involves the installation of 0.5 miles of underground ductline for 46kV subtransmission lines and related work at existing substations. Three routes are being considered by HECO for the Makaloa Substation to Pumehana Street area of Phase 1, one preferred route and two alternate routes (Figure 3).

2.1.1 Proposed Action

The Makaloa Substation is located on the northwest corner of Makaloa and Amana Streets, and the McCully Substation is located on the southwest corner of the McCully and Lime Street intersection. Between Makaloa Substation and Poni Street, one new circuit would be installed in the existing ductline, and one new circuit would be installed in the newly constructed ductline. From Poni Street, the two new circuits in the existing ductline would continue until Kalakaua Avenue. At Kalakaua Avenue, the ductline would proceed in the *makai* direction along Kalakaua Avenue for a short distance, until the intersection with Fern Street. The ductline would then proceed in the Koko Head direction along Fern Street until the intersection of Fern and Hau'oli Streets, continue in the *makai* direction along Hau'oli Street, and turn in the Koko Head direction onto Lime Street. After continuing a short distance along Lime Street, the ductline would end at the McCully Substation (Figure 3). This area is referred to as the "Makaloa to Pumehana Area," and this route is referred to as the "Preferred Route."

Additional new ductline construction and 46 kV circuit installation within existing paved roadways proposed under Phase 1 includes the following:

-- one new 46 kV circuit, approximately 720 feet long, installed in a new ductline between the McCully Substation and an existing overhead 46 kV circuit near the intersection of Date and Pumehana Streets;

-- one new 46 kV circuit, approximately 50 feet long, installed in a new ductline between the Kamoku Substation on the *makai* side of Date Street and the existing overhead 46 kV circuit on the *mauka* side of Date Street (the "Kamoku/Date Street Area"); and

-- one new 46 kV circuit, approximately 330 feet long, installed in a new ductline from the Kamoku Substation proceeding in the Koko Head direction on Date Street to the existing overhead 46 kV circuit on the *mauka* side of Date Street (the "Kamoku/Date Street Area");

-- one new 46 kV circuit, approximately 420 feet long, installed in a new ductline between an existing overhead 46 kV circuit on Winam Avenue and an existing overhead 46 kV circuit on Mo'oheau Avenue (the "Winam Avenue Area").

2.1.2 Phase 1 Alternative Alignments

In addition to the Preferred Route described above as part of the Proposed Action, HECO considered the use of two alternate routes, both utilizing Kapiolani Boulevard, for the circuits in the new ductline between the Makaloa and McCully Substations.

2.1.3 Alternative Alignment 1

Between the Makaloa Substation and McCully Substation, Alternative Alignment 1 would proceed as follows. From the Makaloa Substation, the circuits in new ductline would exit the substation to Makaloa Street, proceed in the Koko Head direction until Kaheka Street, continue on Kaheka Street in the *makai* direction to Kapi'olani Boulevard, and proceed in the Koko Head direction on Kapi'olani Boulevard to Pumehana Street. At Pumehana Street, the circuits in new ductline would then proceed in the *mauka* direction to Lime Street at the McCully Substation (Figure 3).

2.1.4 Alternative Alignment 2

Between the Makaloa Substation and McCully Substation, Alternative Alignment 2 would proceed as follows. From the Makaloa Substation, the circuits in new ductline would exit the substation to Makaloa Street, proceed in the Koko Head direction to Kalauokalani Way, continue on Kalauokalani Way in the *makai* direction to Kapi'olani Boulevard, and proceed in the Koko Head direction on Kapi'olani Boulevard to Pumehana Street. At Pumehana Street, the circuits in new ductline would then proceed in the *mauka* direction to Lime Street at the McCully Substation (Figure 3).

2.2 PHASE 2

Phase 2 of the Proposed Action has one proposed route. This route begins at the Archer Substation near the corner of Cooke and King Streets. It travels `Ewa along a HECO service road and parking lot areas, from the *mauka* `Ewa corner of the substation until it intersects with Cooke Street where the route turns right (*mauka*) for a short distance, turning Koko Head onto King Street. Phase 2 continues Koko Head on King, turning *mauka* (NE) at McCully Street and ending at the intersection of Young and McCully Streets (Figure 2). This area is referred to as the "King Street Area."

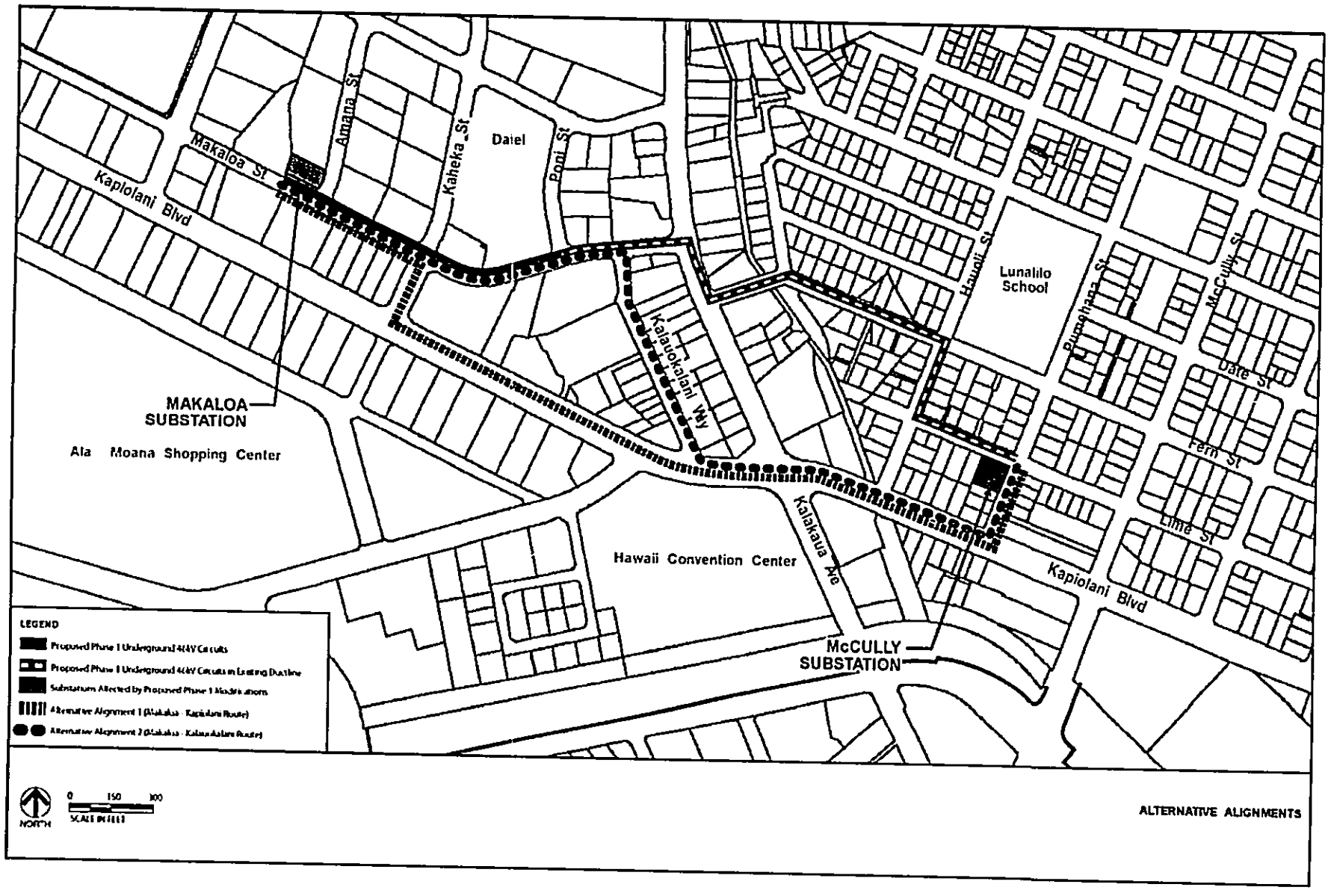


Figure 3: A Portion of Phase 1 of the Proposed Action, Including Alternate Routes

3.0 METHODS

The archaeological assessment was limited to archival research. No field investigations took place because of the developed nature of the project areas. Archival and documentary research was conducted in the following repositories:

- Historic Preservation Division Library and GIS files
- State Archives
- Hawai'i State Library
- Mission House Library
- Hawai'i State Survey Office
- Hamilton Library Hawai'i Pacific Collection at the University of Hawai'i, Mānoa

Archival research was conducted in an area beyond the general vicinity of the project areas. The level of effort focused on previous investigations in the vicinity to obtain an understanding of the potential the project has to encounter archaeological deposits. The general boundaries of this research extended from Beretania Street to Ala Moana/ Ala Wai Boulevards in a *mauka – makai* direction, and from Cooke Street to Kapahulu Avenue in a `Ewa – Koko Head Direction. The research area also included the area near the intersection of Winam Avenue and Mo'oheau Avenue, east of Kapahulu Avenue.

3.1 Scope Of Work

Research focused on the two specific project areas, which are traditionally known as Kewalo and Pāwa'a, and located on the flat lands between Honolulu and Waikīkī. The scope of work for this archaeological assessment includes:

- Traditional legendary and historic background description and accounts by Native Hawaiian historians of the pre-contact and early contact environment of Hawai'i.
- Early accounts and descriptions concerning the project area by early foreign visitors.
- Nineteenth Century document search, including maps and Māhele documents.
- Twentieth Century State Government document search.
- State and Federal Historic Registered Sites identification, including burials.
- Previous archaeological investigations in the immediate vicinity of the project areas.
- Burials encountered on archaeological sites or inadvertently on construction sites.

4.0 TRADITIONAL AND HISTORIC BACKGROUND

A review of the traditional background of the area is provided in the accompanying Cultural Impact Assessment (LeSuer and Cleghorn 2004). This material is not repeated here and the reader is referred to LeSuer and Cleghorn (2004). However, two specific findings are relevant for the current archaeological assessment.

In the research of the Land Commission Awards (LCAs) of the Great Māhele, the existence of two fishponds was documented. These were in the LCAs of 706 and 8241.

LCA 706 was awarded to Kukuna Neki. A historic map of Kukuna Neki's property, where Phase 2 of the Proposed Action begins, shows a three part traditional fishpond (LeSuer and Cleghorn 2004:31). The claimant, Kukuna Neki addressed the Māhele committee on September 2, 1847:

> I hereby state my claim for my lot, as follows: it was from my makuas to me. It is outside of the kula of Kahua, makai of the road to the French lot.
>
> This is the place where my lot is situated. That is my explanation to you. (Reynolds 1847:307, no. 706; as cited in LeSuer and Cleghorn 2004:31)

On February 7, 1848, John Ii gave sworn testimony for the claimant (Kukuna Neki). The original testimony hand written in English:

> ...This place is bounded on Waititi side by the French burying grounds. Makai by a fence on the edge of a fish pond, Ewa by Puniwai place; Mauka by Waititi road. It is imperfectly fenced, and has two adobie houses on it. Claimant lives there. I think Jackson and his wife took this place in 1836, when they died it fell to Claimant and her sisters and Hana Haalilio, who have equal rights. (Ii 1848:177, 178; as cited in LeSuer and Cleghorn 2004:31)

John Ii (1800?-1870) was a prominent and well respected Hawaiian who was closely aligned with the Kamehameha family. He served as a member of the House of Nobles and the Privy Council. He was an associate justice of the Superior Court, a Supreme Court justice, and served on the Māhele Board of Commission Officers and the committee to draft the constitution of 1852 (Day 1984:55, as cited in LeSuer and Cleghorn 2004:18).

John Ii's family held extensive property on several islands. One of his claims (LCA 8241) included a traditional pond named Loko Opu which he later sold to the government. The surveyor, Mr. Alexander in describing the Ii's location boundaries testified that:

> "makai westerly corner the pond of Opu, said to be the "Kumu" of the land of Opu or Makiki, of Kamehameha V is cut off the line following a well established fish pond bank or kuaona [Kuauna]."(Alexander 1874:4, as cited in LeSuer and Cleghorn 2004:20)

Loko Opu is also listed in the State Survey Office Green Book of Artesian Wells and is described as:

> "Government well in Miki, in a lot purchased from J. Ii's Estate, "Niagara Well". Elevation of ground 12.0 feet. Water in stand pipe 42.5 feet above sea level. Diameter of pipe 6 inches. Estimated flow 1½ millions of gallons per 24 hours, when open." (State Survey Office nd: entry 5, page 1, as cited in LeSuer and Cleghorn 2004:20).

Niagara Well is likely the traditional pond Loko Opu. Loko Opu is in the vicinity of the HECO Makaloa Substation, and sediments associated with this pond may be encountered during project excavations at the substation site.

4.1 SUMMARY

The current project areas are located on the Kewalo and Pāwa'a flat lands of Kalua`ōlohe and Kapahulu, all within the *ahupua'a* of Honolulu and Waikīkī. Legendary and early historic accounts describe the land area between the communities of Honolulu and Waikīkī as including habitation sites, wet and dry land agricultural areas, artesian freshwater springs, salt making ponds, marsh lands, and various types of fish and duck ponds.

Following the early contact years much of this cultivated plain was left fallow. Disuse of this land area was due to Native population migration into the busy Honolulu port and town area, and an overall decrease in Native Hawaiian population due to the introduction of foreign disease.

As post-contact years passed and the foreign population increased, land use on these plains changed. There was an increase in habitation sites especially by foreigners. While fish and duck ponds and some marshland agriculture continued, these cultural practices decreased. A few foreign business ventures began to appear and the plains became characterized with an increasing amount of livestock. Much of the once cultivated land become fallow and was then used for grazing.

During the years of the Great Māhele (1848-1852) much of the land area was awarded or sold to foreign persons and Hawaiian *ali'i* who had in recent years been gifted, sold or mortgaged parcels by the king, other *ali'i*, or the Hawaiian Government. As immigration increased into the nineteen hundreds most of this land was resold in subdivided parcels—continually diminishing in size. Today, the entire Honolulu and Waikīkī plain is densely urbanized.

The land area transformed from a traditional Hawaiian cultural landscape into a Western urban landscape. This transformation was influenced by its position between two busy centers of population—Kou (Honolulu) and Waikīkī —both culturally active throughout pre and post-contact Hawai'i.

5.0 SITES ON THE NATIONAL AND STATE REGISTERS OF HISTORIC PLACES

Three historic sites along Phase 2 of the Proposed Action have been placed on the State and National Registers of Historic Places (SRHP and NRHP) because of their local and national significance (Figure 4). No SRHP or NRHP sites have been recorded along Phase 1 of the Proposed Action or the alternative alignments. The Phase 2 NRHP sites are briefly described below.

5.1 THOMAS SQUARE

The Thomas Square Park is located at the northeast corner of the intersection of King and Ward Streets. It is bounded by King Street (south), Beretania Street (north), Ward Avenue (west), and Victoria Street (east). Thomas Square was placed on the Hawai'i Register of Historic Places on March 23, 1972 and assigned identification number 80-14-9990. In 1974, Thomas Square was placed on the National Register of Historic Places (NRHP). The NRHP identifies the historic importance of Thomas Square:

> In early 1843, Lord George Paulet, representing the British Crown, overstepped his bounds, landed sailors, seized the government buildings in Honolulu and forced King Kamehameha III to cede the islands to England. When Queen Victoria learned of this injustice she dispatched Admiral Richard Thomas to the islands to restore sovereignty. On July 31, 1843, pompous ceremonies were held restoring the Hawaiian Kingdom. From that time the plot of land on which the ceremonies took place has been known as Thomas Square. Kamehameha later officially designated the area after Thomas and in 1850 the area was enlarged. A fountain sits in the middle of the park and banyan trees lend dignity to the foliage. (NRHP 1974:132).

5.2 LINEKONA SCHOOL

Linekona School is located across Victoria Street from Thomas Square on the *mauka*-Koko Head (mountain side; northeast) boundary of Thomas Square. It is bounded today by Victoria Street (west), Beretania Street (north), and Young Street (south). Linekona School does not border the Phase 2 route. Linekona School was placed on the Hawai'i Register of Historic Places on December 17, 1979. Linekona School was placed on the National Register of Historic Places following its federal nomination by the State of Hawai'i in 1979. The National Register of Historic Places Inventory Nomination Form, submitted by the State of Hawai'i, identifies the historic importance of Linekona School:

> The Linekona School is significant as a well-preserved school complex. Architecturally, it is important as a splendid example of turn-of-the-century eclecticism applied to a public building in Hawaii...The mimetic perpetuation of the blue stone motif in the well rendered concrete blocks used on the building is the best known example of this type of craftsmanship in Hawaii, and is well worth preserving...The school is also significant in the history of

> education in Hawaii. At the time of its dedication, its history was traced back to the O'ahu Charity School, which was established in 1831. Instituted as a school to teach the English language to half-whites, it was for a number of years the only English-speaking school in Hawaii, . . . Built on the old Maertents property and facing Thomas Square (NR), the Linekona School is also significant in its contribution to the ambiance of this park area. (NRHP 1979: Significance)

5.3 McKinley High School

McKinley High School is located on the *makai* side (SW) of South King Street at the southwest corner of the intersection of King and Pensacola Streets. It is bounded by South King Street (NE), Kapi'olani Boulevard (SW), Pensacola Street (SE), and the Blaisdell Center property (NW). McKinley High School was placed on the Hawai'i Register of Historic Places on May 3, 1980 and assigned identification number 80-14-9926 (TMK 2-3-9-1). In August of 1980, McKinley High School was placed on the National Register of Historic Places. The National Register of Historic Places Inventory Nomination Form, submitted by the State of Hawai'i, identifies the historic importance of McKinley High School:

> The McKinley High School is significant in the history of education in the State of Hawaii as the oldest high school in the State (sic; Lahainaluna School that opened in 1831 is actually older) and the leading public school in Hawaii during the nineteen twenties and thirties...in 1922 plans were drawn...for a new campus on King Street...Among its 1929 student body of 2,339, 43% were Japanese, 20% were Chinese, 11% Hawaiian, 10% haole (white) and 4% Portuguese. Throughout this decade McKinley offered the general public, which was primarily non-white, a level of education previously obtainable only at haole (white) dominated private schools. The person primarily responsible for the position of McKinley as a harbinger of democratic principles and racial acceptance was Miles E. Carey, the school's principal from 1924 to 1948. McKinley High School is also architecturally significant as one of the most elegant examples of Spanish Colonial revival architecture in Hawaii, (NRHP 1980: Significance)

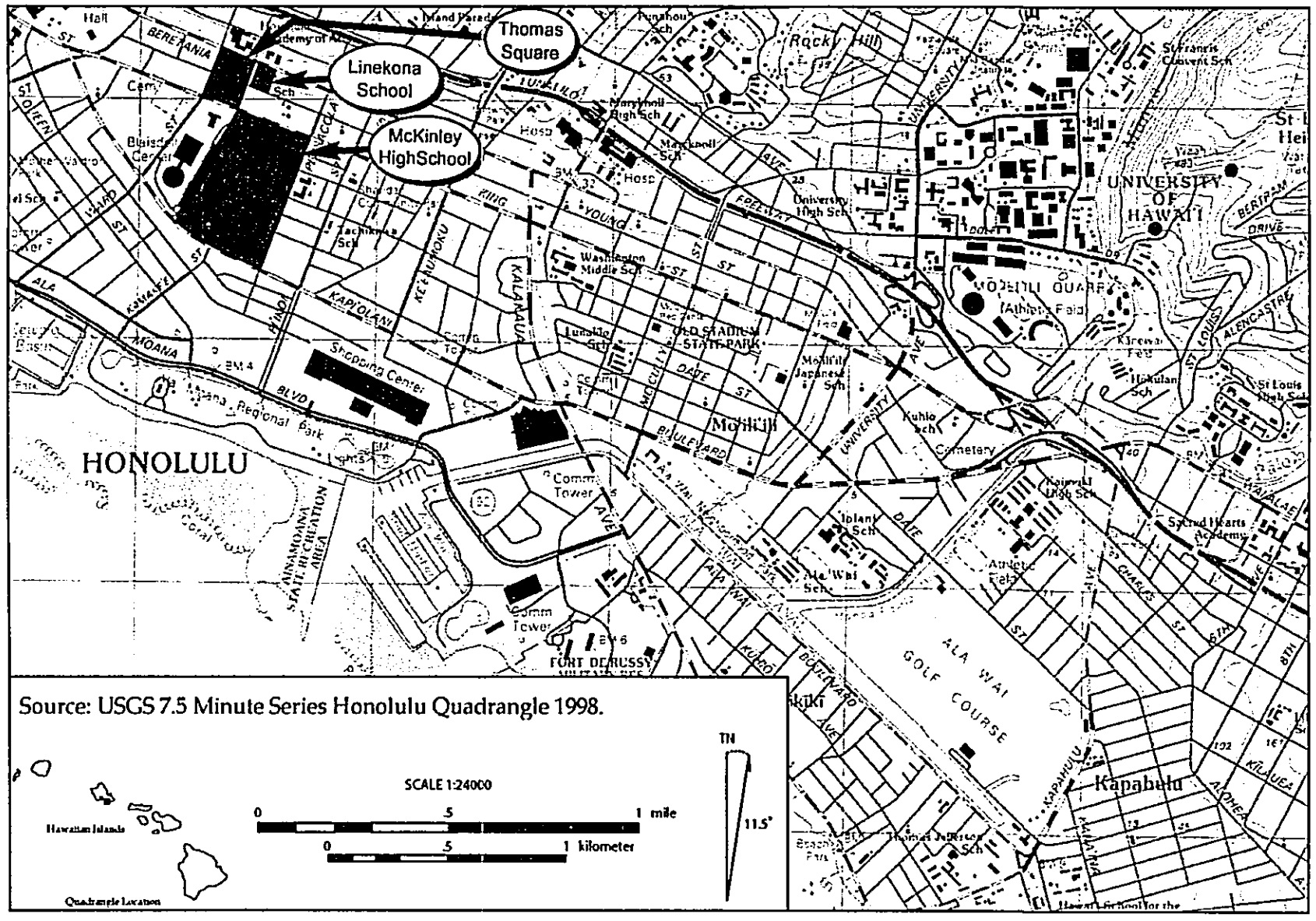


Figure 4: Locations of NRHP Sites

6.0 ARCHAEOLOGICAL BACKGROUND

Only a few archaeological projects have been conducted in the general vicinity of the proposed HECO project routes. Much of the information about the early-contact use of the area is tentative and unconfirmed archaeologically. The archaeological reports summarized below are the most relevant by proximity. Figure 5 shows the locations of archaeological resources that have been documented during these archaeological investigations or identified on historic maps. This section begins with a general description of the soils to be expected in the project areas.

6.1 SOILS

Sediments of the traditional Hawaiian landscape on the Kewalo and Waikīkī plains are to a large extent buried beneath fill deposits resulting from the land reclamation activities of the 1920's and 1930's (Nakamura 1979). The General Soil Map for O'ahu (Foote, et. al. 1972) designates the general soil association for the southern coastal flatlands as Lualualei-Fill land-'Ewa association sediments. Foote et al. (1972) characterize this association as including deep, nearly level to moderately sloping, well drained soils that have fine textured or moderately fine textured subsoil or underlying material, and areas of fill land. A finer soil delineation on O'ahu shows that the Phase 1 areas include: soils designated Ph at the Makaloa Substation; EmA, KIA, and FL for the Makaloa to Pumehana Area, includingthe two alternative alignments considered by HECO; soil designation KIA for the Kamoku/Date Street Area; and soil designation MuB for the Winam Avenue Area. Phase 2 in the King Street Area is almost entirely designated as MkA soils except a small portion of FL soils at the King and McCully Streets intersection, where the project route turns (NE) toward Young Street (Foote et al. 1972: Map 62). These soils are described below:

EmA: 'Ewa silty clay loam, moderately shallow, 0 to 2 percent slopes. The depth to coal limestone is 20 to 50 inches. Runoff is very slow, and the erosion hazard is no more than slight. A few small areas were less than 20 inches deep. This soil is (can be) used for sugarcane, truck crops, and pasture (Foote et al. 1972:30).

KIA: Kawaihapai clay loam, 0 to 2 percent slopes. This soil occupies smooth slopes. Included in mapping were small areas where the slope is 3 to 7 percent and the texture is silty clay. Also included were small areas of poorly drained soils and small areas of Jaucas soils. Permeability is moderate. Runoff is slow, and the erosion hazard is no more than slight. The available water capacity is about 1.8 inches per foot in the subsoil. In places roots penetrate to a depth of 5 feet or more. In some places this soil is subject to flooding. This soil is used for sugarcane, truck crops, pasture, and orchards (Foote et al. 1972:64).

FL: Fill land, mixed. This land type occurs mostly near Pearl Harbor and in Honolulu, adjacent to the ocean. It consists of areas filled with material dredged from the ocean or hauled from nearby areas, garbage and general material from other sources. This land type is used for urban development including airports, housing areas, and industrial facilities (Foote et al. 1972:31).

Ph: This soil is on low coastal plains . . . the surface layer is a very dark gray, mottled clay about 12 inches thick. The subsoil is about 19 inches thick, is very dark gray and very dark grayish-brown, mottled clay that has angular and subangular structure. The substratum is muck or peat. . . Permeability is very slow. Runoff is very slow to ponded, and the erosion hazard is no more than slight (Foote et al. 1972: 112)

MuB: Molokai silty clay loam, 3 to 7 percent slope. On this soil, runoff is slow to medium and the erosion hazard is slight to moderate. Included in mapping were a few small areas that are eroded to soft, weathered rock. Also included in mapping on Oahu were small areas of dark reddish-brown silty clay loams that overlie fine-textured, gravelly alluvium and small areas of dark reddish-brown silty clay soils that have a mottled subsoil. This soil is used for sugarcane, pineapple, pasture, wildlife habitat, and homesites (Foote et al. 1972:96).

MkA: Makiki clay loam, 0 to 2 percent slope. These soils are on well-drained soils on alluvial fans and terraces in the city of Honolulu. These soils formed in alluvium mixed with volcanic ash and cinders. . . . This soil contains cinders and rock fragments, underlain by a massive but similar subsoil. Volcanic cinders lie below this strongly acid to medium acid soil. Permeability is moderately rapid. Runoff is slow, and the erosion hazard is no more than slight. The available water capacity is about 1.7 inches per foot of soil. In places roots penetrate to a depth of 5 feet or more. This soil is almost entirely in urban use (Foote et al. 1972:91).

6.2 Previous Archaeological Investigations

Ogden Environmental and Energy Services Co., Inc. conducted historical background research for the property at 802 Punahou Street (Anderson 1995a). This portion of Punahou Street is located *makai* (south) of King Street, east of Kalākaua Avenue, north of Fern Street, and on the west side of Punahou Street. This land area was traditionally known as Pāwa'a. The purpose of this study was to assess the potential for significant subsurface archaeological resources in the project area (Anderson 1995a:1). The surrounding land area was given to the missionary Gerrit P. Judd in 1839; the King's gift to Mr. Judd became Land Commission Award claim 660 on August 31, 1847 (Anderson 1995a:13).

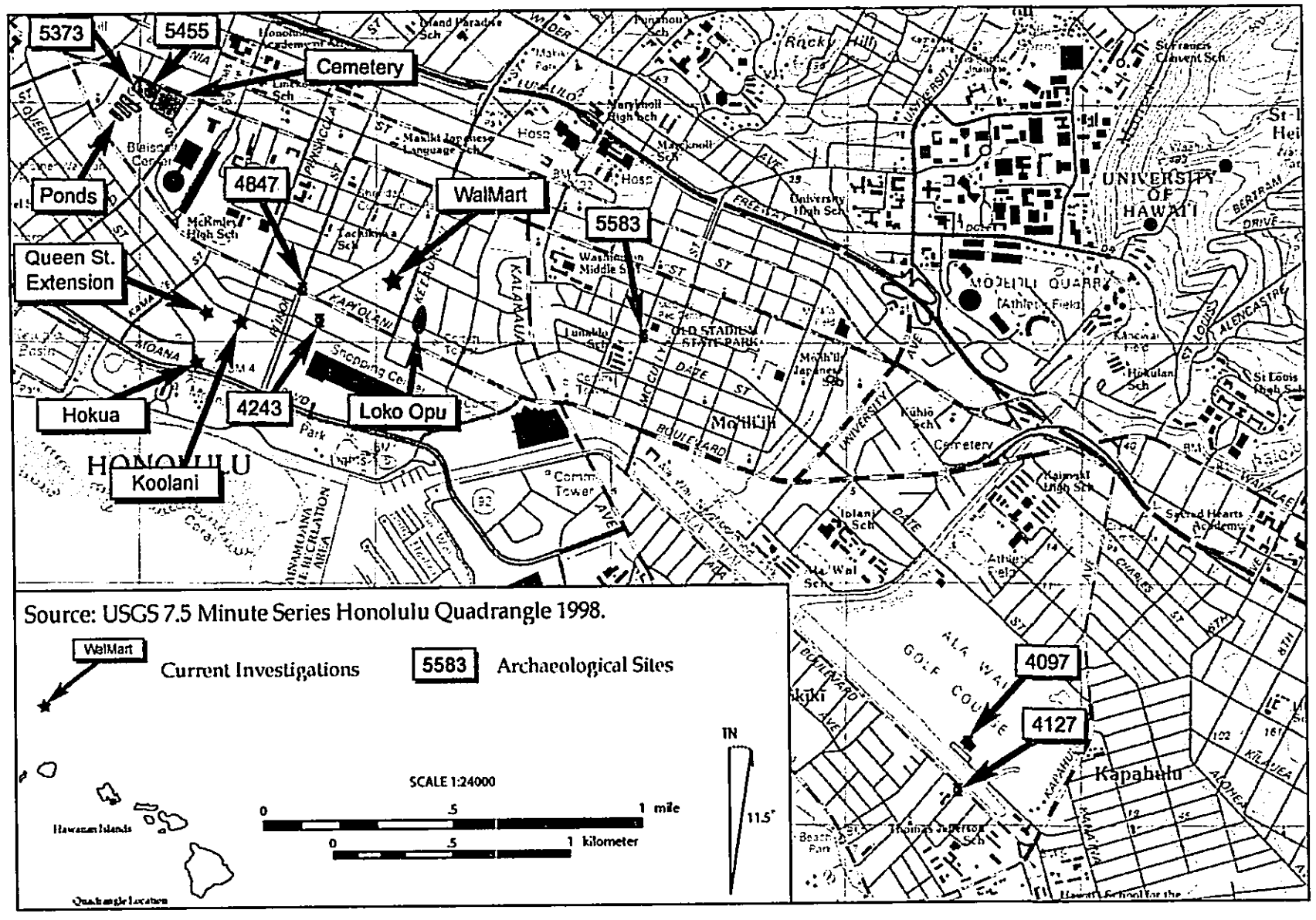


Figure 5: Archaeological Sites Identified by Historic Maps or Archaeological Investigations

In Mr. Judd's testimonial claim he describes the land parcel as "containing 12 acres, more or less of pasture ground...the greater part was an unproductive marsh, the rest completely destitute of vegetation except a few cocoa-nut trees." (Anderson 1995a:13). Anderson concluded that:

> The Waikīkī area has been widely noted in early historical documents as being an area of intense cultivation...It is possible that the project area was utilized for wetland agriculture in pre-Contact times, then due to population decline, the land was abandoned until it was awarded to Gerrit Judd, who reused the property for *lo'i* and pasture lands. Stratigraphic deposits consistent with wetland agriculture may be present in the project area, as well as associated agricultural or habitation sites. (Anderson 1995a:17).

On January 21, 1998, Cultural Surveys Hawai'i reported that human remains were inadvertently encountered on January 16, 1998 at the intersection of Citron and Pumehana Streets (Winieski 1998). The burial was found at 60-70 cm below surface in a moist and very dark gray to black layer of compact plastic clay (Winieski 1998:2). State Site number 50-80-14-5583 was assigned by SHPD (Figure 5). The stratigraphy above this dark clay layer consisted of a 35 cm thick layer of coral fill under a 10 cm gravel pad topped with 10 cm of road asphalt (Winieski 1998:2). Winieski reported that it was not possible to determine cardinal orientation, whether the burial was flexed or extended, or if the burial was *in situ* (1998:2). Given the condition and stratigraphic position of the exposed skeletal remains, Winieski posed that it is possible that the burial was disturbed during construction of the road, and that no skeletal remains were found in the overlying coral fill (1998:2). "No artifacts, midden, grave goods, or coffin remains were observed" (Winieski 1998:2).

Marc Smith (State Parks archaeologist) reported that one human skeletal remain was inadvertently found on a construction site at 1341 Kapi'olani Boulevard (Smith 1989:1). It was found near the back (*makai*) side of the property. No additional human remains were found during the on site inspection, and it was collected and turned over to SHPD.

After analyzing the piece of bone found by Mark Smith, Michele Douglas reported that "SHPD #120 is...a single human left femoral shaft missing both the proximal and distal ends...The size and gracility of the shaft suggest that it is from a female...Loss of the ends of the bone appears to have occurred some time prior to recovery of the bone as the broken ends are also discolored...There is insufficient evidence to determine ethnicity of this long limb bone" (Douglas 1991:1). State Site number 50-80-14-4243 was assigned to this find by SHPD (Figure 5).

In June of 1994, International Archaeological Research Institute, Inc. reported on inadvertently discovered human remains at the intersection of Pi'ikoi and Kapi'olani Boulevard (Athens et al. 1994). Athens et al. state that "a single individual had been interred in a wetland environment at the time of death" (1994:iii). Osteological analyses concluded the remains represented a substantially complete skeleton of a 12 to 15 year old female of probable Hawaiian/Polynesian ancestry (Athens, et al. 1994: iii). Radiocarbon analysis indicates the individual died between the 13th and 15th centuries, and that the cause of death was likely "severe bone infection of the right pubis" (Athens, et al. 1994: iii). "*Cribra orbitalia* observed in the adolescent's skull and hypoplastic defects in the teeth suggest the probability of nutritional, emotional, or

physiological stress during the first decade of her lifetime."(1994:46). Athens concluded that the wetland deposition of the remains suggests the location was not a result of an intentional burial. State Site number 50-80-14-4847 was assigned to this burial by SHPD (1994: iii) (Figure 5).

In July of 1991, archival research was conducted for portions of Mo'ili'ili and Waikīkī by Allan Schilz (1991) of the Environmental and Energy Services Company, Inc. The purpose of this study was to evaluate potential subsurface archaeological resources within the proposed water line route. This route began at Young Street and traveled south on McCully Street where it turned east onto King Street then south on Wiliwili Street and west onto Kapi'olani Boulevard, at McCully Street the route turned south to the Ala Wai Bridge veering eastward across the Ala Wai Canal onto the Ala Wai Boulevard turning west to McCully Street and south to Kalākaua Avenue where the path turned eastward on Kalākaua Avenue ending at Kūhīo Avenue. Schilz concluded that "clearly, there exists a potential for significant buried historic and prehistoric resources within the proposed pipeline corridor...This is particularly true as the corridor approaches Waikīkī and Kalākaua Avenue" (1991: 10).

In November of 2003, Cultural Surveys Hawai'i, Inc. reported findings from an archaeological subsurface inventory survey for an approximate six acre lot on the *mauka* (N) side of Kapi'olani Boulevard. This property is bounded by Pensacola, Kamaile, and Pi'ikoi Streets (O'Hare, et. al 2003). The purpose of the project focused on the evaluation of significance for any subsurface cultural deposits found during subsurface backhoe trench testing. Twenty-four test trenches were excavated. Two sites were registered and assigned numbers by SHPD; Site 50-80-14-6636 identifies a former wetland and berm, and Site 50-80-14-6637 identifies an historic dump dating from 1920 to 1940, based on an analysis of historic glass artifacts. No further archaeological work was recommended for this project area.

An archaeological and historical assessment was conducted by Paul H. Rosendahl, Ph.D., Inc. (PHRI) for the area of the proposed Hawai'i Convention Center, located at the corner of Kalākaua Avenue and Kapi'olani Boulevard (Maly, et al. 1994). Maly writes that "Based on legendary and early historic period accounts of the Kālia-Waikīkī area, and on the previous archaeological research in Waikīkī, a variety of functional features...are expected to have once been present in the project area" (Maly, et al. 1994:32). The authors continued, identifying potential subsurface features as: agricultural terraces, fish ponds, architectural walls, platforms, terraces, enclosures, alignments, earthworks, midden, refuse deposits, sleeping houses, cooking houses, ceremonial structures, sheds, men's houses, and human burials (ibid). In addition to these potential features, PHRI completed a study of historic maps where they identify the location of a large fishpond—Loko Kūwili— and the Land Commission Award (4572) that includes Loko Kūwili, located at the west boundary of the project area (Maly, et al. 1994:18). It was recommended that a systematic subsurface trench excavation be conducted to identify potential intact stratigraphy pre-dating the land reclamation projects and any intact cultural deposits (Maly et al. 1994:32).

In November of 1996, Cultural Surveys Hawai'i finalized an archaeological data recovery report on the Hawai'i Convention Center site assessed above by PHRI (Hammatt and Shideler 1996). Data recovery findings concluded that "no clear evidence that Kūwili Pond sediments are

present within the project area" (Hammatt and Shideler 1996:23). No further work was recommended (Hammatt and Shideler 1996:24).

In January of 1995 Ogden completed historical background research for the property at 809 South King Street, in Honolulu (Anderson 1995b). This property is adjacent to a Catholic Cemetery and both parcels front the makai side of King Street, along Phase 2 of the Proposed Action. The purpose of this study was to assess for potential subsurface archaeological resources; with a focus on prehistoric Hawaiian agricultural and habitation deposits, historic deposits, and human burials related to the adjoining Catholic Cemetery parcel (Anderson 1995b:1). Anderson writes that the results of historic map research "showing the cemetery indicate that the boundaries of the cemetery have changed over time...However, the boundary that adjoins the project area appears to have stayed relatively unchanged. Therefore, it is unlikely that burials related to the cemetery are located in the project area, although it is possible that some unmarked burials were not accounted for when the cemetery boundaries were established," (Anderson 1995b:8). Regarding the initial use of the Catholic Cemetery, Anderson indicates that the earliest headstone has a date of 1841 (Anderson 1995b:5); two maps dating to circa 1847 depict this cemetery as well (Anderson 1995b:Figures 9, 10). It is possible that the cemetery was initially used a little earlier, but it seems certain that it was in use by about 1841.

Anderson's research reflects that the south King Street area was utilized as residential space by the early to mid-1800s, and that it is likely to have been used in the same manner in pre-contact times (1995b:8). Anderson suggested that the archaeological resource potential for this project area might include: foundation remains, living surfaces, trash pits, outhouses, and garden or activity areas (1995b:8). Finally, Anderson posed that human burials unrelated to the Catholic Cemetery could also be expected.

Anderson's archaeological inventory survey report contained analyses of Western material culture from two trash pit features—of housewares, bottles and ceramics. These analyses dated one trash pit (Feature 3) from 1815-1910, and another trash pit (Feature 5) from 1821-1929 (Anderson 1995c:83). One traditional artifact—a basalt adze fragment—was found while the area around Feature 3 was being excavated with a back-hoe (Anderson 1995c:83). A total of five pit features (1-5) were recorded. Features 1, 2, and 4 are described as modern trash pits (Anderson 1995c:28,35). Features 3 and 5 pits are larger, possibly out-house pits (Anderson 1995c:28,35). Anderson concludes that "the lack of historic cultural features other than pits suggests that the ground was greatly disturbed by twentieth century development" and that "The lack of any pre-Contact [before 1778] cultural deposits such as living surfaces, fishponds, or associated activity areas might also indicate that the level of disturbance was such as to affect these possible resources as well...The single pre-Contact artifact, the basalt adze fragment, was probably discarded with the rest of the trash in the mid- to late 1800s, although it may represent pre-Contact use of the area." (Anderson 1995c:83). Anderson recommended archaeological monitoring for subsurface excavation adjacent to the cemetery wall (1995c:85). State Site number 50-80-14-5373 was assigned to this site by SHPD (Figure 5).

In June of 1996, in compliance with the SHPD requirements, Ogden provided archaeological monitoring of excavation activities adjacent to the Catholic Cemetery's west fence boundary;

within the required 10 foot corridor (Anderson and Aronson 1997:i). During this 10 foot corridor Phase I monitoring one human burial was found (Site 50-80-14-5455), and it was not considered related to the cemetery, as subsurface fence posts (Feature 2) found under the existing cemetery wall clearly delineated a historical boundary (Anderson and Aronson 1997:67). Eight subsurface features were documented: three dog burials, a basalt mound, subsurface post holes, a trash concentration, and a recent trash pit (Anderson and Aronson 1997:58-67). It was recommended that no further monitoring of construction excavation was needed unless archaeological resources were inadvertently encountered (Anderson and Aronson 1997:67).

During the Phase II – unmonitored construction activities in Area A – Ogden informed SHPD that the contractor in charge of construction excavations had informed them that human remains had been encountered (Anderson and Aronson 1997:72). Construction activities were ceased in the area of the remains. The proper agencies were notified, and it was agreed upon that the disturbed remains were to be collected to prevent further damage. The locations of undisturbed *in situ* remains were recorded and all parties decided that emergency excavation and removal of the remains would be necessary (Anderson and Aronson 1997:72). A total of 20 burials were removed: eight adult females, five adult males, two juveniles, and five infants (Anderson and Aronson 1997:72). All but two of the twenty burials were interred fully extended in coffins (Anderson and Aronson 1997:72). Three sets of these burials were interred superimposed (one above another), possibly signifying family relationship (Anderson and Aronson 1997:72). The coffin burials indicate influence from American missionaries and thus date to after 1820, which is the arrival date for the first American missionaries.

This cluster of 20 burials dated to circa 1840-1865 (Anderson and Aronson 1997:260). The burials in this cluster were laid in a different orientation to those in the Cemetery, and did not have related Catholic religious artifacts (Anderson and Aronson 1997:262). They also exhibited the Hawaiian tradition of the knocking out of teeth (Anderson and Aronson 1997:262). These burials may represent a family burial ground belonging to previous property owners such as Kukuna Neki-Jackson's family who resided on the land and post-Māhele held title to the land from at least 1836 to 1882, when following her death her property was sold at auction.

Subsequent emergency data recovery excavations (Phase III) were required by SHPD for the area between the Phase II Area A burials and the single burial in Trench 1 of Phase I; this area was termed Area B) (Anderson and Aronson 1997:186). During these emergency data recovery excavations, eight additional adult female burials were encountered (Anderson and Aronson 1997:193). These eight coffins were interred more in line with the cemetery burial plots and contained later and religious artifacts (Anderson and Aronson 1997:262). Anderson and Aronson conclude that the burials from Phase III, are likely related to the Catholic Cemetery given their spatial association, similar burial orientation, the presence of artifacts common for Catholicism, and the similar artifact chronology in relation to the known years of operation for the cemetery circa 1840-1920 (Anderson and Aronson 1997:260-262).

In September of 1997, Anderson (1995d) prepared an additional monitoring and archaeological testing plan for a proposed underground storage tank at One Archer Lane, property adjacent to Anderson's previous three projects summarized above (Anderson 1995b & c; Anderson and

Aronson 1997). All of these reports address parcels that are in close proximity to the adjoining Historic 19th century Catholic Cemetery. The location of the proposed underground storage tank is also in close proximity to Test Trench 4, a trench excavated during the sub-surface inventory survey (Anderson 1995c). This trench was located in the area of the Hamauku Tract (Lot 6), adjoining the cemetery at the southwest boundary parallel to the cemetery fence. Modern rubbish was found at the deepest layers (>2 m deep) of this trench; artifacts recorded included large brushes believed to date to the car wash that once existed in the area (Anderson 1997d:7). Anderson suggested that this area had been used as a landfill (Anderson 1995d: 7).

Based on the findings from Anderson's previous investigations for this property it was concluded that the excavations planned for the proposed underground storage tank area may encounter disturbed deposits of modern debris such as those documented above, and that additional human burial remains could be encountered (Anderson 1997d: 7).

In July of 1994, Chaffee and Spear completed an archaeological assessment of four Hausten Street lots in the traditional land area of Kaluaolohe (today considered part of Mo'ili'ili)—northwest of the Kamoku Substation—with two lots on either side of Hausten Street. In 1994, these lots comprised the site of the then closed Willows Restaurant including asphalt paved parking lots. Chaffee and Spear identified project area soils as Ewa silty clay loam (EmA) with a 0 to 2 percent slope (1994:1). No Land Commission Awards were identified for the project area and no archaeological sites were in close proximity; however, it was reported that Sterling and Summers (1992:281,282) describe two archaeological sites, which include Kanewai Pool (underground) and Kumulae Spring—the latter being on the Willows Restaurant site (Chaffee and Spear 1994:5). Chaffee and Spear found no evidence of significant archaeological surface features in the project area. They determined that if any surface sites or features existed, they were probably destroyed during past development projects (Chaffee and Spear 1994:8). It was recommended that "no further archaeological work need be performed at this location and that further development of these parcels will have "no effect" on significant archaeological sites" (Chaffee and Spear 1994:8).

In 1989, State archaeologists Joyce Bath and Carol Kawachi reported the inadvertent discovery of human remains at the Ala Wai Golf Course (Site 4097), during excavations for a new sprinkler electrical line trench (Bath and Kawachi 1989:1) (Figure 5). The location of the remains is on the makai side of the golf course near the Ala Wai Canal, which is southeast of the Kamoku Substation and west of Winam Avenue—the related areas of proposed HECO construction activities. The trench excavated at the Ala Wai Golf Course measured approximately 60 cm wide by 50 cm deep with the stratigraphic profile showing the area had been filled with soil for grass planting for the golf course (Bath and Kawachi 1989:1). Bones recovered were sent to Dr. Michael Pietrusewsky at the University Of Hawai'i, Manoa for osteological analysis. The results of Dr. Pietrusewsky's analyses (Pietrusewsky and Douglass 1989) were included with the Bath and Kawachi State report (1989). Pietrusewsky and Douglass concluded that the recovered bones represented 2 human burials, both being Polynesian males aged 30-35 and 45-50 (1989:2-2). The remains appeared to date to pre-Contact times, but the cause of death could not be determined (1989:2-3).

In 1992, Dr. Michael Pietrusewsky reported his osteological findings concerning human remains encountered from the Lili'uokalani Gardens Condominium site in the land area of Hamohamo in Waikīkī. This archaeological findings were reported by Earl Neller (1984) and the site was assigned State Site Number 50-80-14-4127 (Figure 5). Dr. Pietrusewsky's findings concluded that the recovered remains represented at least nine individuals—four adult males, three adult females, two adolescents, one isolated fetus, and one or two additional adults represented by bones unrelated to the more complete burials (Pietrusewsky 1992:8). Of the major burials four were determined as Polynesian, three were determined probable Polynesian, and the two adolescents could not be determined (Pietrusewsky 1992:9).

Pietrusewsky stated that "Two of the adult females and one adult male exhibit tooth evulsion, a trait now thought to be restricted in time to the late prehistoric and early historic period in Hawai'i (Pietrusewsky and Douglas 1992). Three of the adult males are of relatively short stature. Very few of the mandibles have the characteristic Polynesian rocker jaw condition." (Pietrusewsky and Douglas 1992:8). It was also determined that four of the individuals may have been related, and that the remains were of Polynesian ancestry (Pietrusewsky and Douglas 1992:8). Burial position could only be determined for two of the individuals. These two individuals were buried in a flexed position in fairy shallow pits -- 2 to 3 feet below surface including recent surface soil fill (Pietrusewsky and Douglas 1992:1-9). Pietrusewsky added that "The absence of historic artifacts, the mostly flexed position of the burials, contents of the burial fill and historic information led Neller to conclude that the skeletons must be more than 200 years old." (Pietrusewsky and Douglas 1992:1).

6.3 On-going Archaeological Investigations

Discussions with staff at the State Historic Preservation Division combined with recent newspaper articles indicate that four on-going projects in the vicinity of the project areas have encountered human burials (Figure 5). No reports of these findings have yet been written and submitted to the SHPD. These projects include:

- the Wal Mart complex in the Sheridan Street "super block," where 44 sets of human remains have been found;
- the Queen Street extension project that links Queen Street and Waimanu Street, where over 30 sets of remains have been found;
- The Hokua condominium project at Ala Moana Boulevard and Auahi Street, where human bone fragments have been recovered; and
- The Ko`olani on Waimanu Street, where more than seven sets of human remains have been found.

7.0 SUMMARY AND DISCUSSION

The current project areas are located on the Honolulu and Waikīkī plains. Legendary and early historic accounts characterize the land areas as having habitation sites, wet and dry land agricultural areas, freshwater artesian wells, salt making ponds, marsh lands, and various types of fish ponds. Following the early contact years much of this cultivated plain was left fallow. Disuse of this land area was due to Native population migration into the busy Honolulu port and town area, and an overall decrease in population due to the introduction of foreign disease. As post-contact years passed, land use in the area was increasingly characterized with livestock, grazing land, residential and business lots. Fish and duck ponds and some marshland agriculture continued. During the years of the Great Māhele much of the land in the area was awarded or sold to foreign persons and Hawaiian *ali'i* who had in recent years been gifted, sold, or mortgaged parcels by the king, other *ali'i*, or the Hawaiian Government. As immigration increased into the 1900s, most of this land was resold in parcels diminishing in size creating a densely urbanized landscape for the entire Kewalo and Waikīkī plain.

Archaeological and archival investigations in the vicinity of the project areas suggest that three areas may have subsurface archaeological resources. These are: an un-named fishpond complex, the Catholic Cemetery, and Loko Opu (Figure 6).

Historic maps indicate that a possible complex of three fishponds may be located beneath the surface of HECO's Ward Avenue Complex. Trenching excavations for the initiation of the Phase 2 construction may reveal the sediments associated with this complex of ponds.

A Catholic Cemetery currently fronts King Street between Archer Lane and Ward Avenue. This cemetery has existed since at least 1841. Previous archaeological investigations for the adjacent One Archer Lane development revealed the existence of human burials beyond the current boundaries of the cemetery. It is possible that human burials may extend *mauka* of the current boundaries of the cemetery, within the present-day King Street roadway. It is possible that project excavations in this area may encounter human burials.

The traditional pond Loko Opu appears to be located in the vicinity of the HECO Makaloa Substation. This pond has been well documented on historic maps but its location has yet to be confirmed archaeologically because no archaeological investigations have taken place in this location. Excavations within the Makaloa Substation at the initiation of the Phase 1 construction may encounter sediments associated with this pond.

In addition to these three identified areas, there is also the possibility of isolated human burials through the project areas. The review of previous archaeological investigations has shown that inadvertent discoveries of human remains have been made in several locations in the general vicinity of the project area.

Given the urban nature of the project areas, and the fact that the possible archaeological resources are buried beneath existing streets, it is not feasible to conduct independent archaeological investigations to gather additional information about these resources. Rather, it seems more prudent to document and properly treat these resources during the course of construction excavations. Generally, any subsurface archaeological features encountered during construction and any inadvertent burials found will need to be treated appropriately and in accordance with governmental requirements.

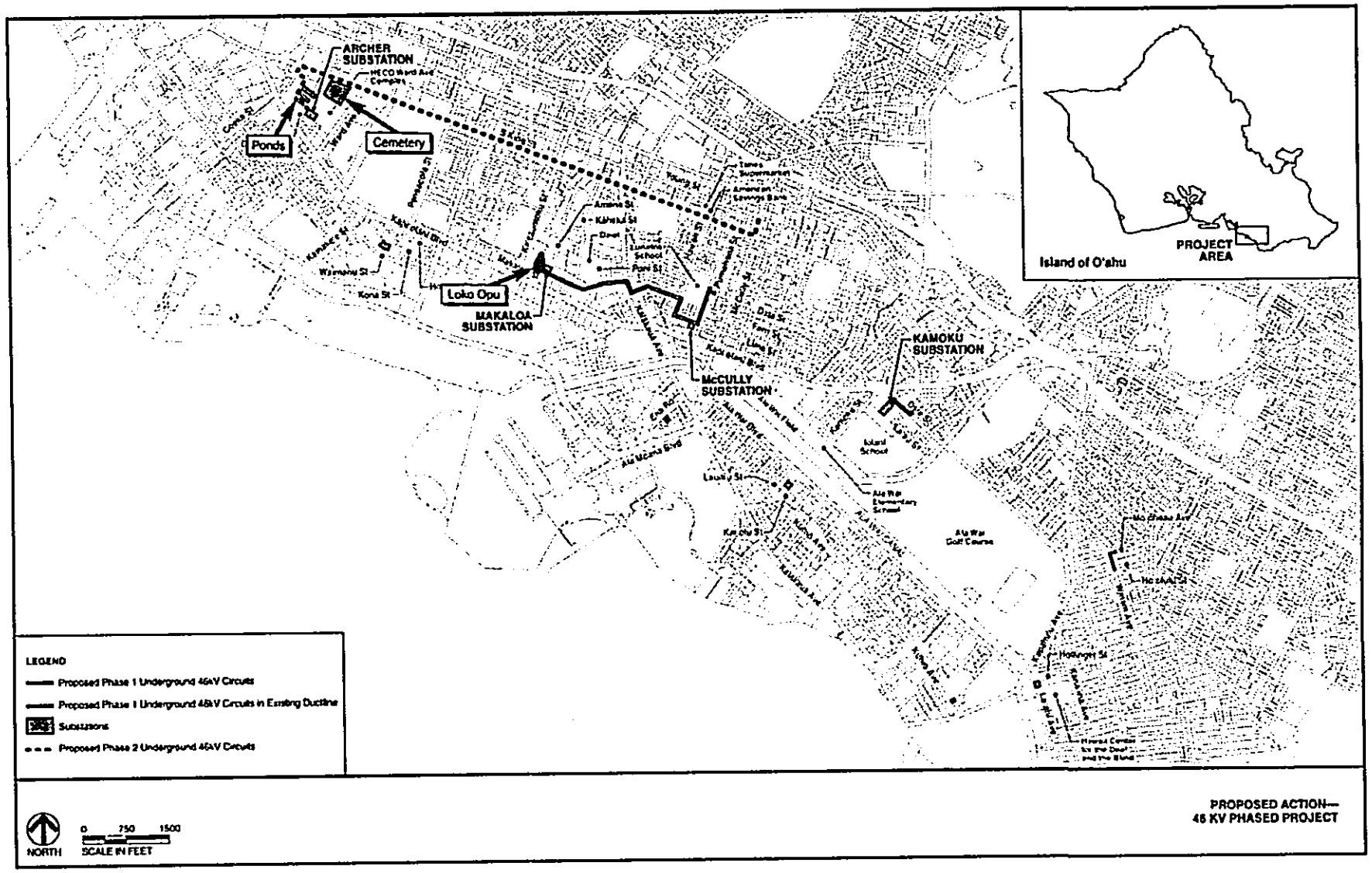


Figure 6: Areas of Archaeological Potential

8.0 REFERENCES CITED

Anderson, Lisa
1995a Historical Background Research for Properties Consisting of Tax Map Keys: 1-2-3-23:25 and 1-2-3-31:02, and 122 Honolulu, Hawai'i. Ogden Environmental and Energy Services Co., Inc., Honolulu, Hawai'i.

Anderson, Lisa
1995b Historical Background Research The King Street Place Property Tax Map Keys: 1-2-1-044: 041, 042, 043 Honolulu, Hawai'i. Ogden Environmental and Energy Services Co., Inc., Honolulu, Hawai'i.

Anderson, Lisa
1995c Archaeological Sub-Surface Inventory Survey of the King Street Place Property, Honolulu, Hawai'i (TMK No. 1-2-1-044:041, 042, and 043). Ogden Environmental and Energy Services Co., Inc., Honolulu, Hawai'i.

Anderson, Lisa
1995d Monitoring and Archaeological Testing Plan for the Proposed KITV4 Underground Storage Tank Placement at One Archer Lane, Honolulu, Hawaii (TMK No. 1-2-1-044:041, 042, and 043). Ogden Environmental and Energy Services Co., Inc., Honolulu, Hawai'i.

Anderson, Lisa and K. Aronson
1997 Archaeological Monitoring and Emergency Data Recovery of One Archer Lane, Honolulu, Hawai'i (TMK No. 1-2-1-044:041, 042, and 043). Ogden Environmental and Energy Services Co., Inc., Honolulu, Hawai'i.

Athens, J. Stephen, C. Erkelens, J. V. Ward, R. H. Cowie, and M. Pietrusewsky
1994 The Archaeological Investigation of Inadvertently Discovered Human Remains at the Pi'ikoi and Kapi'olani Intersection, Kewalo, Waikīkī, O'ahu, Hawai'i. International Archaeological Research Institute, Inc., Honolulu, Hawai'i.

Chaffee, David B. and Robert L. Spear
1994 An Archaeological Assessment Of Four Hausten Street Lots In Mo'ili'ili Manoa, Waikiki Ahupua'a, O'ahu, Hawai'i. Scientific Consultant Services Inc. Kaneohe, Hawaii.

Douglas, Michele
1991 Memorandum: Human Skeletal Remains Recovered from Kapi'olani Blvd. Michele T. Douglas, M.A., 2017 Halekoa Drive, Honolulu, Hawai'i.

Hammatt, H. H. and D. W. Shideler
1996 Archaeological Data Recovery at the Hawai'i Convention Center Site Waikīkī, Kona District, O'ahu (TMK 2-3-35:001). Cultural Surveys Hawai'i, Kailua, O'ahu, Hawai'i.

Hawai'i Register of Historic Places
1972 Thomas Square (Site 80-14-9990/TMK 2-4-1-1)
1979 Linekona School (Site 80-14-1339/TMK 2-4 2-20)
1980 McKinley High School (Site 80-14-9926/TMK 2-3-9-1)

Maly, Kepā, L. J. Franklin and P.H. Rosendahl
1994 Archaeological and Historical Assessment Study Convention Center Project Area Land of Waikīkī Kona District, Island of O'ahu (TMK:2-3-35 and 2-3-36:018,024,025). Paul H. Rosendahl, Ph.D., Inc., Hilo, Hawai'i.

Nakamura, Barry S.
1979 The Story of Waikīkī and the "Reclamation" Project. Masters Thesis, University of Hawaii.

National Register of Historic Places
1974 Thomas Square (Site 80-14-9990/TMK 2-4-1-1)

National Register of Historic Places Inventory Nomination Form
1979 Linekona School (Site 80-14-1339/TMK 2-4 2-20)
1980 McKinley High School (Site 80-14-9926/TMK map 2-3-9-1)

Neller, Earl
1984 An Informal Narrative Report On The Recovery Of Human Skeletons From A Construction Site In Waikīkī On Paoakalani Street, Honolulu, Hawai'i. State Historic Preservation Office. Honolulu, Hawai'i.

O'Hare, Constance R., D. Borthwick and H. H. Hammatt
2003 An Archaeological Inventory Survey of a Property in Waikīkī *Ahupua'a*, *'Ili* of Kewalo, Kona District, O'ahu. Cultural Surveys Hawai'i, Inc., Honolulu, Hawai'i.

Pietrusewsky, Michael
1992 Human Remains from the Lili'uokalani Gardens Site, Hamohamo, Waikiki, O'ahu. University Of Hawaii, Manoa. Honolulu, Hawai'i. Historic Preservation Office Report 0-187.

Pietrusewsky, M and M. T. Douglas
1989 Two Burials Found at Ala Wai Golf Course Honolulu, O'ahu. University Of Hawaii, Manoa. Honolulu, Hawai'i. In Bath and Kawachi 1989.

Pietrusewsky, M and M. T. Douglas
1992 Tooth Evulsion In Ancient Hawai'i. *American Journal of Physical Anthropology*. Supplement 14:131-132 (Abstract).

Schilz, Allan J.
1991 Archaeological Literature and Archival Review Mo'ili'ili and Waikīkī Districts, Honolulu. Environmental and Energy Services Company, Inc. Honolulu, Hawai'i.

Smith, Marc
1989 Memorandum: Human Bone at 1341 Kapi'olani Ave., Honolulu, O'ahu. State Archaeologist (SHPD Report 0-578)

Winieski, John
1998 Inadvertent Discovery of Human Remains at the Intersection of Citron and Pumehana St. Cultural Surveys Hawai'i, Kailua, O'ahu, Hawai'i (SHPD Report 0-1624).

Appendix C2

Cultural Impact Assessment

CULTURAL IMPACT ASSESSMENT FOR THE HAWAIIAN ELECTRIC COMPANY, INC.: EAST O'AHU TRANSMISSION PROJECT – 46kV PHASED PROJECT

Prepared by

C. Celeste LeSuer, B.A.
and
Paul Cleghorn, Ph.D.

Pacific Legacy, Inc.
332 Uluniu Street
Kailua, Hawai'i 96734
(808) 263-4800

Prepared for

Belt Collins Hawaii, Ltd.
2153 North King Street, Suite 200
Honolulu, Hawaii 96819-4554

4 August 2004

ABSTRACT

Pacific Legacy, Inc., at the request of Belt Collins Hawai'i, Ltd., conducted a cultural impact assessment (CIA) to be included in an Environmental Assessment (EA) for the Hawaiian Electric Company (HECO). The EA being prepared concerns land areas related to proposed routes for the HECO East O'ahu Transmission Project—46kV Phased Project in Honolulu, O'ahu, Hawai'i.

The purpose of this cultural impact assessment (CIA) is to identify traditional cultural practices, which could be compromised by the proposed project and to comply with the Hawai'i State Department of Health Act 50 "Guidelines for Cultural Impact Assessments."

The current project areas are located on the Honolulu and Waikīkī plains, including the land areas of Kalua`ōlohe and Kapahulu. Early historic accounts describe the land area as having habitation sites, wet and dry land agricultural areas, freshwater artesian wells, salt making ponds, marsh lands, and various types of fish ponds. Following the early post contact years (contact with Europeans is dated to 1778 with the arrival of Captain James Cook) much of the cultivated land was left fallow. Disuse of this land area was due to Native population migration into the busy Honolulu port and town area, and an overall decrease in population due to the introduction of foreign disease. As the years passed, land use in the areas were increasingly characterized with livestock, grazing land, residential and business lots. Fish and duck ponds and some marshland agriculture continued. During the years of the Great Māhele much of the land was awarded or sold to foreign persons and Hawaiian *ali'i* who had in recent years been gifted, sold, or mortgaged parcels by the king, other *ali'i*, or the Hawaiian Government. As immigration increased into the nineteen hundreds, most of this land was resold in parcels diminishing in size leaving the entire Honolulu and Waikīkī plains characterized today by dense urbanization.

The transition to today's urban center has erased the existence of any of the traditional cultural practices that took place in the project areas during pre and early post-contact Hawai'i.

The primary cultural concern in the project area is the potential of encountering human burials. Human burials have been found concentrated near the Catholic Cemetery along King Street, as well as inadvertently discovered in various construction excavations in the vicinity. There is a possibility of encountering burials beneath King Street adjacent to the Catholic Cemetery.

TABLE OF CONTENTS

1.0 INTRODUCTION 1

1.1 Cultural Impact Assessment Purpose 1

2.0 PROJECT AREA SETTING 4

2.1 Phase 1 4

2.2 Phase 2 5

3.0 METHODOLOGY 8

4.0 TRADITIONAL AND HISTORICAL BACKGROUND 9

4.1 Legendary Accounts 9

4.2 Early Contact Accounts 10

4.3 The Māhele Years 14

4.4 Kupuna Interviews 31

5.0 SUMMARY AND DISCUSSION 32

6.0 REFERENCES CITED 34

LIST OF FIGURES

Figure 1: Map of Island of O'ahu with *Moku* (Districts) and *Ahupua'a* 2

Figure 2: Location of Proposed Action: Phase 1 and Phase 2 (New 46kV Ductlines and Affected Substations) 3

Figure 3: A Portion of Phase 1 of the Proposed Action, Including Alternate Routes 6

Figure 4: Phase 2 of the Proposed Action 7

Figure 5. Pāwa'a-Miki-Kālia Lands Showing Approximate Location of the Proposed Action (Source: S.E. Bishop Map) 17

Figure 6. Kamoku Lands Showing Approximate Location of the Proposed Action (Source: S.E. Bishop Map 1881) 21

Figure 7. Sketch Map Kapahulu Lands, 1878. 23

Figure 8. Kapahulu Lands Showing Approximate Location of the Proposed Action (Source S.E. Bishop Map 1881) 24

Figure 9. Kapahulu Lands 1898 Showing Approximate Location of the Proposed Action (C.J. Willie, Map of Honolulu and Vicinity). 25

Figure 10. Kewalo-Kuhua-Pāwa'a Lands Showing Approximate Location of the Proposed Action (Source: S.E. Bishop Map 1881, 1884). 28

1.0 INTRODUCTION

Pacific Legacy, Inc., at the request of Belt Collins Hawai'i, Ltd. conducted a cultural impact assessment to be included in an Environmental Assessment concerning areas related to the proposed Hawaiian Electric Company, Inc., East O'ahu Transmission Project—46kV Phased Project in Honolulu, O'ahu, Hawai'i. The project is located within the traditional land divisions or *ahupua`a* of Honolulu and Waikīkī in the district or *moku* of Kona (Figure 1).

The East Oahu Transmission Project is comprised of two independent phases of work, Phase 1 and Phase 2, collectively the "Proposed Action." (Figure 2). Phase 1 involves the installation of 0.5 mile of new underground ductline for 46kV subtransmission lines and related work at eight existing substations. Underground 46kV lines would be installed in the Ala Moana, McCully, Moiliili, and Kapahulu areas in the new ductline and in approximately 0.4 mile of existing underground ductline. Existing 46kV and 12 kV lines would be removed from the existing ductline. Phase 2 involves the installation of 1.9 miles of new underground ductline for 46kV subtransmission lines and related work at one substation. Three underground 46kV lines would be installed in the new ductline in the Kakaako, Makiki, and McCully areas, predominantly along King Street. Phase 2 involves the installation of 1.9 miles of underground ductline for 46kV subtransmission lines, and related work at one substation. Phase 2 includes: (1) the installation of three underground 46kV lines in the Kakaako, Makiki, and McCully areas, and (2) a 138kV/46kV transformer installation at the existing Archer Substation with associated protective relaying.

1.1 Cultural Impact Assessment Purpose

On November 19, 1997, guidelines for Assessing Cultural Impacts intended for inclusion in Environmental Impact Statements were adopted by the Environmental Council. The purpose of a cultural impact assessment (CIA) is to identify traditional cultural practices which could be compromised by proposed development projects, and to comply with the Hawai'i State Department of Health Act 50 "Guidelines for Cultural Impact Assessments."

The CIA guidelines state that project properties as well as surrounding property areas, shall be studied to determine the potential for significant and/or adverse effects on cultural practices of the community and State from the proposed construction or development. These guidelines also recommend personal interviews be conducted with knowledgeable informants and traditional cultural practitioners, concerning the cultural practices identified for the area.

On April 26, 2000 Governor Ben Cayetano signed into law Act 50. The following CIA investigations are intended to satisfy Act 50, which has the stated purpose to:

(1) Require that environmental impact statements include the disclosure of the effects of a proposed action on the cultural practices of the community and State; and
(2) Amend the definition of "significant effect" to include adverse effects on cultural practices.

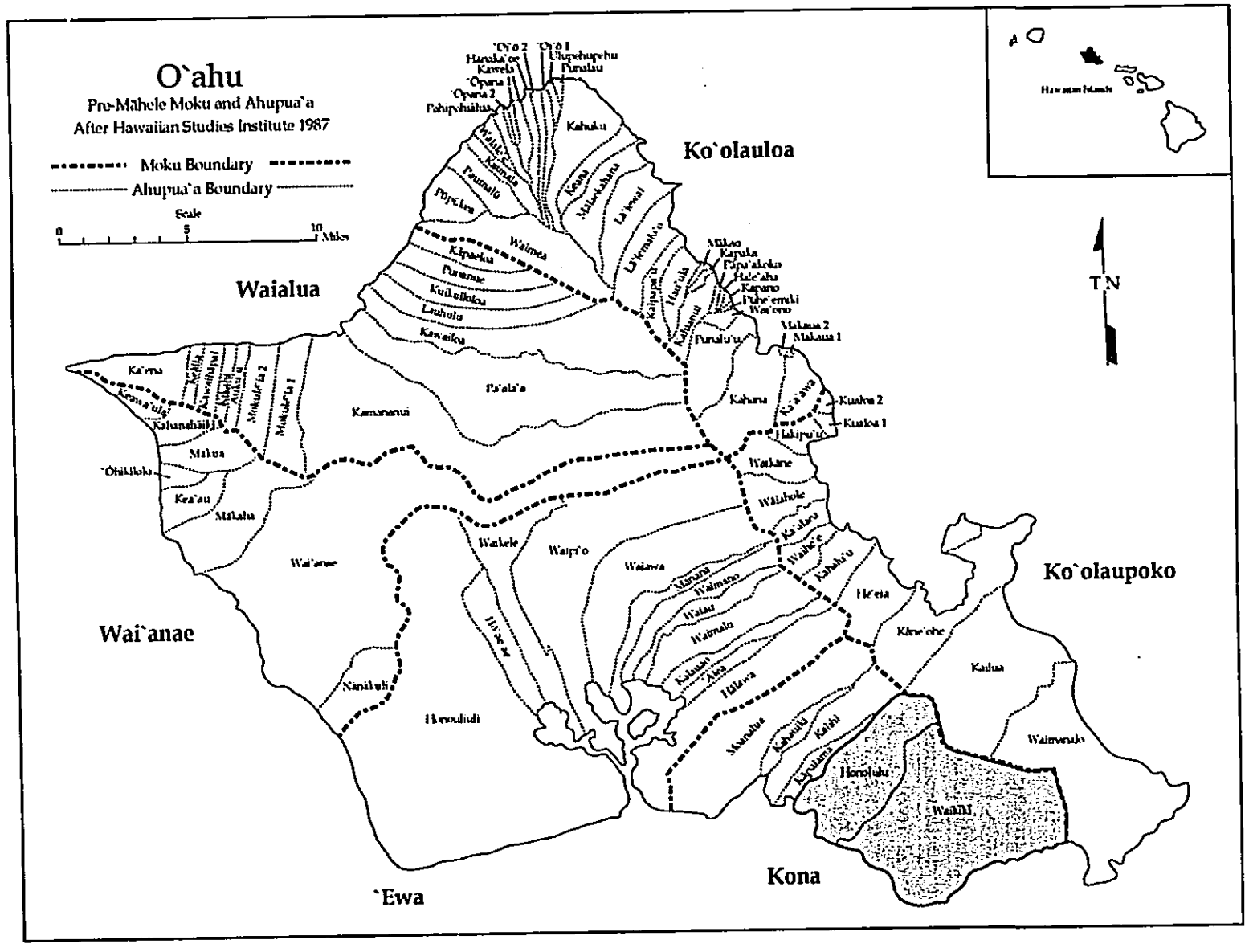


Figure 1: Map of Island of O'ahu with *Moku* (Districts) and *Ahupua'a*

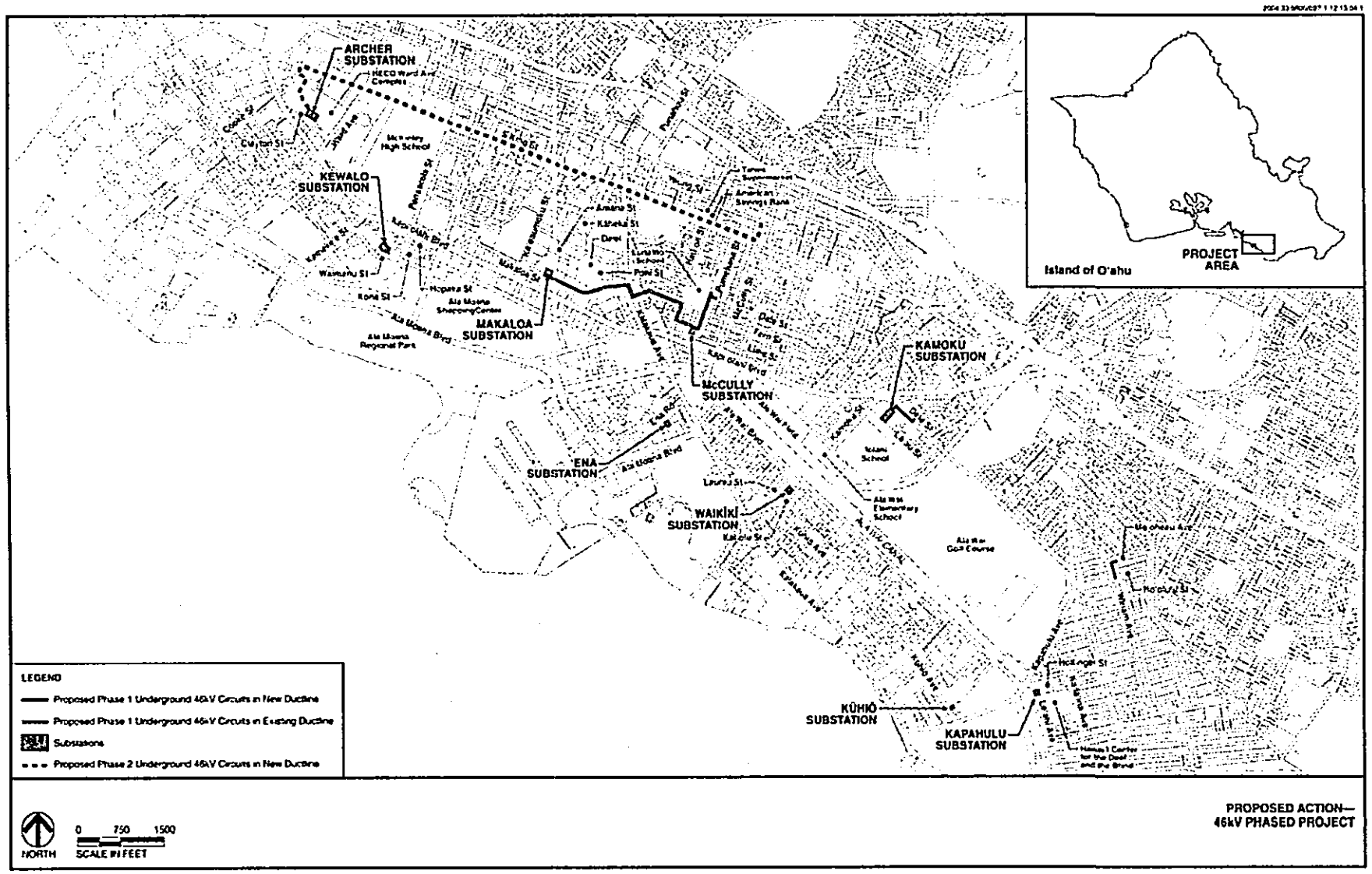


Figure 2: Location of Proposed Action: Phase 1 and Phase 2 (New 46kV Ductlines and Affected Substations)

2.0 PROJECT AREA SETTING

The Proposed Action is located in the southern leeward district of Kona on the island of O'ahu, Hawai'i. Project routes are located within the *ahupua'a* of Honolulu and Waikīkī on the Honolulu and Waikīkī plains and in the land areas of Kaluaolohe and Kapahulu, which all lie between the base of the Ko'olau Mountains and Valleys and the seaward coastline to the south, (Figure 1). Downtown Honolulu is to the west and Diamond Head is to the southeast. Today the entire project area landscape is urbanized, and the project routes are located on existing public streets, with a small portion on HECO private property (Figure 2).

For the purpose of this report, specific description of the project's multiple area locations will be divided into two sections: Phase 1, including the area from Makaloa Substation to Pumehana Street, Kamoku Substation, a portion of Date Street, and the area near the intersection of Mo'oheau Avenue and Winam Avenue in Kapahulu; and Phase 2 on and near King Street.

2.1 PHASE 1

Phase 1 of the Proposed Action involves the installation of 0.5 miles of underground ductline for 46kV subtransmission lines and related work at existing substations. Three routes are being considered by HECO for the Makaloa Substation to Pumehana Street area of Phase 1, one preferred route and two alternate routes (Figure 3).

2.1.1 Proposed Action

The Makaloa Substation is located on the northwest corner of Makaloa and Amana Streets, and the McCully Substation is located on the southwest corner of the McCully and Lime Street intersection. Between Makaloa Substation and Poni Street, one new circuit would be installed in the existing ductline, and one new circuit would be installed in the newly constructed ductline. From Poni Street, the two new circuits in the existing ductline would continue until Kalakaua Avenue. At Kalakaua Avenue, the ductline would proceed in the *makai* direction along Kalakaua Avenue for a short distance, until the intersection with Fern Street. The ductline would then proceed in the Koko Head direction along Fern Street until the intersection of Fern and Hau'oli Streets, continue in the *makai* direction along Hau'oli Street, and turn in the Koko Head direction onto Lime Street. After continuing a short distance along Lime Street, the ductline would end at the McCully Substation (Figure 3). This area is referred to as the "Makaloa to Pumehana Area," and this route is referred to as the "Preferred Route."

Additional new ductline construction and 46 kV circuit installation within existing paved roadways proposed under Phase 1 includes the following:

-- one new 46 kV circuit, approximately 720 feet long, installed in a new ductline between the McCully Substation and an existing overhead 46 kV circuit near the intersection of Date and Pumehana Streets;

--one new 46 kV circuit, approximately 50 feet long, installed in a new ductline between the Kamoku Substation on the *makai* side of Date Street and the existing overhead 46 kV circuit on the *mauka* side of Date Street (the "Kamoku/Date Street Area");

-- one new 46 kV circuit, approximately 330 feet long, installed in a new ductline from the Kamoku Substation proceeding in the Koko Head direction on Date Street to the existing overhead 46 kV circuit on the *mauka* side of Date Street (the "Kamoku/Date Street Area"); and

-- one new 46 kV circuit, approximately 420 feet long, installed in a new ductline between an existing overhead 46 kV circuit on Winam Avenue and an existing overhead 46 kV circuit on Mo'oheau Avenue (the "Winam Avenue Area").

2.1.2 Phase 1 Alternative Alignments

In addition to the Preferred Route described above as part of the Proposed Action, HECO considered the use of two alternate routes, both utilizing Kapiolani Boulevard, for the circuits in the new ductline between the Makaloa and McCully Substations.

Alternative Alignment 1
Between the Makaloa Substation and McCully Substation, Alternative Alignment 1 would proceed as follows. From the Makaloa Substation, the circuits in new ductline would exit the substation to Makaloa Street, proceed in the Koko Head direction until Kaheka Street, continue on Kaheka Street in the *makai* direction to Kapi'olani Boulevard and proceed in the Koko Head direction on Kapi'olani Boulevard to Pumehana Street. At Pumehana Street, the circuits in new ductline would then proceed in the mauka direction to Lime Street at the McCully Substation (Figure 3).

Alternative Alignment 2
Between the Makaloa Substation and McCully Substation, Alternative Alignment 2 would proceed as follows. From the Makaloa Substation, the circuits in new ductline would exit the substation to Makaloa Street, proceed in the Koko Head direction to Kalauokalani Way, continue on Kalauokalani Way in the makai direction to Kapi'olani Boulevard, and proceed in the Koko Head direction on Kapi'olani Boulevard to Pumehana Street. At Pumehana Street, the circuits in new ductline would then proceed in the mauka direction to Lime Street at the McCully Substation (Figure 3).

2.2 PHASE 2

Phase 2 of the Proposed Action has one proposed route. This route begins at the Archer Substation near the corner of Cooke and King Streets. It travels `Ewa along a HECO service road and parking lot areas, from the *mauka* `Ewa corner of the substation until it intersects with Cooke Street where the route turns right (*mauka*) for a short distance, turning Koko Head onto King Street. Phase 2 continues Koko Head on King, turning *mauka* at McCully Street and ends at the intersection of Young and McCully Streets (Figure 4). This area is referred to as the "King Street Area."

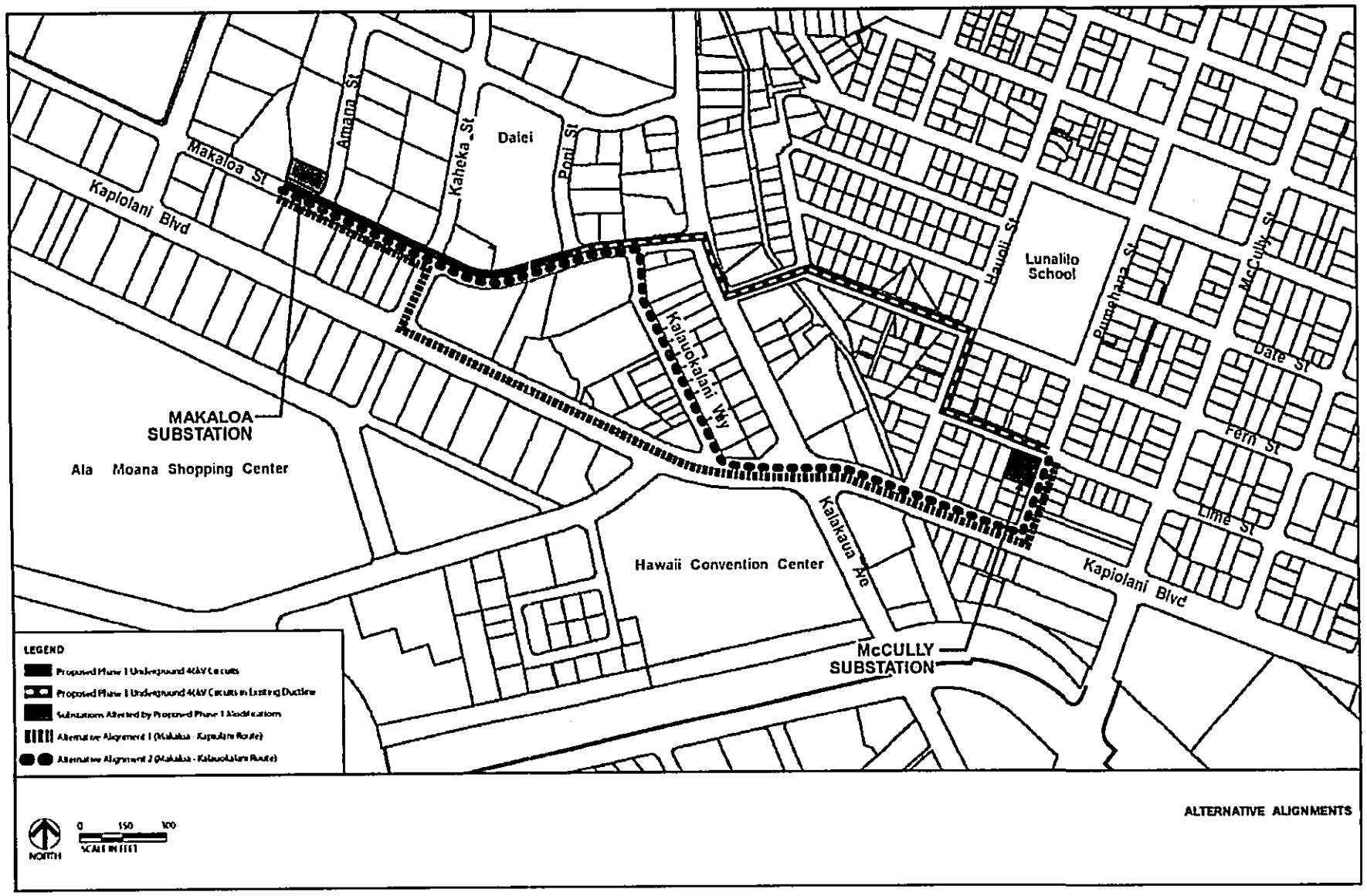


Figure 3: A Portion of Phase 1 of the Proposed Action, Including Alternate Routes

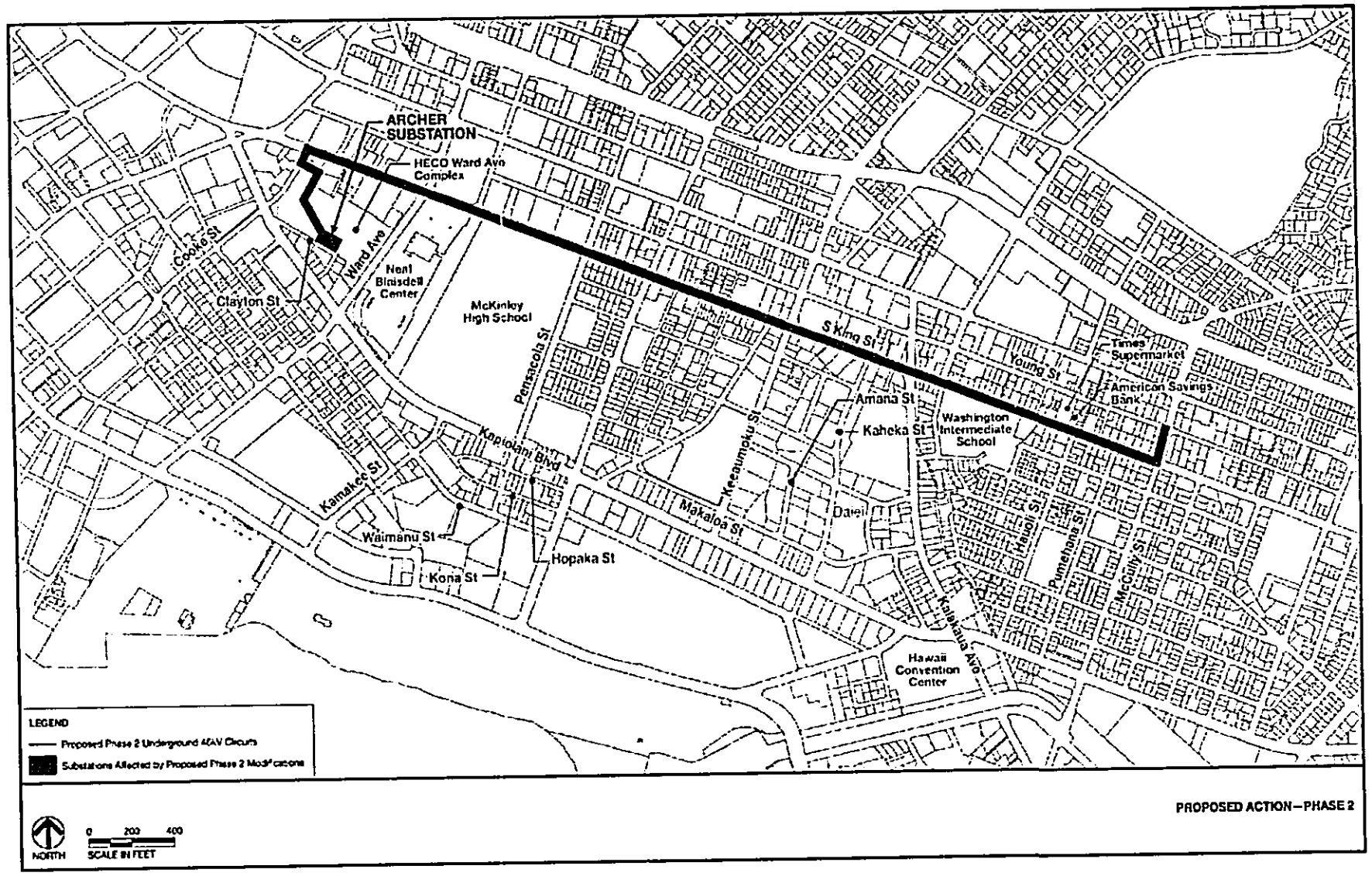


Figure 4: Phase 2 of the Proposed Action

3.0 METHODOLOGY

The purpose of this cultural impact assessment (CIA) is to identify traditional cultural practices and/or beliefs, which could be compromised by the proposed project and to comply with the Hawai'i State Department of Health Act 50 "Guidelines for Cultural Impact Assessments". The CIA guidelines state that project properties as well as surrounding property areas shall be studied to determine the potential for significant and/or adverse effects on cultural practices of the community and State from the proposed construction or development. These guidelines also recommend personal interviews be conducted with knowledgeable traditional cultural practitioners (*kupuna*) and knowledgeable cultural informants, concerning the cultural practices identified for the area.

Agencies utilized during the research for historical documents included:

- State Historic Preservation Division, Archaeology Program
- State Historic Preservation Division, Burial Program
- O'ahu Island Burial Council
- State Archives
- Hawai'i State Library
- Mission House Library
- Hawai'i State Survey Office
- Office of Hawaiian Affairs
- University of Hawai'i, Manoa, Hamilton Library Hawai'i Pacific Collection

Research focus concentrated on historical documents pertinent to cultural practices in the project area; identifying pre- and post-contact land use and related potential subsurface features, including potential locations for burials. The level of effort focused on literary sources of the vicinity to obtain an understanding of the traditional practices that were carried out here. The general boundaries of this research extended from Beretania Street to Ala Moana/ Ala Wai Boulevards in a *mauka – makai* direction, and from Cooke Street to Kapahulu Avenue in an `Ewa – Koko Head Direction. The research area also included the area near the intersection of Winam Avenue and Mo'oheau Avenue, east of Kapahulu Avenue.

In addition, a search to locate knowledgeable *kupuna* of Hawaiian descent, in hopes of identifying traditional cultural practices and beliefs was carried out. The main sources for information on locating *kupuna* include: local state, private, and cultural agencies that either deal with or are concerned with traditional Hawaiian cultural preservation.

4.0 TRADITIONAL AND HISTORICAL BACKGROUND

The Proposed Action is located on the Kewalo and Pawa'a flat lands and in the land areas of Kalua`ōlohe and Kapahulu, within the *ahupua'a* of Honolulu and Waikīkī. Legendary and early historic accounts describe this land area between the communities of Honolulu and Waikīkī as including habitation sites, wet and dry land agricultural areas, artesian freshwater springs, salt making ponds, marsh lands, and various types of fish and duck ponds.

Following the early contact years much of this cultivated plain was left fallow. Disuse of this land area was due to Native population migration into the busy Honolulu port and town area, and an overall decrease in Native Hawaiian population due to the introduction of foreign disease.

As post-contact years passed and the foreign population increased land use on these plains changed. There was an increase in habitation sites especially by foreigners and while fish and duck ponds and some marshland agriculture continued, these cultural practices were decreasing in number. A few foreign business ventures began to appear, and the plains became characterized with an increasing amount of livestock, and much of the once cultivated land which had become fallow was being used as grazing land.

During the years of the Great Mahele much of the land in the area was awarded or sold to foreign persons and Hawaiian *ali'i* who had in recent years been gifted, sold or mortgaged parcels by the king, other *ali'i*, or the Hawaiian Government. As immigration increased into the nineteen hundreds most of this land was resold in subdivided parcels—continually diminishing in size. Today, the entire Honolulu and Waikīkī plain is densely urbanized.

The land area transformed from a traditional Hawaiian cultural landscape into a Western urban landscape. This transformation was influenced by its position between to busy centers of population—Kou (Honolulu) and Waikīkī —both culturally active throughout pre and post-contact Hawai'i. Legendary and historic descriptive accounts are documented below.

4.1 LEGENDARY ACCOUNTS

A. Fornander describes the wetlands as being developed into a system of fishponds and taro pond fields circa the 15th century, citing traditional oral histories (1921:314).

Sterling and Summers (1978:279) describe the traditional legend of Loheloa as taking place on the Kaluaolohe land area (see Figure 8). Sterling and Summers write that (1978:279):

> Loheloa came from Waipio on a huge log. He came first to Makapuu and then to Keauau Point, now called Leahi (Diamond Head). He saw a strange glow like a ball of fire there. He asked for the chief Olohe and was told that the light was his.
>
> He saw some fishermen who told him to go away for he was scaring the fish. He called

to Ku and Hina to bring them a school of fish which they did. The natives were grateful. He lifted his huge canoe and rested one end at Hauula and the other at Namahana, against the hill. He told the people that he wanted to wrestle with their chief Olohe, a dogman who lived at Apuakehau, Waikiki. A messenger was sent to bring Loheloa to the chief and Loheloa suggested that they wrestle in the open where they can be seen. He would bet his bones and his canoe on himself.

Olohe and Loheloa fought on the field now know as Kapiolani Park. Olohe punched and raised a gale that flattened the ilima bushes. Loheloa slapped his ear hard enough to throw him in the air. The place he fell is called Kalua-Olohe (Olohe's pit) to this day. Loheloa won and the people shouted with joy over the defeat and death of their cruel chief.

4.2 Early Contact Accounts

The early descriptions of O'ahu which include the present project area, describe a productive flat cultivated plain with wet and dry agriculture, aquaculture, waterfowl and habitation sites.

In 1792 Captain Vancouver and his surgeon-naturalist Archibald Menzies visited O'ahu and each described this area:

On shores, the villages appeared numerous, large, and in good repair; and the surrounding country pleasingly interspersed with deep, though not extensive valleys; which, with the plains near the sea-side, presented a high degree of cultivation and fertility.

...guides led us to the northward through the village, to an exceedingly well made causeway, about twelve feet broad, with a ditch on each side.

This opened our view to a spacious plain, which, in the immediate vicinity of the village, had the appearance of the open common fields in England/ but, on advancing, the major part appeared to be divided into fields of irregular shape and figure, which were separated from each other by low stone walls, and were in a very high state of cultivation. These several portions of land were planted with the eddo or taro root, in different stages of inundation; none being perfectly dry, and some three to six or seven inches under water. The causeway led us near a mile from the beach, at the end of which was the water we were in quest of. It was a rivulet five or six feet wide, and about two or three feet deep, well banked up, and nearly motionless; some small rills only, finding a passage through the dams that checked the sluggish stream, by which a constant supply was afforded to the taro plantations.

[We] found the plain in a high state of cultivation, mostly under immediate crops of taro; and abounding with a variety of wild fowl, chiefly of the duck kind...the intermediate vallies, which were all inhabited, produced some large trees, and made a pleasing appearance. The plains, however, if we may judge from the labour bestowed on their cultivation, seemed to afford the principal portion of different vegetable productions on which the inhabitants depend for their subsistence (Vancouver 1798: I, 461-464).

Given Vancouver's description of the direction and the surroundings of their inland walk,

which was to search for fresh water, it appears that they anchored off Waikīkī, went ashore and hiked inland north on old Waikīkī Road (present day Kalākaua Avenue). This mile long hike would put them at approximately King Street. Archibald Menzies describes the same trek:

> The verge of the shore was planted with a large grove of cocoanut palms, affording a delightful shade to the scattered habitations of the natives...We pursued a pleasing path back into the plantation, which was nearly level and very extensive, and laid out with great neatness into little fields planted with taro, yams, sweet potatoes, and the cloth plant [paper mulberry, used for the making of *tapa* cloth]. These, in many cases, were divided by little banks on which grew the sugar cane and a species of Dracaena without the aid of much cultivation, and the whole was watered in a most ingenious manner by dividing the general stream into little aqueducts leading in various directions so as to be able to supply the most distant fields at pleasure, and the soil seems to repay the labour and industry of these people by the luxuriancy of its productions. Here and there we met with ponds of considerable size, and besides being well stocked with fish, they swarmed with waterfowl of various kinds such as ducks, coots, water hens, bitterns, plovers and curlews (1920:23-24)

Kamakau described early contact changes taking place on the plains of Kewalo, following Kāmehameha's early introduction to rum in 1791 and a related foreign business venture in 1809:

> The first taste that Kamehameha and his people had of rum was at Kailua in 1791 or perhaps a little earlier, brought in by Captain Maxwell.
>
> It was while Kamehameha was on Oahu that rum was first distilled in the Hawaiian group. In 1809 rum was being distilled by the well-known foreigner, Oliver Holmes, at Kewalo, and later he and David Laho-loa distilled rum at Makaho. Kamehameha set up a still at Kahapa'akai, and from this beginning rum-making spread over the group from Oahu to Hawaii. Rum drinking became general, and both chiefs and chiefesses indulged in it. Two kinds were distinguished, the tabu rum to be drunk by men alone and not to be touched by the women, and the free rum which women might drink but not in company with men. The free eaters, who were undiscriminating and godless, and some of the chiefesses became inveterate topers. Rum became the custom at feasts, the men drinking their kind and the chiefesses theirs. The commoners drank everywhere (1961:193-194).
>
> Before the battle of Nu'uanu there were living on Oahu with Kalanikupule Mr. Oliver Holmes, Shomisona, Mr. Lele, Mr. Mela [Miller], Mr. Keaka'ele'ele [Black Jack], and some other foreigners. When Kamehameha conquered the island, they all came over to his side. [After the battle of Nu'uanu in 1796] (1961:174).

Oliver Holmes [Homa], the first rum distiller, arrived on the American ship *Margaret* on March 5, 1792 (Day 1984:146). He was an American, born in Plymouth, Massachusetts. He left New Bedford to trade in the Pacific, and was one of the first dozen foreigners to live in Hawaii. He may have been the only foreigner to have been in the service of Kalanikapule. After his joining Kamehameha, Holmes married Mahi Kalanihooulumokuiekai, daughter of a high chief of Ko'olau. They had a number of daughters and at least one son (Day 1984:53; Kamakau 1961:251). He was content with his very Hawaiian household in a grass-roofed dwelling. Holmes became governor of O'ahu. He supported the establishment of the Protestant mission

in 1820, and was said to be a member of the prominent Holmes family of New England. Mr. Holmes provisioned visiting ships and sojourning ship captains were his paying guests (Day 1984:53).

During these early years a great plague ravaged the Native population in the Hawaiian Islands. It was most likely the bubonic plague that arrived circa 1804 (Day 1984:146). This plague prevented the June 7th planned invasion of Kaua'i by Kamehameha I, and killed many chiefs including Chief Kameeiamoku (Day 1984:146).

An 1825 account of the area confirms that the fishponds and pond fields of Waikīkī were still in use at that time "*innumerable* artificial freshwater ponds extending a mile inland" (Bloxam 1925:35, 36); however, three years later, in 1828, Chamberlain writes that the fishponds and taro pond fields of Waikīkī had been abandoned and were overgrown with reeds (1957:26). Both Bloxam and Chamberlain, attribute the fallow state to population decline due to the introduced disease and the destructive foraging of livestock.

Kamakau refers to this foraging of livestock in an incident that took place sometime between October of 1827 and March of 1828. Queen Ka'ahumanu had made enemies of the British Consul, foreign merchants, Boki, and Manuia after declaring Mr. Richards not guilty of libel charges brought by the English Captain Buckle (Kamakau 1961:281-283). This incident likely refers to the early road that is now King Street:

> The consul beat up one of her keepers who had chased away the consul's cattle which roamed at large all the way to Pawa'a and were eating Ka'ahumanu's plantings at Kapuka'oma'oma'o in Manoa. This man, Kane-kuahine, was roped about the neck by the consul and dragged behind his carriage, tossed up and down all along the plains, his chin and ribs broken, and was only saved from being killed by getting his hand inside the noose (Kamakau 1961:283).

Kamakau notes an early attempt to give away the lands of Kewalo circa 1828,

> Ka-iki-o-'ewa, finding himself deep in debt to Mr. French and other foreign merchants, was arranging to pay his debts by giving over the lands of Kewalo and Kulaokahu'a to Mr. French. This merchant never made any complaints in business matters, but took all the sandalwood which others refused, even white wood or small wood...He accepted Ka-iki-o-'ewa's offer and made ready to erect a wooden frame building...on the Waikīkī side...Ka-'ahu-manu heard of this and sent a man to forbid Mr. French's building on the land and issued and order that none of the chiefs was to dispose of lands or give over any to the foreigners in payment of debts, for the king alone had the power of disposing of land anywhere in the group. She was then obliged to assume the indebtedness of all the chiefs, and when the chiefs discovered that the government was assuming the debts, there was a rush to turn them over to her (1961:285-286).

In 1828, Captain Boelen gives a description of the area east of the Mission house and specific to the area of Phase 2 of the Proposed Action (the King Street Area) . His notes suggest that strolling foreigners walked this route (along King Street) and stopped at a tavern, that of a Mr. Allen:

> ...two foot paths—now King and Young Streets--to the east were where "foreigners go strolling in the evening. Here, one passes a few very nice estates that maintain considerable herds of goats and sheep, and along the way there is a sort of tavern where one usually goes to drink milk" (Broeze 1988:63).

In another reference to this tavern and the Pāwa'a area, Kamakau writes that in 1831 there was peace all over Hawai'i and Ka'ahumanu was attempting reform (1961:304):

> ...anxious to stamp out all other forms of worship. She ordered foreign houses of prostitution closed, but did not molest the liquor-selling establishment run by the foreigners inside the city or the two outside, one at Pāwa'a owned by a black foreigner, Mr. Allen, the other at Kalia in the coconut grove belonging to Ka-hanau-maika'i owned by the Englishmen James C. Lyman (1961:304).

Stewart writes that this establishment was owned by Anthony Allen and was approximately two miles to the east from the mission houses; the surrounding plain was "uncultivated and entirely unshaded" and the tavern area included about a dozen thatched houses plastered with mud (1970:157). Athens suggests that this habitation site "was probably the settlement that would later be known as "Little Britain" in the 1840s" (Athens et al. 1994:7).

Mr. Anthony Allen was a former black slave from New York who came to Hawai'i in 1810. He married a Hawaiian girl and acquired land and livestock (Day 1984:3). During the next quarter of a century he became one of the most prosperous foreign residents on O'ahu (Day 1984:3). In 1820, when the first missionaries arrived he welcomed them with a feast, and continued to supply them with vegetables and fruit (Day 1984:3). He operated a farm on the plain toward Waikīkī with Hewahewa, ran a small boardinghouse for seamen, and sold goat's milk in the town (Day 1984:3) and at his tavern. Mr. Allen died in 1835.

Forbes notes that the "Little Britain" location later became the country residence of the British Consul William Miller around 1846. Forbes describes the property as an enclosed compound which by the 1850s would include a dwelling house, a cook house, a storehouse, a bowling alley, and a small hospital (Forbes 1992:136,137).

Another foreign disease presented itself in May of 1853 and Kamakau notes how a house in Kahu'a (the area *mauka* and *makai* of King Street and towards the sea on the Kewalo plain), was used as a hospital:

> To a people living happily in a pleasant land with purple mountains, sea-girt beaches, cool breezes, life long and natural, even to extreme old age [to these people], with the coming of strangers, there came contagious diseases which destroyed the native sons of the land. No longer is the sound of the old man's cane heard on the long road, no longer do the aged crouch about the fireplace, no longer do those helpless with age stretch

> themselves on their beds, no longer do they remain withering in the house like the cane-blossom stalks plucked and dried for the dart-throwing game. We are praying to God that we may reach the length of life of our forbears, We build churches, labor day and night, give offerings to charity and the Sabbath dues, but the land is become empty; the old villages lie silent in a tangle of bushes and vines, haunted by ghosts and horned owls, frequented by goats and bats.
>
> The smallpox came, and dead bodies lay stacked like kindling wood, red as singed hogs. Shame upon those who brought the disease and upon the foreign doctors who allowed their landing! The ship displayed the yellow flag,...Three months later the disease broke out like a volcanic eruption...it was isolated at the house for storing ox carts at Honuakaha on the south side of town, and this became a receiving station for smallpox patients.
>
> The house at Honuakaha was crowded, and Mr. Johnstone's house on Kahu'a plain was taken as a hospital and the other houses in the yard put to use (1961:416-417).

Kamakau writes that Pi'ikoi invited King Kamehameha III to his house at Kewalo on December 15, 1854, the king died the next day (1961:421):

> Pi'ikoi invited the king to attend his house warming at Kewalo and the king consented and rode out that evening with the queen and the minister of the interior and some of the chiefs. The table was loaded with everything good to eat, but there were no strong drinks, only ale and beer.

4.3 THE MĀHELE YEARS

In the mid 19th century a movement organized by Western businessmen and politicians culminated in the Māhele of 1848. Legal ownership of land was to be awarded to persons who could show a rightful and/or traditional claim. A group of men, mostly Westerners, were organized as the Māhele Land Commission Officers. These men required persons desiring legal ownership of land which they claimed as their own to petition and present their claim to the commission board. Land Commission Officers could request witnesses be called to testify and confirm a person's claim to particular land areas. Māhele documents, however, show that many *ali'i* were not expected to present testimony. The commission at a later date would award or deny their claim of ownership.

Māhele testimonies are recorded in two sources at the State Archives; the Native and Foreign Register and the Native and Foreign Testimony volumes. Much of the Māhele testimony focuses on identifying geographic location; this is most often done using cultural land area and directional terms, and people's names or titles. It is not always possible to distinguish the location of an awarded parcel on available historic maps, particularly when the award includes more than one parcel, with the Māhele era terms used in testimony. Boundaries can be described using one or more of the many traditional land area terms used for sections within the larger *ahupua'a* such as *'ili, mo'o, paukū, lele, etc.*, and many of these terms were not incorporated into the historic maps. Persons names or titles present similar problems when used to identify property boundaries: Hawaiian persons of non-alii status are not well documented, names are often misspelled and spelled differently in different documents

pertaining to the same property, and the use of a person's title in a boundary description such as "*makai* is the *konohiki* land" presents a problem if we do not know who the *konohiki* (headman under the chief for a land division within an ahupua'a) was.

Many testimonies give brief descriptions as to the natural environment and cultural practices present on a parcel: identifying agriculture, aquaculture, habitation, natural resources, roads, and tenant persons or families, etc. Inconsistency in testimony renders this information incomplete, but allows for a degree of insight into the environment of the Māhele years which as previously mentioned followed many years of disuse of the land in the Waikīkī Ahupua'a flat lands. In addition, little environmental information is recorded for many large parcels awarded to *ali'i*, as many submitted their petitions without description of the property's environment or tenants and they were often not required to provide witness testimony in uncontested cases.

Māhele documents include Land Commission Award petitions (LCA), and claimant and witness testimony in the Native and Foreign Registers (NR/FR) and the Native and Foreign Testimony (NT/FT), Royal Patents (RP), Land Grants (LG), and Boundary Commission Claims (BCC/ or BCId in the Waihona'Aina Māhele Database). The Waihona'Aina Māhele Database has been organized by the Waihona'Āina Corporation, which has translated many of the Native Hawaiian testimonies.

Māhele documents pertaining to Phase 1 and Phase 2 of the Proposed Action will be discussed below by the following traditional land area sections:

Traditional Land Area	Project Phase	Proposed Action Area
Pāwa'a-Miki-Kālia	Phase 1	Makaloa to Pumehana Area
Kamoku	Phase 1	Kamoku/Date Street Area
Kapahulu	Phase 1	Winam Avenue Area
Kewalo-Kahua-Pāwa'a	Phase 2	King Street Area

Māhele land awards researched were those related to the project areas as depicted on the S. E. Bishop 1881 Hawaiian Government Survey Map of Waikīkī. Due to the large size of this map, each project land sections is depicted on corresponding map portion (Figure 5,6,8, & 10).

Portions of foreign and Native (if translated) testimonials from both claimants and witnesses are first summarized in table form for each traditional land section to depict the environment and cultural practices present on the land during the Mahele years of the mid 19th century. Additional descriptive information follows the table summary for areas of historic interest.

4.3.1 Pāwa'a-Miki-Kālia Lands

The Makaloa to Pumehana Area which is part of Phase 1 of the Proposed Action is in the traditional Pāwa'a-Miki-Kālia Lands. The Preferred Route begins at the HECO Makaloa Substation and moves eastward across Kalākaua Avenue (Old Waikīkī Road), ending at the McCully Substation at the intersection of Pumehana and Lime Streets. The path of the Preferred Route and the two alternative routes on the west side of Kalākaua Avenue, from the Makaloa

Substation to Kalākaua Avenue, lie in an area traditionally referred to as Miki; Miki is a land section within the larger area of Pāwa'a *ili* just above Kālia *ili*. When these routes cross to the east side of Kalākaua Avenue they are in the central area of Pāwa'a. Pukui, Elbert and Mookini (1974:182) literally define Pāwa'a as "canoe enclosure", and state that "It is said that canoes were brought here from the sea by canal." (1974:182). Five Māhele awards in or around the Makaloa to Pumehana Area provide the following information:

Māhele Award	Awardee Name	Cultural Practices and Environment
LCA 8241, Apana 3, Royal Patent 5704	John Ii	Habitation prior to and during the Māhele (14 Hawaiian family names), ancient *auwai*, fishpond
LCA 32 F.L.	E.K. Kunewa	Habitation, *kio pua* (baby fish pond), 2 *lo'i*,
LCA 31 F.L., RP 3715	Waihinano (Waihinalo)	Habitation, taro *lo`i*, 1 kula, coconut tree, kō`ele (a small land unit farmed by commoners for the chief on Fridays), *lele*, bird raising pond, road/path,
LCA 660, Royal Patent 103	Gerrit P. Judd	Habitation (2 houses), Kula, marsh (unknown amount drained by Judd, wall/fence, watercourse, road/path, many kō`ele, coconut trees, *lo`i*, pasture ground
Land Grant 3098	L. McCully	*lo`i*, fishponds, and numerous watercourses

Figure 5 shows the location of the above awards. The Preferred Route and the two alternative routes begin at the present day Makaloa Substation within John Ii's LCA award; near Kalākaua Avenue the Preferred Route is partially located in E. K. Kunewa's LCA 32 FL which is bounded on the mauka (north) end by Waihnano's LCA award. On the east side of Kalākaua Avenue, for the most part, the Preferred Route is located within the LCA of Gerrit P. Judd. The Preferred Route ends at McCully Substation at the present day Pumehana Street, near L. McCully's Land Grant 3098.

John Ii (1800?-1870) was the son of a Kona, Hawaii chief. His parents followed Kamehameha I to Oahu and Ii was born in Waipi'o, 'Ewa, O'ahu. He became a member of the royal court at age 10 and became the companion of the young Prince Liholiho (Kamehameha II). He assisted the missionaries with the translation of English text into Hawaiian, and in his later years wrote articles for the Hawaiian newspaper *Kuokoa* (later translated by Mary K. Pukui (1959) in *Fragments of Hawaiian History*). John Ii served as a member of the House of Nobles and the Privy Council. He was an associate justice of the Superior Court, a Supreme Court justice, and served on the Māhele Board of Commission Officers and the committee to draft the constitution of 1852 (Day 1984:55). He was a prominent and well respected Hawaiian.

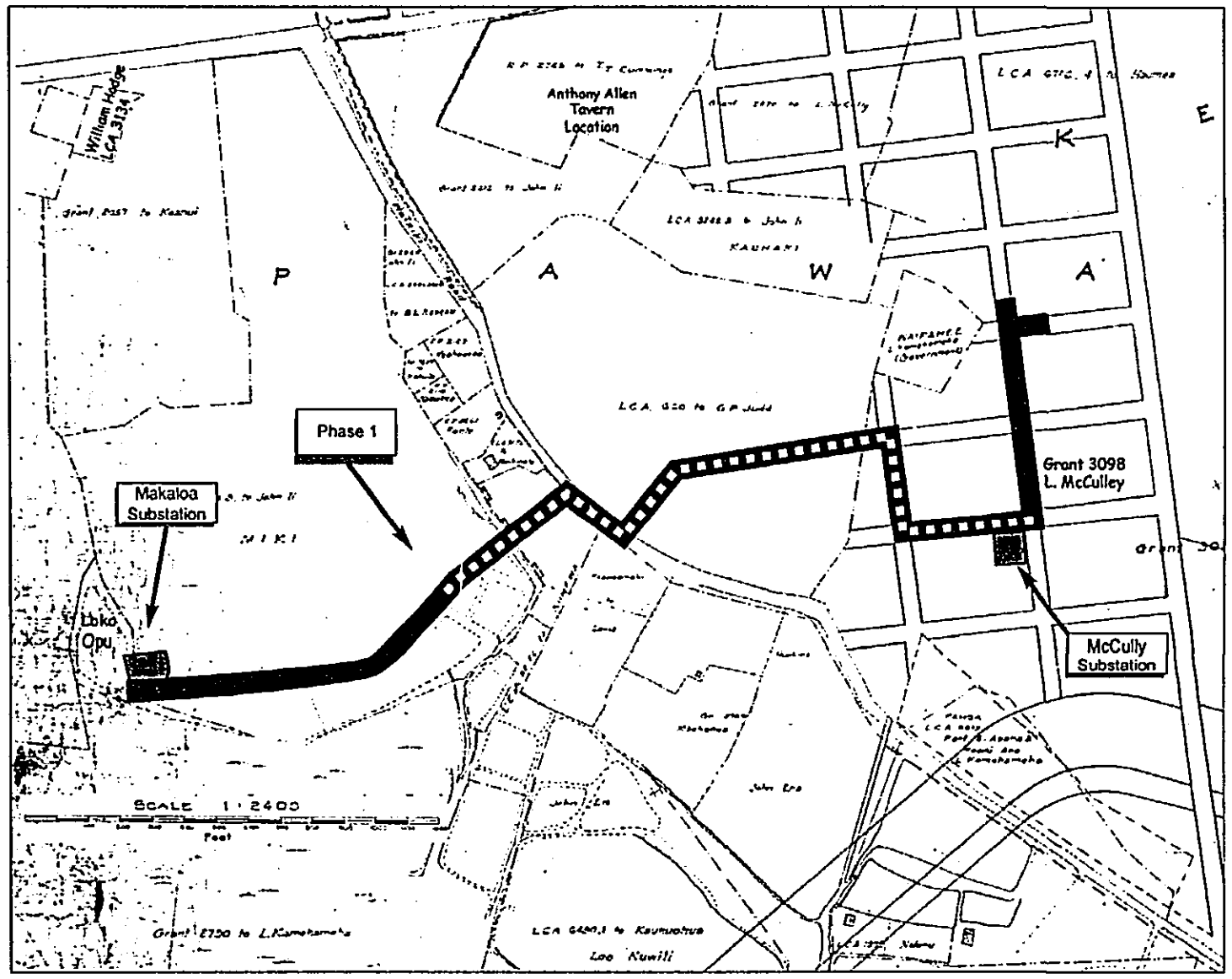


Figure 5. Pāwa'a-Miki-Kālia Lands Showing Approximate Location of the Proposed Action (Source: S.E. Bishop Map)

John Ii's family held extensive property on several islands. The Māhele documents concerning the property listed in the above table reveals little cultural and environment information, due to Ii's prominent *ali'i* standing. In 1873, three years after Ii's death, the guardians of Airine Haalou Ii petitioned for a Boundary Commission Claim on Miss Ii's behalf for the Pāwa'a property and lele Aipaako in Nuuanu. The Waihona'Aina Māhele Database list Boundary Commission Claim numbers as BCId 508. Information in the petition for Airine Ii's claim (BCId: 508) documents the presence of an ancient *auwai*, and ancient *Kahua maika* (ancient *maika* game field), taro patches, a house belonging to a Portuguese man, and a *kahua hale* (house foundation). Ii's property included a traditional pond named Loko Opu which he later sold to the government. In the BCId 508 petition, the surveyor Mr. Alexander in describing the Ii's location boundaries testified that (Alexander 1874:4):

> "makai westerly corner the pond of Opu, said to be the "Kumu" of the land of Opu or Makiki, of Kamehameha V is cut off the line following a well established fish pond bank or kuaona [Kuauna].".

Loko Opu is also listed in the State Survey Office Green Book of Artesian Wells (entry number 5, page 1) and is described as:

> "Government well in Miki, in a lot purchased from J. Ii's Estate, "Niagara Well". Elevation of ground 12.0 feet. Water in stand pipe 42.5 feet above sea level. Diameter of pipe 6 inches. Estimated flow 1½ millions of gallons per 24 hours, when open." (State Survey Office nd: entry 5, page 1).

Niagara Well is likely the traditional pond Loko Opu, which has been historically mapped, but not confirmed archaeologically (Figure 5). It is in the vicinity of the HECO Makaloa Substation, and sediments associated with this pond may be encountered during project excavations at the substation site.

As the Preferred Route reaches Kalākaua Avenue it passes through Mahele land award LCA 32 F.L., awarded to E. K. Kunewa. Kunewa gave testimony on December 30, 1851 stating (Native Register 731 v3):

> The Land Commissioners, Greetings: I hereby state my claim for land in the 'ili of Kalia, Waikiki, Kona, Oahu. There are two lo'i. At Haole, Ili of Kalia, is one section of watercourse, one house site, one pool for raising young fish, two fishponds. At Kalia are two pools for raising young fish. With thanks, KUNEWA X his mark

E. K. Kunewa brought Kaainoa as witness on January 6, 1852 and his testimony is recorded as follows (Native Testimony 273.10):

> Kaainoa sworn I have seen his land at Haole and Kalia which are ilis for Waikiki, Oahu.
> Section 1 - 2 patches in Haole ili in Waikiki.
> Section 2 - Pauku stream and Kio pua in Kalia.
> Section 3 - House site and kio pua.
> Section 4 - 2 ponds and 2 kio puas

The above description of the geographic location for sections (1-4)—which use cultural directional terms and people's names or titles—follow the testimony (Native Testimony 273.10). The description for Section 3 is most likely related to the Phase 1 Makaloa to Pumehana Area, although, it is possible that the others do as well because there are separated sections within this LCA parcel as depicted in Figure 5. No other LCA parcels with this number were found in the Waikīkī *Ahupua'a* as yet (Native Testimony 273.10). As shown above, the area presently being considered for part of the Phase 1 Makaloa to Pumehana Area , was characterized during the mid-19th century with agricultural patches, ponds, a house site and a number of *Kio pua*—cultivated ponds for raising baby fish (Waihona 'Āina Mahele database).

Dr. Gerrit P. Judd and his wife Laura Judd were American missionaries who came to Hawaii in 1828. King Kamehameha III gifted a large parcel of land in Pāwa'a to Dr. Judd in the 1830s which lies east of Old Waikīkī Road (Kalākaua Avenue) and *makai* of King Street. Dr. Judd was awarded the Pāwa'a land during the Māhele in LCA 660 on August 31, 1847. Phase 1 of HECO's Proposed Action crosses into Dr. Judd's LCA on the east side of Kalākaua Avenue (Old Waikīkī Road) at Fern or at Kapi'olani Boulevard. In Mr. Judd's testimonial claim he describes the land parcel:

> ...I claim a piece of land in Waikiki called Pawaa. It was given me in 1839 by the King through Kaikeoewa who offered it to me of his own accord, as a reward for my services rendered to his Majesty as Physician...I have been in possession ever since I received the land. It consists of 1st Kalo land in the valley of Makiki adjoining John Ii's land, and extends quite across the little valley. There are one or two tenants on the Kalo ground, placed there by myself.
>
> 2d Land on the road to Waikiki, at present enclosed according to the Native boundaries; and containing 12 acres, more or less of pasture ground. When I received this piece the greater part was an unproductive marsh, the rest completely destitute of vegetation except a few cocoa-nut trees. I have expended more than a thousand dollars in enclosures, ploughing, draining...and at the present time, the land has become valuable (Judd 1847:102, no. 660).

This Makaloa to Pumehana Area was utilized for wetland agriculture and as an inland canoe enclosure in pre and early post-Contact times, as stated above, then due to population decline and urban migration the land was abandoned and became fallow with large portions turning to marsh lands. When Gerrit Judd acquired the land in 1839 he cultivated portions of the property and used other portions for pasture lands. Anderson (1995c:17) documents that this Pāwa'a property "was held by various members of the Judd family until the mid twentieth century, when it was transferred through a series of private ownerships," evolving into a dense low income residential housing area.

Lawrence McCully was granted Land Grant 3098 in 1873. The grant reveals that McCully received the land in Fee Simple from Kamehameha IV (Lunalilo) who wrote in his statement that McCully was "his faithful and loyal disposed subject for the consideration of One Thousand Dollars ($1,000.00), paid into the Royal Exchequer, all that certain piece of Land...". This piece of land included 118 acres. Although land grant documents usually document only the land survey this grant reveals that there were *lo'i*, fishponds, and numerous watercourses in the area.

4.3.2 Kamoku Lands

The Kamoku/Date Street Area, part of Phase 1 of the Proposed Action, is just east of the intersection of Kapiolani and Date Streets. The planned HECO project construction will extend from the Kamoku Substation onto Date Street and move eastward along Date. The S.E. Bishop map of 1881 (Figure 6) places this project area in the Waikīkī *Ahupua'a* , in the *'ili of* Pa'akea, Hapuna, and Kamoku. According to Bishop's map Kamoku *'ili* lies east of Hapuna *'ili* and to the west of Kamoku II *'ili*,. It appears that the Kamoku land areas may be an *ahupua'a li'ili'i* (piecemeal, small portions here and there) as defined by Pukui and Elbert (1971:189). Pukui, Elbert and Mookini define Kamoku as "the district or the cut off portion" (1974:82).

The following Mahele awards relate to this portion of the project area and provide useful information on the traditional activities that took place in this area, namely habitation, irrigated agriculture and limited dryland agriculture.

Māhele Award	Awardee Name	Cultural Practices and Environment
LCA 8559-B, Apana 30; Royal Patent 7635, 8193, 8311, 8416;	W. C. Lunalilo	No descriptive cultural information documented
LCA 1431.2	Uma	Habitation, *lo'i, kula,* 1 house, 1 *hala lei* tree, *pō'alima* (chief's plantation where the people worked on Fridays)
LCA 1636.1	Haole	1 house lot with 2 houses, 2 *lo'i*
LCA 4313-B, Apana 2	Pauka'a	3 *lo'i*
LCA 8033.2	Akaole	House lot and 2 *lo'i*
LCA 1267.1	Kawela	1 house lot, 2 *lo'i, and 2 irrigation ditches*

Figure 6 shows the location of the above awards. LCA *kuleana* award for Uma is in the project vicinity, and within the larger Apana 30 of Lunalilo's LCA 8559-B. Lunalilo (Prince Bill) became King in 1883 following the death of Kamehameha V. King Lunalilo was a chief of high ancestry, a grandson of a half-brother of Kamehameha I, and his parents were Charles Kanaina and Kekauluohi (a sister of Kuhina nui [i.e. Queen] Kinau).

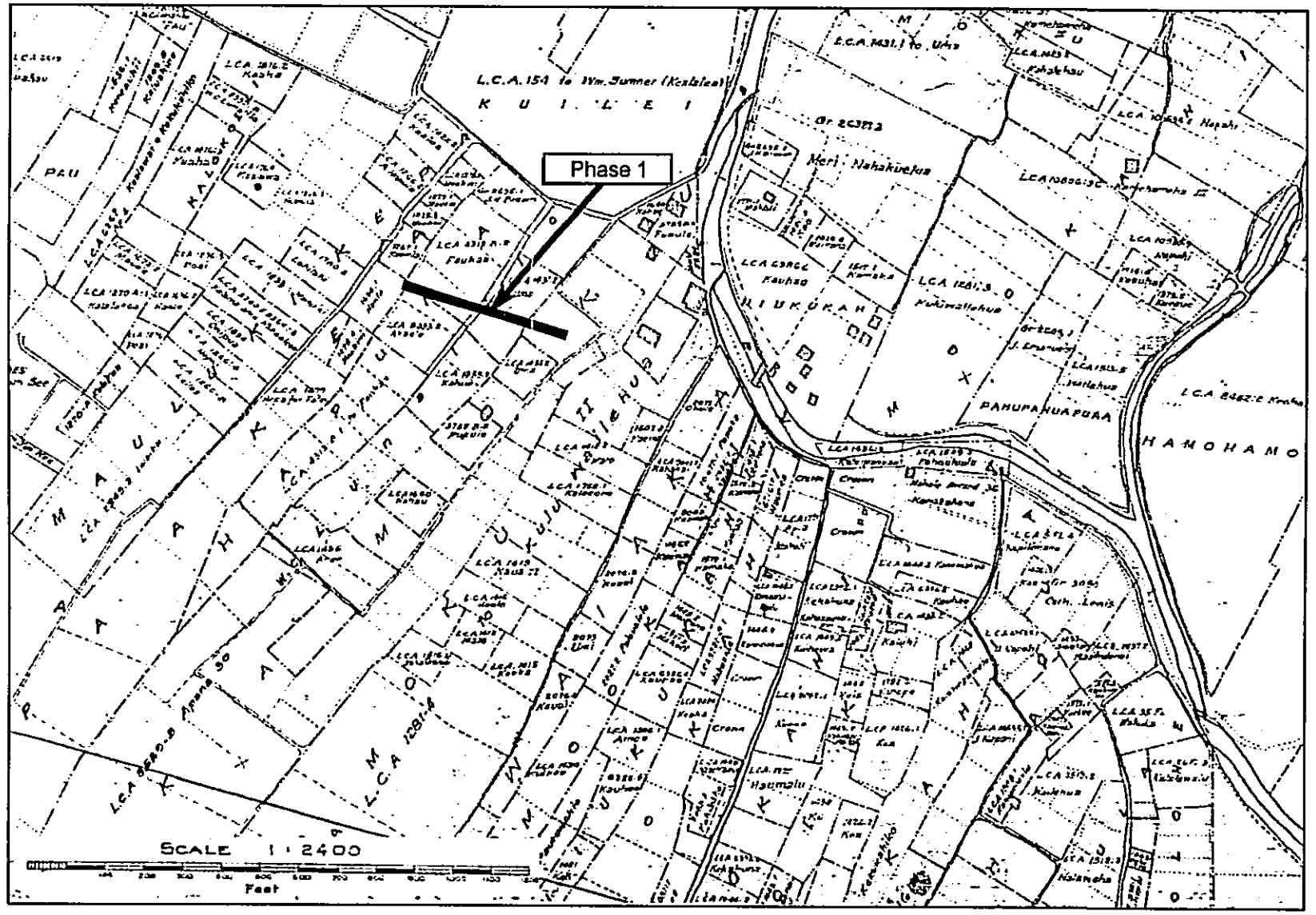


Figure 6. Kamoku Lands Showing Approximate Location of the Proposed Action (Source: S.E. Bishop Map 1881).

4.3.3 Kapahulu Lands

The Winam Avenue Area, part of Phase 1 of the Proposed Action, is located in the *Waikīkī ahupua'a*, in the land area of Kapahulu *'ili*. The traditional areas of Kaluaolohe and Kanukuaula are west of this project area, primarily on the west side of Kapahulu Avenue, and the Winam Avenue Area is off Kapahulu Avenue to the east. Construction activities will take place on Winam Avenue from Ho'olulu Street onto Mo'oheau Avenue (Figure 2).

Sterling and Summers (1978:278) give a brief description of the Kapahulu land area—which includes the Winam Avenue Area:

> when interviewing a Mr. Spencer about the Pahoa and Pohaku Kikeke (the old Hawaiian bell stone which for years lay beside Waialae Road near 5th Avenue. Mr. Spencer, and old-timer, said that "60 or 70 years ago, buildings were scarce and little more than swamp land and pasture lay between Kaimuki and Waikiki. The bell stone at that time was used as a signal by boys to let their friends at the beach know when they were going on a hike or a picnic."

Pukui, Elbert and Mookini define Kapahulu as "the worn out soil" (1974:87). An 1878 Hawaiian Government Survey Map shows the Kapahulu area as including coral, rocky land, and some *kalo* land (Figure 7). Four Māhele awards in this area provide information on activities that took place here:

Māhele Award	Awardee Name	Cultural Practices and Environment
LCA 8559-B, Apana 32, Royal Patent 8165-B #38	W. C. Lunalilo	No descriptive cultural information documented
LCA 5873; Royal Patent 2576, 2766;	Kahanaumaikai	Habitation (7 Hawaiian family names)
Land Grant 3388	Henry F. Poor	No descriptive cultural information documented,
LCA 35 F.L.; Royal Patent 4889	Mahuku	Habitation, 9 taro *lo`i*, coconut trees, *lele kō`ele*, pasture, 2 watercourses

The S.E. Bishop 1881 map for this land section does not incorporate the entire Winam Street Area as it was not entirely subdivided or developed at the time (Figure 8).

An 1898 Map of Honolulu and Vicinity (Figure 9) shows the addition of Winam Avenue above Cambell Avenue, but the *mauka* extension of Winam Avenue, where the current HECO project activities will take place was depicted as unsubdivided. This area must have been subdivided sometime after 1898.

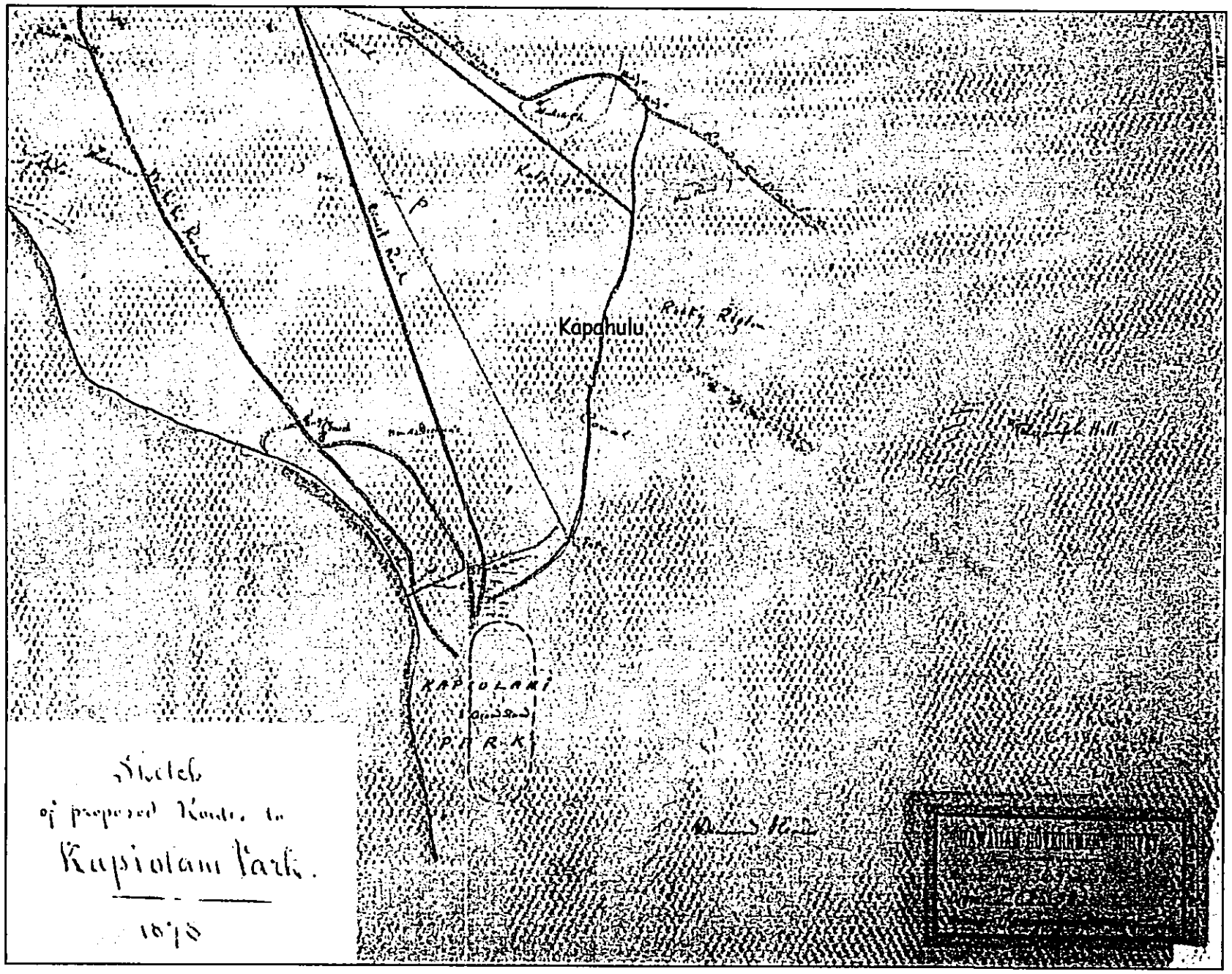


Figure 7. Sketch Map Kapahulu Lands, 1878.

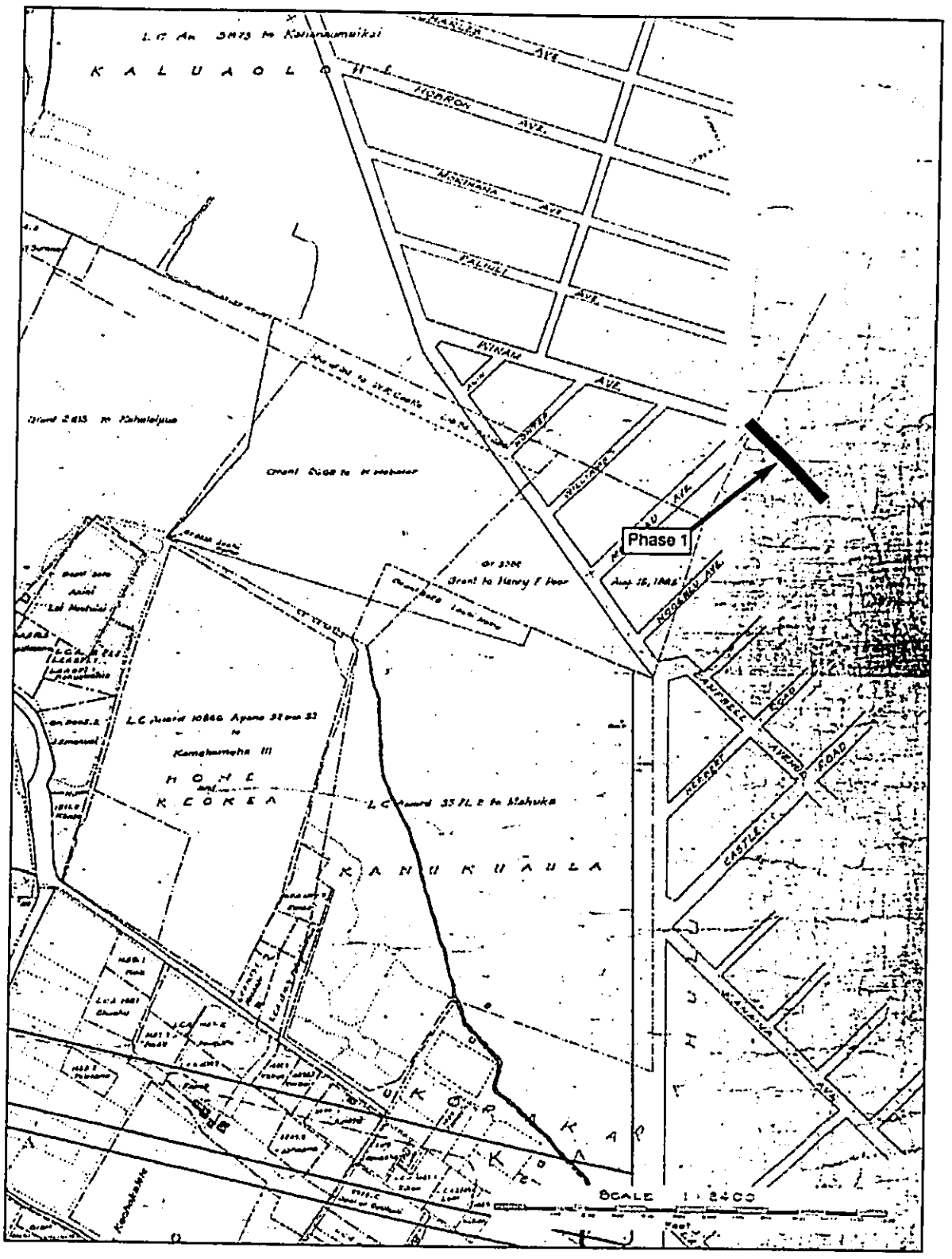


Figure 8. Kapahulu Lands Showing Approximate Location of the Proposed Action (Source S.E. Bishop Map 1881).

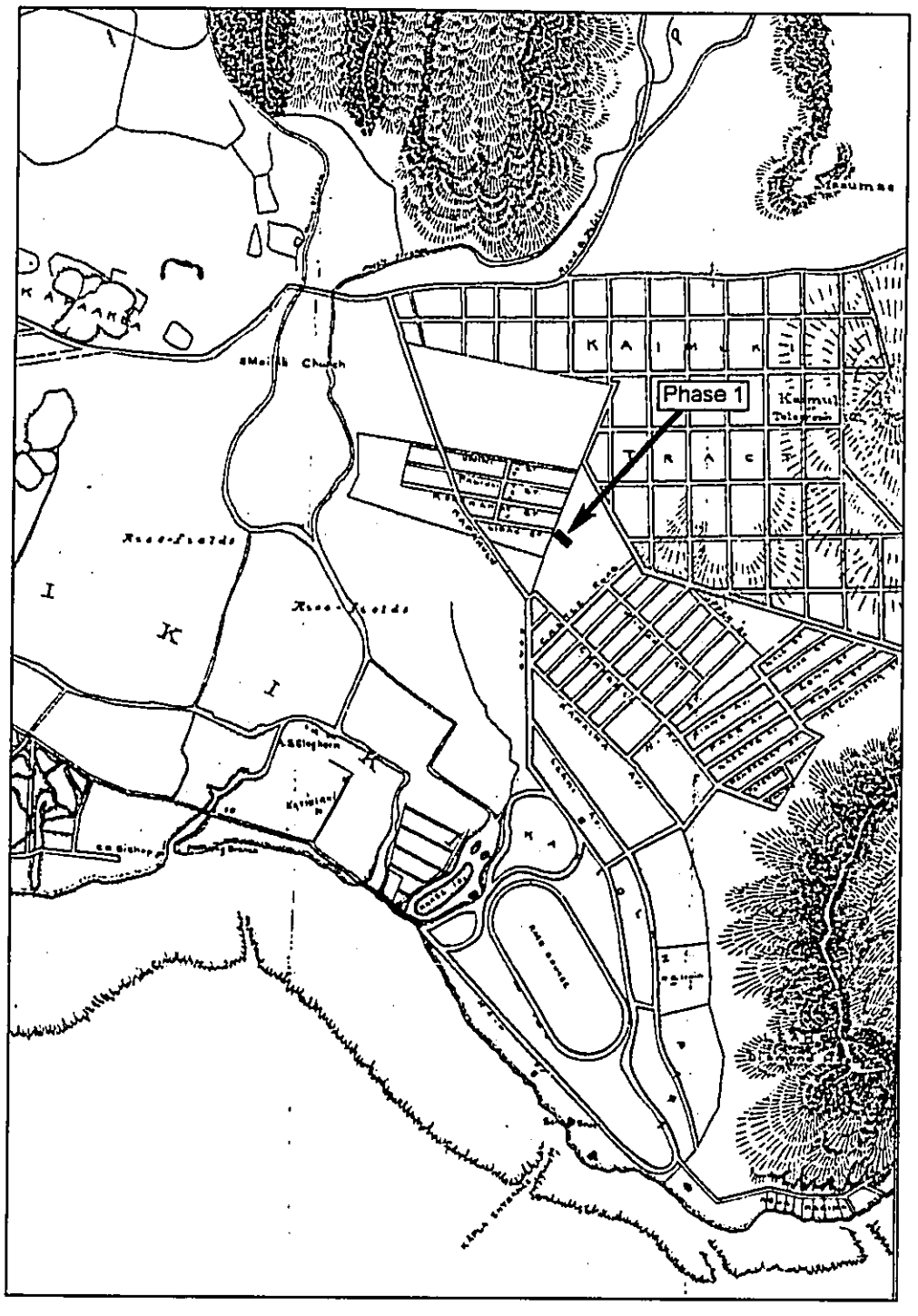


Figure 9. Kapahulu Lands 1898 Showing Approximate Location of the Proposed Action (C.J. Willie, Map of Honolulu and Vicinity).

In the traditional area of Kaluaolohe, Kahanaumaikai was awarded LCA 5873. It is adjacent to the Lunalilo LCA to the northwest (on the west side of Kapahulu Avenue). The Hawaiian tenants on Kahanaumaikai's Kaluaolohe land gave Native Testimony as a group stating that (N.T. 25-26v10):

> Be it known by all men through this document, We, whose names and numbers appear below all tenants of Kahanaumaikai's ili land in Kaluaolohe in Waikiki, Oahu and we have filed our interest in this ili land to the land officers who settle land claims.
>
> And by this document we are reverting our deeds forever to Kahanaumaikai, our konohiki, for him and for his heirs or substitutes, to have or to sell perhaps, according to his desire it would not be right for us to object. He (konohiki) will defray all expenses concerning our documents for this shall be his own estate. Let all believe and understand that every statement above is true. It would not be proper for us to over turn this conveyance at a later date. In truth we pen our signatures on this 18th day of July 1851 in Honolulu. Oahu.

The tenants listed in this document included the family names of Pukaiea, Upai Kukapele, Kanohona Kamamana, Umiumi, Opu and Wahineaea. The above example shows a process that did not secure Native families permanent rights to their living areas due to the interpretation of the Māhele by the *konohiki*.

Land Commission Award 35 F.L. is to the west of the Winam Avenue project area. This LCA (35 FL) was awarded to Mahuka. On January 10, 1852, Mahuka gave testimony (Native Register V3:732) when applying to the Land Commissioners for a Mahele ownership award. This award included two areas in Honolulu and two areas in Waikīkī. One land parcel was located in the area of Kanukuaula, to the southwest of the Winam Avenue Area (Figure 8). In addressing the commissioners Mahuka stated (Native Register V3:732):

> Greetings to the Land Commissioners: I hereby state my claim at...and the 'ili of Kanukuaula, Waikiki, Kona, Oahu, are nine taro lo'i and two watercourses...Those are my claims in the Fort Lands; they are true claims and I am prepared to bring witnesses when you call. I am, with thanks, MAHUKA

Mahuka presented three witnesses for collaborating testimony on January 12, 1852: Kumupala, Kanaohilo, and Nakai. Kanaohilo gave testimony for Mahuka's claim in the area of Kanukuaula near Kapahulu (Native Testimony V10:276-277):

> Kanaohilo, sworn, I have seen his land of 9 patches and banks of two streams. Two sections are in Kanukuaula, Waikiki.
> Section 1 – 4 patches and a stream.
> Section 2 – 5 patches.

Section 1	Mauka	Koaka ili
	Waialae	Kaneloa ili
	Makai	Hamohamo ili
	Honolulu	Kanukuaula, for Nalaweha ili
Section 2	Mauka	Kalia stream
	Waialae	Kaluahole ili
	Makai	Kanukuaula, for Nalaweha
	Honolulu	Pahuphuapuaa

The above is an example of the traditional cultural practice for discerning parcel boundaries. Only a few of the land area names can be located on the 1881 S.E. Bishop Map (Figure 8).

4.3.4 Kewalo-Kuhua-Pāwa'a Lands

The King Street Area of Phase 2 of the Proposed Action is in the traditional Kewalo-Kuhua-Pāwa'a Lands. Phase 2 of HECO's Proposed Action begins at HECO's Archer Substation off Clayton Street; this route angles through this property moving west and north, turning left and going *mauka* (north) on Cooke Street then turning right onto King Street and moving eastward to McCully Street. At McCully Street the route turns left and goes *mauka* (north) ending at Young Street.

The King Street Area is located in the flat lands on the eastern boundary of Honolulu and on the flat lands in the ahupua'a of Waikīkī. There are numerous LCA documents for this extensive area. However, for the purposes of this report only those directly affected by the proposed construction activities will be summarized. Much of the project route runs along King Street which was already a road at the time of the Māhele and was not included in any award, thus only bordering awards with noteworthy cultural information are summarized below:

Māhele Award	Awardee Name	Cultural Practices and Environment
LCA 10605; RP 5716,	Kamakee Pi'ikoi	Habitation, protected fish, wood, water, leases, *lele*,
LCA 569; RP 4465	Puniwai	Habitation, 1 house lot, fence, well, salt lands, *lokoia* , road/path, old fish pond *makai* of property,
LCA 706	Kukuna Neki (Susan Jackson) and her sister Hana Haalilio	Habitation, 2 adobe houses, 3 section fishpond, wall/fence, well
LCA 200, RP 85, 7215	Kaina	Habitation, 2 house lots, wall/fence, kula,
LCA 3134; RP 7185	William Hodge	Habitation, 1 house lot,
LCA 3135; RP 6924	James Walker	Habitation, 3 house lots, *kula*, road/path, wall/fence (adobe wall), marine carpenter, pasture land, tenants
LCA 264; RP 7628	Thomas Cummings (purchased from Allen family in 1845)	Habitation, 1 house lot with 2 story house (1st floor stone, 2nd floor wood), 1 stone building, 1 bullock pen, fence,

The S.E. Bishop Hawaii Territory Survey Honolulu Kewalo Map of 1884 (Figure 10) depicts the beginning portion of the Phase 2 project area and shows that the project begins in the LCA awarded to Kamakee Pi'ikoi. As the route nears Cooke Street the LCA of Puniwai is crossed until reaching King Street. Along the *makai* side of King Street LCA parcels belonging to Kukuna Neki and Hana Haalilo of the Jackson family and the Kaina family are passed as the route moves east. The Kaina LCA 200 originally included the Catholic Cemetery west of what

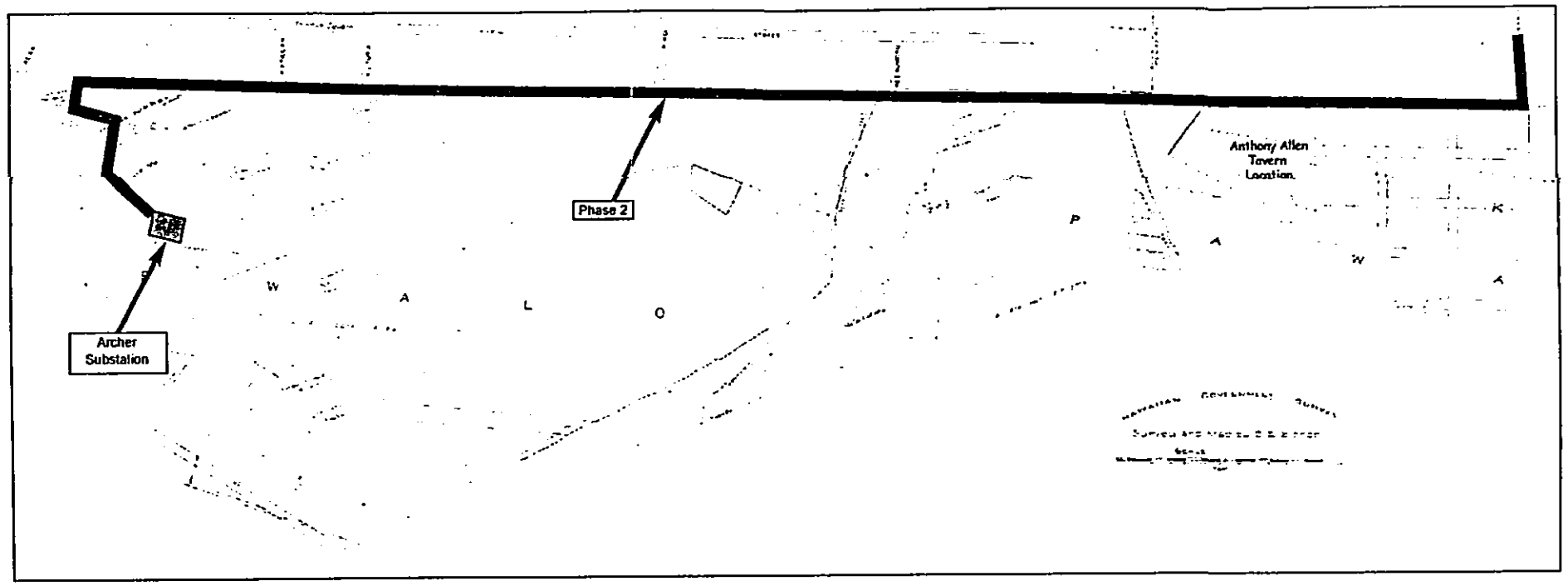


Figure 10. Kewalo-Kuhua-Pāwa'a Lands Showing Approximate Location of the Proposed Action (Source: S.E. Bishop Map 1881, 1884).

is now Ward Avenue. The entire Kaina award at this location was later sold to the Ward family. The William Hodge parcel is located mid way between Sheridan Streets and the Old Waikīkī Road (Kalakaua Avenue). The LCA 3135 of James Walker was not located on either Bishop Map, but the description may place it next to the parcel of William Hodge.

The remainder of the route is depicted on the 1881 Hawaiian Government Survey Waikīkī Map of S.E. Bishop and the two maps have been incorporated into Figure 10. The LCA of Thomas Cummings, a noteworthy site, is located further east on King Street past Old Waikīkī Road (Kalakaua Avenue) and a parcel granted to John Ii as Grant 2616. Grant 2870 to L. McCully and LCA 6716.4 to Haumea lies to the east of the T. Cummings LCA *makai* of King Street.

LCA 706 awarded to Kukuna Neki and the Kaina LCA 200 are noteworthy in that: there is a good deal of information on Kukuna Neki and her property; and the Kaina property for originally containing what was to become the French Catholic Cemetery on King Street and a large portion of what became the Ward Plantation along what is now Ward Avenue.

A historic map of Kukuna Neki's property, where Phase 2 of the Proposed Action begins, shows a three part traditional fishpond (see Figure 10). The claimant, Kukuna Neki—also known as Susan Jackson and later Susan Reynolds—addressed the Mahele committee on September 2, 1847:

> I hereby state my claim for my lot, as follows: it was from my makuas to me. It is outside of the kula of Kahua, makai of the road to the French lot.
>
> This is the place where my lot is situated. That is my explanation to you. (Reynolds 1847:307, no. 706)

On February 7, 1848, John Ii gave sworn testimony for the claimant (Kukuna Neki). The original testimony hand written in English:

> ...This place is bounded on Waititi side by the French burying grounds. Makai by a fence on the edge of a fish pond, Ewa by Puniwai place; Mauka by Waititi road. It is imperfectly fenced, and has two adobie houses on it. Claimant lives there. I think Jackson and his wife took this place in 1836, when they died it fell to Claimant and her sisters and Hana Haalilio, who have equal rights. (Ii 1848:177, 178)

John Ii's original testimony written in Hawaiian has been translated and reads:

> "This property is at Kahua and I have seen it; a cemetery, Waikiki; a pond, toward the sea; a well, Ewa and Waikiki street is on the mountainside. This place has been enclosed but the fence that is on the Oceanside has fallen to the ground. There are two adobes in there and Neki lives there. Neki had received this land from Polunu, his [*sic*] mother, in the year 1836. When his [*sic*] mother died, everything was left for Neki and her young sister, Hana, of Haalilio. No one has objected..." (Ii 1848:504, no.706)

Property transaction documents at the State Bureau of Conveyances provided additional information on this property. Kukuna (now Susan Reynolds) leased portions of the property to

William Duncan in 1857 and 1861 (Liber 9:558 & 14:311). In 1878 she mortgaged the property to Stephen Spencer, which included "a dwelling house, outhouses and 7 2/5 acres of land situated on King Street adjoining the west side of the Catholic Cemetery" (Liber 55:213). In 1882—months before the mortgage would be paid in full—Kukuna died in 1882 and her four living children lost the property to a public auction arranged by Spencer on March 18, 1882.

The French Roman Catholic Cemetery, originally part of the Kaina LCA 200, is located at 839 South King Street, on the *makai* side of the street and adjacent to Kukuna Neki's property to the northwest. The original date of Catholic acquisition of the property is not known. Anderson's (1995c) research regarding the cemetery conveys that the earliest death date—of the readable headstones—dates to 1841. Anderson suggests that it is unlikely that a Catholic Cemetery was open during the years between 1829 and 1839 when the Catholic religion was banned and Catholics were persecuted and imprisoned by the Hawaiian Government.

While this is a possibility, a few related issues allow for alternative potential conclusions: first, the account of early Catholic arrivals by Kamakau and their lessened number when sent away by Premier Ka'ahumanu; and second, a large number of potential earlier unmarked graves accounted for within the cemetery which may have originally had wood markers that deteriorated; and the additional 30 undocumented burials found outside the current cemetery boundaries, to the northwest, during Anderson's three phase monitoring and archaeological emergency data recovery in 1997 (Anderson and Aronson 1997:69). These alternative issues are posed lending to the possibility of earlier use of the area for the burial of Catholics who may have died of natural death or persecution hardships during the years prior to 1840.

The LCA of Thomas Cummins is historically noteworthy and solves the question of the location of the early Anthony Allen Tavern. Early post contact descriptions—discussed in section 4.2 Early Contact Accounts— of the King Street route to the east of Honolulu talk of the black man who arrived early (1810) in post contact Hawaii and made a life for himself with a Hawaiian wife and a popular tavern. The exact location of the tavern was not mentioned and reports have speculated as to its location elsewhere.

In 1846, Thomas Cummings (or Cummins) testified for the Foreign Register (168-170v1) stating:

> Gentlemen, I herewith hand you a written document for a premises (house and land) which I bought of Allen's family, cash. November 1845.

Cummings presented the documents pertaining to this transaction from the Allens, those still living being present:

> Know all men by these presents that we, George E Allen, Antony D. Allen and Salley Allen, for and in consideration of the sum of four hundred dollars to us in hand at the signing of these presents paid by Thomas Cummins, now residing at Honolulu, Oahu, the receipt whereof we do hereby acknowledge; have bargained, sold & delivered , ...unto the said Thomas Cummins a piece of ground situated in the district of Puwaa; the said piece of ground having on it two buildings, one with the lower part stone, and upper part wood, and the other a

> small stone house, and one bullock pen, bounded as follows, ...The said George C. Allen, Antony D. Allen and Sally Allen in manner aforesaid, and for their heirs, Executors, administrators and assigns, do by these presents relinquish all claim to the said piece of ground and singular the buildings & improvements thereon,...

John Ii testified for Cummins in June of 1848 and it was recorded in the Foreign Testimony volumes (364v2:73-claim 264):

> John Ii, sworn, I know this place claimed by Mr. Cummins. The Allens got this land from an old high priest, Hewahewa. The father of the Allen Boyd [boys], who sold the land to Mr. Cummins came here before the Missionaries, and this land was given him in time of Kamehameha 1st, the old man Allen, who is now dead, had a large land given him at first, and it was afterwards all taken away from him but this piece. This land is fenced and has a large house on it. It joins Dr. Judd's land and is in Waititi, Oahu.

A slight variation and additional information of John Ii's testimony has been translated from the Native Testimony (124v3:390-claim 264) by the Waihona'Aina Corporation and reads:

> John Ii, sworn and said, I have seen Alani's place at Pawaa in Waikiki. Alani's [Allen] property had been from Hewahewa. This was during the time of Kamehameha I. Land was the reason he had lived there in the beginning, that is the land in Kapeau's possession. When he lived there, he put up a fence and built a house. When Alani died, I heard the property had been bequested for his children. This place is in (by) G.P. Judd's property. In the 1847, I heard the place had been sold to Thomas Cummins to pay his (Alani's/Allen's) debts.

4.4 Kupuna Interviews

The following agencies and persons were contacted in attempts to locate *kupuna* for interviews.

- Historic Preservation Division, Archaeology Program, Kapolei, O'ahu, Hawai'i

Eric Komori	referred to Van Diamond
Elaine Jourdane	referred to Van Diamond and Kana'i Kapeliela

- O'ahu Burial Council

Van Diamond	Mr. Diamond stated he was not from the project area, but that people had come forward as cultural descendants or concerned knowledgeable persons for other projects in the area, and that the identity of these persons would be listed with Kana'i Kapeliela at the State Burial Program.

- Office of Historic Preservation Division, Burial Program, Kapolei, O'ahu, Hawai'i

Kana'i Kapeliela	no referral provided
Kai'ana Markell	no referral known, persons that have come forward for the area were not knowledgeable of any cultural practices or beliefs. He would relay inquiry to Nathan Napoka and ask him to get back to Pacific Legacy.

- Office of Hawaiian Affairs (OHA)
  711 Kapi'olani Boulevard #500
  Honolulu, Hawaii 96813

Lance Foster	referred to Lucy Meyer
Lucy Meyer	referred to Ward Family History book

- Waikiki Descendents Group

one member, Cy Kamuela Harris was identified as having traditional information on the general area.

Three potential interviewees were identified: Nanette Purnell, expert on Hawaii Cemetery Research; C. Dudley Pratt fifth generation of the Judd family and former CEO of HECO; and Cy Kamuela Harris of the Waikiki Descendents Group. No success was achieved in interviewing Nanette Purnell or Cy Harris. An interview was obtained with Dudley Pratt, but no significant information regarding traditional cultural practices of the area was obtained.

5.0 SUMMARY AND DISCUSSION

This cultural impact assessment has relied on archival sources made up primarily of native and foreign testimonies that were recorded in the mid-1800s. This information was augmented by other historical and traditional literary sources. Good faith efforts were made to locate knowledgeable individuals that could provide additional information on the traditional activities that took place in the project areas, but these efforts were unsuccessful. The archival research that was conducted was successful in generally identifying the traditional activities that took place in the vicinity of the project areas.

The current project areas are located on the Honolulu and Waikīkī flat plains, including the land areas of Kalua`ōlohe and Kapahulu. Legendary and early historic accounts characterize this land area as having habitation sites, wet and dry land agricultural areas, freshwater artesian wells, salt making ponds, marsh lands, various types of fish ponds, and business ventures of early foreigners. Following the early contact years much of the cultivated land was left fallow; disuse was due to population migration into the busy Honolulu port and town area, and a decrease in population due to the introduction of foreign disease. As post-contact years passed land use in the areas were increasingly characterized with livestock, grazing land, small farms, residential and business lots. Fish and duck ponds and some marshland agriculture continued. During the years of the Māhele Hawaiian individuals and families were awarded lands they

could show a rightful claim to as long as the person traditionally in charge of the land had no objections. Much of the land was awarded or sold to foreign persons and Hawaiian *ali'i* who had in recent years been gifted, sold, or mortgaged parcels by the king, other *ali'i*, or the Hawaiian Government. As immigration increased into the nineteen hundreds most of this land was resold in parcels diminishing in size; this process led to the entire Kewalo and Waikīkī plain characterized today by a crowded urban landscape.

The transition to today's urban center has erased the existence of any of the traditional cultural practices that took place in the project areas during pre and early post-contact Hawai'i.

The primary cultural concern in the project area is the potential of encountering human burials. Human burials have been found concentrated near the Catholic Cemetery along King Street, as well as inadvertent discoveries in various construction excavations in the vicinity. The possibility of encountering burials beneath King Street adjacent to the Catholic Cemetery is high.

Excavations on HECO's Ward Avenue complex and Makaloa Substation properties may also expose sediments from buried traditional fishponds identified on historical maps. Such encounters may prove beneficial and add to our knowledge of this portion of Honolulu by shedding light on vegetation and land use changes in the area.

6.0 REFERENCES CITED

Anderson, Lisa
1995a Historical Background Research for Properties Consisting of Tax Map Keys: 1-2-3-23:25 and 1-2-3-31:02, and 122 Honolulu, Hawai'i. Ogden Environmental and Energy Services Co., Inc., Honolulu, Hawai'i.

Anderson, Lisa
1995b Historical Background Research The King Street Place Property Tax Map Keys: 1-2-1-044: 041, 042, 043 Honolulu, Hawai'i. Ogden Environmental and Energy Services Co., Inc., Honolulu, Hawai'i.

Anderson, Lisa
1995c Archaeological Sub-Surface Inventory Survey of the King Street Place Property, Honolulu, Hawai'i (TMK No. 1-2-1-044:041, 042, and 043). Ogden Environmental and Energy Services Co., Inc., Honolulu, Hawai'i.

Anderson, Lisa and K. Aronson
1997 Archaeological Monitoring and Emergency Data Recovery of One Archer Lane, Honolulu, Hawai'i (TMK No. 1-2-1-044:041, 042, and 043). Ogden Environmental and Energy Services Co., Inc., Honolulu, Hawai'i.

Athens, J. Stephen, C. Erkelens, J. V. Ward, R. H. Cowie, and M. Pietrusewsky
1994 The Archaeological Investigation of Inadvertently Discovered Human Remains at the Pi'ikoi and Kapi'olani Intersection, Kewalo, Waikīkī, O'ahu, Hawai'i. International Archaeological Research Institute, Inc., Honolulu, Hawai'i.

Bloxam, A.
1925 *Diary of Andrew Bloxam.* Bishop Museum Special Publication 10, Bishop Museum Press, Honolulu.

Broeze, F.
1988 *A Merchant's Perspective: Captain Jacobus Boelen's Narrative of his Visit to Hawai'i in 1828.* The Hawaiian Historical Society, Honolulu.

Chamberlain, L.
1957 Tour Around Oahu. 1828. *Sixty fifth Annual Report of the Hawaiian Historical Society for the year 1956,* Honolulu.

Day, A. Grove
1984 *A Biographical Dictionary History Makers Of Hawaii.* Mutual Publishing of Honolulu, Honolulu, Hawaii.

Forbes, D
1992 *Encounters with Paradise.* Honolulu Academy of Arts, Honolulu.

Fornander, A.
1921 *Collection of Hawaiian Antiquities and Folklore.* Bishop Museum Press, Honolulu.

Hammatt, H. H. and D. W. Shideler
1996 Archaeological Data Recovery at the Hawai'i Convention Center Site Waikīkī, Kona District, O'ahu (TMK 2-3-35:001). Cultural Surveys Hawai'i, Kailua, O'ahu, Hawai'i.

Ii, John
1848 State Archives Foreign Testimony 177 & 178 no.706
1848 State Archives Native Register Testimony 177 & 178 no.706

Judd, Gerrit P State Archives Foreign Testimony 102 no. 660

Judd, Laura Fish
2003 *Honolulu Sketches of Life in the Hawaiian Islands.* Members of the Judd Family, Honolulu, Hawai'i.

Kamakau, Samuel Mānaiakalani
1961 *Ruling Chiefs.* Kamehameha Schools Press, Honolulu.

Maly, Kepa, Leta Franklin, and Paul H. Rosendahl
1994 Archaeological and Historical Assessment Study Convention Center Project Area Land of Waikīkī Kona District, Island of O'ahu (TMK: 2-3-35 and 2-3-36:018,024,025). Paul H. Rosendahl, Ph.D., Inc., Hilo, Hawai'i.

Menzies, A.
1920 *Hawaii Nei 128 Years Ago.* Edited by W. Wilson. The New Freedom, Honolulu

O'Hare, Constance R., Douglas Borthwick and Hallett H. Hammatt
2003 An Archaeological Inventory Survey of a Property in Waikīkī *Ahupua'a, 'Ili* of Kewalo, Kona District, O'ahu. Cultural Surveys Hawai'i, Inc., Honolulu, Hawai'i.

Reynolds, Kukuni Neki Jackson
1847 State Archives Native Register 367 no. 706

State Survey Office
nd Green Book of Artesian Wells In And Near Honolulu.

Sterling, Elspeth P. and Catherine C. Summers
1978 *Sites Of Oahu.* Bishop Museum Press. Honolulu, Hawaii.

Stewart, C. S.
1970 *Journal of a Residence in the Sandwich Islands during the Years 1823, 1824, and 1825.* Originally published in 1830. University of Hawai'i Press, Honolulu.

Vancouver, G
1798 *A Voyage of Discovery to the North Pacific Ocean and Around the World...Performed in the years 1790-1795.*, vol. I. John Stockdale, London.

Appendix D1

Magnetic Field Evaluation

Hawaiian Electric Company

East Oahu Transmission Project

Magnetic Field Evaluation

Prepared for
Hawaiian Electric Company
Honolulu, Hawaii 96840

Prepared by
Enertech Consultants of Santa Clara, Inc.
300 Orchard City Drive, Suite 132
Campbell, California 95008

July 22, 2004

NOTICE

This report was prepared by the organization(s) named below as an account of work sponsored by Hawaiian Electric Company (HECO). Neither Hawaiian Electric Company (HECO), Enertech Consultants, nor any person acting on their behalf: (a) makes any warranty, express or implied, with respect to the use of any information, apparatus, method, or process disclosed in this report or that such use may not infringe privately owned rights; or (b) assumes any liabilities with respect to the use of or for damages resulting from the use of any information, apparatus, method, or process disclosed in this report.

Prepared by
Enertech Consultants of Santa Clara, Inc.
Campbell, California

TABLE OF CONTENTS

Section	Page
Executive Summary	x
Introduction	1
Project Description	1
Units of Measure	3
Description of Magnetic Fields	3
Measurement Equipment	5
Instrumentation Calibration	6
Magnetic Field Measurements at Selected Project Locations	6
Magnetic Field Calculations at Selected Project Locations	8
Computer Modeling Assumptions	21
HECO Electrical Facility Characterization	22
Magnetic Field Measurements at Everyday Environments in Honolulu	25
Review of Selected Institutions Near Proposed Project	32
Magnetic Field Standards	34
Summary and Conclusions	36
References	39

Appendix	Page
A - Diagram of Electrical Facilities at Segment Locations	A-1
B - Magnetic Field Measurements at Segment Locations	B-1
C - Magnetic Field Profile Calculations at Segment Locations	C-1
D - Segment 'J' Phasing Analysis	D-1
E - Magnetic Field Measurements of HECO Electrical Facilities	E-1
F - Magnetic Field Measurements at Public Locations	F-1
G - HECO Documentation of Electrical Facilities, Loading, and Selection of Segment Locations	G-1

TABLES

Report Table		Page
Table 1.	Magnetic Fields From Household Appliances	4
Table 2.	U.S. Population with Average Field Exposure Exceeding Given Level	5
Table 3.	Summary of Magnetic Field Measurements at the Ala Moana Shopping Mall	26
Table 4.	Summary of Magnetic Field Measurements at the Daiei Department Store	27
Table 5.	Summary of Magnetic Field Measurements at the Ward Shopping Center	28
Table 6.	Summary of Magnetic Field Measurements at the McCully Shopping Center	28
Table 7.	Summary of Magnetic Field Measurements at the State Capitol Building	29
Table 8.	Summary of Magnetic Field Measurements at the McCully – Moiliili Public Library	29
Table 9.	Summary of Magnetic Field Measurements at the Straub Hospital	30
Table 10.	Summary of Magnetic Field Measurements at the Central Pacific Bank	30
Table 11.	Summary of Magnetic Field Measurements at the U.S. Post Office	31
Table 12.	Summary of Magnetic Field Measurements at the Jack-In-The-Box Restaurant	31
Table 13.	Summary of Selected Institutions Near Proposed Project and Projected Magnetic Field in 2009	33
Table 14.	Summary of State Transmission Line Standards and Guidelines for Magnetic Fields	34
Table 15.	Summary of ICNIRP Exposure Guidelines For Magnetic Fields	35
Table 16.	Summary of ACGIH 60 Hz Exposure Guidelines For Magnetic Fields	35

Appendix Table		Page
Table A-1.	Summary of Existing Transmission Line Facilities and Loading Information for Each Segment of the Proposed Project	A-26
Table A-2.	Summary of Proposed Transmission Line Facilities and Loading Information for Each Segment of the Proposed Project	A-27
Table B-1.	Summary of Line Loading for Each Segment During Field Measurements	B-12

TABLES

Appendix Table		Page
Table D-1.	Calculated Magnetic Field Versus Measurements at Segment 'J' With Day of Measurement Loading for Phasing Configurations #1 - #6	D-2
Table D-2.	Calculated Magnetic Field Versus Measurements at Segment 'J' With Day of Measurement Loading for Phasing Configurations #7 - #12	D-4
Table D-3.	Calculated Magnetic Field Versus Measurements at Segment 'J' With Day of Measurement Loading for Phasing Configurations #13 - #18	D-6
Table D-4.	Calculated Magnetic Field Versus Measurements at Segment 'J' With Day of Measurement Loading for Phasing Configurations #19 - #24	D-8
Table D-5.	Calculated Magnetic Field Versus Measurements at Segment 'J' With Day of Measurement Loading for Phasing Configurations #25 - #30	D-10
Table D-6.	Calculated Magnetic Field Versus Measurements at Segment 'J' With Day of Measurement Loading for Phasing Configurations #31 - #36	D-12
Table E-1.	Magnetic Field Measurements of Substation Transformers at Kapiolani Substation	E-1
Table E-2.	Magnetic Field Measurements of Substation Transformers at McCully Substation	E-2
Table E-3.	Magnetic Field Measurements of Substation Transformers at Moiliili and Kewalo Substations	E-3
Table E-4.	Average of Normalized Magnetic Field Measurements For HECO Substation Transformers	E-5
Table E-5.	Magnetic Field Measurements of Manholes at Kapiolani Boulevard and Ward Avenue	E-7
Table E-6.	Magnetic Field Measurements of Manholes at Kapiolani Boulevard and Ward Avenue	E-8
Table E-7.	Magnetic Field Measurements of Manholes at Kapiolani Boulevard and Ward Avenue	E-9
Table E-8.	Average of Normalized Magnetic Field Measurements For HECO Manholes	E-11
Table E-9.	Magnetic Field Measurements of Risers at Various Honolulu Locations	E-13
Table E-10.	Average of Normalized Magnetic Field Measurements For HECO Risers	E-15

FIGURES

Report Figure		Page
Figure 1.	Magnetic Field Measurements Being Conducted on the Sidewalk at King Street	7
Figure 2.	Projected Magnetic Field for Segment 'A' Under 2009 Forecasted Normal Loading (Makaloa Street between Kaheka and Poni Streets)	10
Figure 3.	Projected Magnetic Field for Segment 'B' Under 2009 Forecasted Normal Loading (Fern Street between Punahou and Hauoli Streets)	11
Figure 4.	Projected Magnetic Field for Segment 'C' Under 2009 Forecasted Normal Loading (Pumehana Street between Lime and Date Streets)	12
Figure 5.	Projected Magnetic Field for Segment 'D' Under 2009 Forecasted Normal Loading (Date Street west of Kamoku Substation)	13
Figure 6.	Projected Magnetic Field for Segment 'E' Under 2009 Forecasted Normal Loading (Date Street east of Kamoku Substation)	14
Figure 7.	Projected Magnetic Field for Segment 'F' Under 2009 Forecasted Normal Loading (Winam Avenue between Hoolulu and Mooheau Streets)	15
Figure 8.	Projected Magnetic Field for Segment 'G' Under 2009 Forecasted Normal Loading (Date Street between Pumehana and McCully Streets)	16
Figure 9.	Projected Magnetic Field for Segment 'H' Under 2009 Forecasted Normal Loading (Kapiolani Boulevard between Wiliwili and McCully Streets)	17
Figure 10.	Projected Magnetic Field for Segment 'I' Under 2009 Forecasted Normal Loading (King Street between Ward Avenue and Victoria Street)	18
Figure 11.	Projected Magnetic Field for Segment 'J' Under 2009 Forecasted Normal Loading (Kapiolani Boulevard between Clayton Street and Ward Avenue)	19
Figure 12.	Projected Magnetic Field for Segment 'K' Under 2009 Forecasted Normal Loading (Sheridan Street between Kapiolani Boulevard and Makaloa Street)	20
Figure 13.	Average Normalized Magnetic Field Attenuation Rate for Substation Transformers	23
Figure 14.	Average Normalized Magnetic Field Attenuation Rate for HECO Manholes	23
Figure 15.	Average Normalized Magnetic Field Attenuation Rate for HECO Riser Poles	24

FIGURES

Appendix Figure		Page
Figure A-1.	Diagram for the HECO East Oahu Transmission Project With Associated Segment Locations	A-1
Figure A-2.	Detailed Diagram for the HECO East Oahu Transmission Project Ewa Side With Associated Segment Locations (Segments 'A' – 'C' and 'G' – 'K')	A-2
Figure A-3.	Detailed Diagram for the HECO East Oahu Transmission Project Diamond Head Side With Associated Segment Locations (Segments 'D' – 'F')	A-3
Figure A-4.	Measurement Location at Segment 'A'	A-4
Figure A-5.	Diagram of Electrical Facilities at Segment 'A'	A-5
Figure A-6.	Measurement Location at Segment 'B'	A-6
Figure A-7.	Diagram of Electrical Facilities at Segment 'B'	A-7
Figure A-8.	Measurement Location at Segment 'C'	A-8
Figure A-9.	Diagram of Electrical Facilities at Segment 'C'	A-9
Figure A-10.	Measurement Location at Segment 'D'	A-10
Figure A-11.	Diagram of Electrical Facilities at Segment 'D'	A-11
Figure A-12.	Measurement Location at Segment 'E'	A-12
Figure A-13.	Diagram of Electrical Facilities at Segment 'E'	A-13
Figure A-14.	Measurement Location at Segment 'F'	A-14
Figure A-15.	Diagram of Electrical Facilities at Segment 'F'	A-15
Figure A-16.	Measurement Location at Segment 'G'	A-16
Figure A-17.	Diagram of Electrical Facilities at Segment 'G'	A-17
Figure A-18.	Measurement Location at Segment 'H'	A-18
Figure A-19.	Diagram of Electrical Facilities at Segment 'H'	A-19
Figure A-20.	Measurement Location at Segment 'I'	A-20
Figure A-21.	Diagram of Electrical Facilities at Segment 'I'	A-21
Figure A-22.	Measurement Location at Segment 'J'	A-22
Figure A-23.	Diagram of Electrical Facilities at Segment 'J'	A-23
Figure A-24.	Measurement Location at Segment 'K'	A-24
Figure A-25.	Diagram of Electrical Facilities at Segment 'K'	A-25

FIGURES

Appendix Figure		Page
Figure B-1.	Magnetic Field Measurements at Segment 'A'	B-1
Figure B-2.	Magnetic Field Measurements at Segment 'B'	B-2
Figure B-3.	Magnetic Field Measurements at Segment 'C'	B-3
Figure B-4.	Magnetic Field Measurements at Segment 'D'	B-4
Figure B-5.	Magnetic Field Measurements at Segment 'E'	B-5
Figure B-6.	Magnetic Field Measurements at Segment 'F'	B-6
Figure B-7.	Magnetic Field Measurements at Segment 'G'	B-7
Figure B-8.	Magnetic Field Measurements at Segment 'H'	B-8
Figure B-9.	Magnetic Field Measurements at Segment 'I'	B-9
Figure B-10.	Magnetic Field Measurements at Segment 'J'	B-10
Figure B-11.	Magnetic Field Measurements at Segment 'K'	B-11
Figure C-1.	Magnetic Field Calculations at Segment 'A'	C-1
Figure C-2.	Magnetic Field Calculations at Segment 'B'	C-2
Figure C-3.	Magnetic Field Calculations at Segment 'C'	C-3
Figure C-4.	Magnetic Field Calculations at Segment 'D'	C-4
Figure C-5.	Magnetic Field Calculations at Segment 'E'	C-5
Figure C-6.	Magnetic Field Calculations at Segment 'F'	C-6
Figure C-7.	Magnetic Field Calculations at Segment 'G'	C-7
Figure C-8.	Magnetic Field Calculations at Segment 'H'	C-8
Figure C-9.	Magnetic Field Calculations at Segment 'I'	C-9
Figure C-10.	Magnetic Field Calculations at Segment 'J'	C-10
Figure C-11.	Magnetic Field Calculations at Segment 'K'	C-11
Figure D-1.	Segment 'J' Phasing Configurations #1 - #6	D-1
Figure D-2.	Segment 'J' Phasing Configurations #7 - #12	D-3
Figure D-3.	Segment 'J' Phasing Configurations #13 - #18	D-5
Figure D-4.	Segment 'J' Phasing Configurations #19 - #24	D-7
Figure D-5.	Segment 'J' Phasing Configurations #25 - #30	D-9

FIGURES

Appendix Figure		Page
Figure D-6.	Segment 'J' Phasing Configurations #31 - #36	D-11
Figure E-1.	Normalized Magnetic Field Measurements for HECO Substation Transformers	E-4
Figure E-2.	Average Normalized Magnetic Field Measurements for HECO Substation Transformers	E-6
Figure E-3.	Normalized Magnetic Field Measurements for HECO Manholes	E-10
Figure E-4.	Average Normalized Magnetic Field Measurements for HECO Manholes	E-12
Figure E-5.	Normalized Magnetic Field Measurements for HECO Risers	E-14
Figure E-6.	Average Normalized Magnetic Field Measurements for HECO Risers	E-16
Figure F-1.	Magnetic Field Measurements at Ala Moana Shopping Mall (Part 1)	F-1
Figure F-2.	Magnetic Field Measurements at Ala Moana Shopping Mall (Part 2)	F-2
Figure F-3.	Magnetic Field Measurements at Daiei Department Store (Part 1)	F-3
Figure F-4.	Magnetic Field Measurements at Daiei Department Store (Part 2)	F-4
Figure F-5.	Magnetic Field Measurements at Ward Shopping Center	F-5
Figure F-6.	Magnetic Field Measurements at McCully Shopping Center	F-6
Figure F-7.	Magnetic Field Measurements at Jack-In-The-Box Restaurant	F-7
Figure F-8.	Magnetic Field Measurements at McCully – Moiliili Public Library	F-8
Figure F-9.	Magnetic Field Measurements at Straub Hospital	F-9
Figure F-10.	Magnetic Field Measurements at State Capitol Building	F-10
Figure F-11.	Magnetic Field Measurements at Central Pacific Bank	F-11
Figure F-12.	Magnetic Field Measurements at U.S. Post Office	F-12

EXECUTIVE SUMMARY

Hawaiian Electric Company (HECO) has proposed the construction of a new transmission system project, entitled the East Oahu Transmission Project. This project involves the installation of several new underground 46 kV subtransmission lines and transformers. As a result of this proposed installation, some existing electrical facilities (such as 12 kV, 25 kV and 46 kV underground and overhead distribution lines) may be eliminated, remain unchanged, or may increase or decrease in loading. Based upon this evaluation, the following conclusions were reached:

Existing magnetic field levels from HECO facilities are typical of levels from similar facilities throughout the State of Hawaii.

Magnetic field measurements were conducted at eleven selected segments along portions of the proposed project to characterize field strengths due to existing electrical facilities. Existing magnetic field levels along these segments range from a few tenths of a mG to over 25 mG, depending upon location. Existing electric facilities surveyed included 12 kV, 25 kV, 46 kV, and 138 kV power line facilities.

The difference in projected magnetic field levels between the existing and proposed power line configurations under 2009 forecasted loading can decrease slightly, remain unchanged, or increase depending upon the project segment.

In addition to field measurements, magnetic field levels were also calculated for 2009 forecasted normal and Pukele outage conditions for eleven different project segments. The difference in projected magnetic field levels between the existing and proposed power line configurations under 2009 forecasted loading can decrease slightly, remain unchanged, or increase depending upon the project segment. For Segment 'I' (where no 46 kV power lines presently exist), the projected magnetic field generally remains unchanged since the proposed underground 46 kV power lines would only be utilized under Pukele outage conditions. For Segment 'E' (east of Kamoku Substation where modifications to an existing overhead 46 kV power line are proposed), the range of projected magnetic field levels decreases slightly since the 2009 forecasted load is somewhat lower for the proposed configuration than for the existing configuration. At all other segment locations, the projected magnetic field increases due to the proposed power line configuration under 2009 forecasted loading conditions. While the largest magnetic field increases typically occur within street locations, projected magnetic field levels can also increase at sidewalk locations. Under proposed 2009 Pukele outage conditions, the projected magnetic field increases at all segment locations.

If the project is implemented, the proposed underground circuits would have little effect on EMF levels at nearby institutions; EMF levels will be in the range of common everyday levels.

A magnetic field assessment was performed to evaluate present and future levels at various institutions along the proposed project. Several institutions are located near portions of the proposed project, including day care centers, pre-schools and schools, hospitals, churches, and retirement homes. Distance measurements were taken to determine the closest building edge to the proposed project. Using these distance measurements, the projected magnetic fields for 2009 loading conditions were evaluated for each of these institutions. Six different institutions are located within 100 feet of the proposed project. The two closest institutions are the Kaplan Test Preparation Center and the Lunalilo Elementary School. For the Kaplan Test Preparation Center, projected 2009 magnetic field levels of 0.0 mG with the existing power line configuration would increase about 1.1 mG with the proposed configuration under normal loading. For the Lunalilo Elementary School, projected 2009 magnetic fields of about 4.0 mG with the existing power line configuration would decrease to about 3.3 mG with the proposed configuration under normal loading (due to some field cancellation). Four other institutions within 100 feet would have no projected magnetic field under normal operating conditions, since the underground power lines are only loaded during Pukele outage conditions (and even then the projected field at the closest building edge is less than 1 mG). There are five additional institutions located within 200 feet of the proposed project. Of these, two institutions have projected magnetic fields of about 0.6 or less under Pukele outage conditions, and three institutions would have no projected magnetic field under normal operating conditions (since the underground power lines are only loaded during Pukele outage conditions and have negligible projected field influence of about 0.1 mG). Beyond 200 feet, the projected magnetic field influence from the proposed project is negligible.

The proposed substations, manholes, and risers of the East Oahu Transmission Project will be similar to existing facilities and have very low EMF levels at a relatively short distance away.

Another aspect of the proposed East Oahu Transmission Project is the installation of new transformers within certain substations, manholes in the streets, and risers on wooden poles at sidewalk locations. The magnetic field from a substation transformer or manhole is typically reduced by about 90% at a distance of about 20 feet away from the facility (for transformers, magnetic fields due to these sources are typically reduced to ambient levels at the substation perimeter). For this project, the closest property line is at least 30 feet away from any proposed substation transformer location. For risers, the magnetic field is typically reduced by over 90% at a distance of about 3 feet away from the riser.

There are a wide variety of EMF levels and sources encountered in everyday life that are comparable to EMF due to electric power facilities.

In addition to measuring and calculating magnetic fields for electrical facilities associated with the proposed project, magnetic field measurements of everyday environments were performed at ten different locations in Honolulu. These measurements were performed to provide a range of magnetic field levels encountered in everyday locations and for comparison with the magnetic field levels associated with the proposed East Oahu Transmission Project. Measured magnetic fields ranged from 0.1 mG to over 99 mG in everyday environments. Many of these magnetic field sources are common appliances and electrical devices, such as refrigeration units in supermarkets, electric stoves in food preparation areas, library security gates, escalators, vending machines, display counters, video games, cash registers, and ATM machines.

There are no Federal or State of Hawaii health standards for 60 Hertz magnetic fields.

Over the past two decades, there has been research investigating exposure to EMF. Although there are no Federal health standards in the United States specifically for 60 Hertz magnetic fields, two organizations have developed guidelines or limits: the International Commission on Non-Ionizing Radiation Protection and the American Conference of Governmental Industrial Hygienists. The measured and projected magnetic field levels associated with the proposed East Oahu Transmission Project are far below these guidelines or limits.

There are at least two states that have adopted "status quo" engineering standards for magnetic fields. The purpose of most of these standards is to make the field levels from new power lines similar to the field levels from existing overhead transmission lines. The measured and projected magnetic field levels associated with the proposed East Oahu Transmission Project are well below these other state standards.

INTRODUCTION

Hawaiian Electric Company (HECO) has proposed the construction of a new power line[1] project, entitled the East Oahu Transmission Project. This project involves the installation of several new underground 46 kV power lines and transformers. This proposed action would allow HECO to transfer electrical loads between substations serving high-demand areas of the island, addressing existing and future transmission problems. As a result of this proposed installation, some existing electrical facilities (such as 12 kV, 25 kV and 46 kV underground and overhead power lines) along portions of the project and beyond may be eliminated, remain unchanged, or may increase or decrease their loading.

HECO retained Enertech Consultants to evaluate the magnetic field levels associated with this proposed project. This evaluation included magnetic field measurements along selected segments of the proposed project line, magnetic field calculations for these segments for both existing and proposed power line configurations, assessment of existing HECO facilities, identification of nearby environments to the proposed project, and magnetic field measurements in common, everyday locations around the Honolulu project area. The results of this evaluation are presented within this report.

PROJECT DESCRIPTION

The East Oahu Transmission Project is comprised of two independent phases of work. The first phase, "Phase 1", involves the installation of 0.5 miles of underground duct line for 46kV subtransmission lines, and related work at eight substations, in order to interconnect three 46kV circuits out of the Pukele Substation, at the end of HECO's Northern 138kV transmission corridor, to four 46kV lines connected to HECO's Southern 138kV transmission corridor. Phase 1 includes: (1) the installation of six underground 46kV lines in the Ala Moana, McCully, Moiliili, and Kapahulu areas, (2) a 138kV/46kV transformer installation at the existing Kamoku Substation with associated protective relaying, (3) a 46kV/12kV transformer installation at the existing Makaloa Substation with associated switchgear, (4) various switching and reconnections on the existing 46kV and 12kV systems near Makaloa and McCully Substations, (5) removal of existing 46kV and 12kV cables between Makaloa and McCully Substations, (6) removal of an existing 46/12kV transformer and associated switchgear from McCully Substation, and (7) modifications of various existing distribution substations in the Honolulu area.

The second phase, "Phase 2", involves the installation of 1.9 miles of underground duct line for 46kV subtransmission lines, and related work at one substation, in order to interconnect four out of the five remaining 46kV circuits out of the Pukele Substation to three other 46kV lines connected to HECO's Southern 138kV transmission corridor. Phase 2 includes: (1) the installation of three underground 46kV lines in the Kakaako, Makiki, and McCully areas, and (2)

[1] The term "power lines" is used generically to describe transmission, subtransmission and distribution lines.

a 138kV/46kV transformer installation at the existing Archer Substation with associated protective relaying.

Phase 1 is proposed for construction beginning in 2006 and is expected to require 12 months to complete, while Phase 2 construction is proposed for 2008 – 2009 and is expected to require 15 months to complete. Eleven different segments along portions of the proposed power line project were selected by HECO to represent the various changes which would result from construction of the project. These locations, identified as segments 'A' thru 'K', designate the following locations and proposed electrical modifications:

Phase 1:

- Segment 'A' – Makaloa Street between Kaheka and Poni Streets: Three existing 46 kV underground power lines would be replaced with two 46 kV power lines (one power line in a new duct), while three existing 12 kV underground power lines would remain.
- Segment 'B' – Fern Street between Punahou and Hauoli Streets: Three existing 46 kV underground subtransmission lines and three 12 kV underground power lines would be replaced with two 46 kV underground power lines within the existing duct, while an existing 12 kV overhead distribution line would remain.
- Segment 'C' – Pumehana Street between Lime and Date Streets: One new 46 kV underground power line would be installed in new duct, while an existing 46 kV overhead and an existing 12 kV overhead power line would remain.
- Segment 'D' – Date Street west of Kamoku Substation: One new 46 kV underground intertie would cross Date Street (from the substation to an existing pole that will be replaced with a thicker pole) and feed an existing 46 kV overhead power line, while one existing 138 kV and two existing 25 kV underground power lines would remain and one existing 12 kV overhead power line would also remain.
- Segment 'E' - Date Street east of Kamoku Substation: One new 46 kV underground intertie would cross and then travel down Date Street (from the substation to an existing pole) and feed an existing 46 kV overhead power line, a segment of the existing 46 kV power line between segments 'D' and 'E' would be removed, and an existing 12 kV overhead power line would remain.
- Segment 'F' – Winam Avenue between Hoolulu and Mooheau Streets: A new 46 kV underground power line in a new duct would connect two existing 46 kV overhead power lines, while an existing 12 kV overhead power line would remain.
- Segment 'G' – Date Street between Pumehana and McCully Streets: An existing 46 kV overhead power line would have increased loading and an existing 12 kV underbuild power line would remain.
- Segment 'H' – Kapiolani Boulevard between Wiliwili and McCully Streets: An existing 46 kV overhead power line would have increased loading, an existing 12 kV underbuild power line would remain, and one existing 138 kV underground power line and two existing 25 kV underground power lines would also remain.
- Segment 'J' – Kapiolani Boulevard between Clayton Street and Ward Avenue: Three existing 46 kV underground power lines would have increased loading and two existing 138 kV underground power lines would remain.

- Segment 'K' – Sheridan Street between Kapiolani Boulevard and Makaloa Street: Three existing 46 kV underground power lines would have increased loading and one existing 12 kV overhead power line would remain.

Phase 2:

- Segment 'I' – King Street between Ward Avenue and Victoria Street: Three new 46 kV underground circuits would be installed in a new duct.

Maps of the various project segments (identified by its respective letter) are presented in Appendix A. A detailed diagram of each segment, showing the existing and proposed electrical facilities at each segment, is also included in Appendix A. The descriptions of Segments 'A','B' and 'C' incorporate two changes in Phase 1 of the project now planned by HECO. Appendix G presents the criteria for HECO's selection of these segments for analysis.

UNITS OF MEASURE

Magnetic field (B) is commonly reported using units of gauss (G). However, it is usually more convenient to report magnetic field using a smaller unit, the milligauss (mG) that is equal to one-thousandth of a gauss (i.e., 1 mG = 0.001 G).

Some technical reports also use units of Tesla (T) or microTesla (μT), where 1 μT = 0.000001 T. The conversion between the magnetic field units is 1 mG = 0.1 μT and 1 μT = 10 mG. Although the term EMF includes both the electric and magnetic field, it is common for EMF to denote only the magnetic field.

DESCRIPTION OF MAGNETIC FIELDS

An electric current flowing in a conductor (e.g. electric equipment, household appliance, power circuits, etc.) creates a magnetic field. The most commonly used magnetic field intensity unit of measure is the milligauss (mG). As a general reference, the earth has a natural static or direct current (DC) magnetic field of about 360 mG in Honolulu (Merrill 1983).

As with electric fields, the magnetic fields from electric power facilities and appliances differ from static (or DC) fields because they are caused by the flow of 60 Hz alternating currents. Power frequency magnetic fields also reverse direction at a rate of 60 cycles per second, corresponding to the 60 Hz operating frequency of the power systems in the United States. The magnetic field is stronger near an electric current source and decreases with distance away from the source.

Since the magnetic field is caused by the flow of an electric current, a device must be operated to create a magnetic field. The Illinois Institute of Technology Research (IITRI) measured magnetic field strengths of a large number of common household appliances for the U.S. Navy (Gauger 1985). Appliance measurements were also conducted by Enertech Consultants for the Electric Power Research Institute or EPRI (Silva 1989). Typical magnetic field values for some appliances are presented in Table 1 to facilitate a better understanding of magnetic field strength values.

Table 1. Magnetic Fields From Household Appliances

	Magnetic Field (mG)	
Appliance	**12" Away**	**Maximum**
Electric Range	3 to 30	100 to 1,200
Electric Oven	2 to 25	10 to 50
Garbage Disposal	10 to 20	850 to 1,280
Refrigerator	0.3 to 3	4 to 15
Clothes Washer	2 to 30	10 to 400
Clothes Dryer	1 to 3	3 to 80
Coffee Maker	0.8 to 1	15 to 250
Toaster	0.6 to 8	70 to 150
Crock Pot	0.8 to 1	15 to 80
Iron	1 to 3	90 to 300
Can Opener	5 to 250	10,000 to 20,000
Mixer	6 to 100	500 to 7,000
Blender, Popper, Processor	6 to 20	250 to 1,050
Vacuum Cleaner	20 to 200	2,000 to 8,000
Portable Heater	1 to 40	100 to 1,100
Fans/Blowers	0.4 to 40	20 to 300
Hair Dryer	1 to 70	60 to 20,000
Electric Shaver	1 to 100	150 to 15,000
Color TV	9 to 20	150 to 500
Fluorescent Fixture	2 to 40	140 to 2,000
Fluorescent Desk	6 to 20	400 to 3,500
Circular Saws	10 to 250	2,000 to 10,000
Electric Drill	25 to 35	4,000 to 8,000

(Gauger 1985 and Silva 1989)

There are many sources of magnetic fields encountered in everyday activities. These everyday sources have variable temporal and spatial characteristics. A major research project has been undertaken to estimate exposure to ambient 60 Hz magnetic fields. This comprehensive study of contemporary magnetic field exposure was performed for the U.S. Department of Energy

(Enertech 1998). The objective of this work was to characterize personal magnetic field exposure of the general population. This was accomplished by randomly selecting over 1,000 people throughout the United States and recruiting these people to wear a recording magnetic field meter during a typical 24-hour period, including all activity inside and away from the place of residence (Silva 1999). The study population was selected in a manner to be representative of the general population. The measurement population (both genders) included about 874 adults and 138 children. Some key findings of this unique study included:

- The national average 24-hour exposure: 1.25 mG.
- About 14.3% of the U.S. population is exposed to a 24-hour Avg. exceeding 2 mG.
- About 25% of the U.S. population spend more than one hour in fields > 4 mG.
- About 9% of the U.S. population spend more than one hour in fields > 8 mG.
- About 1.6% of U.S. population experience 1,000 mG (or higher) during a 24-hour period.

Table 2 summarizes the results of "The 1,000 Person Study" (based on a population of 267 million).

Table 2. U.S. Population with Average Field Exposure Exceeding Given Level

	Average		
24-Hr Field	**EST. PORTION**	**95% Confidence Interval**	**POPULATION RANGE**
> 0.5 mG	76.3%	73.8 % - 78.9 %	197 - 211 million
> 1 mG	43.6%	40.9 % - 46.5 %	109 - 124 million
> 2 mG	14.3%	11.8 % - 17.3 %	31.5 - 46.2 million
> 3 mG	6.3%	4.7 % - 8.5 %	12.5 - 22.7 million
> 4 mG	3.6%	2.5 % - 5.2 %	6.7 - 13.9 million
> 5 mG	2.42%	1.65 % - 3.55 %	4.4 - 9.5 million
> 7.5 mG	0.58%	0.29 % - 1.16 %	0.77 - 3.1 million
> 10 mG	0.46%	0.20 % - 1.05 %	0.53 - 2.8 million
> 15 mG	0.17%	0.035 % - 0.83 %	90 thousand - 2.2 million

(Enertech 1998)

MEASUREMENT EQUIPMENT

An EMDEX II Magnetic Field Digital Exposure Meter was used to record power-frequency (60 Hertz) magnetic field levels of the overhead and underground power lines and substation electrical equipment. The EMDEX II is a computer-controlled, three-axis, AC exposure meter. Each of the three-axis sensors measures the magnetic field and the on-board computer calculates

a resultant field value (the resultant is comparable to a maximum field value and is calculated as the square root of the sum of the squares for all three orthogonal axes (B_r=SQRT[$B_x^2 + B_y^2 + B_z^2$]). The data are stored in the computer's memory and downloaded to a personal computer for analysis following the measurement session. In addition, an LCD digital display on the EMDEX II allows the user to see the magnetic field data, as they are stored in the computer's memory. The EMDEX II meter has a range of 0.1 milliGauss (mG) up to 3,000 mG (3 Gauss). The EMDEX II recorded the magnetic field at a sample rate of once every 1.5 seconds. The accuracy of the EMDEX II meters is $\pm$ 2%.
The EMDEX II meter was used in conjunction with a LINear DAta (LINDA) distance measurement wheel to record magnetic field levels as a function of distance. The EMDEX II simultaneously recorded magnetic field and distance data to evaluate field levels across each study segment as lateral profile measurements. Figure 1 presents a photograph of magnetic field measurements being conducted.

An EMDEX SNAP Magnetic Field Meter was used to make general magnetic field survey measurements. The EMDEX SNAP is a computer-controlled, three-axis, AC field meter. An LCD digital display on the meter shows the resultant magnetic field measurement every 0.5 seconds. The EMDEX SNAP meter has a measurement range from 0.1 mG to 1,000 mG (1 Gauss). Typical accuracy of the EMDEX SNAP meter is $\pm$2%.

INSTRUMENTATION CALIBRATION

All magnetic field instruments were calibrated using a 91-centimeter (cm) diameter Helmholtz coil in the Enertech research laboratory. Vertical magnetic fields are generated with magnitudes ranging from 0.5 mG to 1,000 mG and with absolute accuracy of $\pm$2 percent above 10 mG and $\pm$15 percent at 1 mG. Meters were calibrated in accordance with 1994 IEEE/ANSI Standards (IEEE 1994).

MAGNETIC FIELD MEASUREMENTS AT SELECTED PROJECT LOCATIONS

For the proposed East Oahu Transmission Project, eleven different segments along portions of the proposed project were selected to represent the various types of changes which would result from construction of the project. Magnetic field measurements were conducted at each of these locations to characterize existing field strengths due to existing electrical facilities. Measurements were conducted as lateral profile measurements across each location during May 17 – 21, 2004. Appendix B presents graphs of the measured magnetic field as a function of distance for each segment location. Included in Appendix B is a table of the distribution loads for power lines at the time field measurements were performed as recorded by HECO.

Existing magnetic field levels range from a few tenths of a mG to over 25 mG, depending upon location. Existing electric facilities surveyed included overhead and underground 12 kV distribution lines, underground 25 kV distribution lines, overhead and underground 46 kV subtransmission lines,

RECEIVED AS FOLLOWS

and underground 138 kV transmission lines. For streets and sidewalks where no overhead or underground power lines were immediately present, measured magnetic field levels ranged from a few tenths of a mG to about 2 mG. Sidewalk locations with overhead power lines were measured and typically ranged from about 1 mG to about 5.5 mG. Street and sidewalk locations with underground powerlines typically ranged from about 1 mG to a maximum of over 25 mG directly above the underground power line in the street.

Figure 1. Magnetic Field Measurements Being Conducted on the Sidewalk at King Street

MAGNETIC FIELD CALCULATIONS AT SELECTED PROJECT LOCATIONS

In addition to field measurements, magnetic field calculations were also performed for each of the selected project segments. Transmission line computer models were developed using the software program "ENVIRO", which is a module within EPRI's EMFWorkstation program. ENVIRO models the magnetic fields in and around transmission and distribution lines. The ENVIRO software allows the user to enter transmission line configuration information and other parameters into the program and then calculates lateral profiles for power-frequency magnetic fields at designated locations. Results obtained with computer models have been compared with measurement data for operating power lines and calculation accuracy has been evaluated. Typically, the computer model will calculate field values to within ±5% of actual field measurements.

HECO provided existing power line geometry and loading information as described in Appendix G. Circuit routing for the existing and proposed underground lines were provided as HECO plan and profile drawings. Overhead line geometry was collected in the field and confirmed with HECO standard power line drawings. Magnetic field calculations were performed for the existing power line configuration (if the proposed project were not constructed), as well as for the proposed power line configuration. For the existing power line configuration, calculations were performed using a forecasted 2009 normal loading condition. For the proposed project power line configuration, calculations were performed using two forecasted 2009 loading conditions: normal and Pukele outage condition. As defined by HECO in Appendix G, "normal load" means the power line loads at the time of the forecasted system peak load with the HECO transmission system under normal, all lines in-service, state. "Pukele outage condition" means the power line loads at the time of the forecasted system peak load with the Pukele Substation out of service. Details for determining the loading values for power lines within each segment are presented by HECO in Appendix G. Calculations were performed for each line configuration and load condition at a calculation height of 1 meter above ground level (3.28 feet), in accordance with IEEE Standards (IEEE 1994). Calculations were performed assuming that both Phase 1 and Phase 2 of the proposed project are implemented, and that Change #1 and Change #2 are implemented.

The difference in projected magnetic field levels between the existing and proposed power line configurations under forecasted 2009 normal loading can decrease slightly, remain unchanged, or increase depending upon the project segment. Figures 2 through 12 present the calculated magnetic field results for each segment under normal loading conditions for both the existing and proposed power line configurations. For Segment 'C' (on Pumehana Street near Lunalilo School where a new underground 46 kV circuit is proposed), the range of projected magnetic field levels decreases slightly on one side of the street while increasing on the opposite side of the street. Near the school, the projected magnetic field from the existing overhead power lines decrease slightly with the presence of the proposed underground power line (across the street), due to magnetic field cancellation. However, across the street from the school (where the proposed underground power line is located), the projected magnetic field level increases. For Segment 'E' (east of Kamoku

Substation where modifications to an existing overhead 46 kV circuit are proposed), the range of projected magnetic field levels decreases slightly with the proposed power line configuration since the 2009 forecasted load is somewhat lower for the proposed configuration than for the existing configuration. For Segment 'I' (on King Street, where no power lines presently exist), the projected magnetic field remains unchanged since the proposed underground 46 kV circuits would only be utilized under Pukele outage conditions. At all other segment locations, the projected magnetic field increases due to the proposed power line configuration under 2009 forecasted loading conditions. While magnetic field increases typically occur within street locations, projected magnetic field levels can also increase at sidewalk locations. Under proposed 2009 Pukele outage conditions, the projected magnetic field increases at all segment locations. Appendix C presents graphs of the projected magnetic field as a function of distance for each segment location. Appendix C also contains a summary table of the projected 2009 loading values used for each of the power lines at each segment.

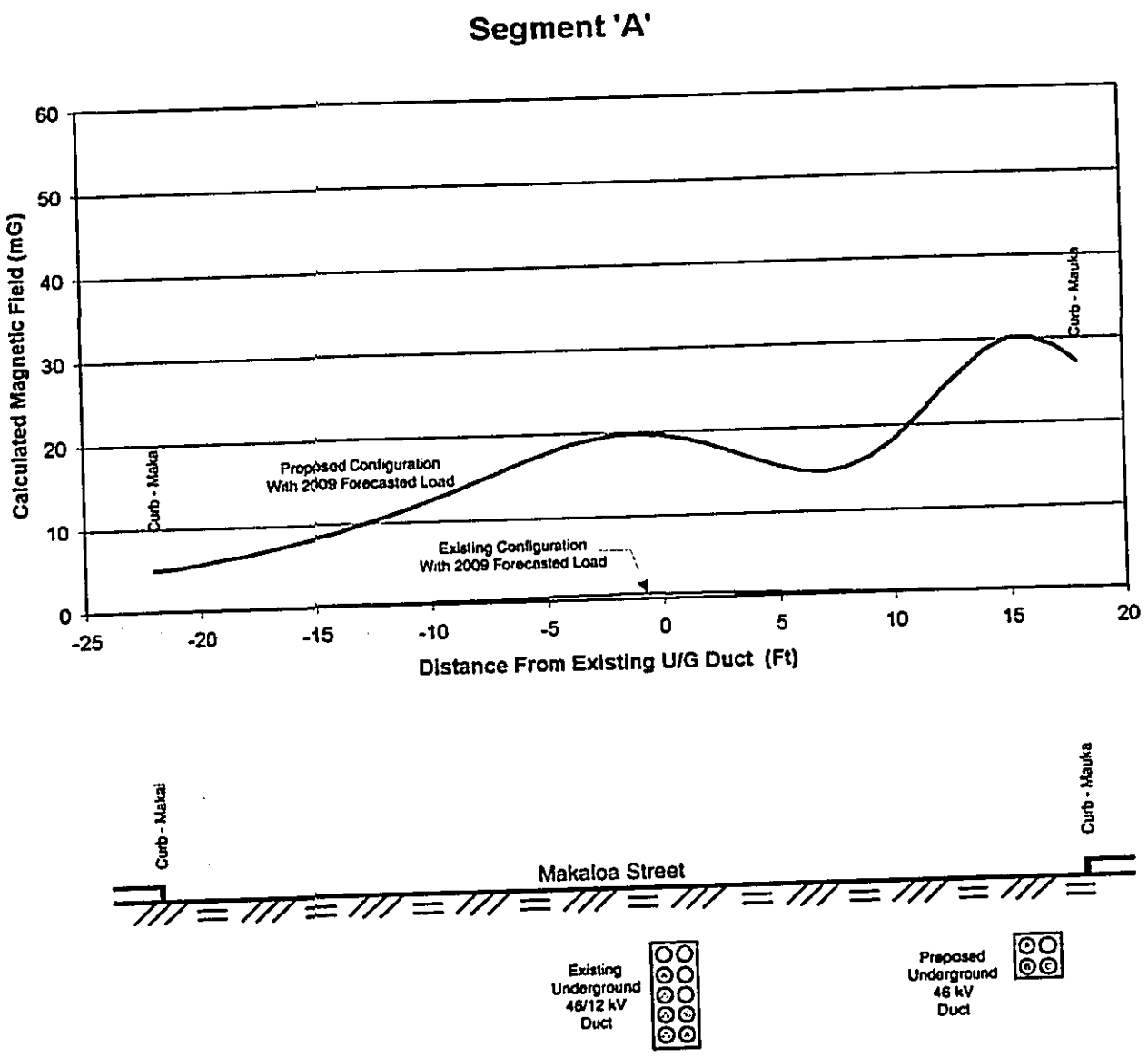


Figure 2. Projected Magnetic Field for Segment 'A' Under 2009 Forecasted Normal Loading (Makaloa Street between Kaheka and Poni Streets)

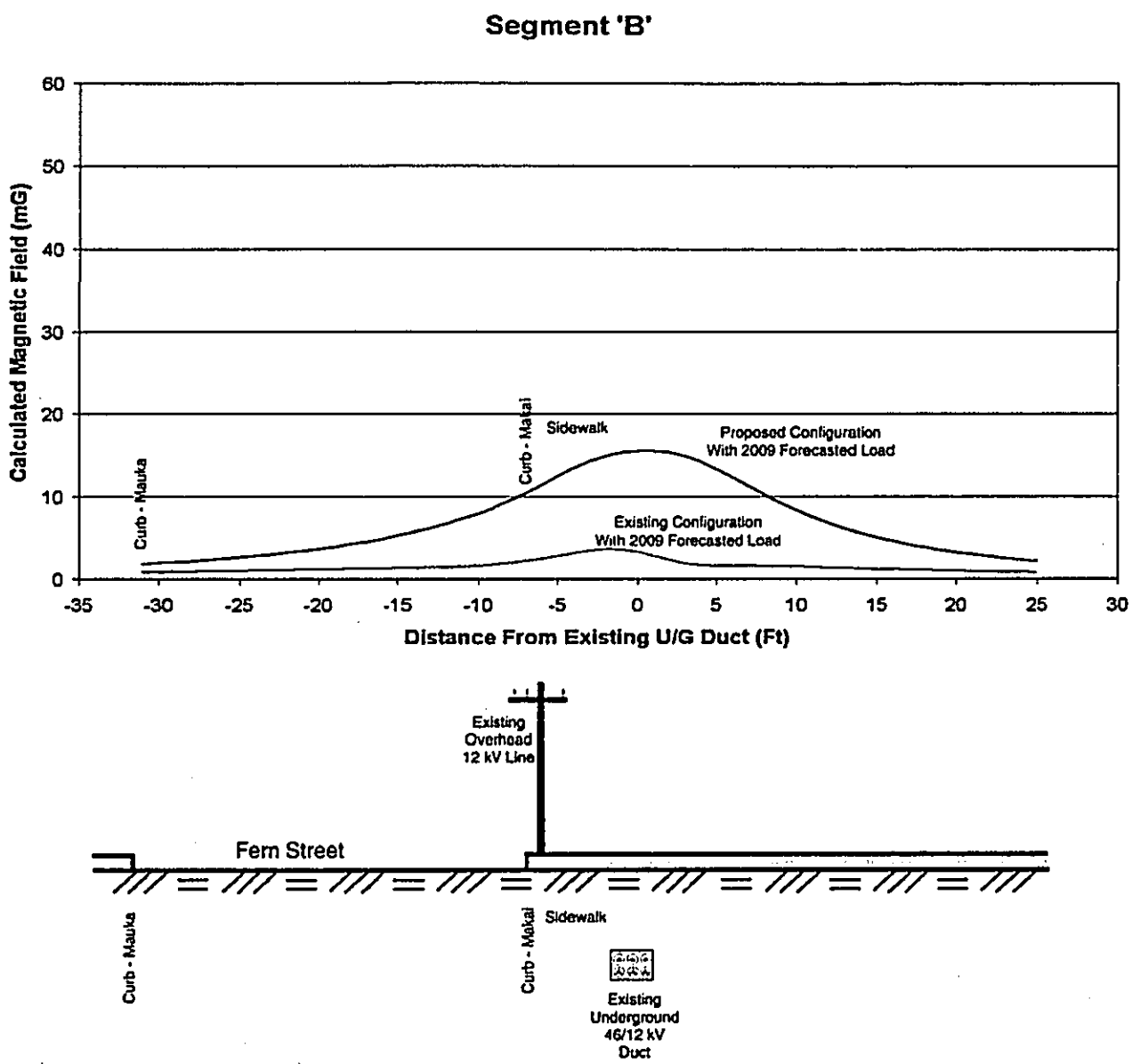


Figure 3. Projected Magnetic Field for Segment 'B' Under 2009 Forecasted Normal Loading
(Fern Street between Punahou and Hauoli Streets)

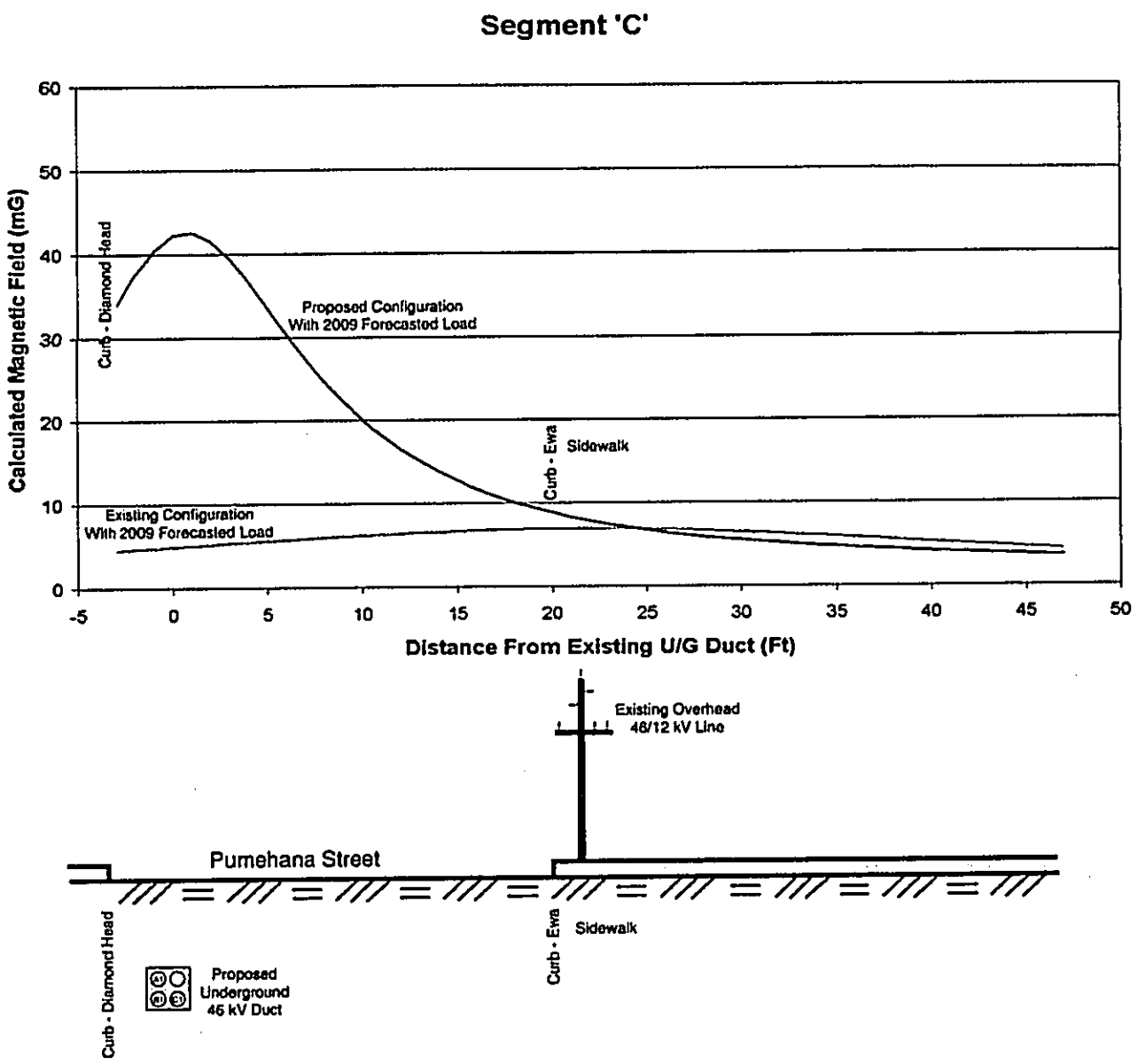


Figure 4. Projected Magnetic Field for Segment 'C' Under 2009 Forecasted Normal Loading (Pumehana Street between Lime and Date Streets)

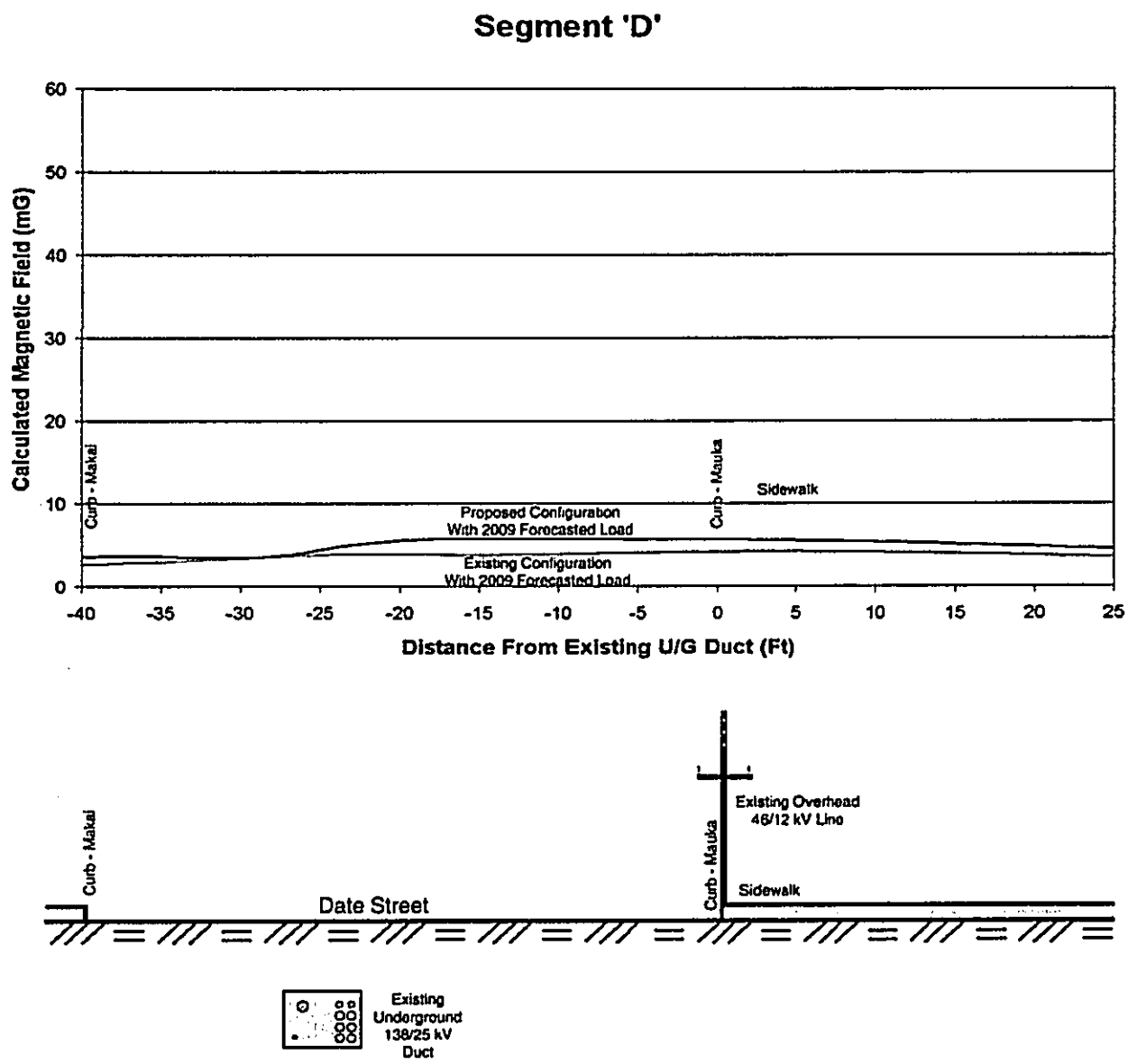
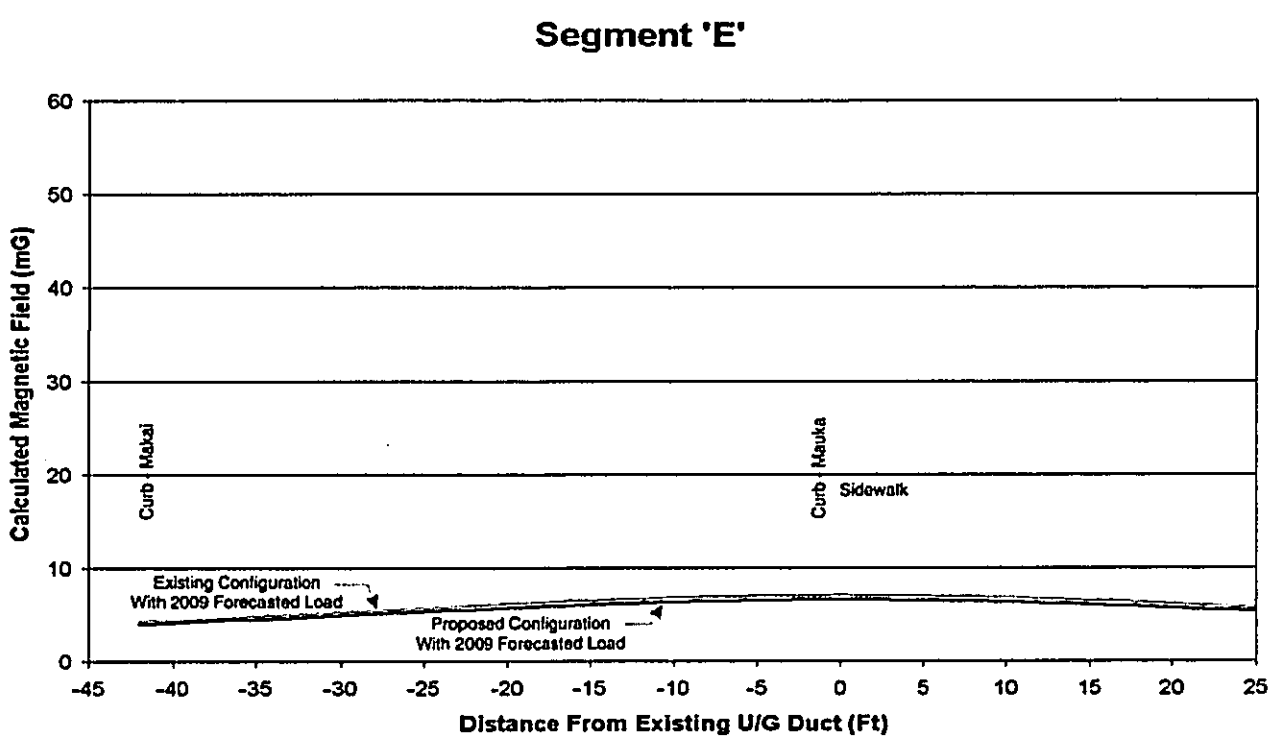


Figure 5. Projected Magnetic Field for Segment 'D' Under 2009 Forecasted Normal Loading (Date Street west of Kamoku Substation)



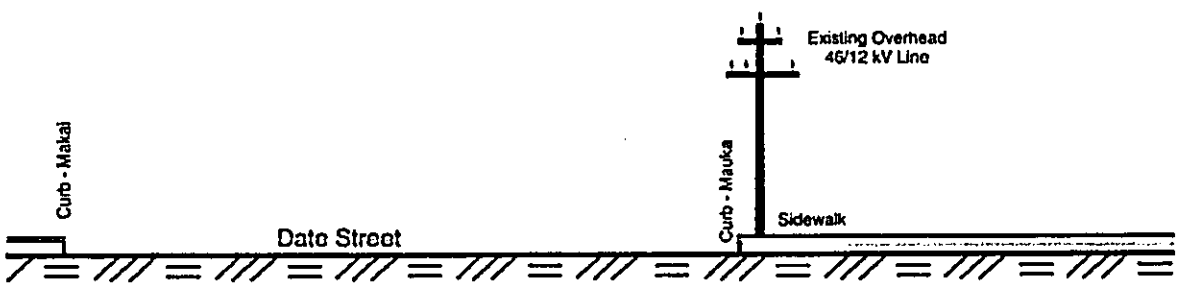


Figure 6. Projected Magnetic Field for Segment 'E' Under 2009 Forecasted Normal Loading (Date Street east of Kamoku Substation)

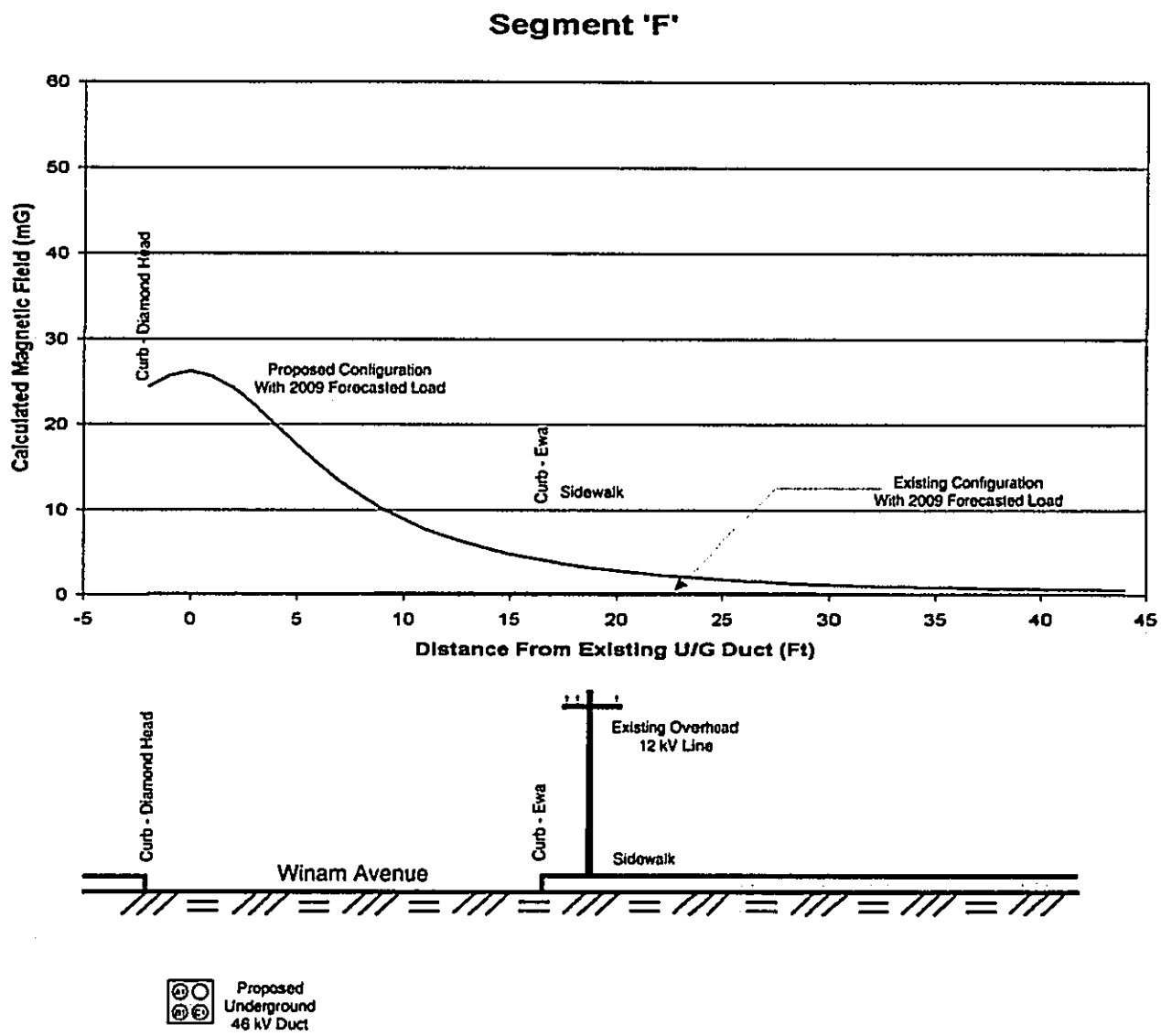


Figure 7. Projected Magnetic Field for Segment 'F' Under 2009 Forecasted Normal Loading (Winam Avenue between Hoolulu and Mooheau Streets)

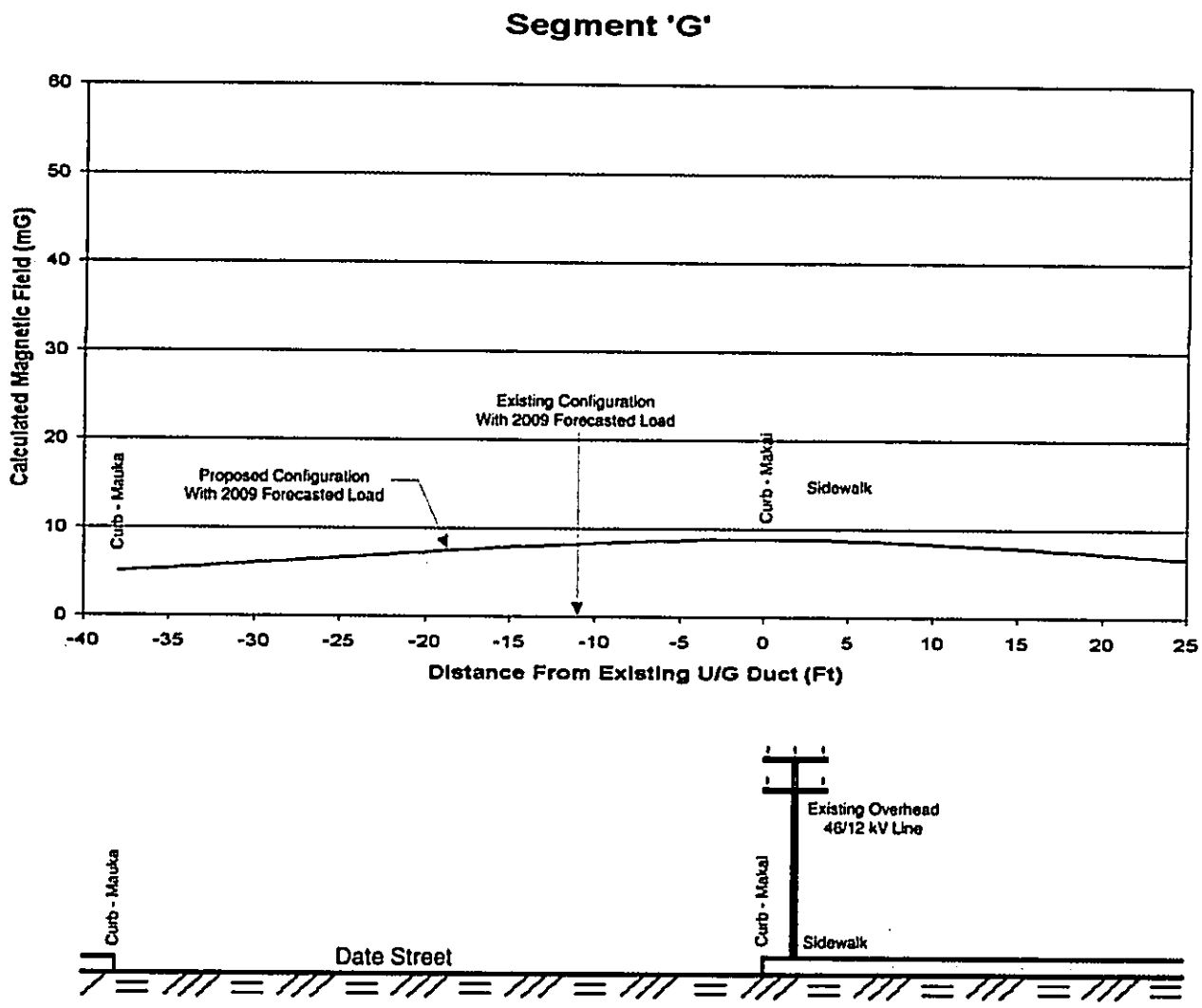


Figure 8. Projected Magnetic Field for Segment 'G' Under 2009 Forecasted Normal Loading (Date Street between Pumehana and McCully Streets)

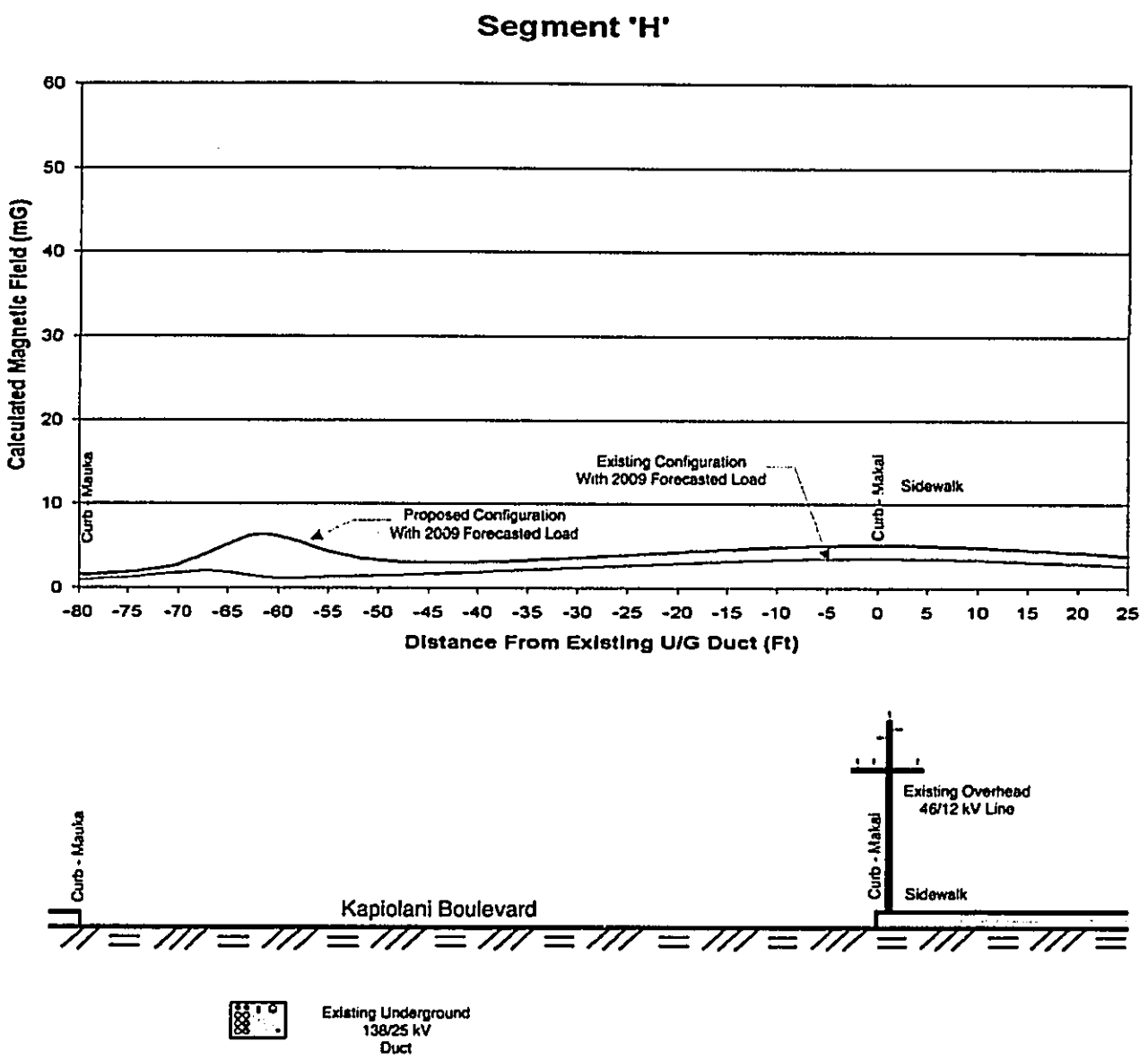


Figure 9. Projected Magnetic Field for Segment 'H' Under 2009 Forecasted Normal Loading (Kapiolani Boulevard between Wiliwili and McCully Streets)

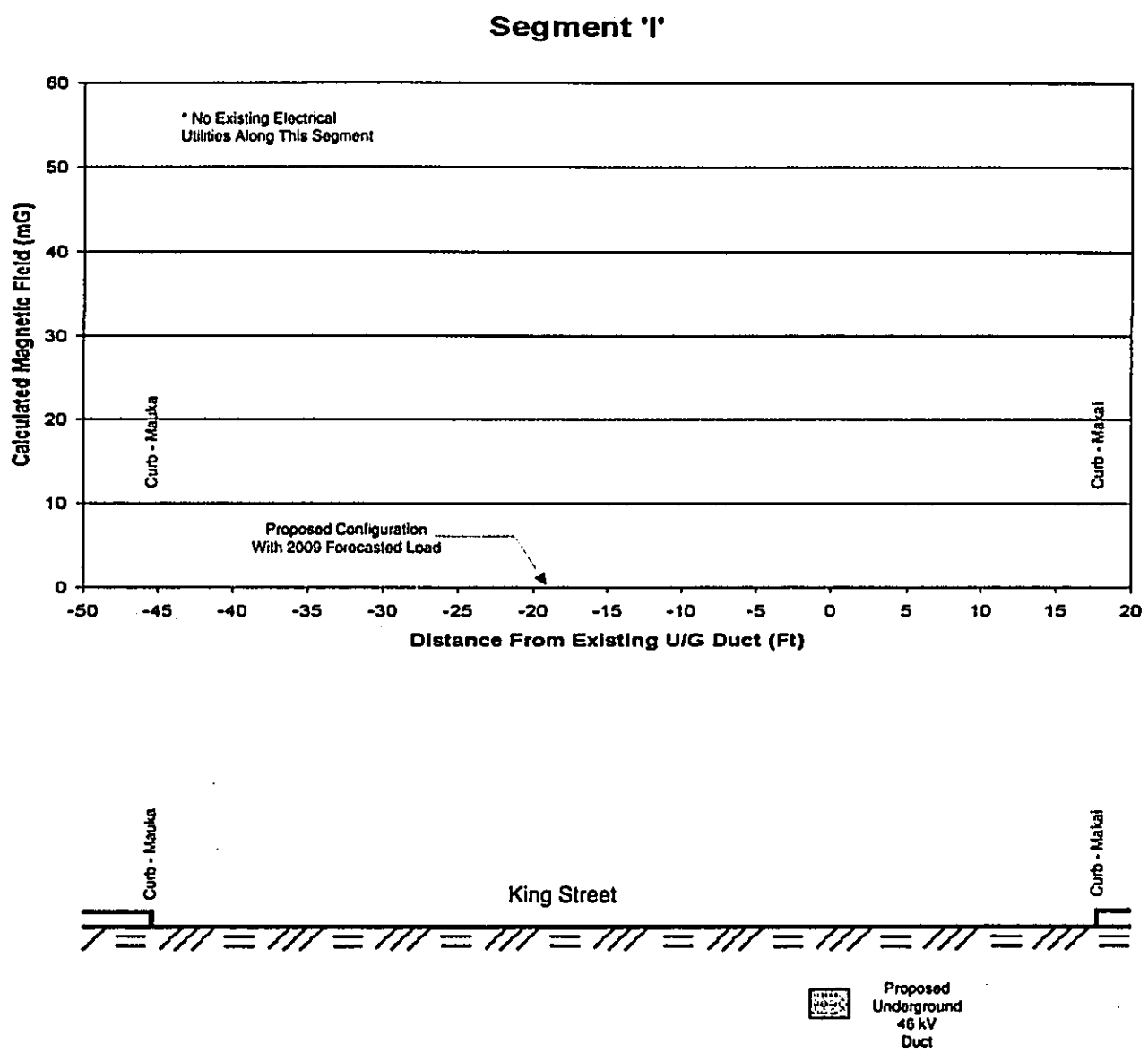


Figure 10. Projected Magnetic Field for Segment 'I' Under 2009 Forecasted Normal Loading (King Street between Ward Avenue and Victoria Street)

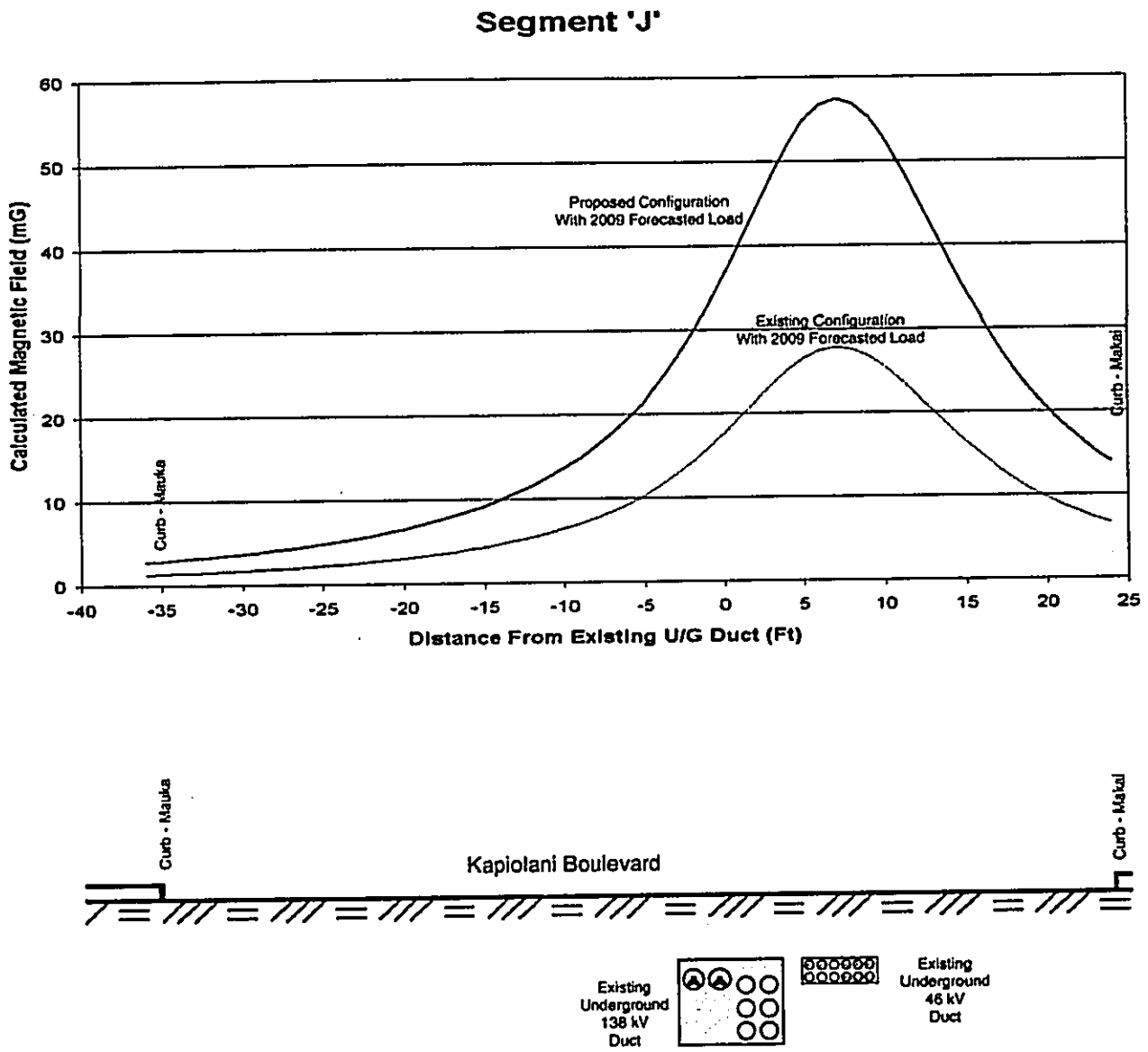


Figure 11. Projected Magnetic Field for Segment 'J' Under 2009 Forecasted Normal Loading (Kapiolani Boulevard between Clayton Street and Ward Avenue)

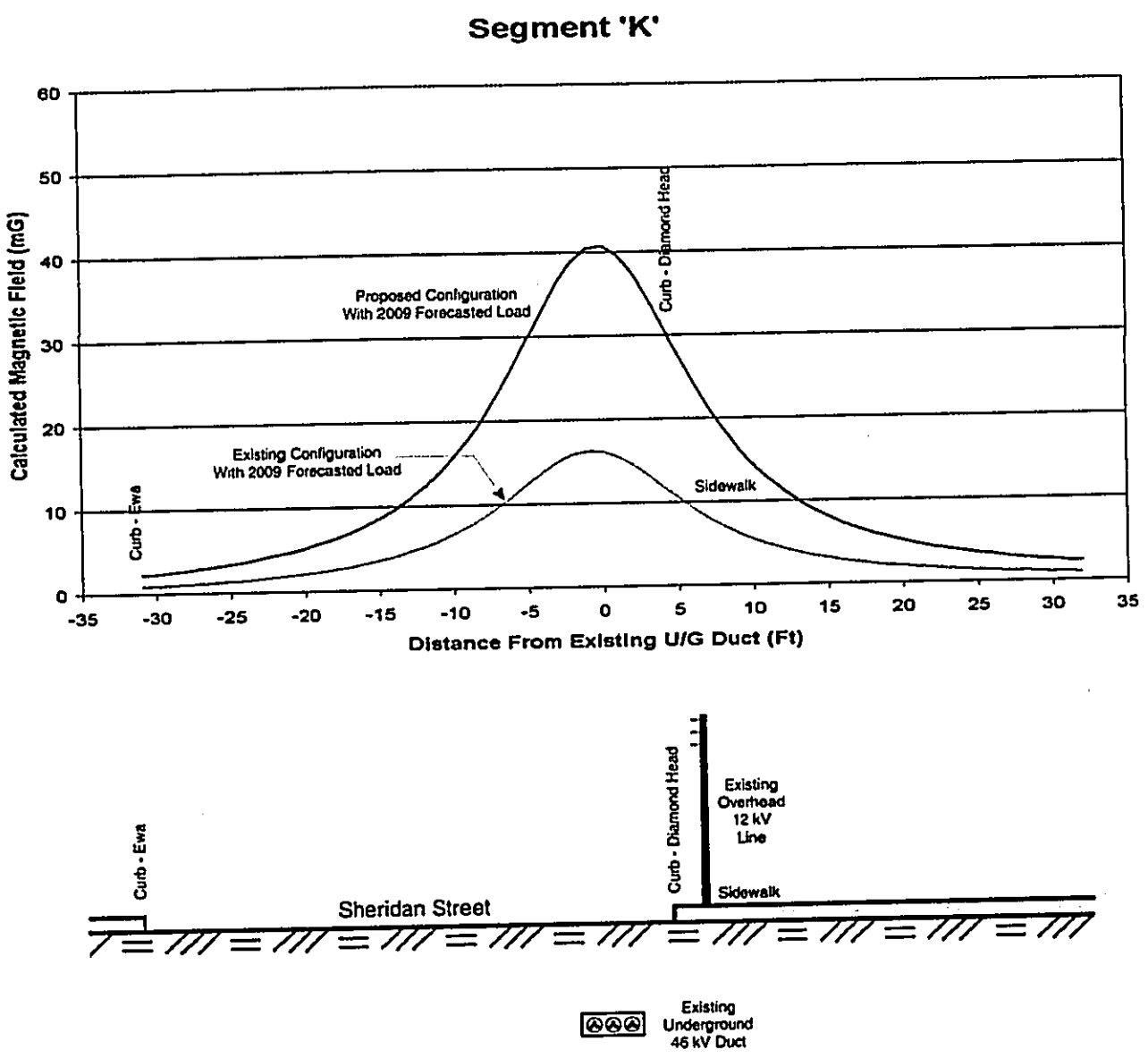


Figure 12. Projected Magnetic Field for Segment 'K' Under 2009 Forecasted Normal Loading (Sheridan Street between Kapiolani Boulevard and Makaloa Street)

For Segment 'J', HECO could not provide the phasing arrangement for two of the three 46 kV underground circuits (Archer #43 and #41). Therefore, computer calculations were performed for "day of measurement" loading to identify the phasing arrangement which most closely matches measured magnetic field levels directly above the 46 kV underground duct (as shown in Appendix B – Figure B-10). All thirty-six possible phasing combinations were modeled, and the phasing arrangement which most closely matched the measured magnetic field level above the underground 46 kV circuits was selected for subsequent field calculations (as presented in Appendix C). As shown in Appendix C, the projected magnetic fields for Segment 'J' at the northern and southern sidewalk curbs respectively are about 1.3 mG and 6.6 mG under existing normal load, 2.8 mG and 14.0 mG under forecasted normal load, and 3.4 mG and 17.5 mG under forecasted Pukele outage condition. If a phasing configuration that results in the highest magnetic field level is assumed (rather than the phasing that most closely matches the measured field level), then these projected magnetic field levels for Segment 'J' at the northern and southern sidewalk curbs respectively would increase to about 1.6 mG and 8.1 mG under existing normal load, 3.4 mG and 16.7 mG under forecasted normal load, and 4.1 mG and 20.2 mG under proposed Pukele outage condition. Appendix D presents the results of this phasing analysis.

COMPUTER MODELING ASSUMPTIONS

Projected magnetic field levels are based upon computer modeling of the line design for the existing and proposed HECO electrical equipment which simulate a real world environment. Enertech has assumed that both Phase 1 and Phase 2 of the East Oahu Transmission Project will be implemented.

While computer modeling is very accurate in calculating magnetic field levels, the computer model contains certain assumptions. For example, the computer model assumes balanced three-phase currents on all of the underground and overhead transmission and distribution circuits. However, there may be some load unbalance or net current on a circuit. An unbalanced current (or net current) can create higher magnetic field levels than projected, and can attenuate much more slowly than magnetic fields from balanced sources. Ground currents can also exist, where electrical current can flow along metallic objects, such as underground steel conduits or pipes. Specific magnitudes for phase angles on a circuit are assumed to be exactly 120-degrees out of phase from each other, and are also assumed to be uniform across circuits. Many of these parameters can vary or are unknown (such as the presence of small load-carrying underground conductors), and therefore may not be included within the computer model. The methods used for the computer modeling are reasonable for a practical characterization of magnetic field levels.

HECO ELECTRICAL FACILITY CHARACTERIZATION

Another aspect of the proposed East Oahu Transmission Project is the installation of new transformers within certain substations, manholes in the streets, and risers on wooden poles at sidewalk locations. To characterize magnetic fields from these types of facilities, magnetic field measurements were conducted at similar existing facilities during May 17 – 21, 2004. Magnetic field measurements were conducted as a function of distance away from each of these types of facilities. Measurement data from these facilities were then normalized to characterize the attenuation rate of the magnetic field versus distance away from each of these facilities. Appendix E provides tables of the actual measurement data used to create these normalized attenuation profiles.

Figure 13 presents the average normalized magnetic field data versus distance graph for 46 kV transformers. Because other magnetic field sources (such as overhead and underground power lines, buswork, and other types of substation equipment) are typically present near substation transformers, it is difficult to characterize magnetic field attenuation strictly from the transformer itself. As shown in Figure 13, other nearby magnetic field sources can influence the actual field measurements and the resulting attenuation rate. The magnetic field from a substation transformer is reduced by over 90% at a distance of about 20 feet away from the transformer housing. Typically, magnetic fields from transformers are reduced to ambient levels at the perimeter of the substation (since transformers are usually centrally located within the substation). For this project, the closest property line is at least 30 feet away from any proposed substation transformer location.

Figure 14 presents the average normalized magnetic field versus distance graph for underground power line manholes. At manhole locations, power line circuit conductors are usually separated for installation or splices. Separating the conductors reduces magnetic field cancellation and creates elevated magnetic fields at these manhole locations. Again, other magnetic field sources (such as other nearby underground power lines) may be present near manhole locations, thereby complicating the characterization of magnetic field attenuation strictly from the manhole itself. As shown in Figure 14, the magnetic field from a manhole is reduced by almost 90% at a distance of about 20 feet away.

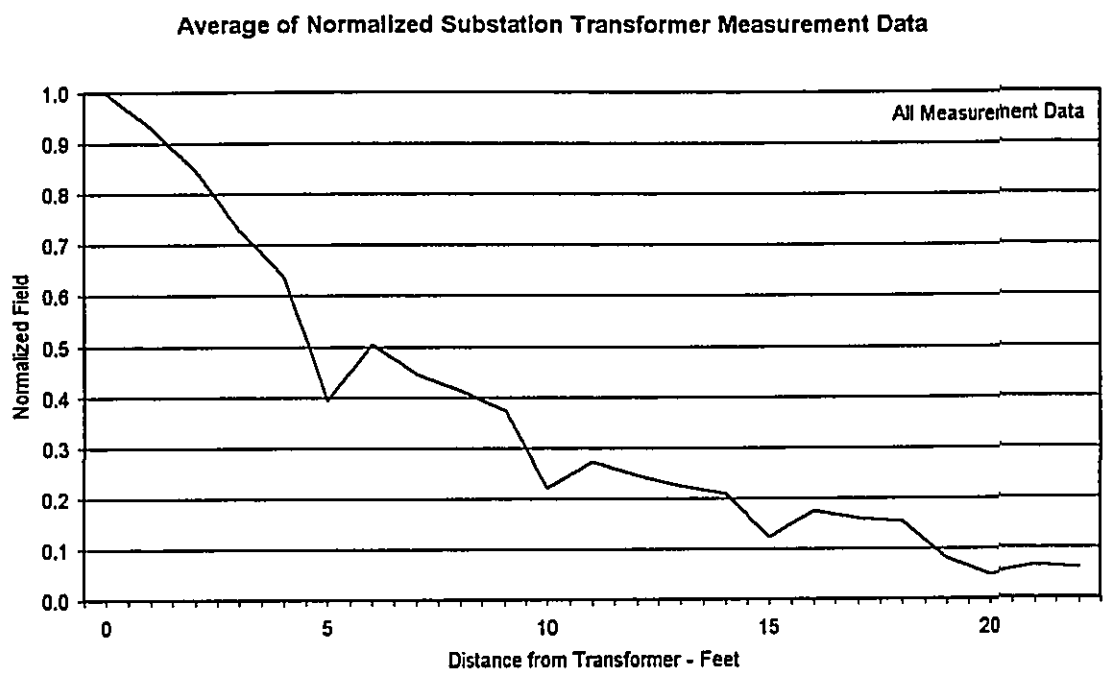


Figure 13. Average Normalized Magnetic Field Attenuation Rate for Substation Transformers

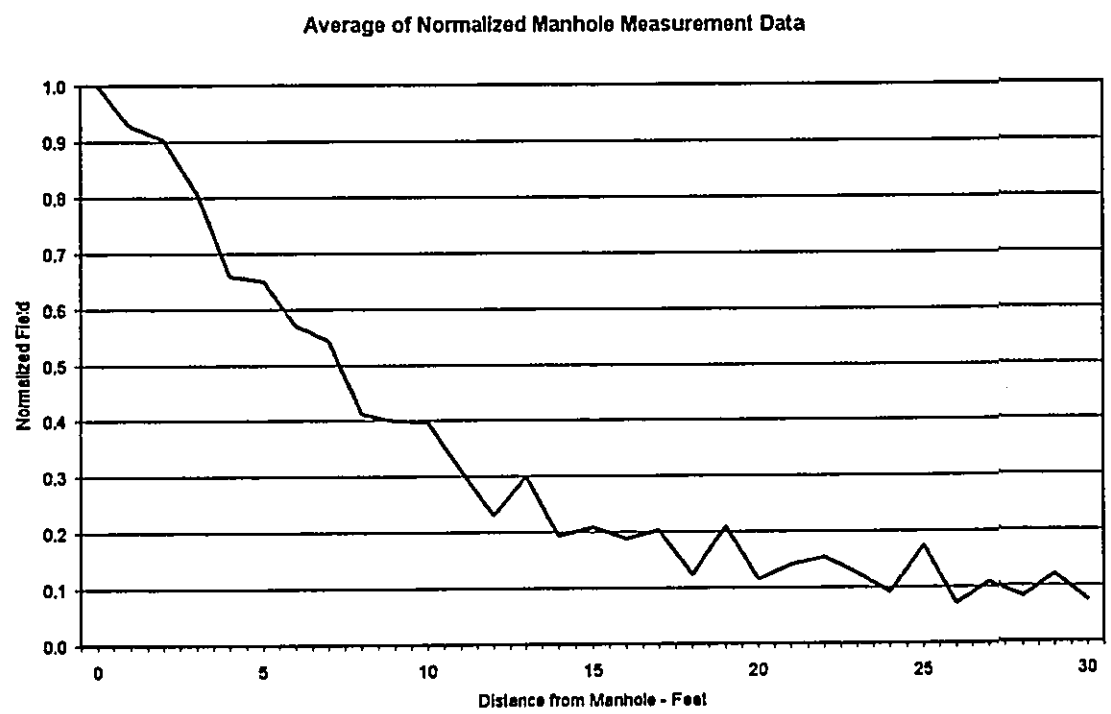


Figure 14. Average Normalized Magnetic Field Attenuation Rate for HECO Manholes

Figure 15 presents the average normalized magnetic field versus distance graph for risers (where overhead circuits transition to underground circuits) mounted to wooden support poles. Some risers are enclosed within steel pipes (which can provide some magnetic field shielding), while other risers are enclosed in plastic pipes (which do not provide any type of shielding). Again, other magnetic field sources (such as the overhead and underground portions of the power line) are present at riser pole locations, thereby complicating the characterization of magnetic field attenuation strictly from the riser itself. As shown in Figure 15, the magnetic field from an average normalized riser attenuates very quickly with distance away from the riser – the average normalized magnetic field is reduced by over 90% at a distance of about 3 feet away from the riser. This attenuation rate is much faster than for substation transformers and manholes, due to the close configuration of the circuit conductors.

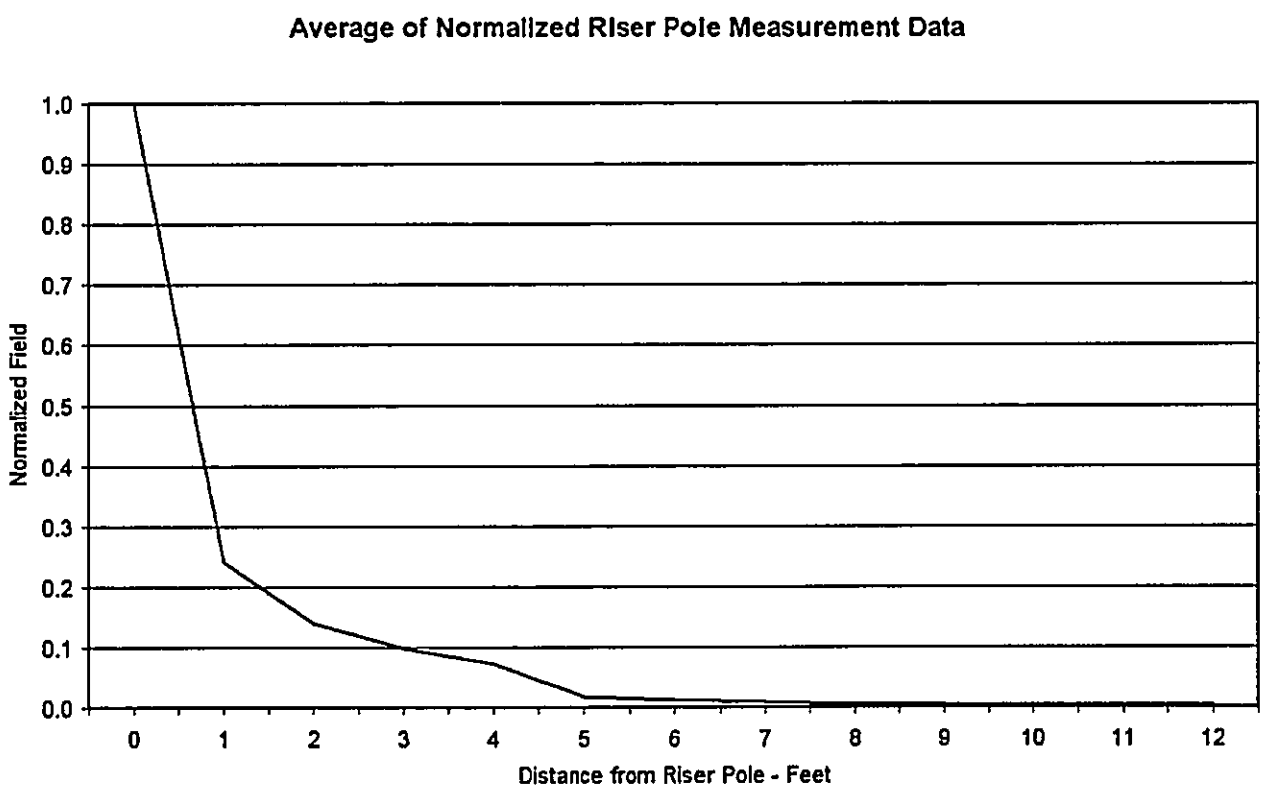


Figure 15. Average Normalized Magnetic Field Attenuation Rate for HECO Riser Poles

MAGNETIC FIELD MEASUREMENTS AT EVERYDAY ENVIRONMENTS IN HONOLULU

In addition to electrical facilities, magnetic field measurements of everyday environments were performed to provide a range of magnetic field levels encountered in everyday locations and for comparison with the magnetic field levels associated with the proposed East Oahu Transmission Project. Magnetic field measurements were conducted at selected locations within Honolulu on May 19 - 21, 2004. Eleven different areas were selected for measurements:

- Ala Moana Shopping Mall
- Daiei Department Store
- Ward Shopping Center
- McCully Shopping Center
- State Capitol Building
- McCully – Moiliili Public Library
- Straub Hospital
- Central Pacific Bank
- U.S. Post Office
- Jack-In-The-Box Restaurant

Tables 3 through 12 present summaries of the magnetic field measurements at these selected locations. Appendix F presents the magnetic field versus time graphs recorded at these locations. As shown in Tables 3 through 12, measured magnetic fields can typically range from 0.1 mG to over 99 mG in everyday environments. Many of these magnetic field sources are common appliances and electrical devices, such as refrigeration units in supermarkets, electric stoves in food preparation areas, library security gates, escalators, vending machines, display counters, video games, and ATM machines. In several cases, magnetic field levels were due to larger area sources which could not easily be identified.

Table 3. Summary of Magnetic Field Measurements at the Ala Moana Shopping Mall

Ala Moana Shopping Mall		
Location	Measured Magnetic Field (mG)	Notes
Overall Measurement Visit	0.1 - 76.5	Average Field = 3.7 mG
Food Court	0.3 - 18.1	Refrigeration Unit = 18.1 mG
Speed Gear Auto Store	0.8 - 20.5	
Jungle Fun Video Arcade	0.9 - 46.3	Arcade Games and Area Source
Just a Second Clock Kiosk	3.3 - 6.2	
Apple Computer Store	0.8 - 3.7	Computer Systems and Monitors
Shirokiya Department Store	0.3 - 23.3	Camera Display = 16 mG, Grill Area = 23 mG
Macy's Department Store	0.1 - 42.9	Godiva Chocolates Cart = 42.9 mG Make-Up Counter = 37.5 mG
Starbuck's Coffee Shop	0.3 - 22.7	Counter Area = 22 mG
Nieman Marcus Department Store	0.1 - 5.3	
Waldenbooks	0.9 - 20.9	Children's Section = 6.7 - 20.9 mG
Thinker Toy Store	0.5 - 7.3	Wood Train Play Area = 5 - 6 mG
Satellite City Hall	0.4 - 2.6	
Open Mall Area	0.2 - 76.5	Base of Escalator = 76.5 mG

Table 4. Summary of Magnetic Field Measurements at the Daiei Department Store

Daiei Department Store		
Location	Measured Magnetic Field (mG)	Notes
Overall Measurement Visit	0.1 - 42.3	Average Field = 2.2 mG
Florist Section	0.3 - 8.2	Refrigeration Unit = 8.2 mG
Produce Section	0.3 - 17.9	
Bakery Section	1.0 - 13.7	Refrigeration Unit = 13.7
Dairy Section	0.5 - 13.7	Refrigeration Unit = 13.7
Frozen Food Section	0.4 - 7.7	Refrigeration Units
Meat Counter	0.8 - 4.6	Freezer = 4.6 mG
Seafood Section	0.6 - 16.9	Freezer = 16.9 mG
Electronics Section	0.1 - 6.1	Soft Drink Machine = 6.1 mG
Greeting Card Section	0.1 - 2.0	
Key Making Area	0.3 - 7.0	Counter Area = 7.0 mG
Young Art Children's Store	0.5 - 3.7	
Newspaper Stand	0.5 - 14.0	ATM Machine = 14.0 mG
Party Supply Section	0.6 - 12.9	
Jewelry Department	0.2 - 18.9	Display Case = 18.9 mG
Blimpies Sandwich Stand	0.5 - 42.3	Counter Area = 42.3 mG
Cajun Grill Food Stand	0.5 - 4.7	
Sunkyu Bakery Stand	0.2 - 7.7	
Café Brew Coffee Stand	0.1 - 13.3	Counter Area = 13.3 mG

Table 5. Summary of Magnetic Field Measurements at the Ward Shopping Center

Ward Shopping Center		
Location	Measured Magnetic Field (mG)	Notes
Overall Measurement Visit	0.1 - 37.1	Average Field = 3.5 mG
Dave and Busters Recreation Center	0.1 - 15.8	Arcade Area = 0.2 - 15.8 mG
Executive Chef Kitchen Store	0.8 - 35.3	Cash Register Counter = 35.3 mG
Honolulu Cookie Company	1.3 - 3.8	Check Out Counter = 3.8 mG
Snakalicious Novelty Store	0.5 - 13.8	Display Case = 13.8 mG
Food Court Eating Area	0.9 - 26.3	
Old Spaghetti Factory Restaurant	1.0 - 10.0	Eating Area in Restaurant = 3.6 mG Average
Outside of Linea Clothing Store	0.2 - 37.1	
Outdoor Mall Areas	0.1 - 26.3	

Table 6. Summary of Magnetic Field Measurements at the McCully Shopping Center

McCully Shopping Center		
Location	Measured Magnetic Field (mG)	Notes
Overall Measurement Visit	0.3 - 11.9	Average Field = 1.7 mG
7-11 Convenience Store	0.7 - 11.9	Ice Machine = 11.9 mG
Aji Ichiban Candy Store	0.4 - 5.1	Cash Register = 5.1 mG
T-Mobile Cellular Telephone Store	0.5 - 1.5	Counter Area = 1.5 mG

Table 7. Summary of Magnetic Field Measurements at the State Capitol Building

State Capitol Building		
Location	**Measured Magnetic Field (mG)**	**Notes**
Overall Measurement Visit	0.1 - 20.7	Average Field = 1.0 mG
Third Floor Office	0.2 - 10.6	Aquarium = 10.6 mG
Third Floor Hallways	0.1 - 2.9	Electrical Panel = 2.9 mG
Second Floor Hallways	0.1 - 0.7	
Basement Hallways	0.2 - 20.7	Walking by Electrical Vault = 20.7

Table 8. Summary of Magnetic Field Measurements at the McCully – Moiliili Public Library

McCully - Moiliili Public Library		
Location	**Measured Magnetic Field (mG)**	**Notes**
Overall Measurement Visit	0.2 - 99.5	Average Field = 2.6 mG
Entering Library	0.4 - 99.5	Security Gate = 99.5 mG
Children's Section	1.0 - 16.9	Story Telling Area = 2.0 mG Study Area = 1.5 mG
Main Counter Area	0.5 - 11.8	
Adult Section Upstairs	0.3 - 6.1	Internet Computer Area = 0.7 mG Drinking Fountain = 6.1 mG
Computer Reference Area	0.9 - 7.3	Computer Terminals
Leaving Library	0.2 - 2.7	

Table 9. Summary of Magnetic Field Measurements at the Straub Hospital

Straub Hospital		
Location	Measured Magnetic Field (mG)	Notes
Overall Measurement Visit	0.2 - 16.5	Average Field = 1.7 mG
Hallways	0.2 - 9.5	Pediatric Waiting Area = 5.6 mG
Emergency Waiting Room	2.6 - 3.5	
Cafeteria	0.4 - 16.5	Salad Bar = 16.5 mG
Gift Shop	0.2 - 0.7	
Pharmacy Waiting Area	0.2 - 1.1	

Table 10. Summary of Magnetic Field Measurements at the Central Pacific Bank

Central Pacific Bank		
Location	Measured Magnetic Field (mG)	Notes
Overall Measurement Visit	0.4 - 8.8	Average Field = 3.2 mG
Reception Area	0.4 - 2.9	
Teller Counter	3.8 - 8.8	

Table 11. Summary of Magnetic Field Measurements at the U.S. Post Office

U.S. Post Office		
Location	Measured Magnetic Field (mG)	Notes
Overall Measurement Visit	0.1 - 2.4	Average Field = 0.4 mG
Waiting in Line	0.1 - 0.2	
Clerk Counter	0.5 - 1.2	
Stamp Vending Machines	0.2 - 2.4	Vending Machine = 2.4 mG

Table 12. Summary of Magnetic Field Measurements at the Jack-In-The-Box Restaurant

Jack-in-the-Box Restaurant		
Location	Measured Magnetic Field (mG)	Notes
Overall Measurement Visit	0.4 - 17.9	Average Field = 1.3 mG
Waiting at Counter	0.5 - 3.6	
Food Pick-Up Counter Area	17.9	
Seated at Eating Area	0.5 - 0.6	
Restroom Area	1.1 - 12.4	Hand Dryer = 12.4 mG

REVIEW OF SELECTED INSTITUTIONS NEAR PROPOSED PROJECT

Several institutions are located near portions of the proposed project. These institutions include day care centers, pre-schools and schools, hospitals, churches, and retirement homes. Distance measurements were taken to determine the closest building edge to the proposed project. Using these distance measurements, the projected magnetic field for 2009 loading conditions were evaluated for each of these institutions. Table 13 presents the results for this evaluation.

Six different institutions are located within 100-feet of the proposed project. Four of these institutions would have no projected magnetic field under normal operating conditions, since the underground power lines along this segment will be only loaded during Pukele outage conditions (and even then the projected field at the closest building edge is less than 1 mG).

The institution closest to the project is the Kaplan Test Preparation Center, which is located on the fifth floor of a multi-story downtown office building. Projected 2009 magnetic field levels (at an elevation of 50 feet above ground level + 1 meter height) of 0.0 mG with the existing power line configuration would increase to about 1.1 mG with the proposed configuration under normal loading at the closest building edge. Under projected 2009 Pukele outage conditions, the projected magnetic field on the fifth floor level of the closest building edge is 1.6 mG. Projected field levels farther into the building would continue to decrease with distance away from the project.

The Lunalilo Elementary School has one corner of the school property near one portion of the proposed project (Segment 'C') and also has another side of the school property near another portion of the proposed project (Segment 'B'); so it appears twice in the table listing. As shown in Table 13, the closest edge of the school building along Segment 'C' has a maximum projected magnetic field of 4 mG under normal loading conditions in 2009 if the project is not implemented. If the proposed project is implemented, the projected magnetic field at the closest edge of Lunalilo Elementary School building to Segment 'C' will be 3.3 mG under normal loading conditions and 2.8 mG under Pukele outage conditions. This demonstrates that the proposed underground circuit would cancel some existing magnetic field from the existing overhead power lines, resulting in some lower magnetic fields at Lunalilo Elementary School if the project is implemented. In 2009, the projected magnetic field at the closest edge of the Lunalilo Elementary School building to Segment 'B' is about 0.3 mG or less whether or not the project is implemented. Projected field levels farther into the school building would continue to decrease with distance away from the project.

There are five additional institutions located within 200-feet of the proposed project. Of these, three institutions would have no projected magnetic field under normal operating conditions (since the underground power lines are only loaded during Pukele outage conditions) and have negligible projected field influence under Pukele outage conditions (0.1 mG). The two other institutions within 200-feet of the proposed project have projected magnetic fields of about 0.6 or less, even under Pukele outage conditions.

Four more institutions are located within 300-feet of the proposed project. However, at these distances, the projected magnetic field influence from the proposed project is less than 0.1 mG.

Table 13. Summary of Selected Institutions Near Proposed Project and Projected Magnetic Field in 2009

Public Institution	Address	Segment	Distance from Center of Power Line to Closest Building Edge	2009 Existing Configuration with Normal Loading Projected Magnetic Field (mG)	2009 Proposed Configuration with Normal Loading Projected Magnetic Field (mG)	2009 Proposed Configuration with Pukele Outage Loading Projected Magnetic Field (mG)
Kaiser Honolulu Clinic	1010 Pensacola Street	I	61'	0.0	0.0	0.7
Kaplan Test Preparation Center	1580 Makaloa, Suite 500	A	39'	0.0	1.1	1.6
Lunalilo Elementary School	810 Pumehana Street	C	50'	4.0	3.3	2.8
Lunalilo Elementary School	810 Pumehana Street	B	87'	0.2	0.2	0.3
Straub Hospital	888 South King Street	I	67'	0.0	0.0	0.6
Tenrikyo Honolulu Church	1902 South King Street	I	60'	0.0	0.0	0.7
Washington Middle School	1663 South King Street	I	82'	0.0	0.0	0.3
Enshrined Deity of Ishizuchi Shrine	2020-2038 South King Street	I	147'	0.0	0.0	0.1
First Chinese Church of Christ - Church	1054 South King Street	I	129'	0.0	0.0	0.1
Kaimuki High School	2705 Kaimuki Avenue	H	123'	0.4	0.6	0.6
Lamb of God Church	612 Isenberg Street	H	179'	0.2	0.3	0.3
McKinley High School	1039 South King Street	I	154'	0.0	0.0	0.1
First Chinese Church of Christ - Preschool	1061 Young Street	I	267'	0.0	0.0	0.0
Kupono Learning Center	2038 South King Street	I	247'	0.0	0.0	0.0
Shingon Buddhism Center	915 Sheridan Street	I	268'	0.0	0.0	0.0
Small Church / Chapel	910 Cooke Street	I	231'	0.0	0.0	0.0
Ala Wai Elementary School	503 Kamoku Street	H	Over 300'	0.0	0.0	0.0
Angels at Play Pre-School (St. Mary's Episcopal Church)	2062 South King Street	I	Over 300'	0.0	0.0	0.0
Bodaiji Mission Church	1251 Elm Street	I	Over 300'	0.0	0.0	0.0
Honolulu Church of God	822 Coolidge Street	G	Over 300'	0.0	0.0	0.1
Iolani School	563 Kamoku Street	H	Over 300'	0.0	0.0	0.0
Lokahi Montessori	1506 Piikoi Street	I	Over 300'	0.0	0.0	0.0
Makiki Christian Church & Pre-School	829 Pensacola Street	I	Over 300'	0.0	0.0	0.0
Mildred Martin Day Care Center	3122 Williams Street	F	Over 300'	0.0	0.0	0.0
Yoshimi Ueki Day Care Center	2630 Nahaka Place	H	Over 300'	0.0	0.0	0.0

MAGNETIC FIELD STANDARDS

There are at least two states that have adopted "status quo" engineering standards for magnetic fields (NIEHS 2002). The purpose of most of these standards is to make the field levels from new power lines similar to the field levels from existing overhead transmission lines. The following Table 14 presents a summary of these standards. The measured and projected magnetic field levels associated with the proposed East Oahu Transmission Project are well below these standards.

Table 14. Summary of State Transmission Line Standards and Guidelines for Magnetic Fields

State Transmission Line Standards and Guidelines		
	Magnetic Field	
State	On R.O.W. *	Edge R.O.W.
Florida	---	150 mG (a) (max. load) 200 mG (b) (max. load) 250 mG (c) (max. load)
New York	---	200 mG (max. load)

* - R.O.W. = right-of-way (or in the Florida standard, certain additional areas adjoining the right-of-way).
(a) - For lines of 69 - 230 kV.
(b) - For 500 kV lines.
(c) - For 500 kV lines on certain existing R.O.W.

Source: NIEHS, 2002.

Although there are no Federal health standards in the United States specifically for 60 Hertz magnetic fields, two organizations have developed guidelines or limits: the International Commission on Non-Ionizing Radiation Protection (ICNIRP 1998) and the American Conference of Governmental Industrial Hygienists (ACGIH 2003). The following Tables 15 and 16 present a summary of the magnetic field levels of these guidelines for ICNIRP and ACGIH, respectively. The measured and projected magnetic field levels associated with the proposed East Oahu Transmission Project are far below the guidelines or limits of Tables 15 and 16.

Table 15. Summary of ICNIRP Exposure Guidelines
For Magnetic Fields

ICNIRP Guidelines for EMF Exposure	
Exposure (60 Hz)	**Magnetic Field**
Occupational	4.2 G (4,200 mG)
General Public	0.833 G (833 mG)

International Commission on Non-Ioning Radiation Protection (ICNIRP) is an organization of 15,000 scientists from 40 nations who specialize in radiation protection.

Source: ICNIRP, 1998.

Table 16. Summary of ACGIH 60 Hz Exposure Guidelines
For Magnetic Fields

ACGIH Occupational Threshold Limit Values for 60-Hz EMF	
	Magnetic Field
Occupational exposure should not exceed	10 G (10,000 mG)
Exposure of workers with cardiac pacemakers should not exceed	1 G (1,000 mG)

American Conference of Governmental Industrial Hygienists (ACGIH) is a professional organization that facilitates the exchange of technical information about worker health protection. It is not a governmental regulatory agency.

Source: ACGIH, 2003.

SUMMARY AND CONCLUSIONS

HECO has proposed the construction of a new transmission system project, entitled the East Oahu Transmission Project. This project involves the installation of several new underground 46 kV subtransmission lines and transformers. As a result of this proposed installation, some existing electrical facilities (such as 12 kV, 25 kV and 46 kV underground and overhead distribution lines) may be eliminated, remain unchanged, or may increase or decrease in loading. Based upon this evaluation, the following conclusions were reached:

Existing magnetic field levels from HECO facilities are typical of levels from similar facilities throughout the State of Hawaii.

Magnetic field measurements were conducted at eleven selected segments along portions of the proposed project to characterize field strengths due to existing electrical facilities. Existing magnetic field levels along these segments range from a few tenths of a mG to over 25 mG, depending upon location. Existing electric facilities surveyed included 12 kV, 25 kV, 46 kV, and 138 kV power line facilities.

The difference in projected magnetic field levels between the existing and proposed power line configurations under 2009 forecasted loading can decrease slightly, remain unchanged, or increase depending upon the project segment.

In addition to field measurements, magnetic field levels were also calculated for 2009 forecasted normal and Pukele outage conditions for eleven different project segments. The difference in projected magnetic field levels between the existing and proposed power line configurations under 2009 forecasted loading can decrease slightly, remain unchanged, or increase depending upon the project segment. For Segment 'I' (where no 46 kV power lines presently exist), the projected magnetic field generally remains unchanged since the proposed underground 46 kV power lines would only be utilized under Pukele outage conditions. For Segment 'E' (east of Kamoku Substation where modifications to an existing overhead 46 kV power line are proposed), the range of projected magnetic field levels decreases slightly since the 2009 forecasted load is somewhat lower for the proposed configuration than for the existing configuration. At all other segment locations, the projected magnetic field increases due to the proposed power line configuration under 2009 forecasted loading conditions. While the largest magnetic field increases typically occur within street locations, projected magnetic field levels can also increase at sidewalk locations. Under proposed 2009 Pukele outage conditions, the projected magnetic field increases at all segment locations.

If the project is implemented, the proposed underground circuits would have little effect on EMF levels at nearby institutions; EMF levels will be in the range of common everyday levels.

A magnetic field assessment was performed to evaluate present and future levels at various institutions along the proposed project. Several institutions are located near portions of the proposed project, including day care centers, pre-schools and schools, hospitals, churches, and retirement homes. Distance measurements were taken to determine the closest building edge to the proposed project. Using these distance measurements, the projected magnetic fields for 2009 loading conditions were evaluated for each of these institutions. Six different institutions are located within 100 feet of the proposed project. The two closest institutions are the Kaplan Test Preparation Center and the Lunalilo Elementary School. For the Kaplan Test Preparation Center, projected 2009 magnetic field levels of 0.0 mG with the existing power line configuration would increase about 1.1 mG with the proposed configuration under normal loading. For the Lunalilo Elementary School, projected 2009 magnetic fields of about 4.0 mG with the existing power line configuration would decrease to about 3.3 mG with the proposed configuration under normal loading (due to some field cancellation). Four other institutions within 100 feet would have no projected magnetic field under normal operating conditions, since the underground power lines are only loaded during Pukele outage conditions (and even then the projected field at the closest building edge is less than 1 mG). There are five additional institutions located within 200 feet of the proposed project. Of these, two institutions have projected magnetic fields of about 0.6 or less under Pukele outage conditions, and three institutions would have no projected magnetic field under normal operating conditions (since the underground power lines are only loaded during Pukele outage conditions and have negligible projected field influence of about 0.1 mG). Beyond 200 feet, the projected magnetic field influence from the proposed project is negligible.

The proposed substations, manholes, and risers of the East Oahu Transmission Project will be similar to existing facilities and have very low EMF levels at a relatively short distance away.

Another aspect of the proposed East Oahu Transmission Project is the installation of new transformers within certain substations, manholes in the streets, and risers on wooden poles at sidewalk locations. The magnetic field from a substation transformer or manhole is typically reduced by about 90% at a distance of about 20 feet away from the facility (for transformers, magnetic fields due to these sources are typically reduced to ambient levels at the substation perimeter). For this project, the closest property line is at least 30 feet away from any proposed substation transformer location. For risers, the magnetic field is typically reduced by over 90% at a distance of about 3 feet away from the riser.

There are a wide variety of EMF levels and sources encountered in everyday life that are comparable to EMF due to electric power facilities.

In addition to measuring and calculating magnetic fields for electrical facilities associated with the proposed project, magnetic field measurements of everyday environments were performed at ten different locations in Honolulu. These measurements were performed to provide a range of magnetic field levels encountered in everyday locations and for comparison with the magnetic field levels associated with the proposed East Oahu Transmission Project. Measured magnetic fields ranged from 0.1 mG to over 99 mG in everyday environments. Many of these magnetic field sources are common appliances and electrical devices, such as refrigeration units in supermarkets, electric stoves in food preparation areas, library security gates, escalators, vending machines, display counters, video games, cash registers, and ATM machines.

There are no Federal or State of Hawaii health standards for 60 Hertz magnetic fields.

Over the past two decades, there has been research investigating exposure to EMF. Although there are no Federal health standards in the United States specifically for 60 Hertz magnetic fields, two organizations have developed guidelines or limits: the International Commission on Non-Ionizing Radiation Protection and the American Conference of Governmental Industrial Hygienists. The measured and projected magnetic field levels associated with the proposed East Oahu Transmission Project are far below these guidelines or limits.

There are at least two states that have adopted "status quo" engineering standards for magnetic fields. The purpose of most of these standards is to make the field levels from new power lines similar to the field levels from existing overhead transmission lines. The measured and projected magnetic field levels associated with the proposed East Oahu Transmission Project are well below these other state standards.

REFERENCES

ACGIH 2003. "Threshold Limit Values for Chemical Substances and Physical Agents", American Conference of Governmental Industrial Hygienists (ACGIH), Cincinnati, 2003.

Enertech 1998. "Survey of Personal Magnetic Field Exposure: 1000-Person Survey", Final Report on Engineering Project No. 6, EMF-Rapid Program, U.S. Department of Energy, Enertech Consultants, 1998.

Gauger 1985. "Household Appliance Magnetic Field Survey", Gauger, J.R. IEEE Transactions on Power Apparatus and Systems, Vol. PAS-104, No. 9:2436-44, 1985.

ICNIRP 1998. "Guidelines for Limiting Exposure to Time-Varying Electric, Magnetic, and Electromagnetic Fields (Up To 300 Hz)", International Commission on Non-Ionizing Radiation Protection (ICNIRP), Health Physics, 74: 494-522, 1998.

IEEE 1994. "IEEE Standard Procedures for Measurement of Power Frequency Electric and Magnetic Fields from AC Power Lines", IEEE Std 644-1994, Institute of Electrical and Electronics Engineers, 1994.

Merrill 1983. The Earth's Magnetic Field, Merrill, R.T., and McElhinny, M.W., International Geophysics Series -Vol. 32, New York: Academic Press, 1983.

NIEHS 2002. "EMF Questions and Answers", EMF Rapid Program Booklet, NIEHS, 2002.

Silva 1989. "Power Frequency Magnetic Fields in the Home", Silva, J.M., et.al., IEEE Transactions on Power Delivery, Vol. PWRD-4, No. 1, pp.465-478, 1989.

Silva 1999. ""Personal Exposure Logging for ELF Fields", Silva, J.M., Radiation Protection Dosimetry, vol. 83, Nos. 1-2, 1999.

APPENDICES

APPENDIX A

Diagram of Electrical Facilities
at Segment Locations

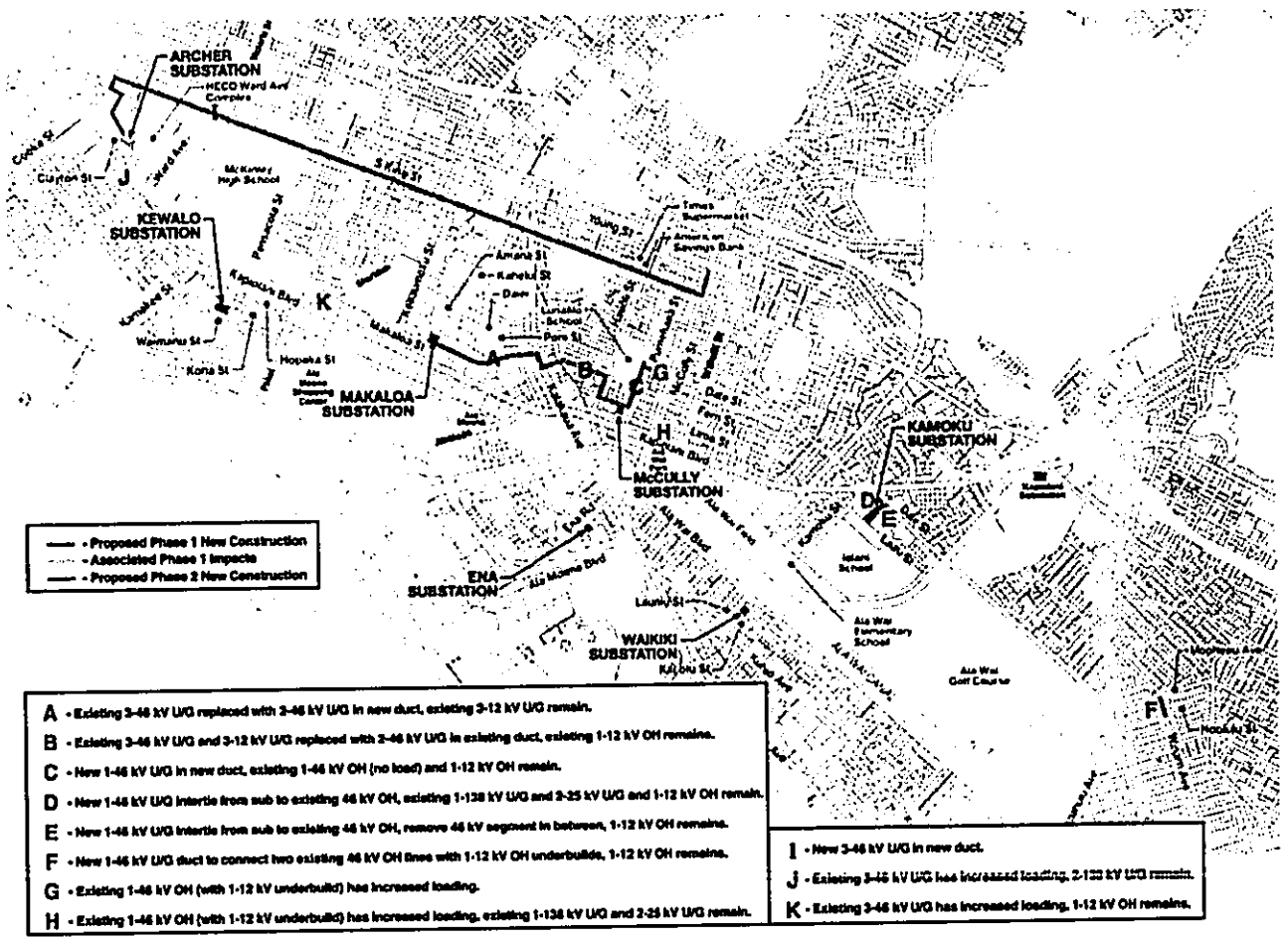


Figure A-1. Diagram for the HECO East Oahu Transmission Project
With Associated Segment Locations

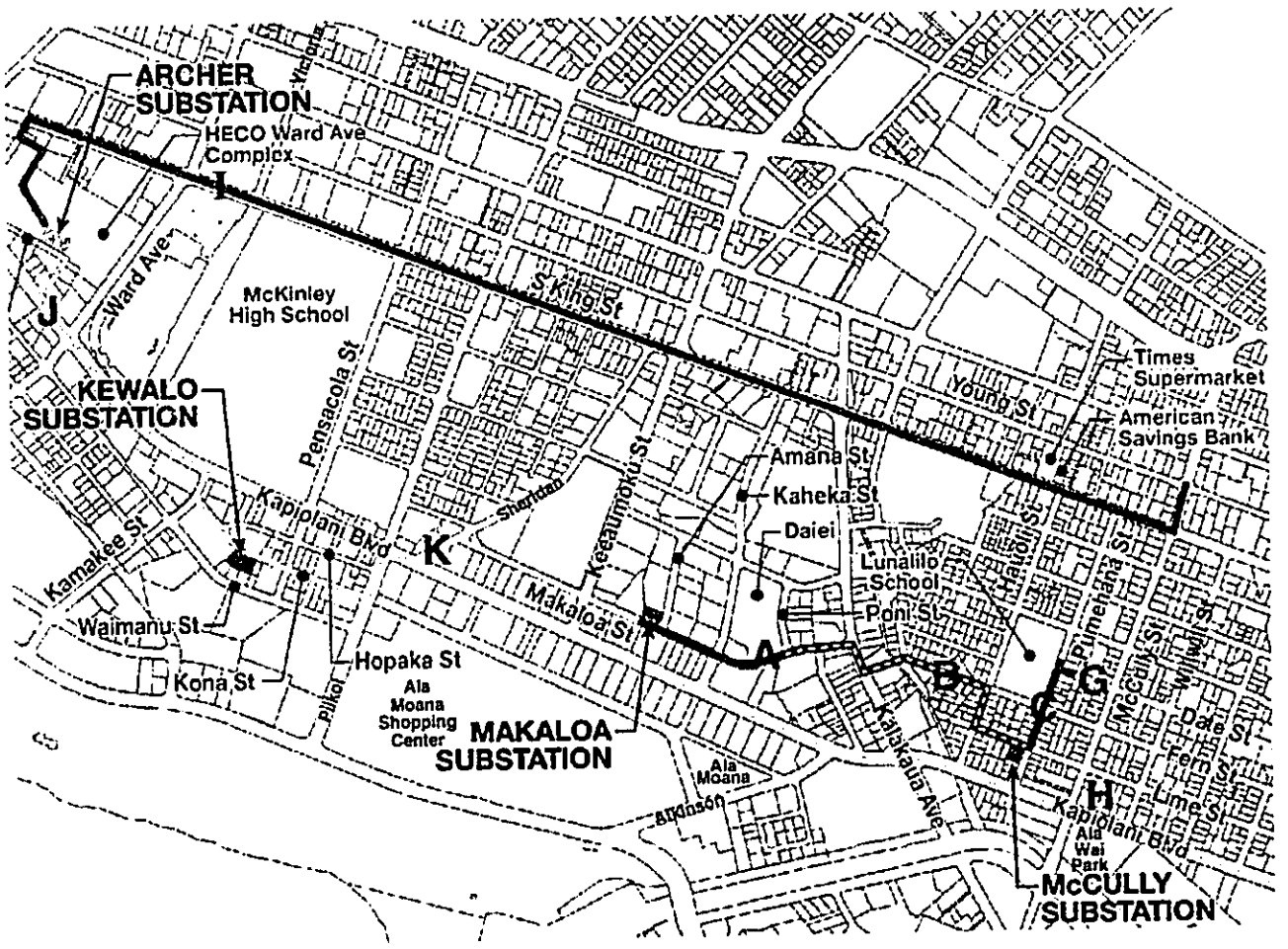


Figure A-2. Detailed Diagram for the HECO East Oahu Transmission Project
Ewa Side With Associated Segment Locations
(Segments 'A' – 'C' and 'G' – 'K')

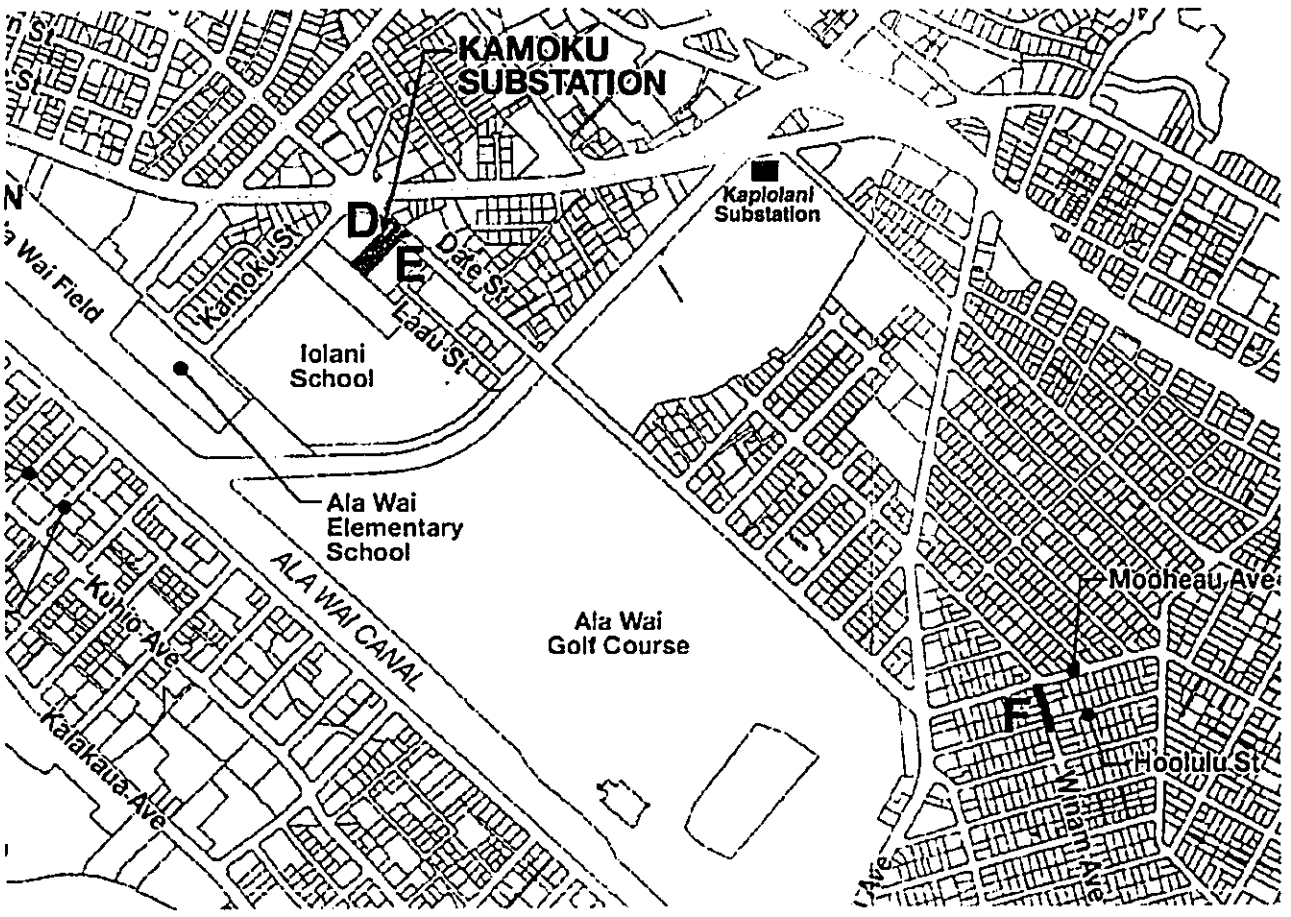


Figure A-3. Detailed Diagram for the HECO East Oahu Transmission Project
Diamond Head Side With Associated Segment Locations
(Segments 'D' – 'F')

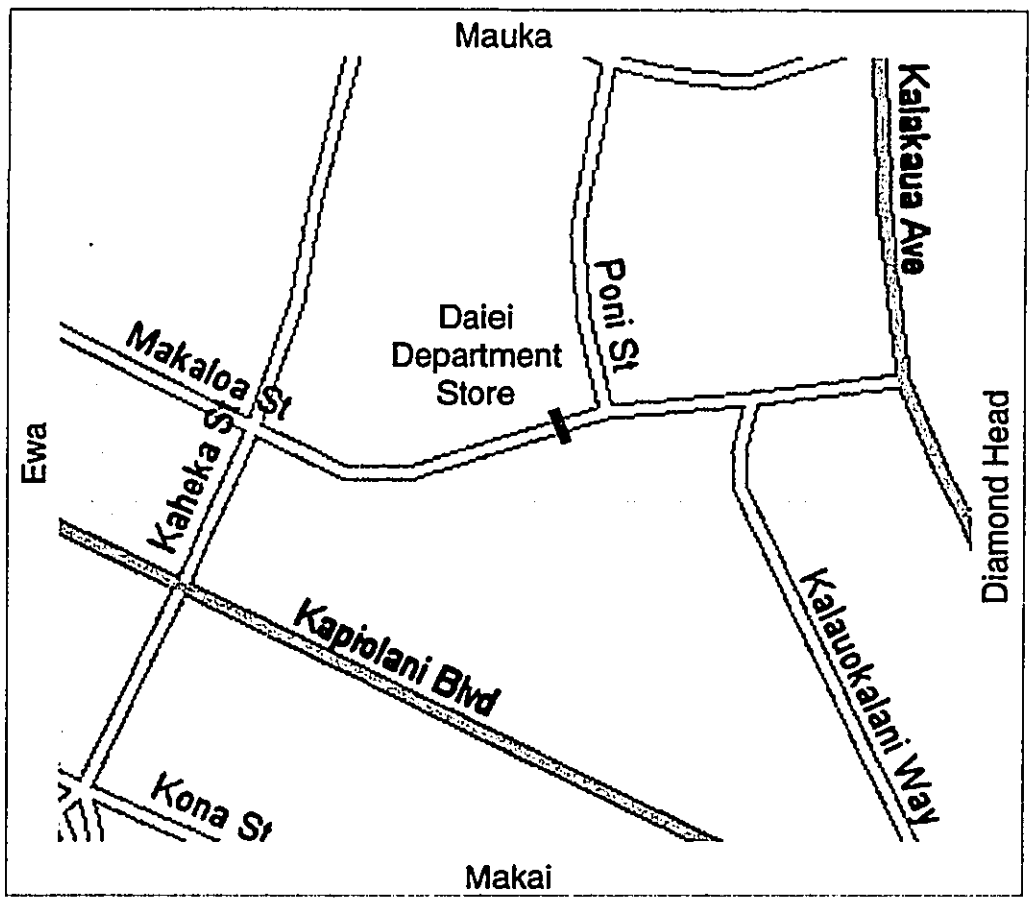
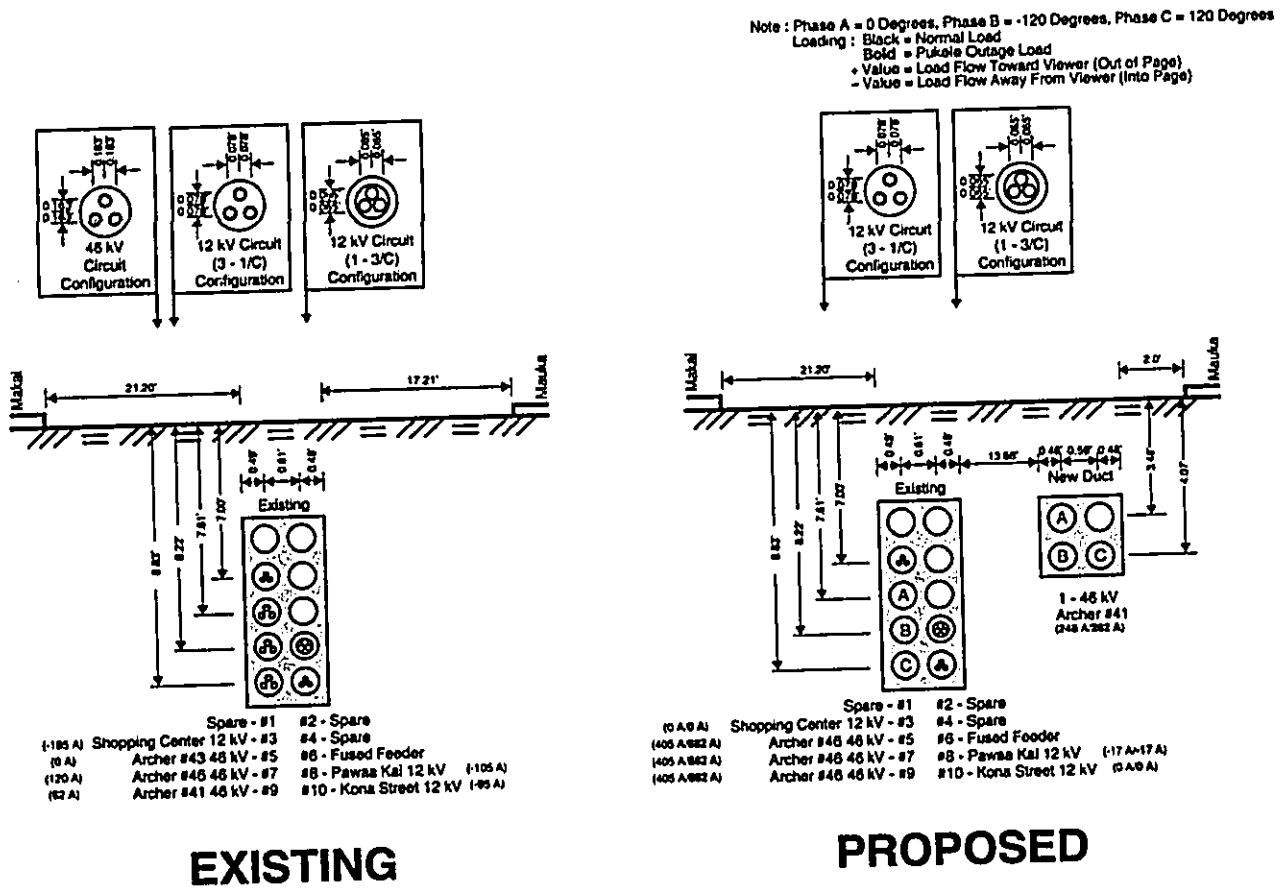


Figure A-4. Measurement Location at Segment 'A'
(Makaloa Street between Kaheka and Poni Streets)



SEGMENT 'A'

Makaloa Street between Kaheka & Poni Streets

Figure A-5. Diagram of Electrical Facilities at Segment 'A'
(Makaloa Street between Kaheka and Poni Streets)

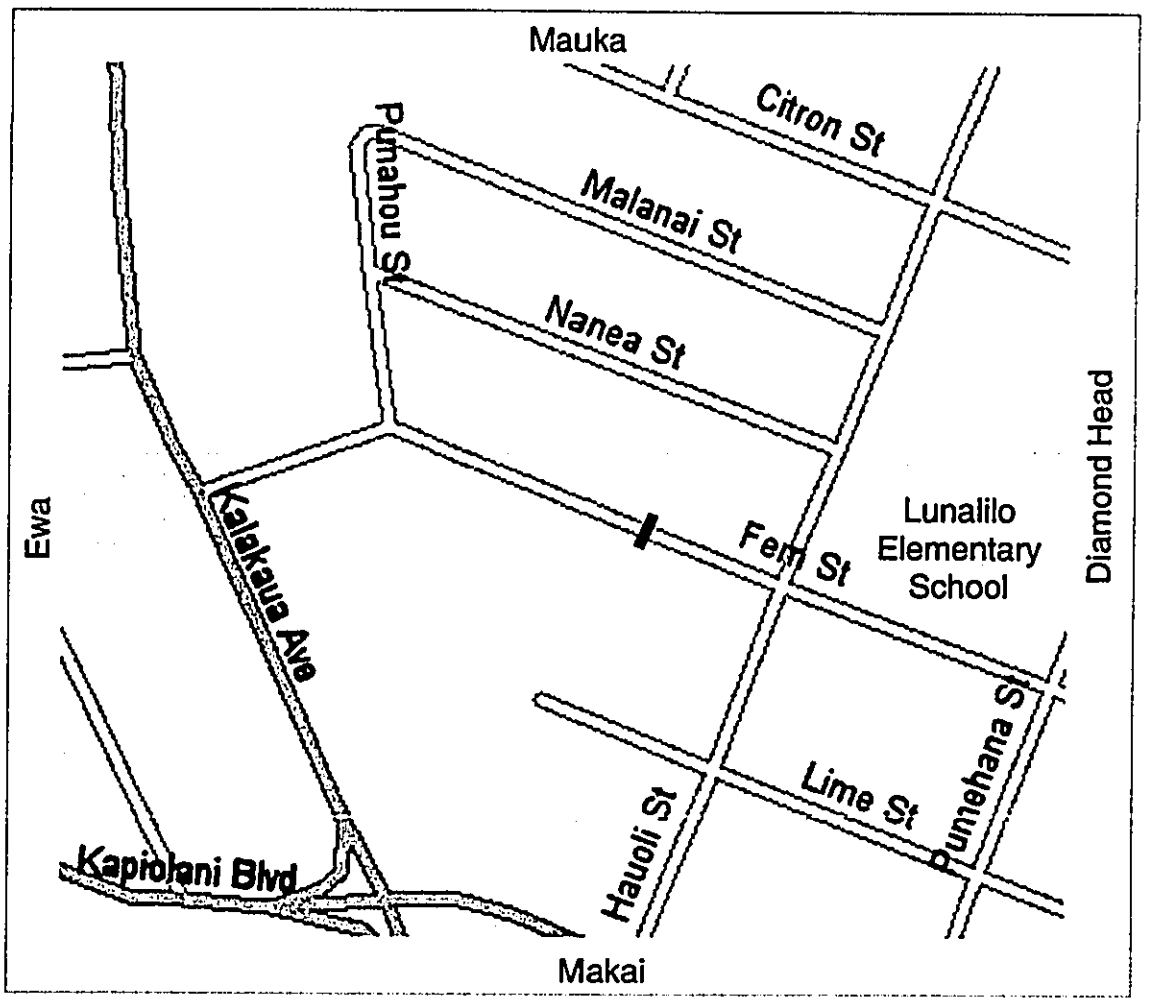
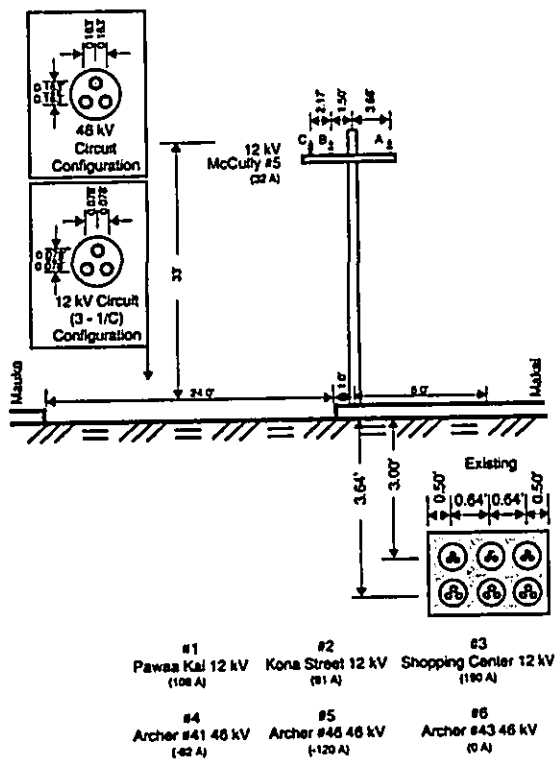
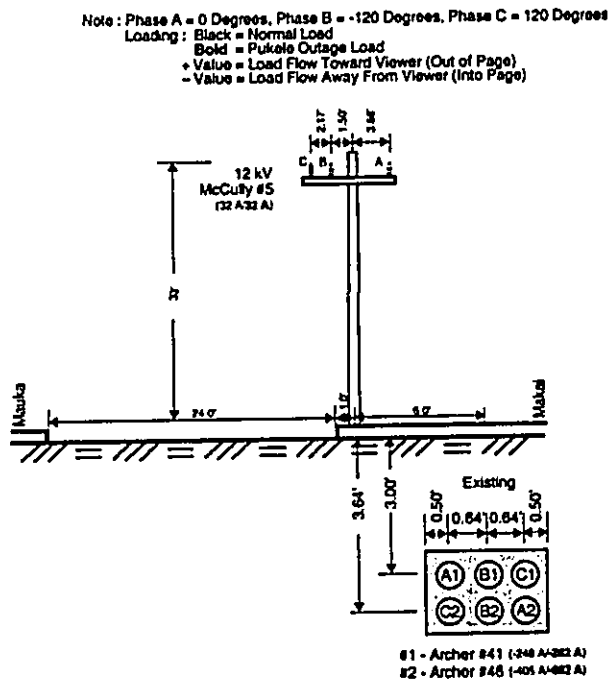


Figure A-6. Measurement Location at Segment 'B'
(Fern Street between Punahou and Hauoli Streets)





EXISTING **PROPOSED**

SEGMENT 'B'

Fern Street between Punahou and Hauoli Streets

Figure A-7. Diagram of Electrical Facilities at Segment 'B'
(Fern Street between Punahou and Hauoli Streets)

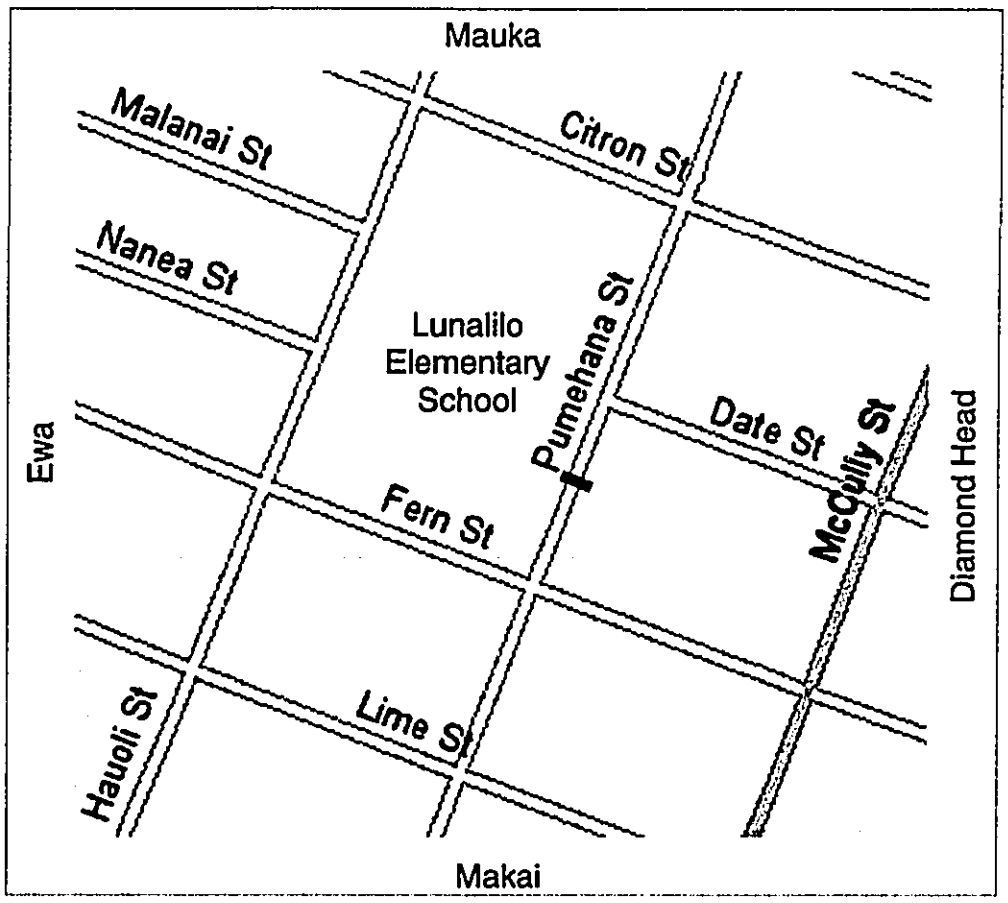
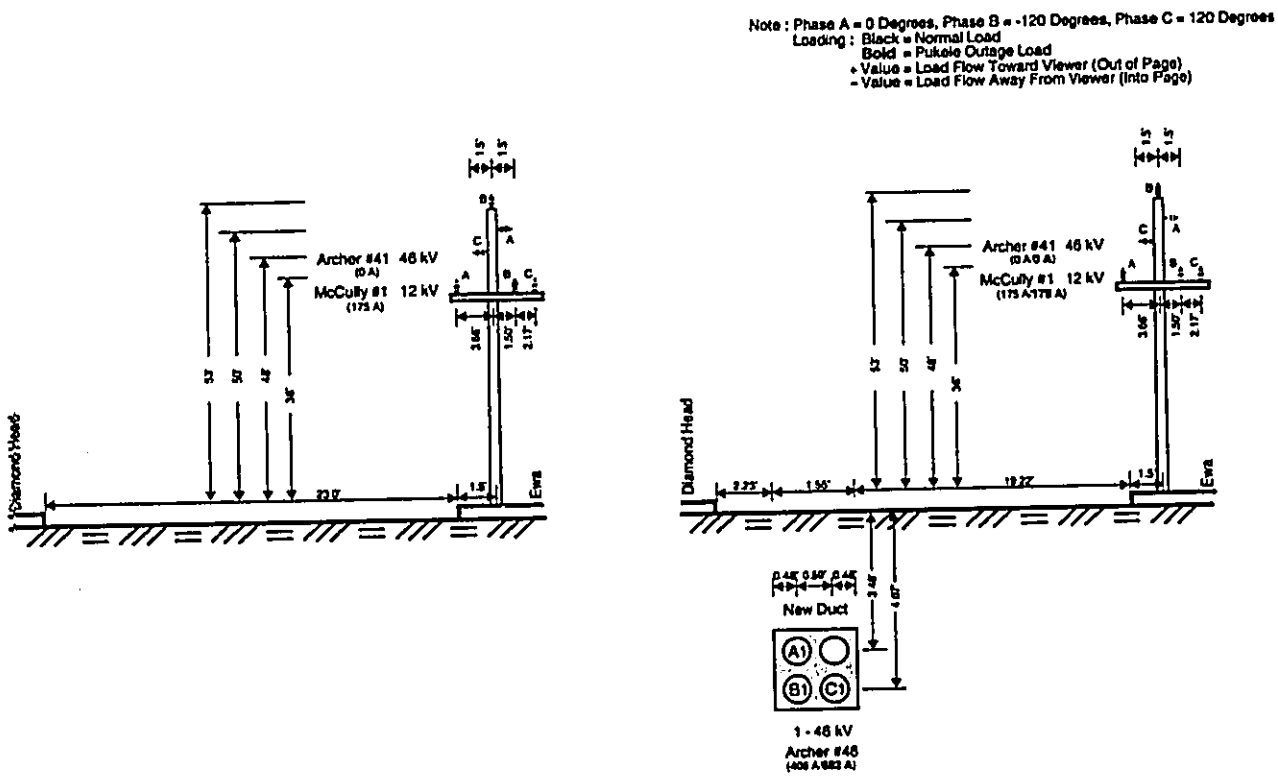


Figure A-8. Measurement Location at Segment 'C'
(Pumehana Street between Lime and Date Streets)



EXISTING **PROPOSED**

SEGMENT 'C'

Pumehana Street between Lime and Date Streets

Figure A-9. Diagram of Electrical Facilities at Segment 'C'
(Pumehana Street between Lime and Date Streets)

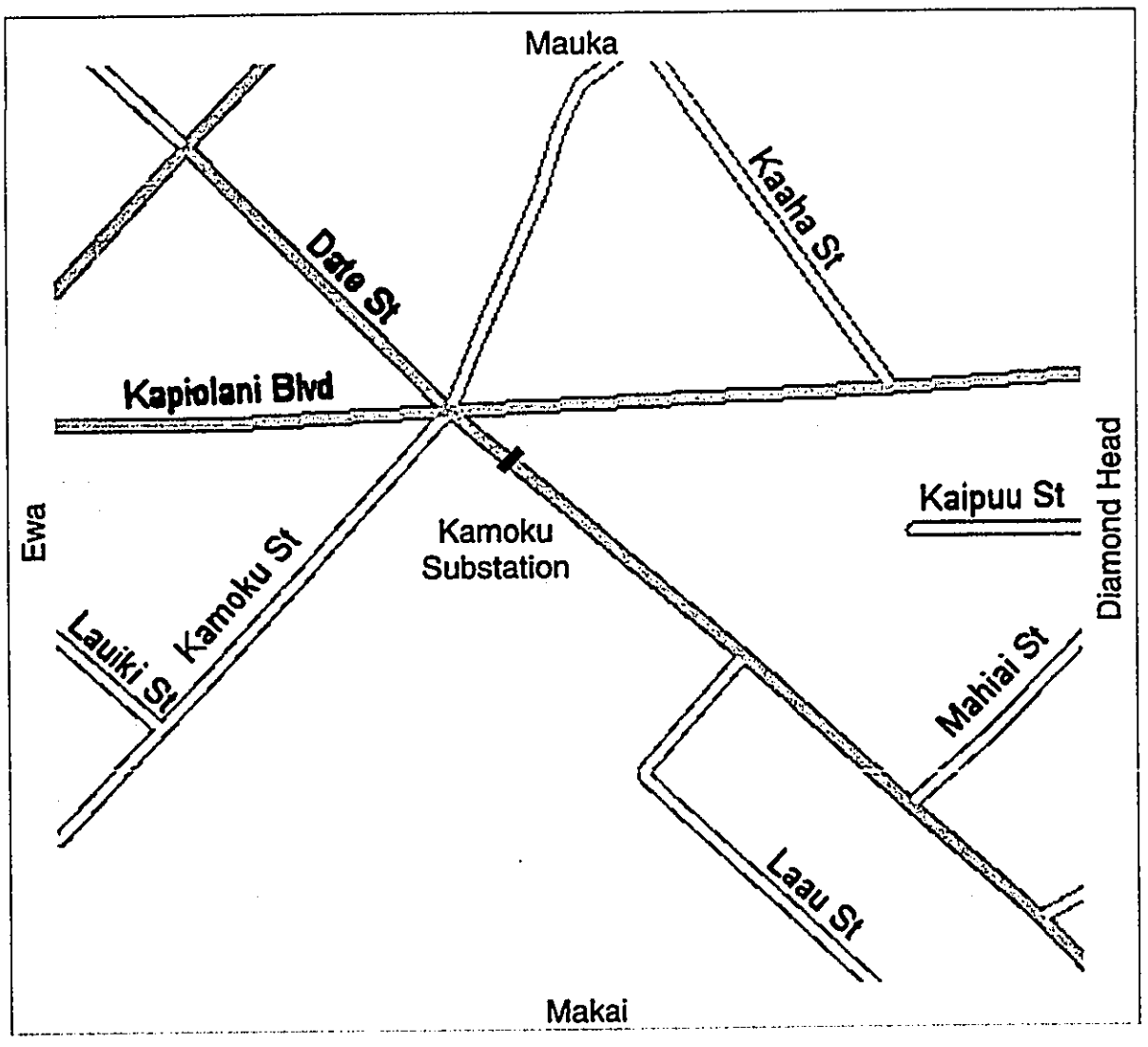
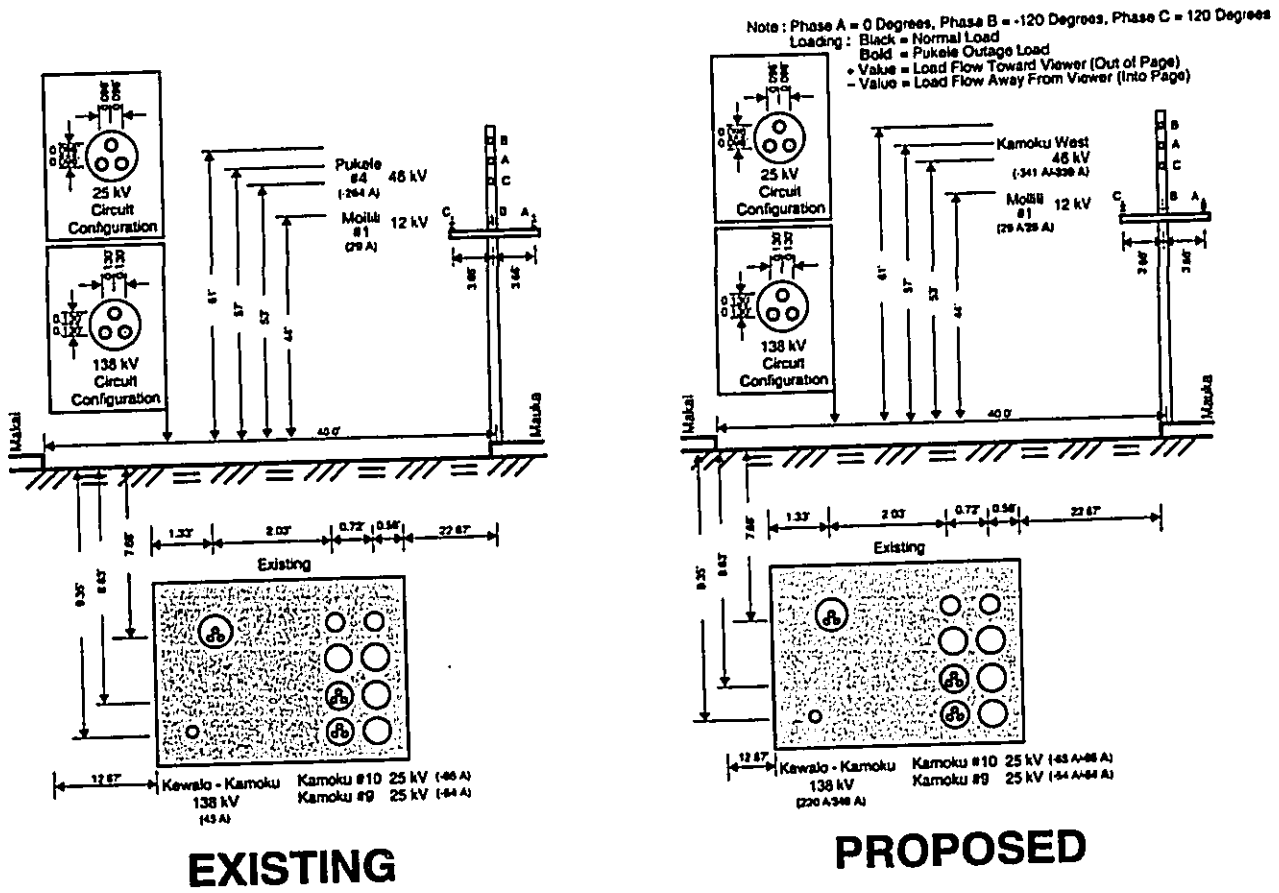


Figure A-10. Measurement Location at Segment 'D'
(Date Street west of Kamoku Substation)



SEGMENT 'D'

Date Street west of Kamoku Substation

Figure A-11. Diagram of Electrical Facilities at Segment 'D'
(Date Street west of Kamoku Substation)

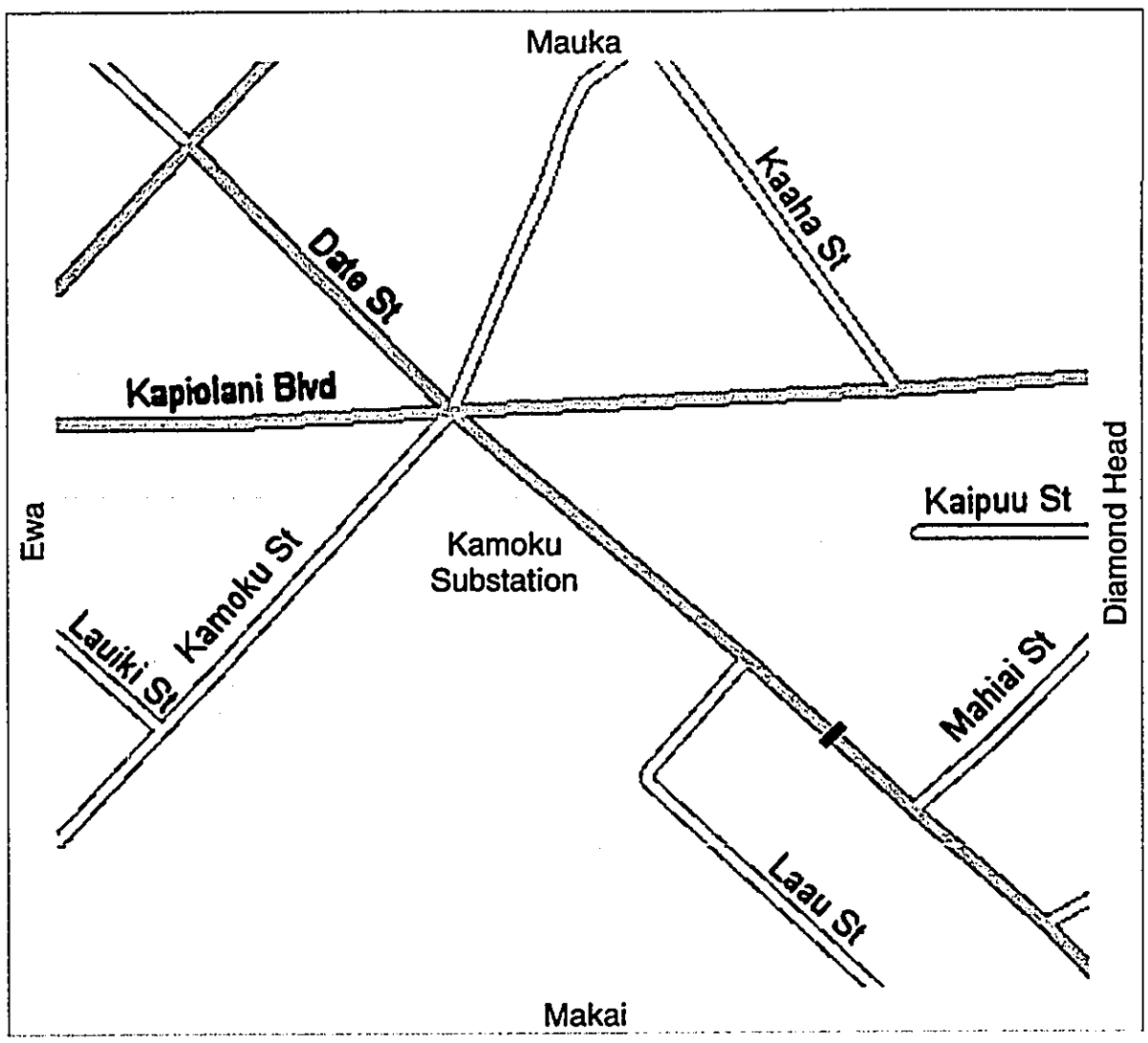
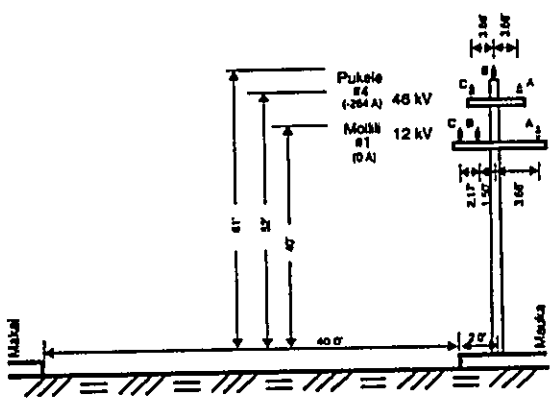
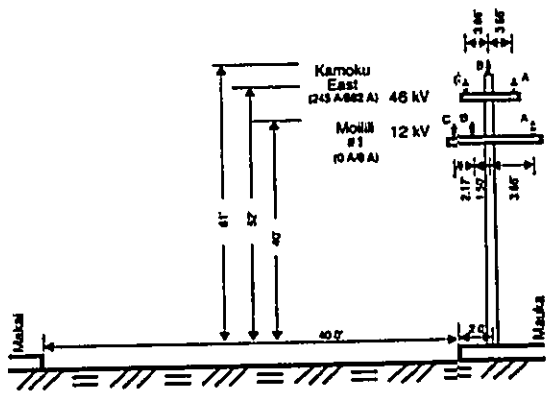


Figure A-12. Measurement Location at Segment 'E'
(Date Street east of Kamoku Substation)

Note : Phase A = 0 Degrees, Phase B = -120 Degrees, Phase C = 120 Degrees
Loading : Black = Normal Load
Bold = Pukele Outage Load
+ Value = Load Flow Toward Viewer (Out of Page)
- Value = Load Flow Away From Viewer (Into Page)





EXISTING **PROPOSED**

SEGMENT 'E'

Date Street east of Kamoku Substation

Figure A-13. Diagram of Electrical Facilities at Segment 'E'
(Date Street east of Kamoku Substation)

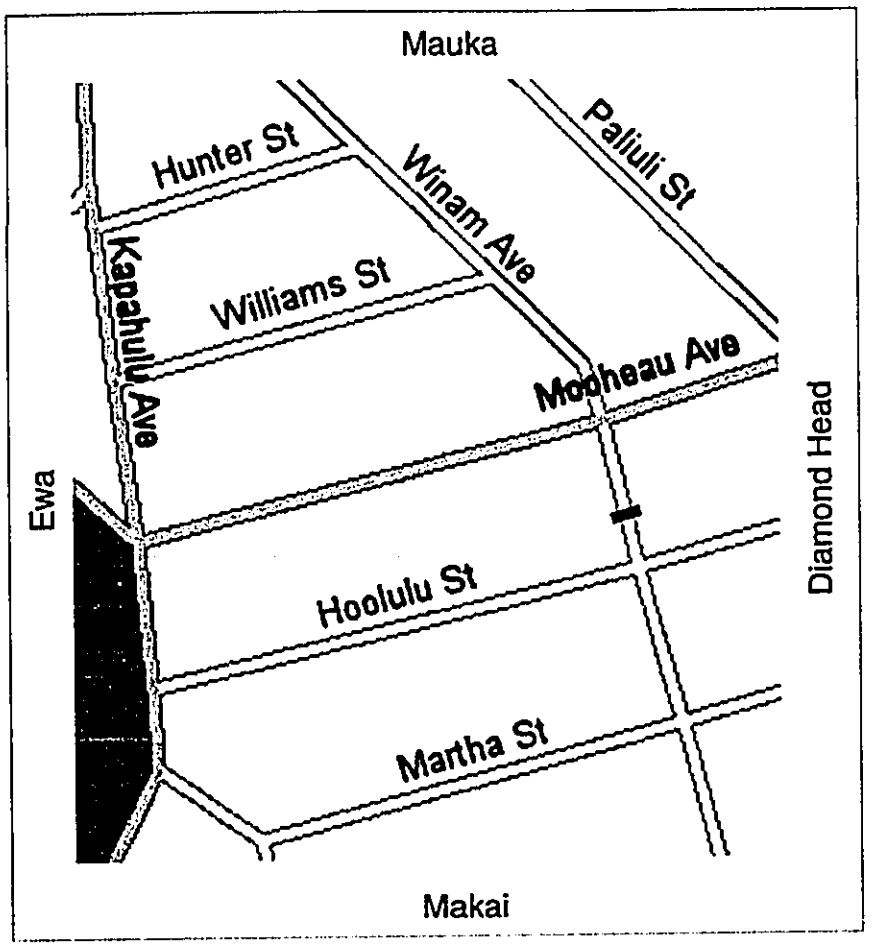
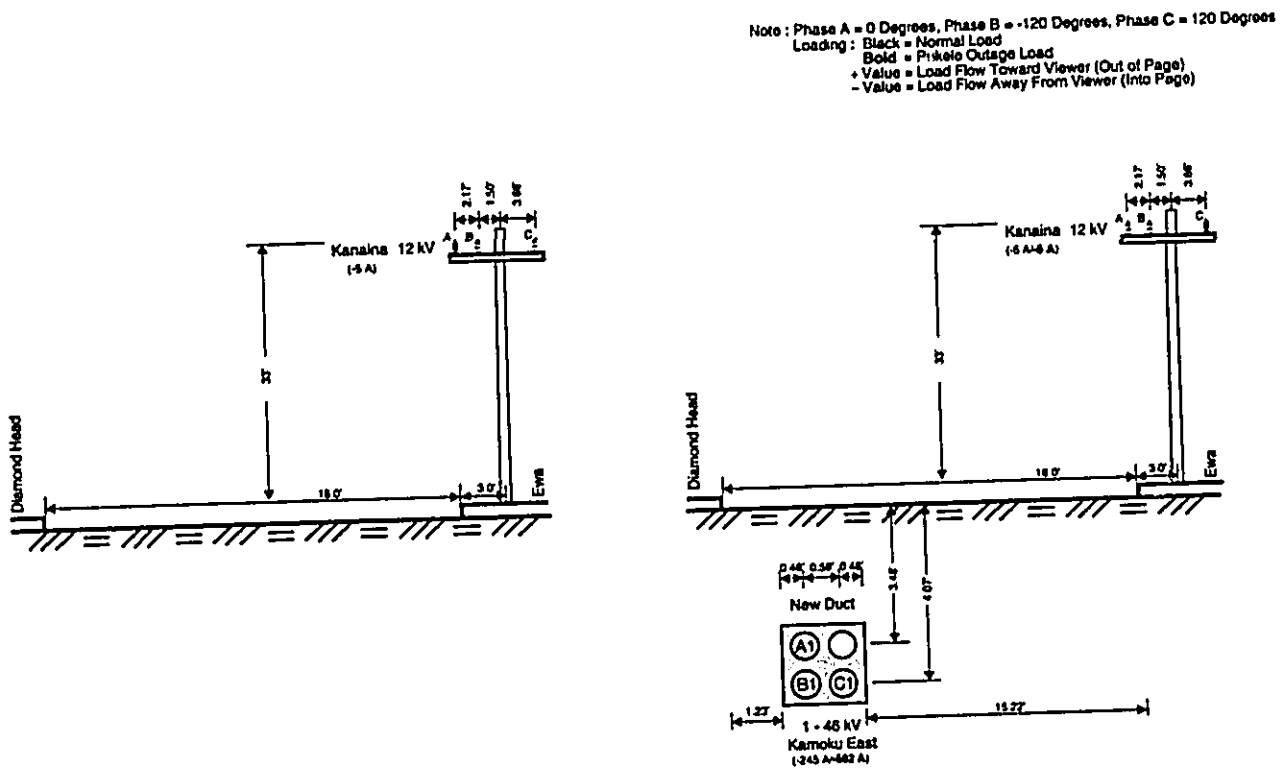


Figure A-14. Measurement Location at Segment 'F'
(Winam Avenue between Hoolulu and Mooheau Streets)



EXISTING **PROPOSED**

SEGMENT 'F'

Winam Avenue between Hoolulu and Mooheau Streets

Figure A-15. Diagram of Electrical Facilities at Segment 'F'
(Winam Avenue between Hoolulu and Mooheau Streets)

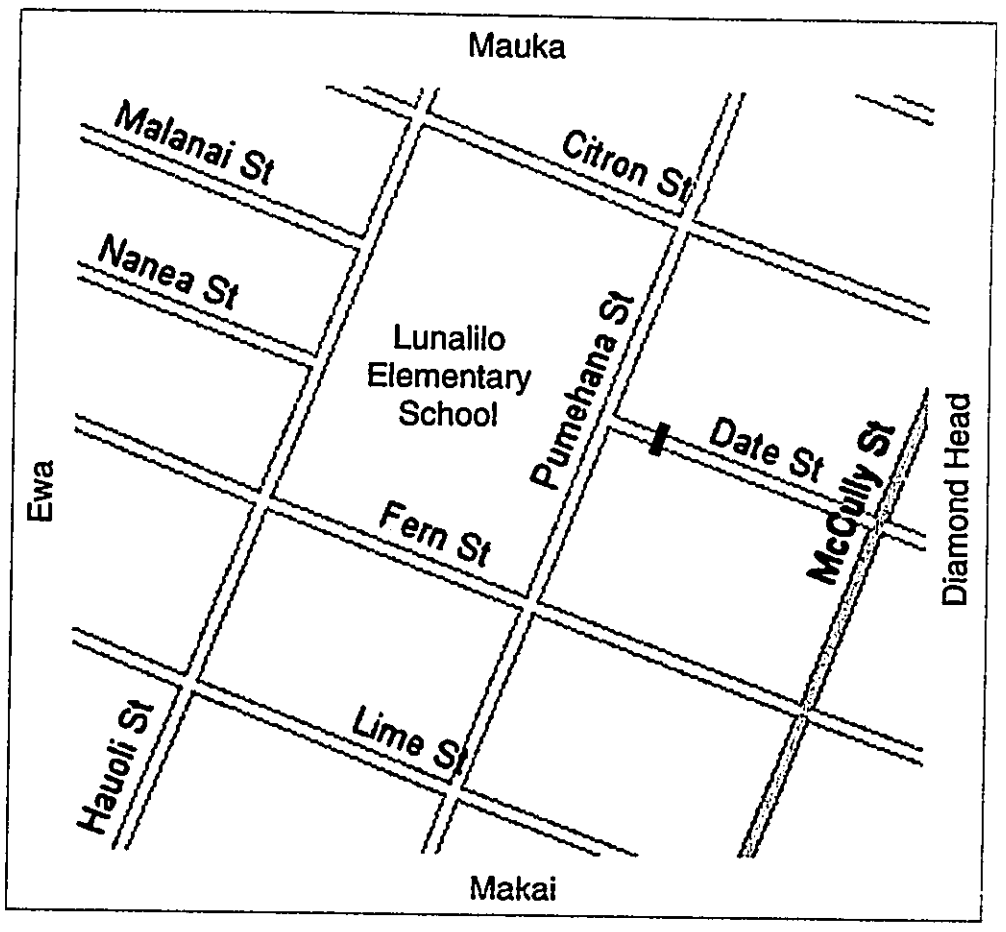
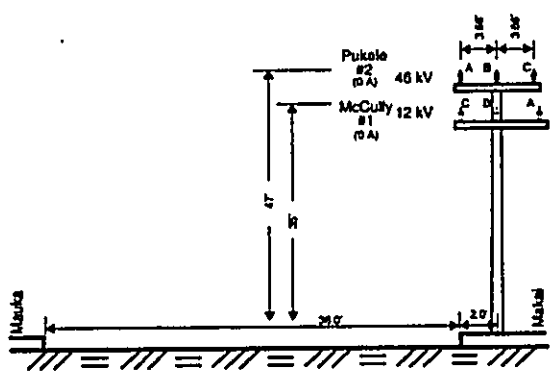
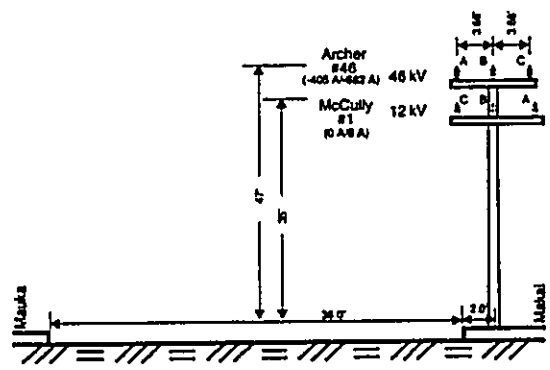


Figure A-16. Measurement Location at Segment 'G'
(Date Street between Pumehana and McCully Streets)

Note : Phase A = 0 Degrees, Phase B = -120 Degrees, Phase C = 120 Degrees
Loading : Black = Normal Load
Bold = Pukele Outage Load
+ Value = Load Flow Toward Viewer (Out of Page)
- Value = Load Flow Away From Viewer (Into Page)





EXISTING **EXISTING - NEW LOADS**

SEGMENT 'G'

Date Street between Pumehana and McCully Streets

Figure A-17. Diagram of Electrical Facilities at Segment 'G'
(Date Street between Pumehana and McCully Streets)

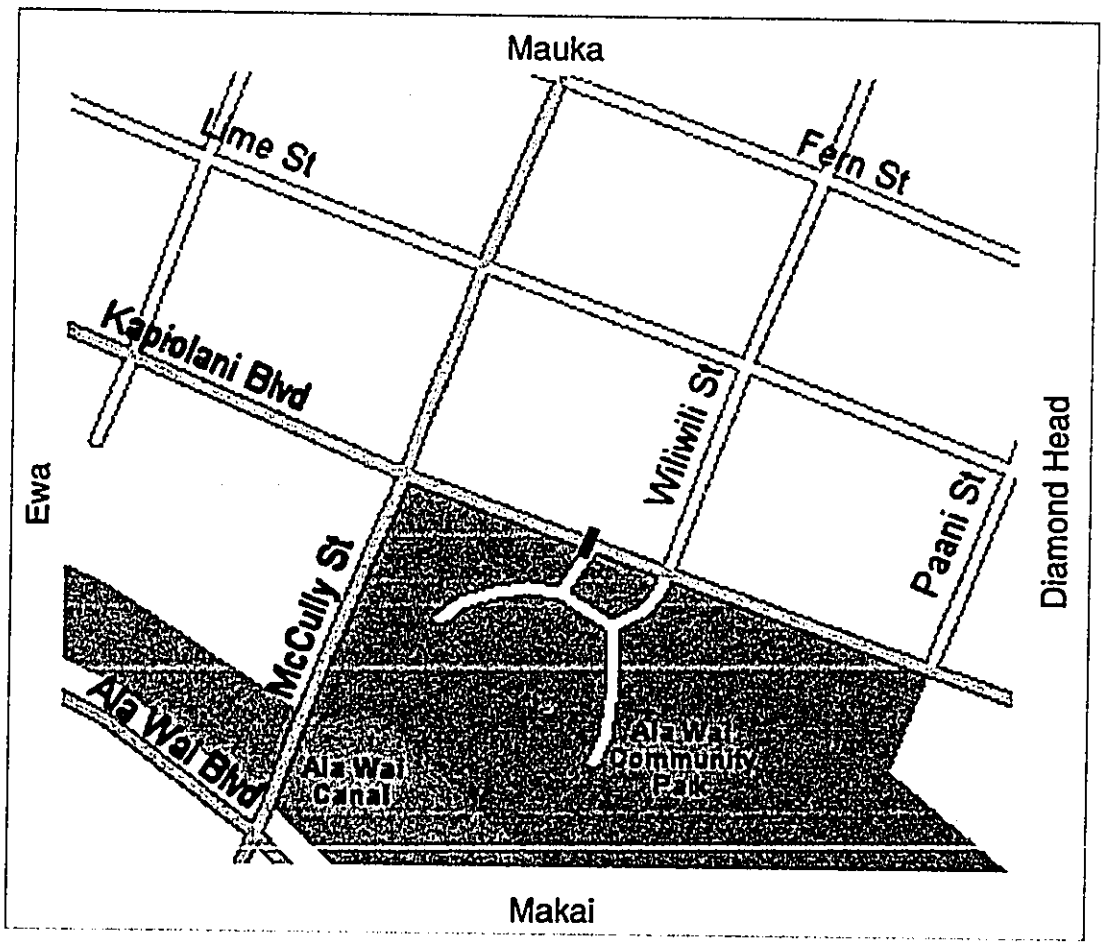
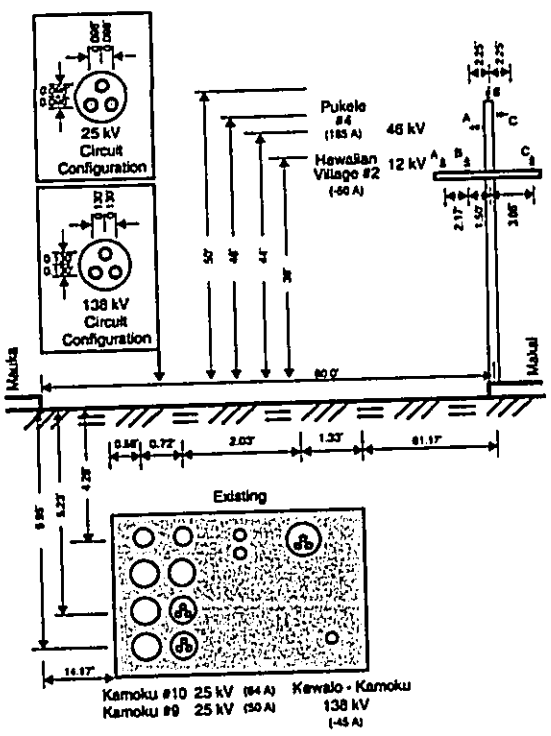
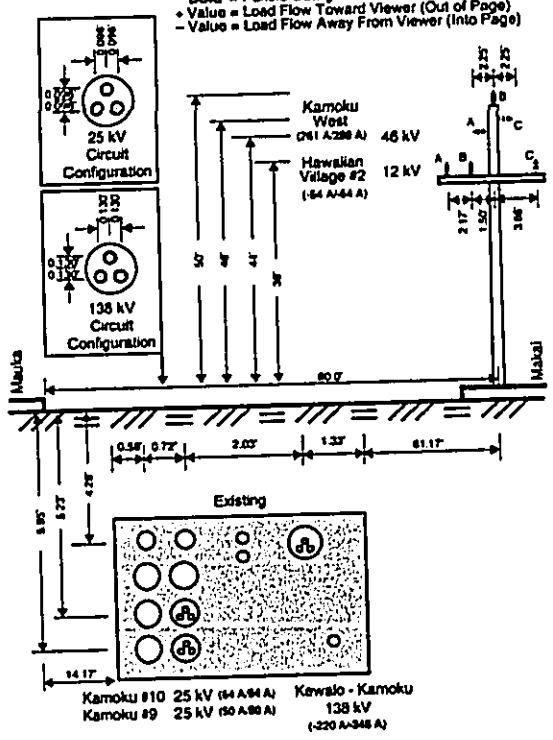


Figure A-18. Measurement Location at Segment 'H'
(Kapiolani Boulevard between Wiliwili and McCully Streets)



EXISTING



EXISTING - NEW LOADS

SEGMENT 'H'

Kapiolani Boulevard between Wiliwili and McCully Streets

Figure A-19. Diagram of Electrical Facilities at Segment 'H' (Kapiolani Boulevard between Wiliwili and McCully Streets)

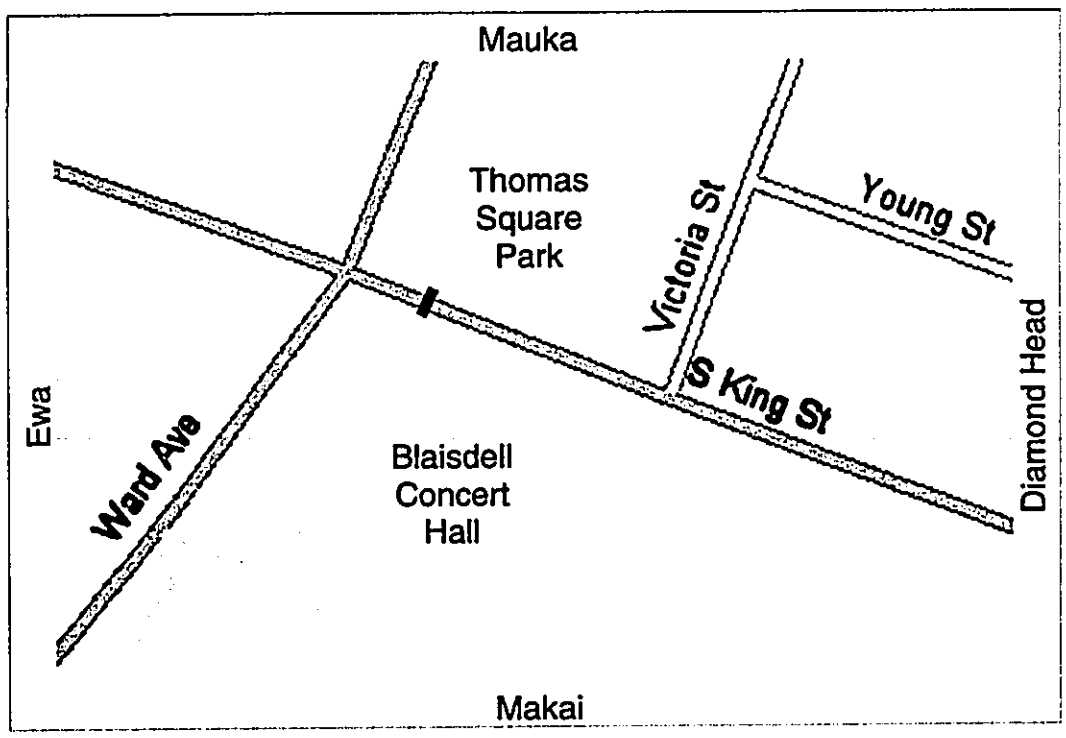
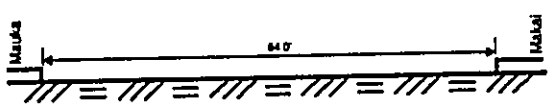
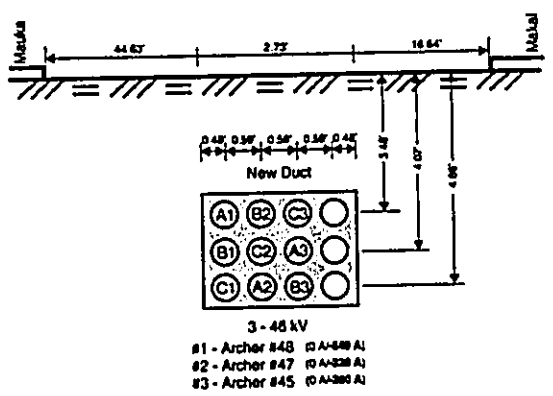


Figure A-20. Measurement Location at Segment 'I'
(King Street between Ward Avenue and Victoria Street)

Note : Phase A = 0 Degrees, Phase B = -120 Degrees, Phase C = 120 Degrees
Loading : Black = Normal Load
Bold = Pukoio Outage Load
+ Value = Load Flow Toward Viewer (Out of Page)
– Value = Load Flow Away From Viewer (Into Page)





EXISTING **PROPOSED**

SEGMENT 'I'

King Street between Ward Avenue and Victoria Street

Figure A-21. Diagram of Electrical Facilities at Segment 'I'
(King Street between Ward Avenue and Victoria Street)

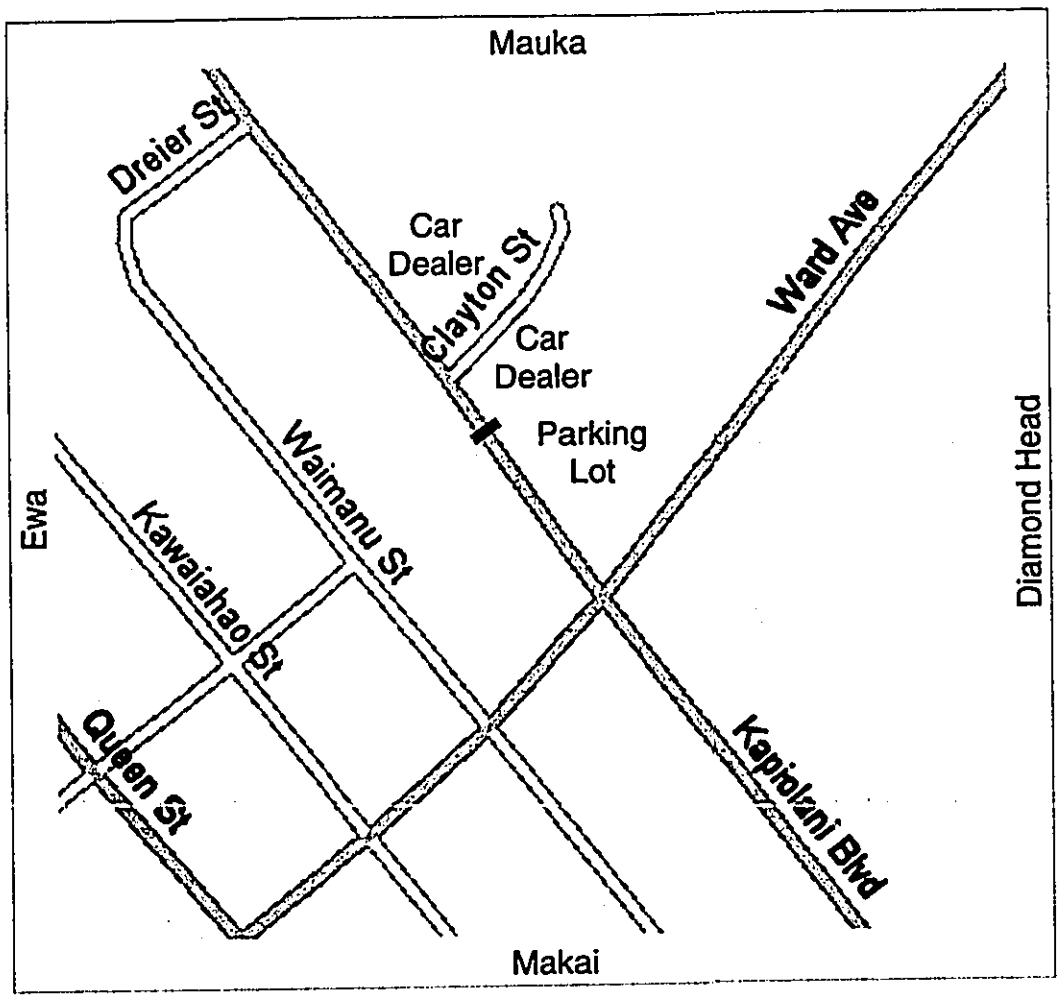
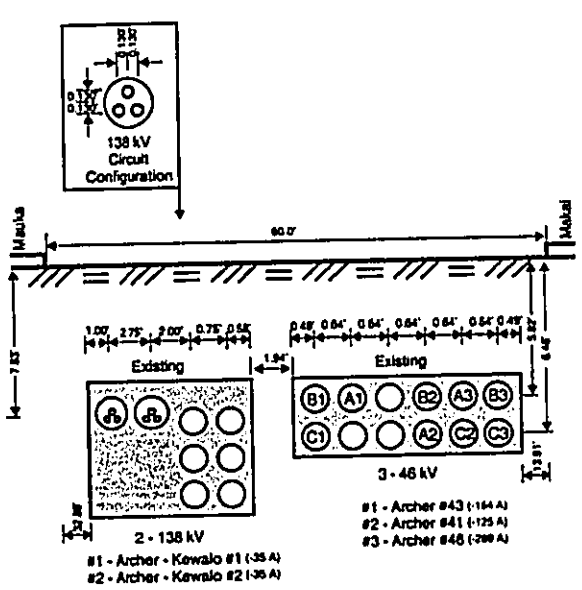
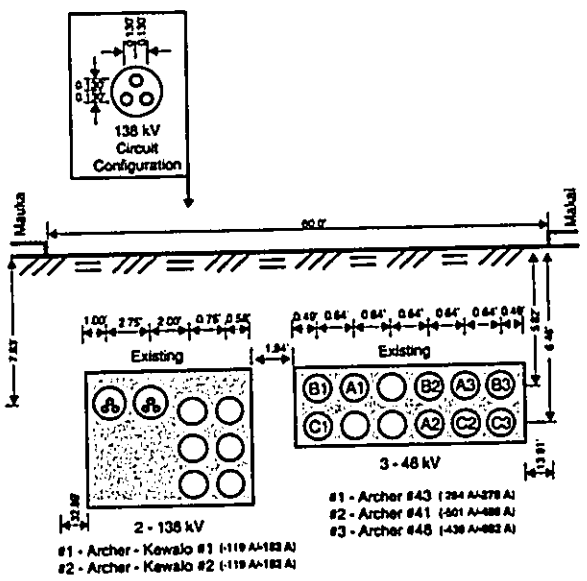


Figure A-22. Measurement Location at Segment 'J'
(Kapiolani Boulevard between Clayton Street and Ward Avenue)

Note : Phase A = 0 Degrees, Phase B = -120 Degrees, Phase C = 120 Degrees
Loading : Black = Normal Load
Bold = Pukele Outage Load
+ Value = Load Flow Toward Viewer (Out of Page)
– Value = Load Flow Away From Viewer (Into Page)





EXISTING **EXISTING - NEW LOADS**

SEGMENT 'J'

Kapiolani Boulevard between Clayton Street and Ward Avenue

Figure A-23. Diagram of Electrical Facilities at Segment 'J'
(Kapiolani Boulevard between Clayton Street and Ward Avenue)

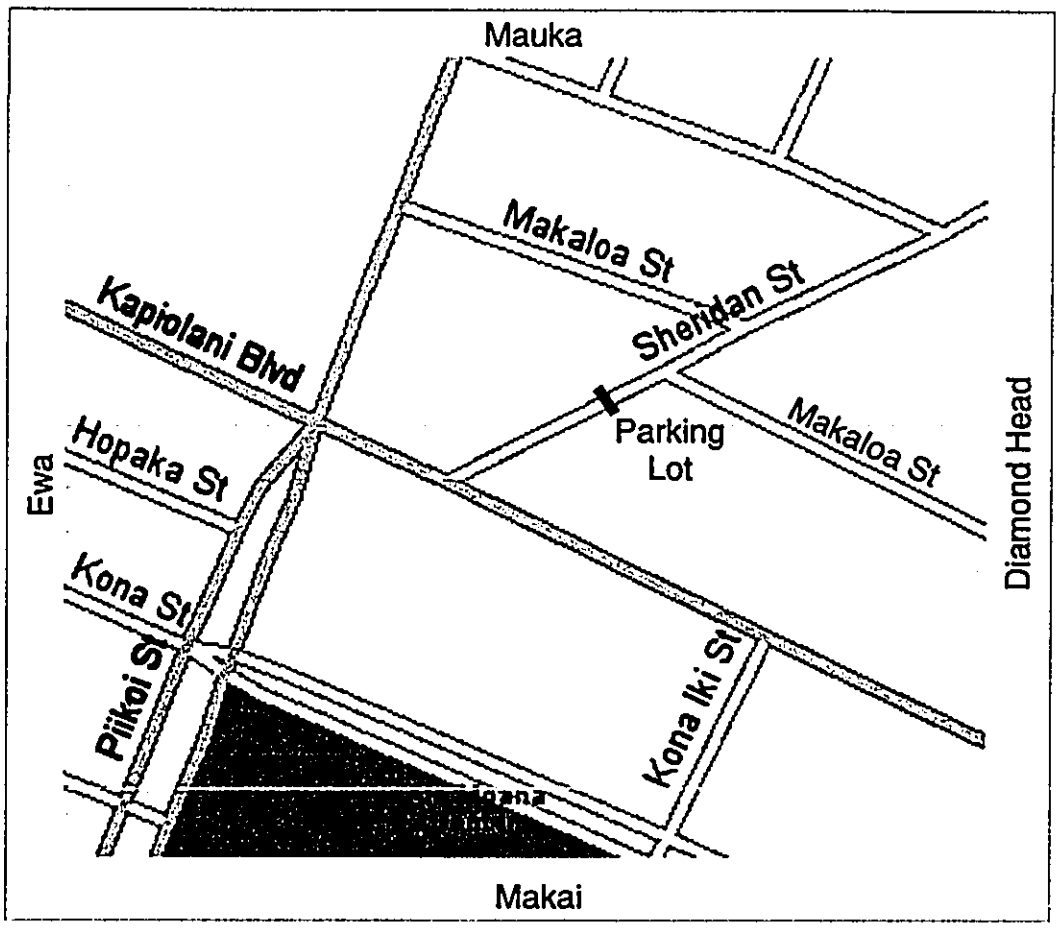
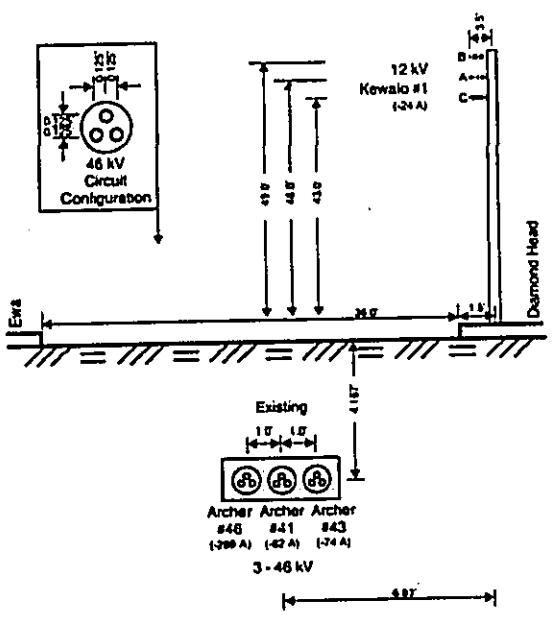
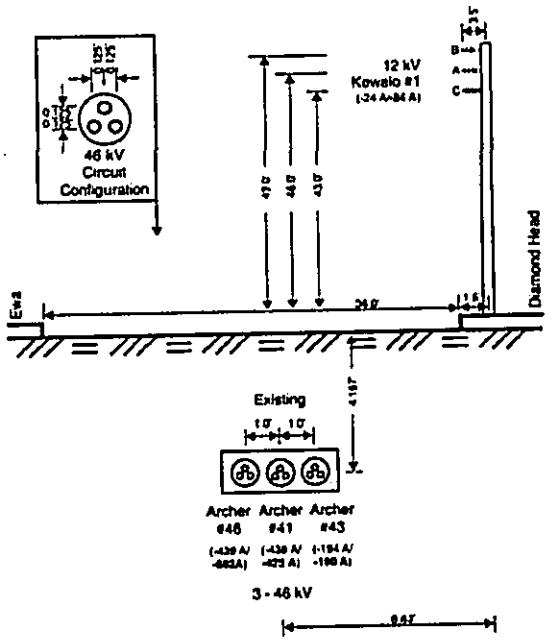


Figure A-24. Measurement Location at Segment 'K'
(Sheridan Street between Kapiolani Boulevard and Makaloa Street)



Note : Phase A = 0 Degrees, Phase B = -120 Degrees, Phase C = 120 Degrees
Loading : Black = Normal Load
Bold = Pukele Outage Load
+ Value = Load Flow Toward Viewer (Out of Page)
- Value = Load Flow Away From Viewer (Into Page)



EXISTING **EXISTING - NEW LOADS**

SEGMENT 'K'

Sheridan Street between Kapiolani Boulevard and Makaloa Street

Figure A-25. Diagram of Electrical Facilities at Segment 'K'
(Sheridan Street between Kapiolani Boulevard and Makaloa Street)

Table A-1. Summary of Existing Transmission Line Facilities and Loading Information for Each Segment of the Proposed Project

HECO : EAST OAHU TRANSMISSION PROJECT - 46 kV PHASED PROJECT

Filename	Phase	Segment	Segment Location/Description	Specific Location	Existing Line Configuration				
					Line Type	Line Voltage	Circuit Name	Amp	Conductor Size
HECO_1AE	1	A	Makaloa Substation to Poni Street	Between Kaheka and Poni Streets	U/G	46 kV	Archer 41	62	600 kcm
HECO_1AP					U/G	46 kV	Archer 43	0	600 kcm
					U/G	46 kV	Archer 46	120	600 kcm
					U/G	12 kV	Pawaa Kai	-105	750 PILC-PJ
					U/G	12 kV	Shopping Center	-195	750 PILC-PJ
					U/G	12 kV	Kona Street	-95	750 PILC-PJ
HECO_1BE	1	B	Poni Street to McCully Substation	Fern Street between Punahou and Hauoli Streets	U/G	46 kV	Archer 41	-62	600 kcm
HECO_1BP					U/G	46 kV	Archer 43	0	600 kcm
					U/G	46 kV	Archer 46	-120	600 kcm
					U/G	12 kV	Pawaa Kai	108	750 PILC-PJ
					U/G	12 kV	Shopping Center	190	750 PILC-PJ
					U/G	12 kV	Kona Street	91	750 PILC-PJ
					O/H	12 kV	McCully 5	32	336 Al
HECO_1CE	1	C	McCully Substation Along Pumehana St. to Date Street (Connects Pukele #2 to Archer #41)	Between Lime and Date Streets	O/H	46 kV	Archer 41	0	556 AAC
HECO_1CP					O/H	12 kV	McCully 1	175	336 Al
HECO_1DE	1	D	Kamoku Substation at Date Street	Date Street West of Kamoku Sub	U/G	138 kV	Kewalo-Kamoku	45	3000 CU HPFF
HECO_1DP					O/H	46 kV	Pukele 4	-264	556 AAC
					O/H	12 kV	Moiliili 1	29	336 Al
					U/G	25 kV	Kamoku 9	-54	1000 PEICN
					U/G	25 kV	Kamoku 10	-65	1000 PEICN
HECO_1EE	1	E	Kamoku Substation at Date Street	Date Street East of Kamoku Sub	O/H	46 kV	Pukele 4	-264	556 AAC
HECO_1EP					O/H	12 kV	Moiliili 1	0	336 Al
HECO_1FE	1	F	Winam Avenue (Between Hoolulu St.and Mooheau - Connects Pukele #4 to Kamoku East)	Winam Avenue between Hoolulu and Winam Streets	O/H	12 kV	Kanaina	-5	#4
HECO_1GE	1	G	Date Street (Near Pumehana St to McCully)	Between Pumehana and McCully Streets	O/H	46 kV	Pukele 2	0	556 AAC
HECO_1GP					O/H	12 kV	McCully 1	0	336 Al
HECO_2HE	1	H	Kapiolani Blvd (At Ala Wai Park - Pukele #4)	Between McCully & Waiwai Streets	U/G	138 kV	Kewalo-Kamoku	-45	3000 CU HPFF
HECO_2HP					O/H	46 kV	Pukele 4	185	556 AAC
					O/H	12 kV	Hawaiian Village #2	-50	336 Al
					U/G	25 kV	Kamoku 9	50	1000 PEICN
					U/G	25 kV	Kamoku 10	64	1000 PEICN
HECO_2IE	2	I	Archer Substation Along King Street	Between Ward Avenue and Victoria Street			None		
HECO_2IP									
HECO_2JE	2	J	Archer Substation Along Kapiolani (to Kamakee Street - Circuits #41, 43, 46)	Between Clayton Street and Ward Avenue	U/G	138 kV	Archer-Kewalo #1	-35	3000 CU HPFF
HECO_2JP					U/G	138 kV	Archer-Kewalo #2	-35	3000 CU HPFF
					U/G	46 kV	Archer 41	-125	1500 kcm
					U/G	46 kV	Archer 43	-164	1500 kcm
					U/G	46 kV	Archer 46	-289	1500 kcm
HECO_2KE	2	K	Along Kapiolani from Pikoi to Makaloa Sub (Circuits #41, 43, 46)	Sheridan Street between Kapiolani and Makaloa Streets	U/G	46 kV	Archer 41	-62	1500 kcm
HECO_2KP					U/G	46 kV	Archer 43	-74	1500 kcm
					U/G	46 kV	Archer 46	-289	1500 kcm
					O/H	12 kV	Kewalo 1	-24	336 Al

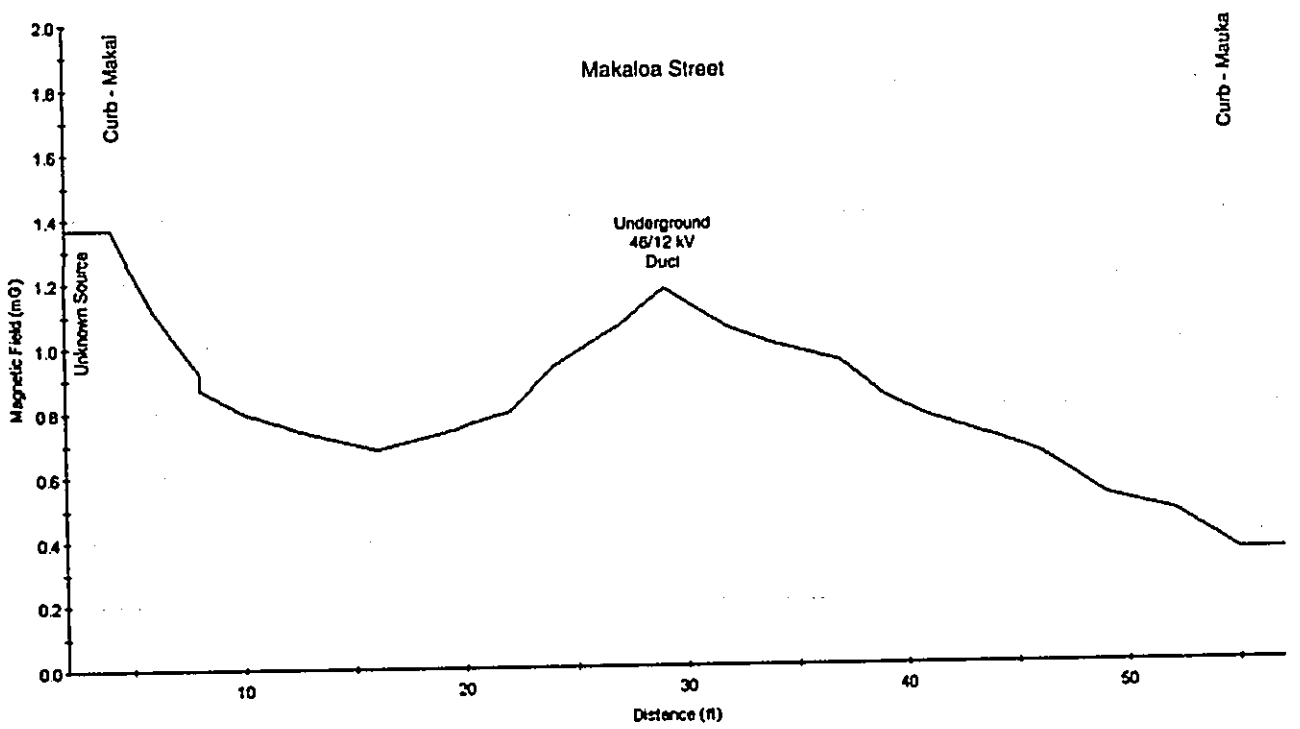
Table A-2. Summary of Proposed Transmission Line Facilities and Loading Information for Each Segment of the Proposed Project

HECO : EAST OAHU TRANSMISSION PROJECT - 46 kV PHASED PROJECT

Filename	Phase	Segment	Segment Location/Description	Specific Location	Proposed Line Configuration: Line Type	Line Voltage	Circuit Name	Amp	Pukele Outage Amp	Conductor Size
HECO_1AE HECO_1AP	1	A	Makaloa Substation to Poni Street	Between Kaheka and Poni Streets	U/G	46 kV	Archer 41	248	262	1500 kcm
					U/G	46 kV	Archer 46	405	682	1500 kcm
					U/G	12 kV	Pawaa Kai	-17	-17	750 PILC-PJ
					U/G	12 kV	Shopping Center	0	0	750 PILC-PJ
					U/G	12 kV	Kona Street	0	0	750 PILC-PJ
HECO_1BE HECO_1BP	1	B	Poni Street to McCully Substation	Fern Street between Punahou and Hauoli Streets	U/G	46 kV	Archer 41	-248	-262	1500 kcm
					U/G	46 kV	Archer 46	-405	-682	1500 kcm
					O/H	12 kV	McCully 5	32	32	336 Al
HECO_1CE HECO_1CP	1	C	McCully Substation Along Pumehana St. to Date Street (Connects Pukele #2 to Archer #41)	Between Lime and Date Streets	O/H	46 kV	Archer 41	0	0	556 AAC
					O/H	12 kV	McCully 1	175	175	336 Al
					U/G	46 kV	Archer 46	405	682	1500 kcm
HECO_1DE HECO_1DP	1	D	Kamoku Substation at Date Street	Date Street West of Kamoku Sub	U/G	138 kV	Kewalo-Kamoku	220	348	3000 CU HPFF
					O/H	46 kV	Kamoku West	-341	-339	1500 kcm
					O/H	12 kV	Moiliili 1	29	29	336 Al
					U/G	25 kV	Kamoku 9	-54	-54	1000 PEICN
					U/G	25 kV	Kamoku 10	-65	-65	1000 PEICN
HECO_1EE HECO_1EP	1	E	Kamoku Substation at Date Street	Date Street East of Kamoku Sub	O/H	46 kV	Kamoku East	245	562	1500 kcm
					O/H	12 kV	Moiliili 1	0	0	336 Al
HECO_1FE HECO_1FP	1	F	Winam Avenue (Between Hoolulu St.and Mooheau - Connects Pukele #4 to Kamoku East)	Winam Avenue between Hoolulu and Winam Streets	U/G	46 kV	Kamoku East	-245	-562	1500 kcm
					O/H	12 kV	Kanana	-5	-5	#4
HECO_1GE HECO_1GP	1	G	Date Street (Near Pumehana St to McCully)	Between Pumehana and McCully Streets	O/H	46 kV	Archer 46	-405	-682	556 AAC
					O/H	12 kV	McCully 1	0	0	336 Al
HECO_2HE HECO_2HP	1	H	Kapiolani Blvd (At Ala Wai Park - Pukele #4)	Between McCully & Wilwil Streets	U/G	138 kV	Kewalo-Kamoku	-220	-348	3000 CU HPFF
					O/H	46 kV	Kamoku West	261	259	1500 kcm
					O/H	12 kV	Hawaiian Village #2	-54	-54	336 Al
					U/G	25 kV	Kamoku 9	50	50	1000 PEICN
					U/G	25 kV	Kamoku 10	64	64	1000 PEICN
HECO_2IE HECO_2IP	2	I	Archer Substation Along King Street	Between Ward Avenue and Victoria Street	U/G	46 kV	Archer 45	0	-280	1500 kcm
					U/G	46 kV	Archer 47	0	-326	1500 kcm
					U/G	46 kV	Archer 48	0	-649	1500 kcm
HECO_2JE HECO_2JP	2	J	Archer Substation Along Kapiolani (to Kamakee Street - Circuits #41, 43, 46)	Between Clayton Street and Ward Avenue	U/G	138 kV	Archer-Kewalo #1	-119	-182	3000 CU HPFF
					U/G	138 kV	Archer-Kewalo #2	-119	-182	3000 CU HPFF
					U/G	46 kV	Archer 41	-501	-489	1500 kcm
					U/G	46 kV	Archer 43	-284	-278	1500 kcm
					U/G	46 kV	Archer 46	-439	-682	1500 kcm
HECO_2KE HECO_2KP	2	K	Along Kapiolani from Piikoi to Makaloa Sub (Circuits #41, 43, 46)	Sheridan Street between Kapiolani and Makaloa Streets	U/G	46 kV	Archer 41	-438	-426	1500 kcm
					U/G	46 kV	Archer 43	-194	-190	1500 kcm
					U/G	46 kV	Archer 46	-439	-682	1500 kcm
					O/H	12 kV	Kewalo 1	-24	-24	336 Al

APPENDIX B

Magnetic Field Measurements
at Segment Locations



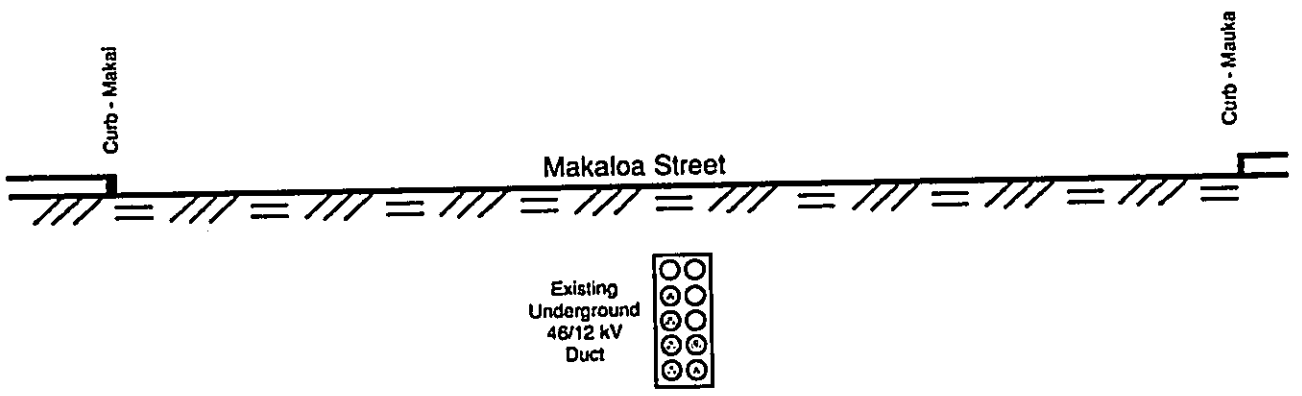


Figure B-1. Magnetic Field Measurements at Segment 'A'
(Makaloa Street between Kaheka and Poni Streets)

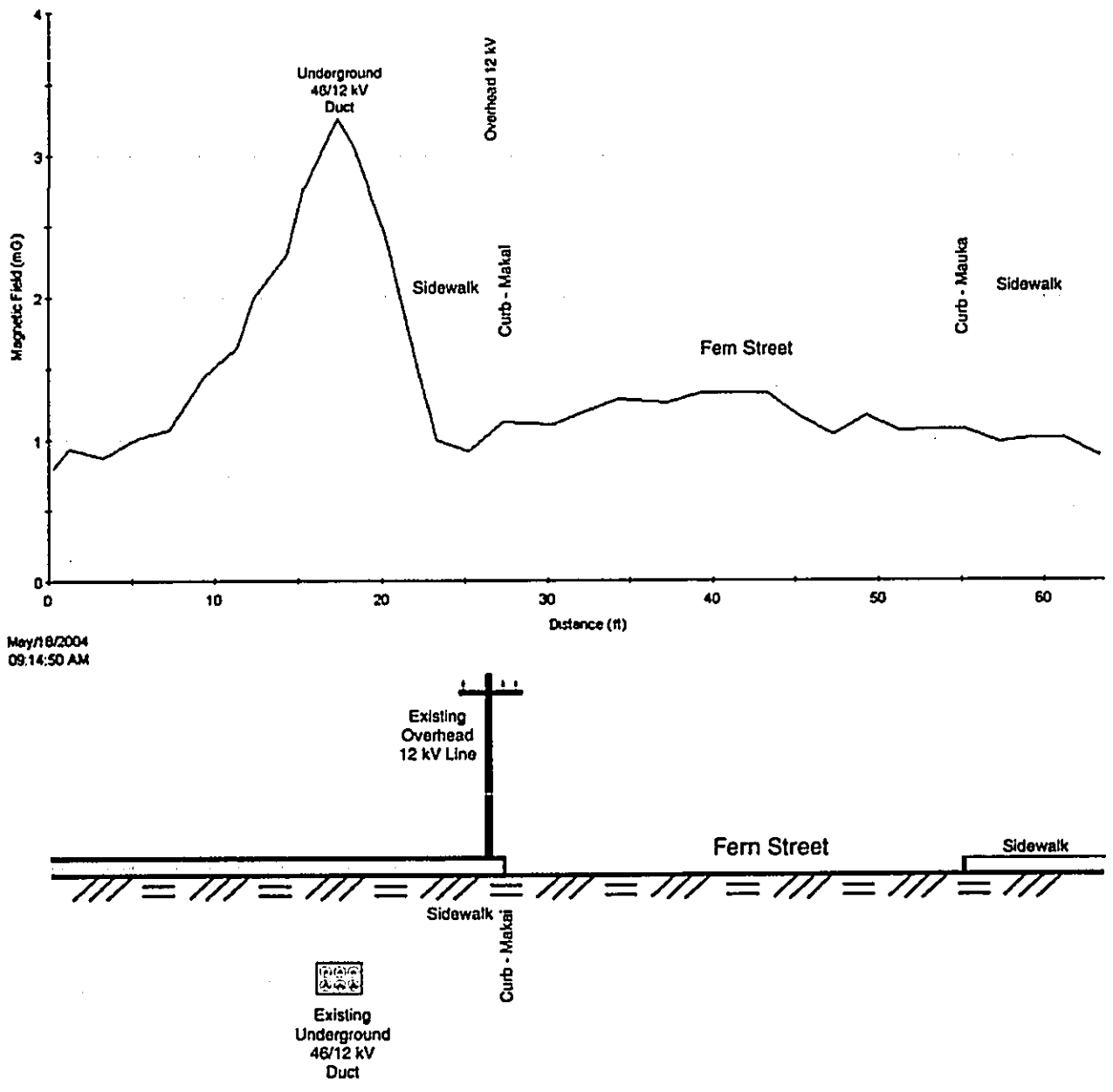


Figure B-2. Magnetic Field Measurements at Segment 'B'
(Fern Street between Punahou and Hauoli Streets)

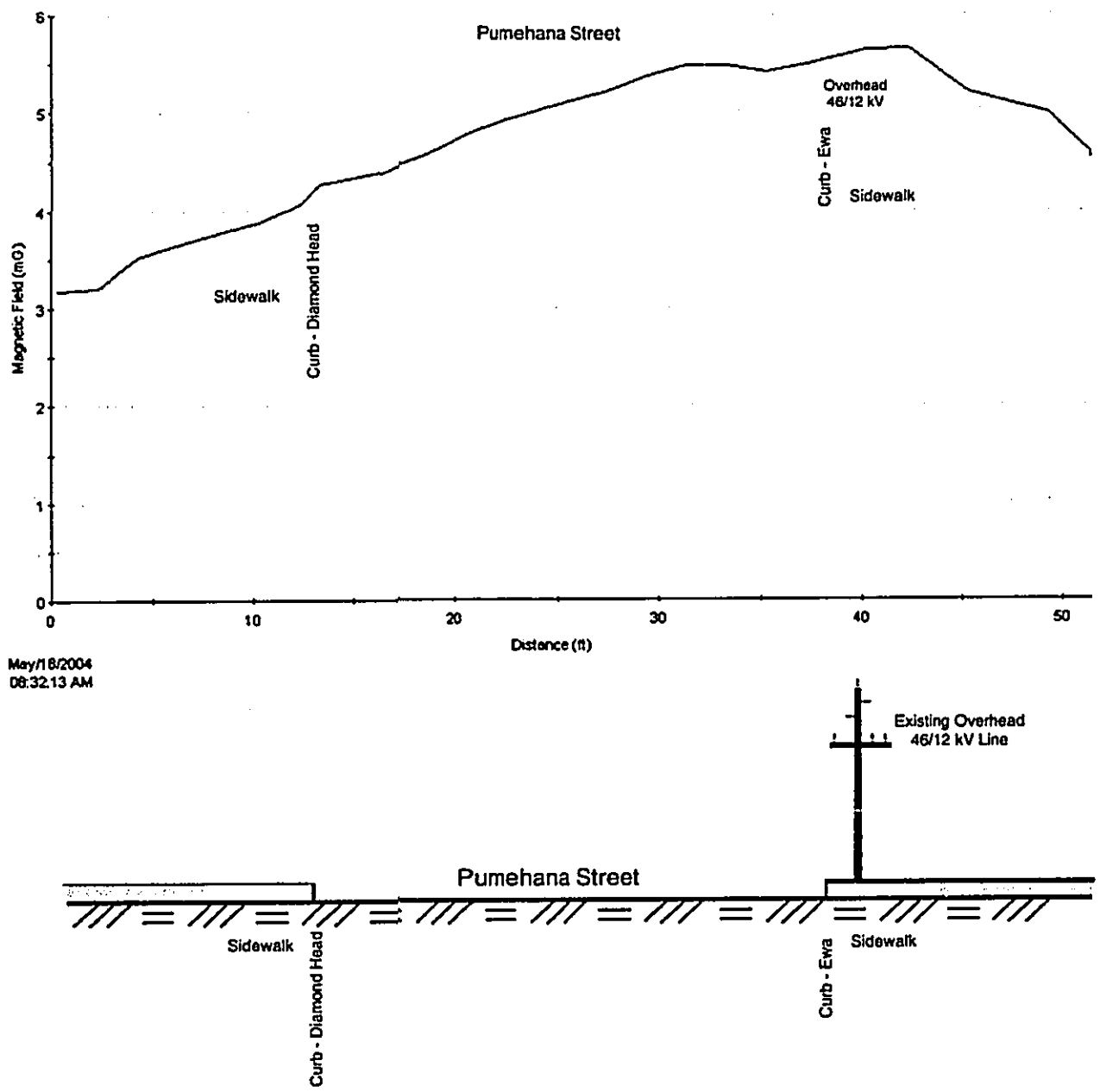


Figure B-3. Magnetic Field Measurements at Segment 'C'
(Pumehana Street between Lime and Date Streets)

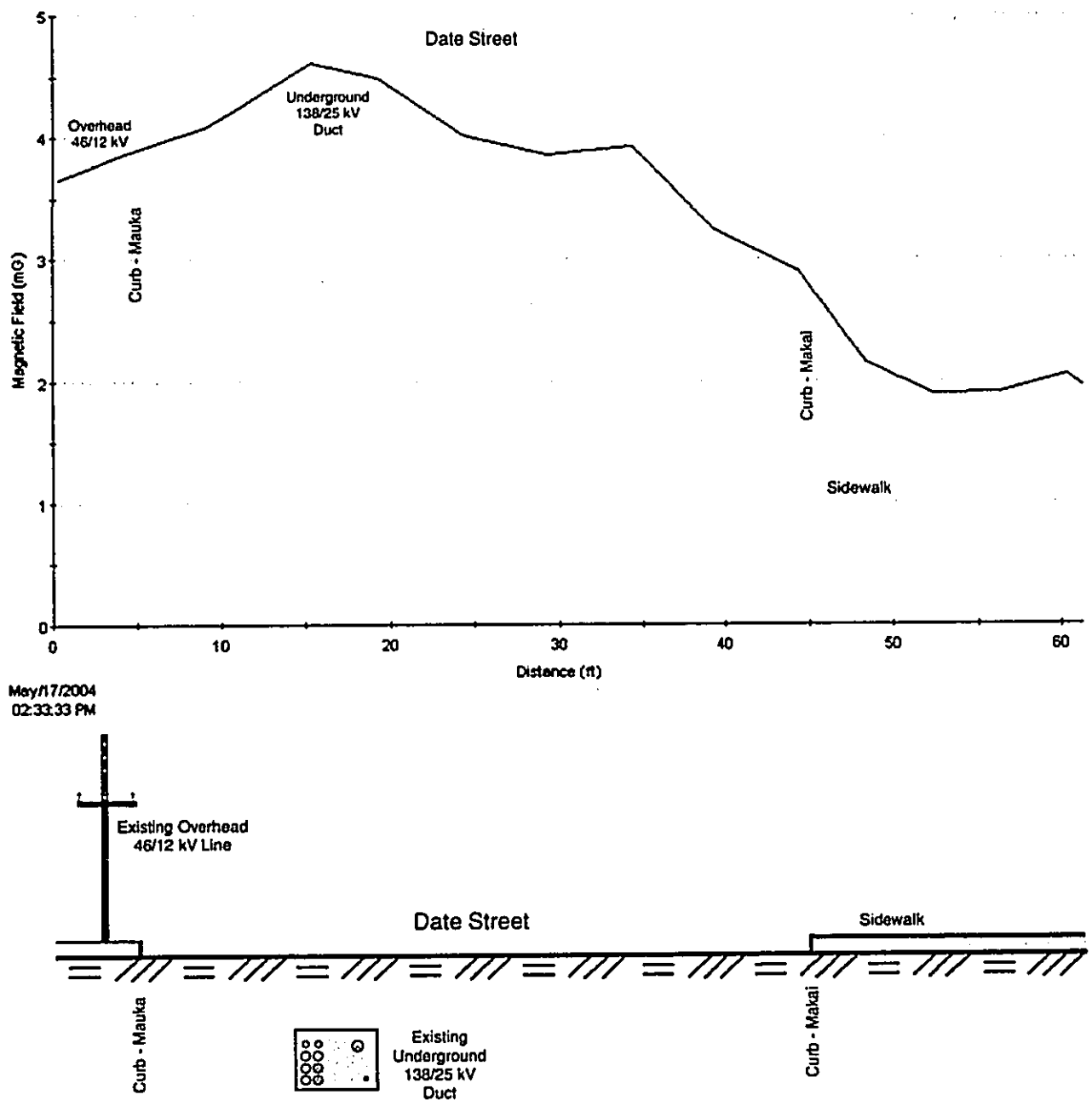
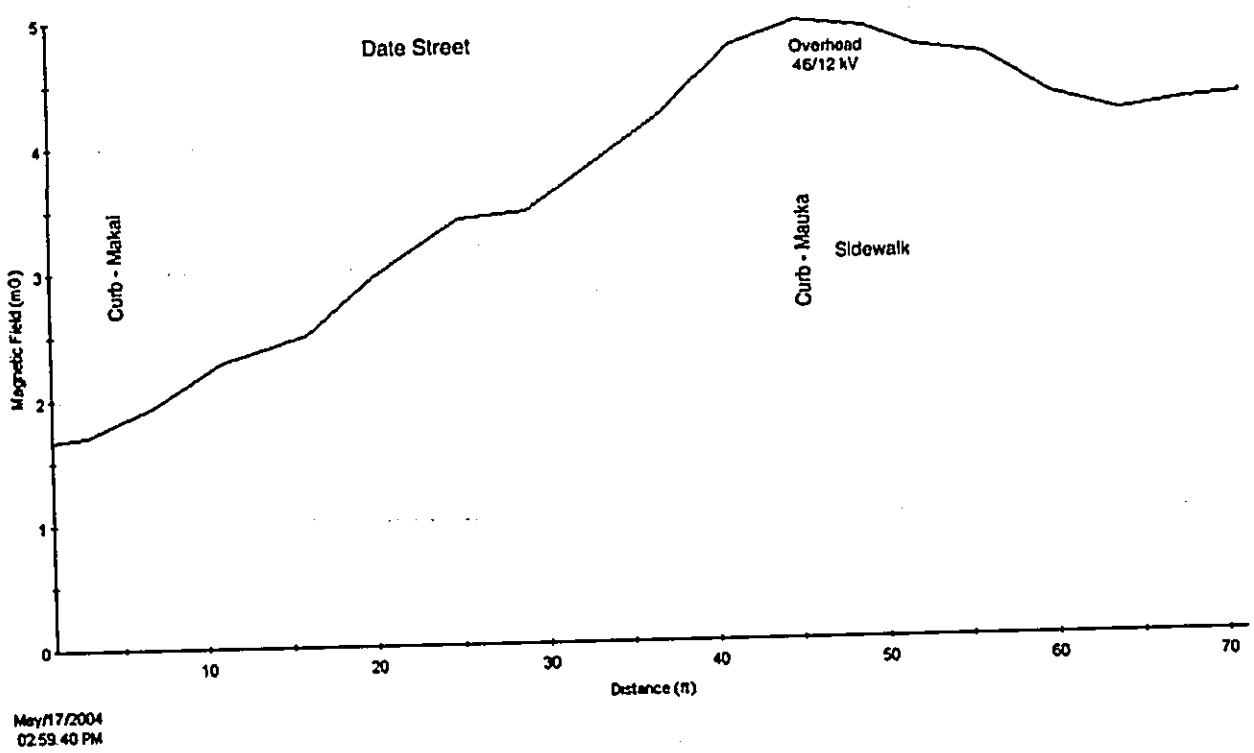


Figure B-4. Magnetic Field Measurements at Segment 'D'
(Date Street west of Kamoku Substation)



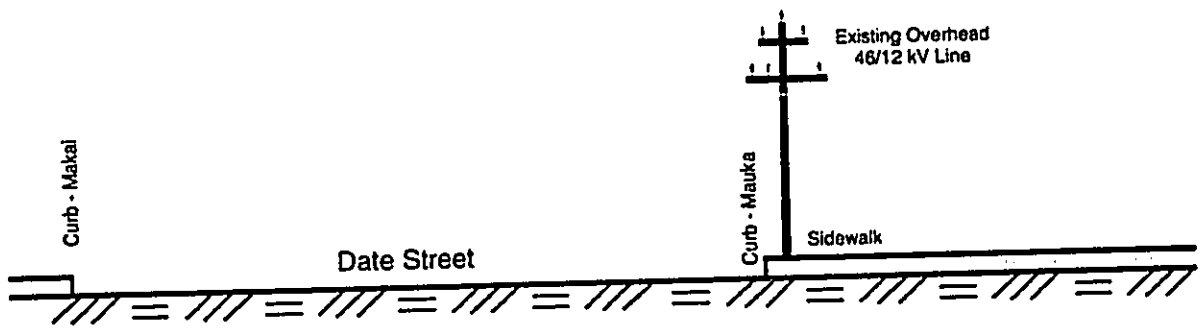


Figure B-5. Magnetic Field Measurements at Segment 'E'
(Date Street east of Kamoku Substation)

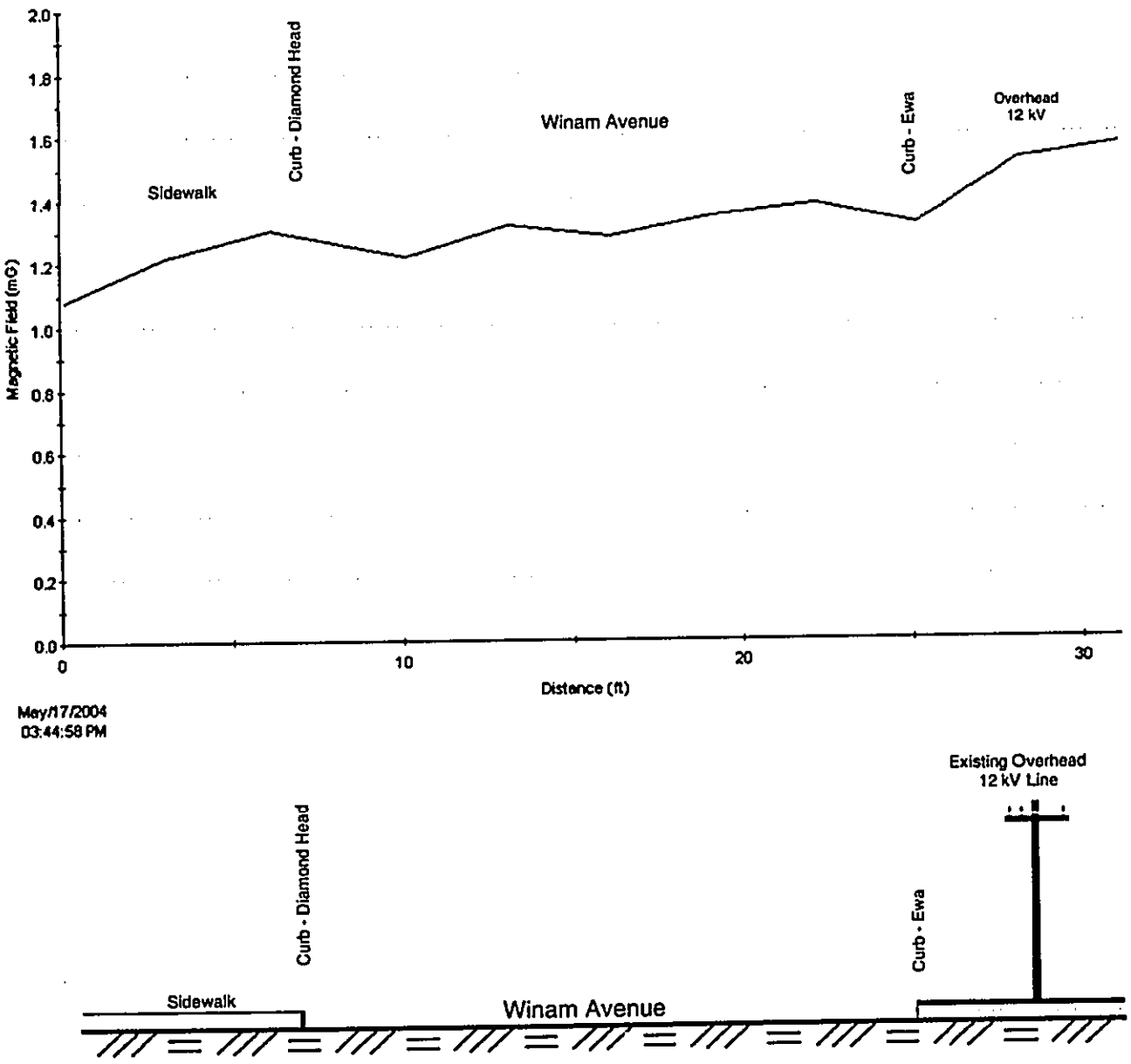
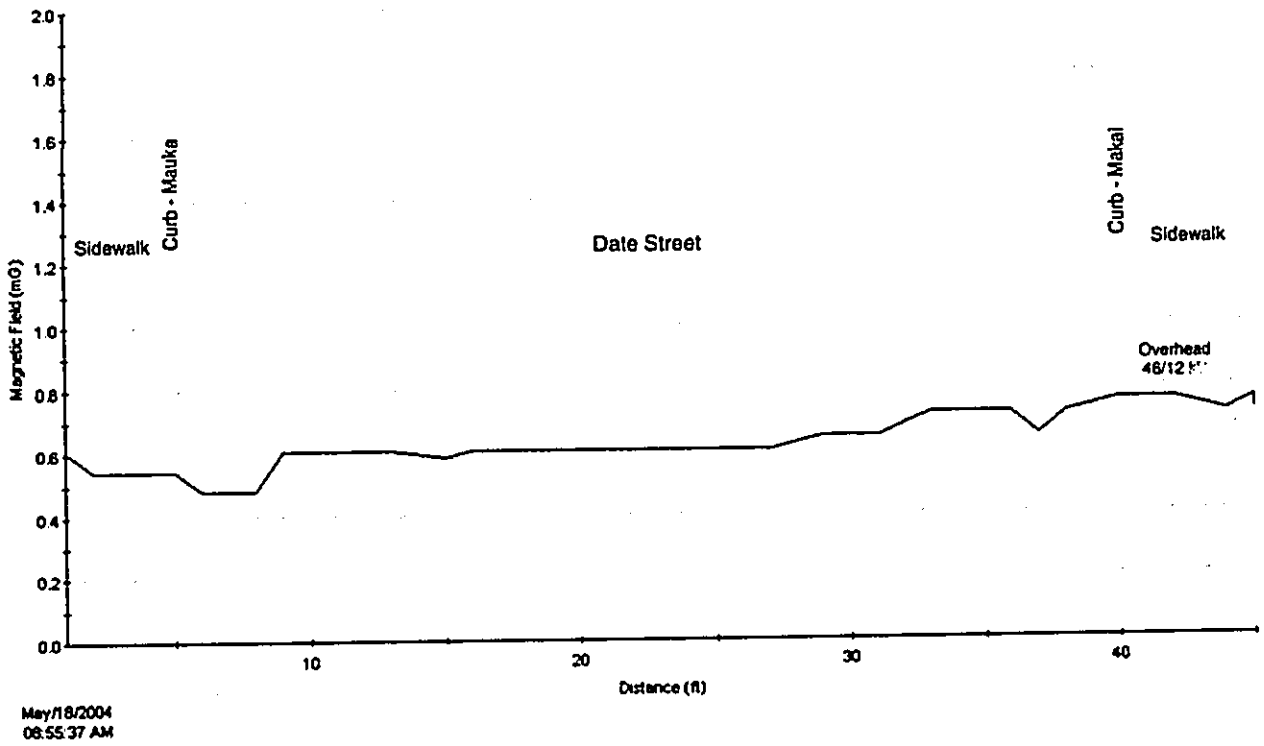


Figure B-6. Magnetic Field Measurements at Segment 'F'
(Winam Avenue between Hoolulu and Mooheau Streets)



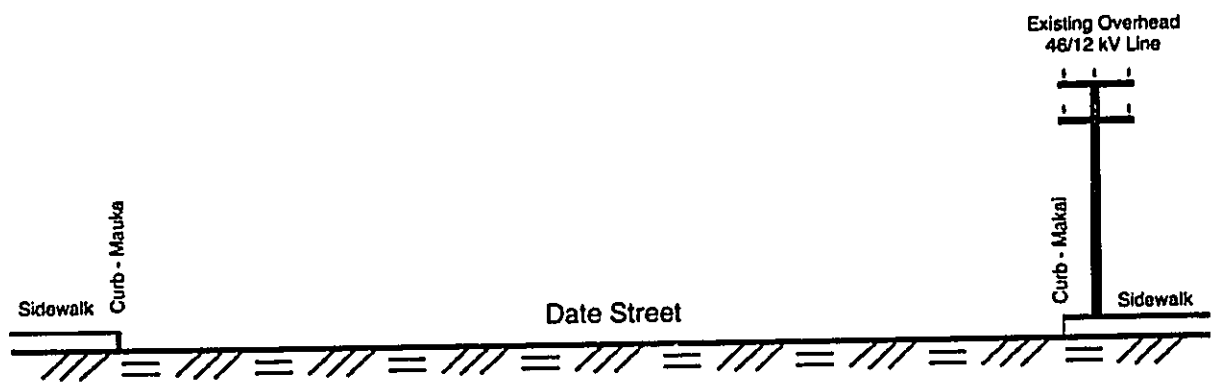


Figure B-7. Magnetic Field Measurements at Segment 'G'
(Date Street between Pumehana and McCully Streets)

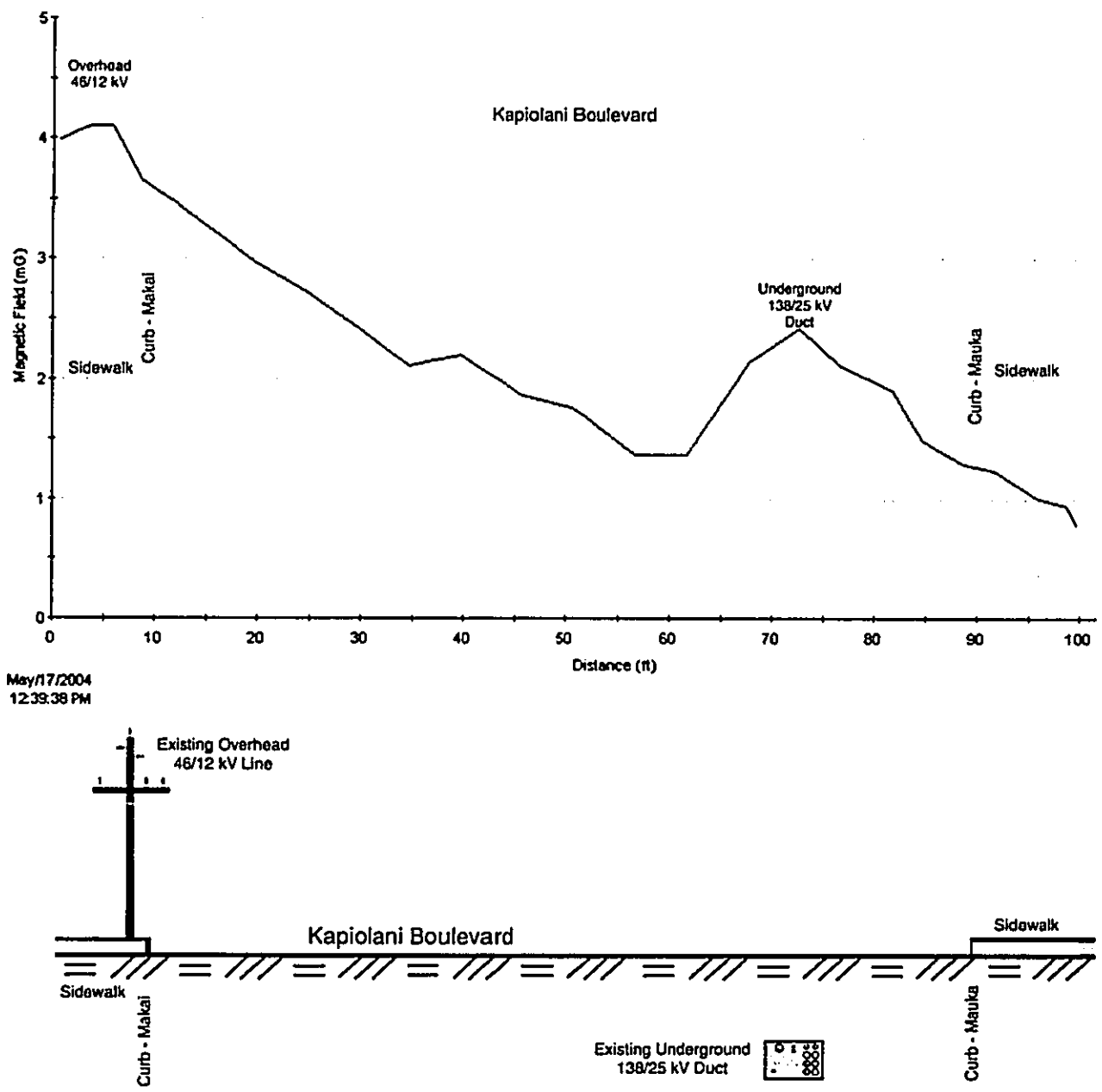
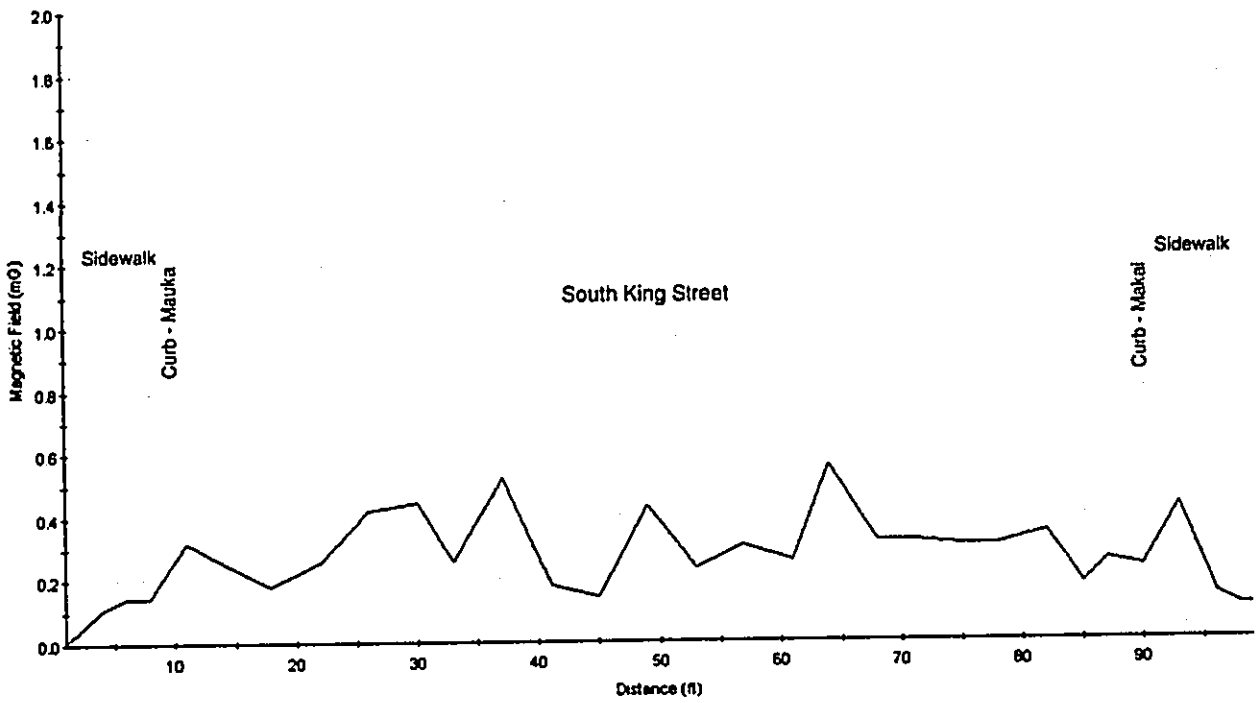


Figure B-8. Magnetic Field Measurements at Segment 'H'
(Kapiolani Boulevard between Wiliwili and McCully Streets)



May/17/2004
11:26:25 AM

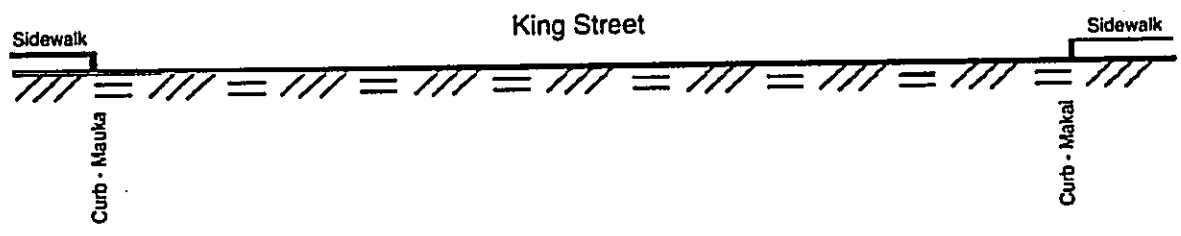
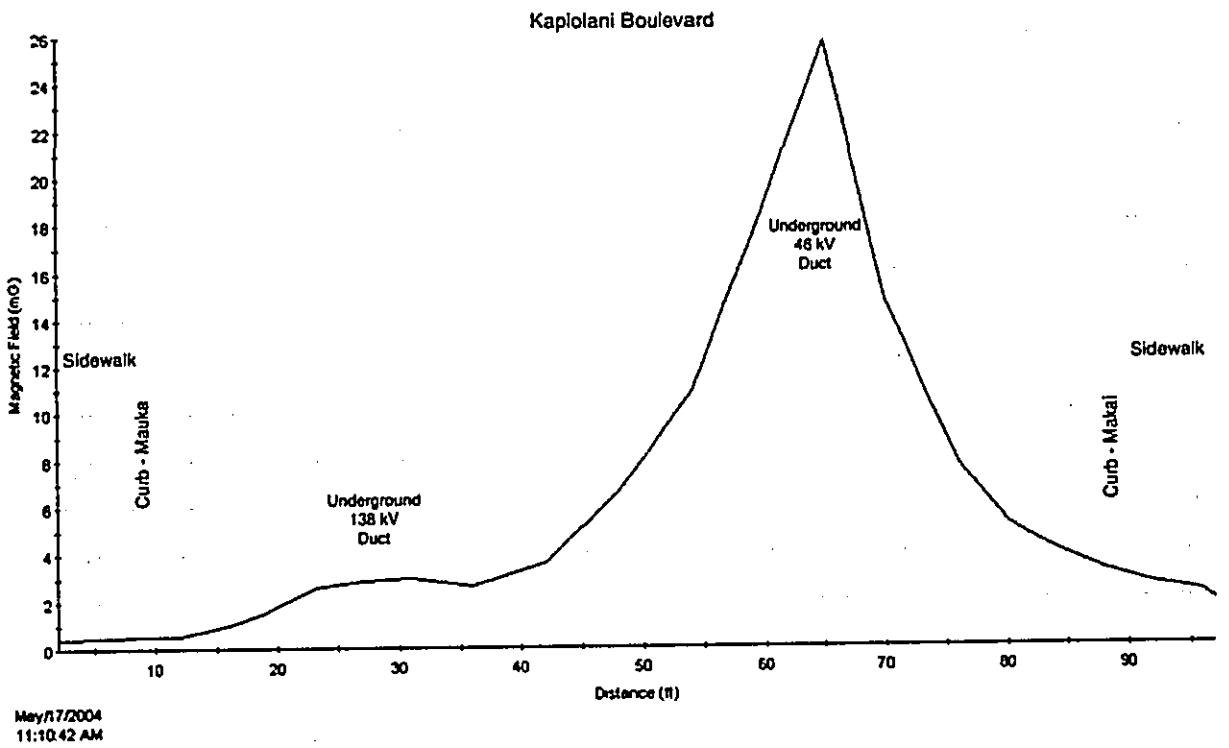


Figure B-9. Magnetic Field Measurements at Segment 'I'
(King Street between Ward Avenue and Victoria Street)



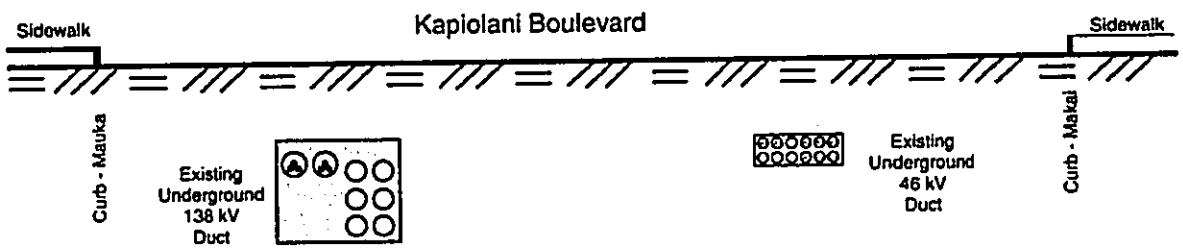
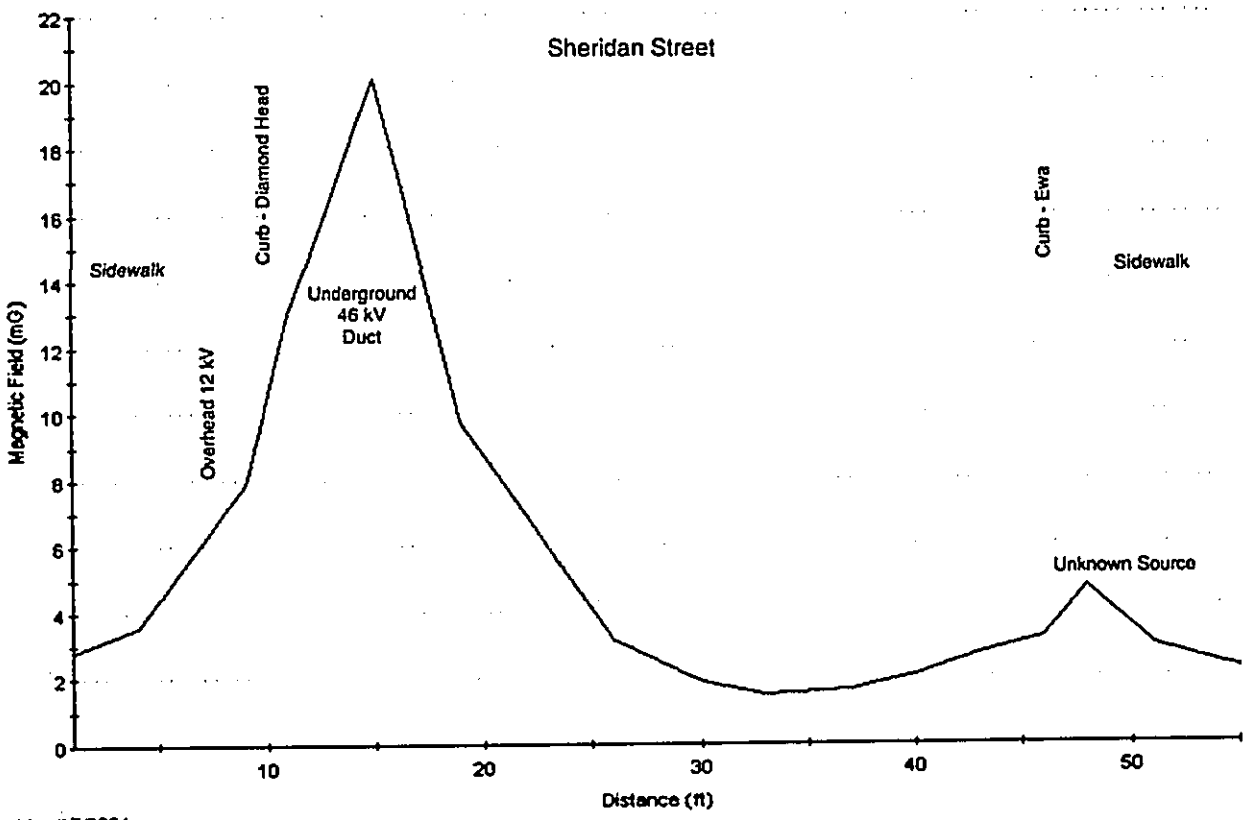


Figure B-10. Magnetic Field Measurements at Segment 'J'
(Kapiolani Boulevard between Clayton Street and Ward Avenue)



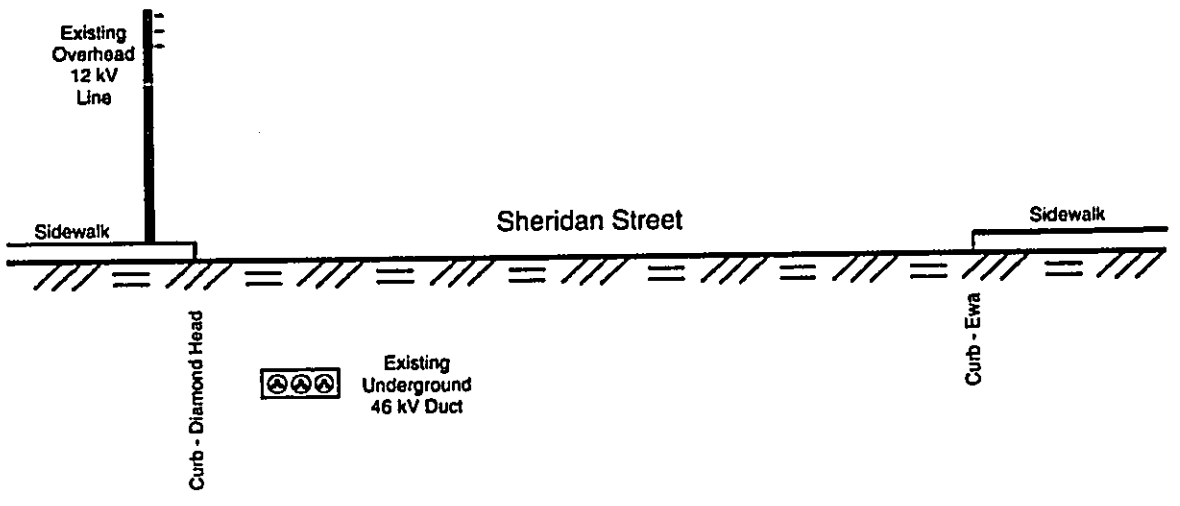


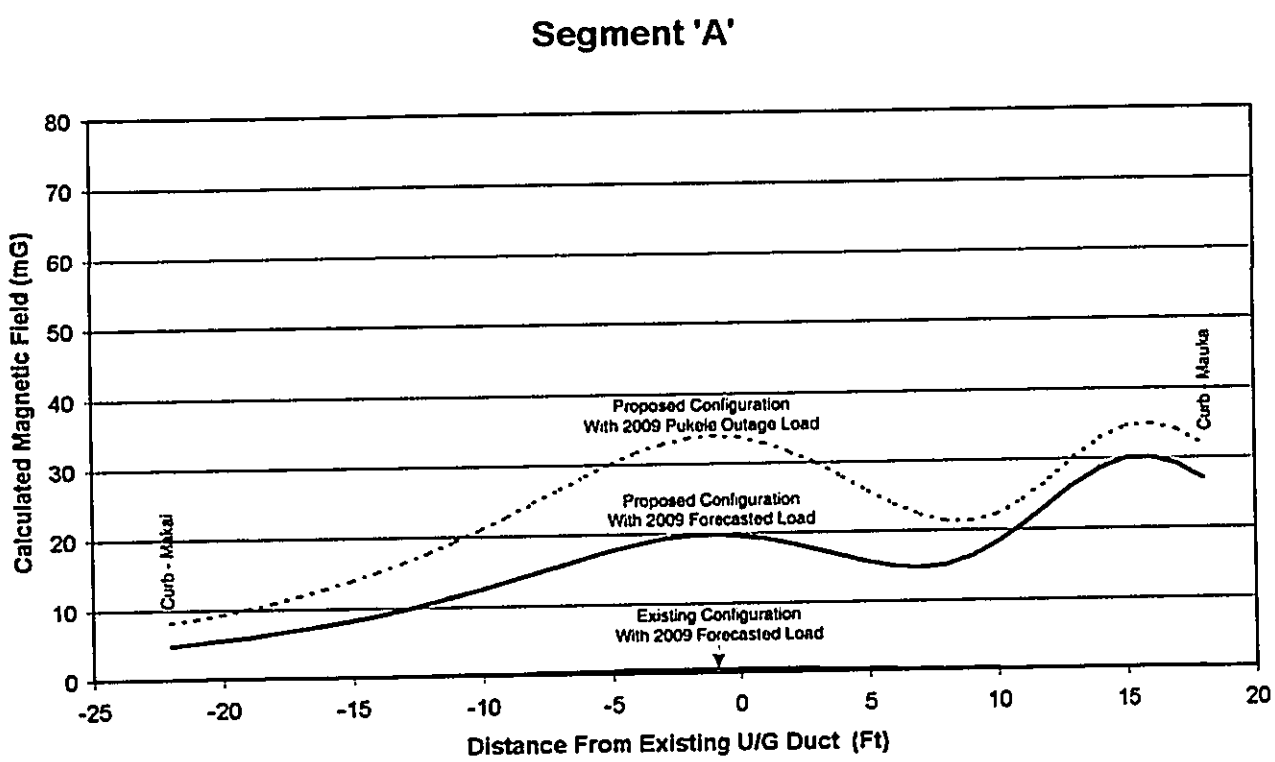
Figure B-11. Magnetic Field Measurements at Segment 'K'
(Sheridan Street between Kapiolani Boulevard and Makaloa Street)

Table B-1. Summary of Line Loading for Each Segment During Field Measurements

Segment	Date	Time	Power Line Name	Load Range (Amps)
A	May 18, 2004	9:58 AM	Archer 41	163 - 173
			Archer 43	0
			Archer 46	100 - 108
			Pawaa Kai	88 - 106
			Shopping Center	180
			Kona Street	84 - 91
B	May 18, 2004	9:14 AM	Archer 41	147 - 159
			Archer 43	0
			Archer 46	100 - 108
			McCully #5	29 - 30
			Pawaa Kai	94 - 111
			Shopping Center	175
			Kona Street	79 - 88
C	May 18, 2004	8:30 AM	Archer 41	0
			McCully #1	167 - 170
D	May 17, 2004	2:45 PM	Kewalo - Kamoku	39
			Kamoku 9	49 - 51
			Kamoku 10	59 - 61
			Pukele #4	240
			Moilili #1	21 - 34
E	May 17, 2004	2:58 PM	Pukele #4	240
			Moilili #1	0
F	May 17, 2004	3:44 PM	Kanaina	3 - 9
G	May 18, 2004	8:54 AM	Pukele #2	0
			McCully #1	0
H	May 17, 2004	12:39 PM	Kewalo - Kamoku	38
			Kamoku 9	45 - 48
			Kamoku 10	57 - 60
			Pukele #4	240
			Hawaiian Village #2	47 - 55
I	May 17, 2004	11:25 AM	No Circuits	N/A
J	May 17, 2004	11:10 AM	Archer - Kewalo #1	36
			Archer - Kewalo #2	30
			Archer 41	194
			Archer 43	121
			Archer 46	226
K	May 17, 2004	11:55 AM	Archer 41	158 - 168
			Archer 43	66 - 70
			Archer 46	230
			Kewalo #1	20 - 27

APPENDIX C

Magnetic Field Profile Calculations
at Segment Locations



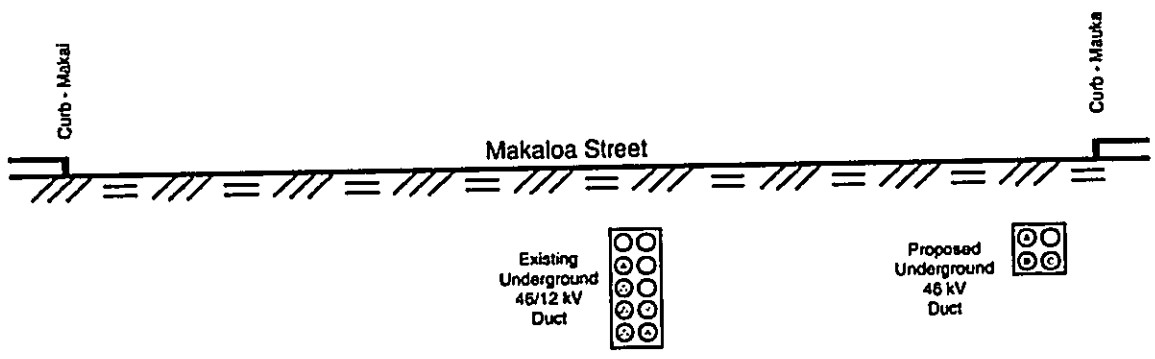


Figure C-1. Magnetic Field Calculations at Segment 'A'

(Makaloa Street between Kaheka and Poni Streets :
three existing 46 kV underground circuits would be replaced with two 46 kV circuits
(one circuit in a new duct), while three existing 12 kV underground circuits would remain)

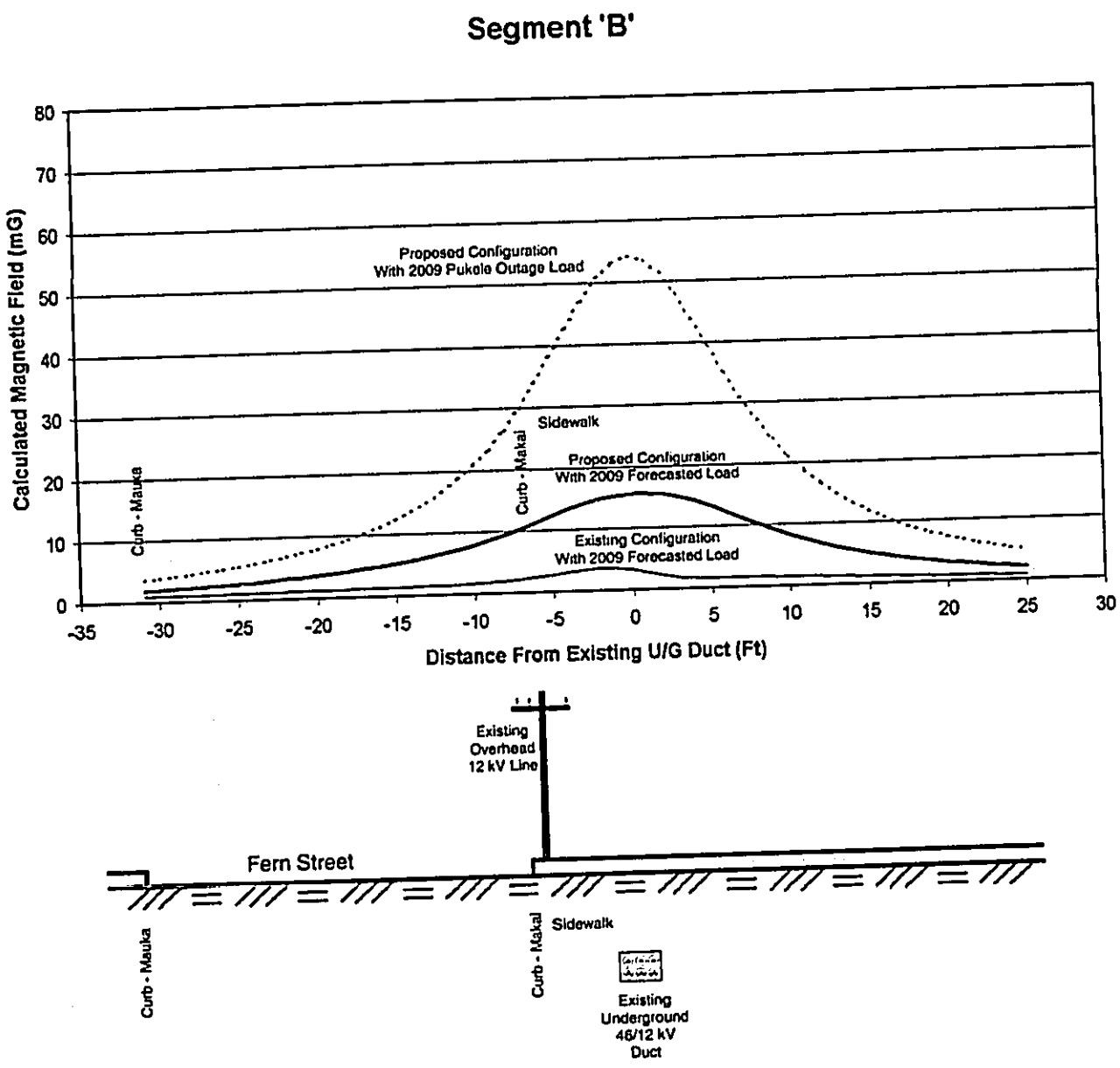


Figure C-2. Magnetic Field Calculations at Segment 'B'

(Fern Street between Punahou and Hauoli Street :
three existing 46 kV underground circuits and three 12 kV underground circuits
would be replaced with two 46 kV underground circuits within the existing duct,
an existing 12 kV overhead distribution line would remain)

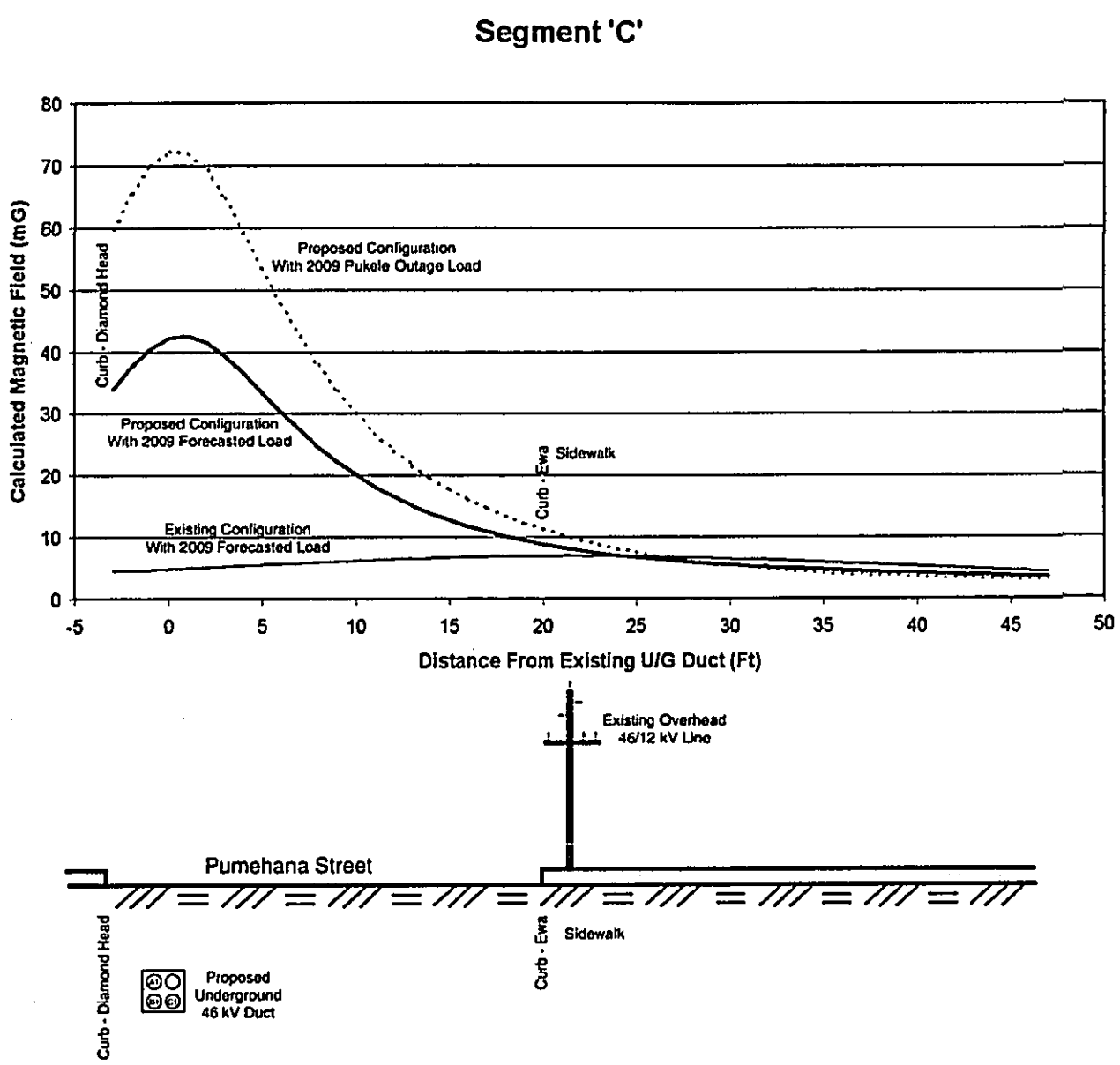


Figure C-3. Magnetic Field Calculations at Segment 'C'

(Pumehana Street between Lime and Date Streets :
one new 46 kV underground circuit would be installed in new duct,
an existing 46 kV and 12 kV overhead power line would remain)

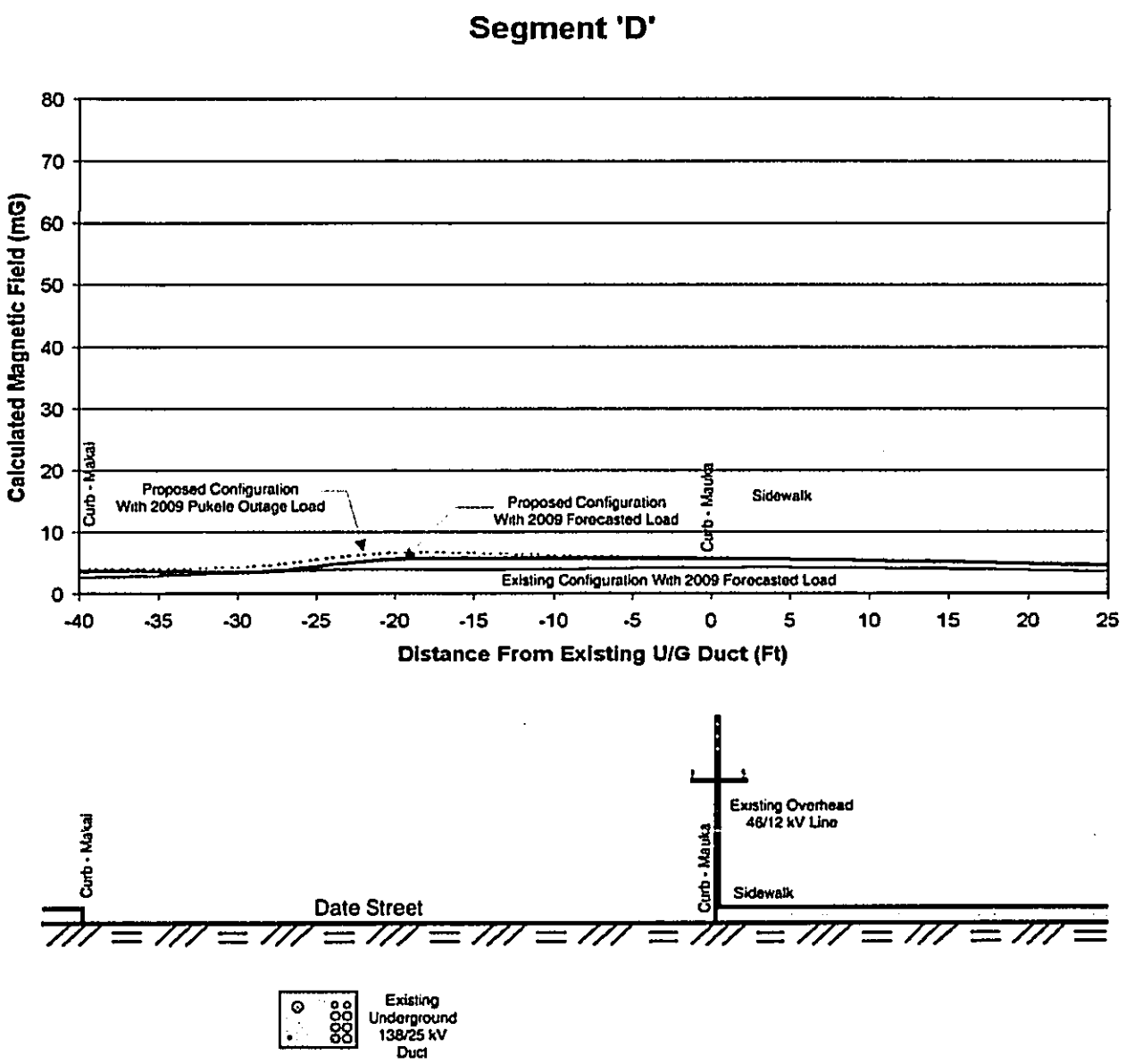


Figure C-4. Magnetic Field Calculations at Segment 'D'

(Date Street west of Kamoku Substation :
one new 46 kV underground intertie would cross Date Street
(from the substation to a new pole) and feed an existing 46 kV overhead circuit,
one existing 138 kV and two existing 25 kV underground circuits would remain,
one existing 12 kV overhead circuit would also remain)

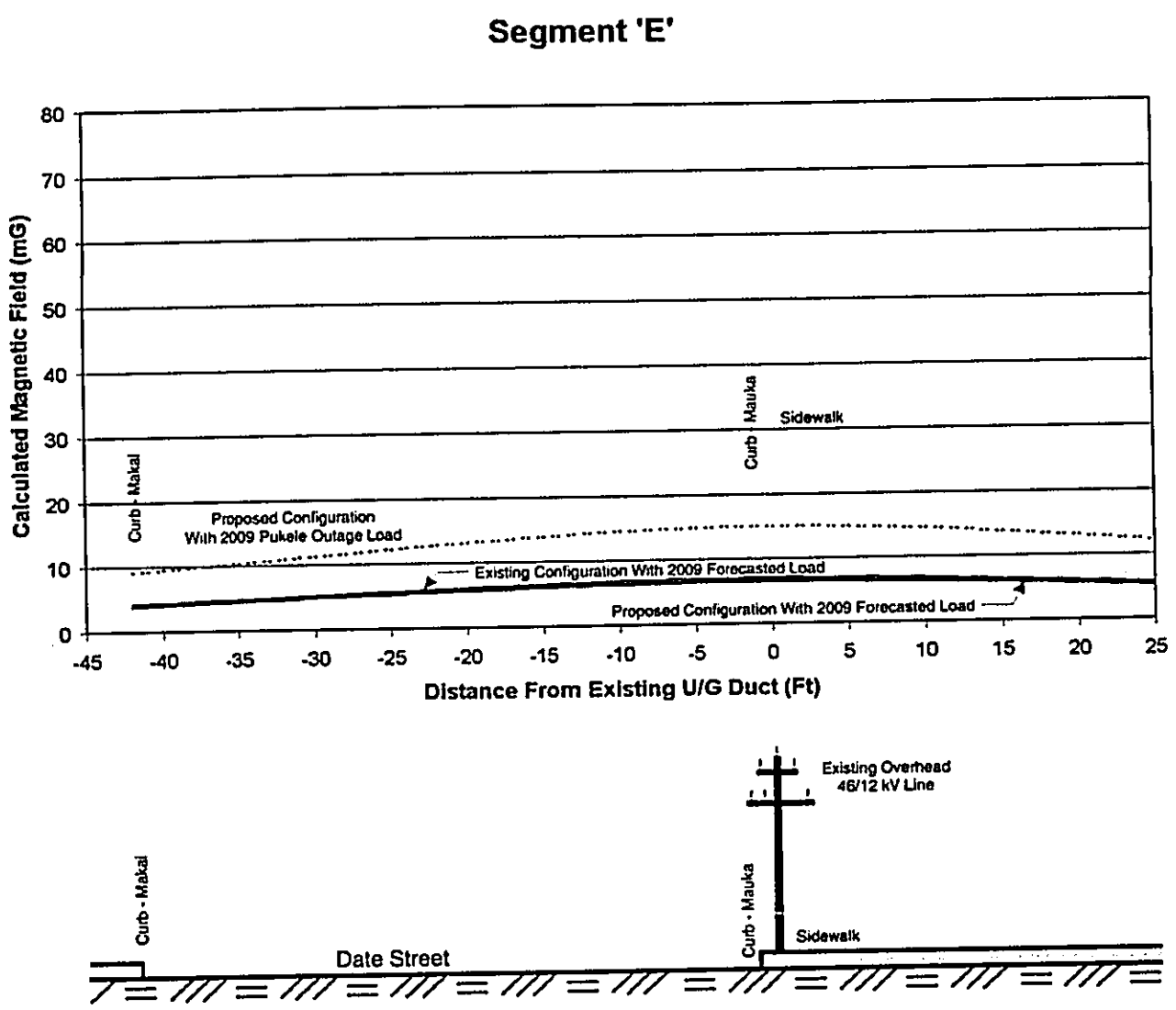


Figure C-5. Magnetic Field Calculations at Segment 'E'

(Date Street east of Kamoku Substation :
one new 46 kV underground intertie would travel down and cross Date Street
(from the substation to an existing pole) and feed an existing 46 kV overhead circuit,
a segment of the existing 46 kV circuit between segments 'D' and 'E' would be removed,
an existing 12 kV overhead circuit would remain)

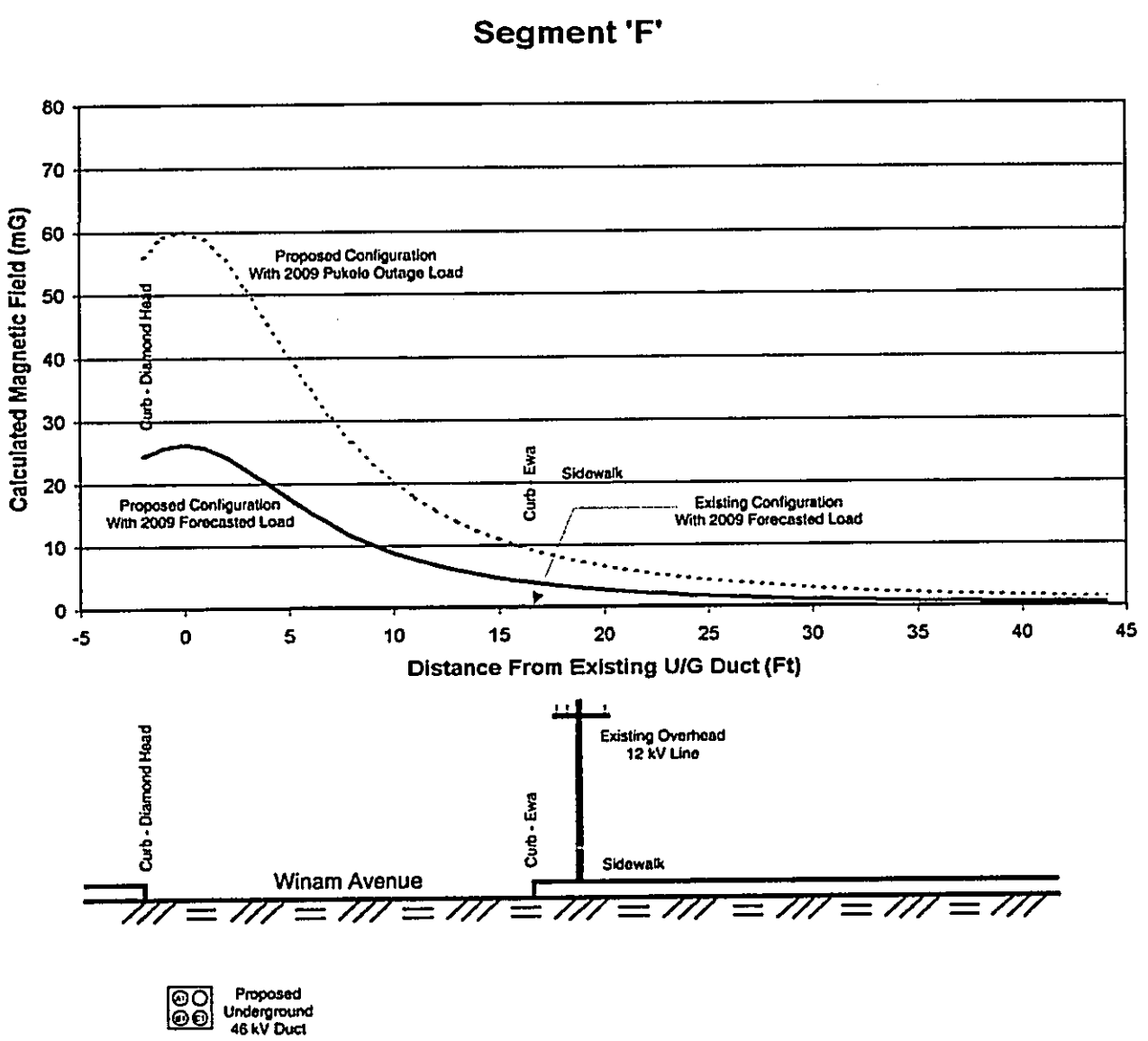


Figure C-6. Magnetic Field Calculations at Segment 'F'

(Winam Avenue between Hoolulu and Mooheau Streets :
one new 46 kV underground circuit in a new duct would connect
two existing 46 kV overhead circuits, an existing 12 kV overhead circuit would remain)

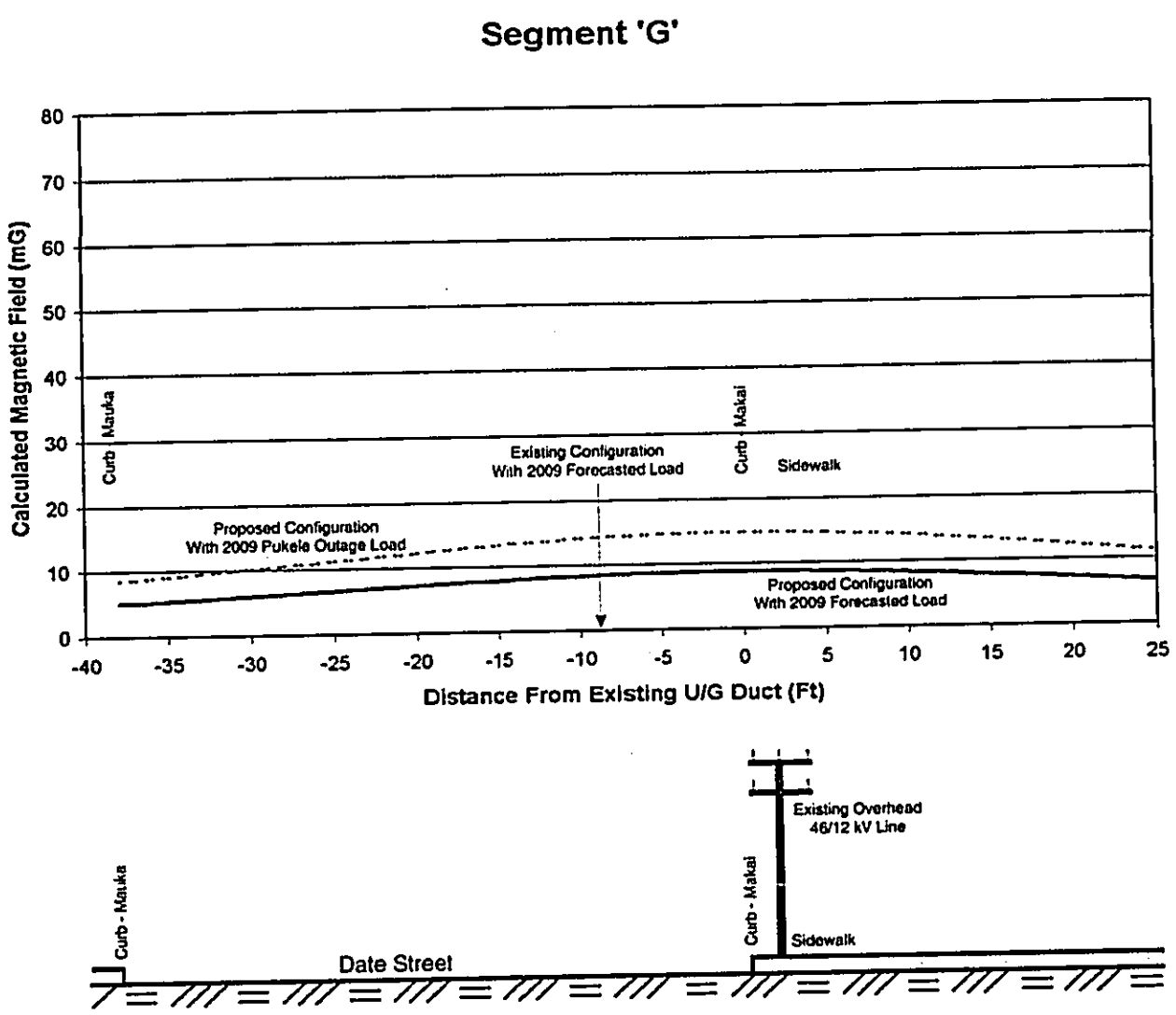


Figure C-7. Magnetic Field Calculations at Segment 'G'

(Date Street between Pumehana and McCully Streets :
one existing 46 kV overhead circuit would have increased loading,
an existing 12 kV underbuild circuit would remain)

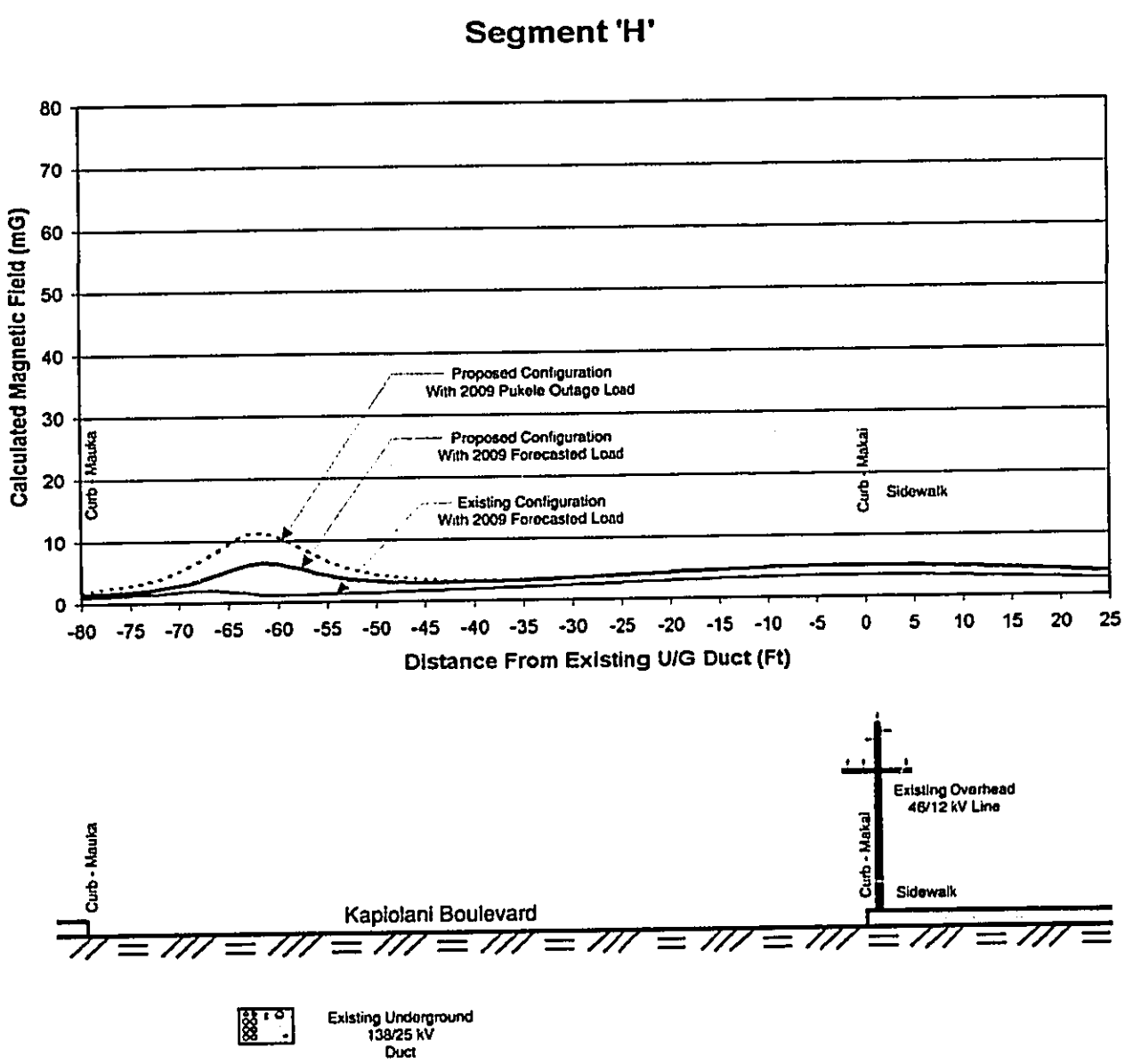
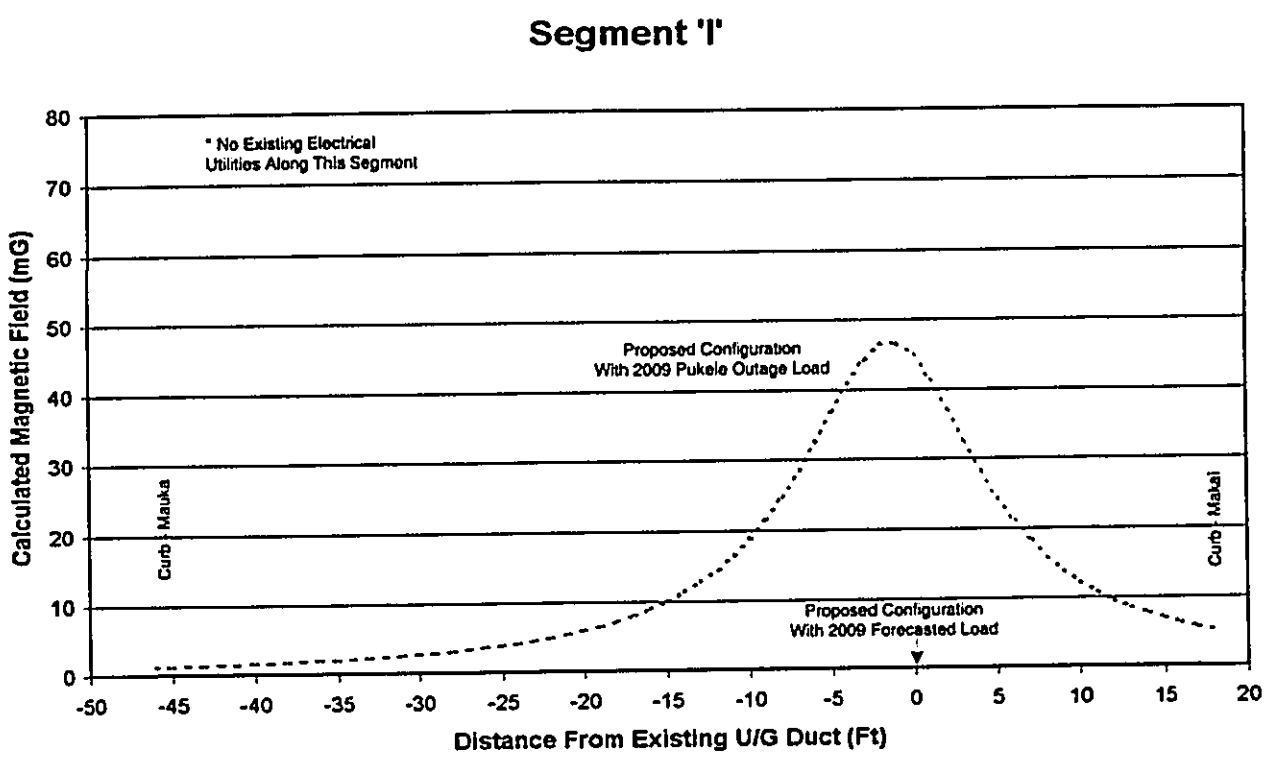


Figure C-8. Magnetic Field Calculations at Segment 'H'

(Kapiolani Boulevard between Wiliwili and McCully Streets :
one existing 46 kV overhead circuit would have increased loading,
an existing 12 kV underbuild circuit would remain,
one existing 138 kV and two existing 25 kV underground circuits remain)



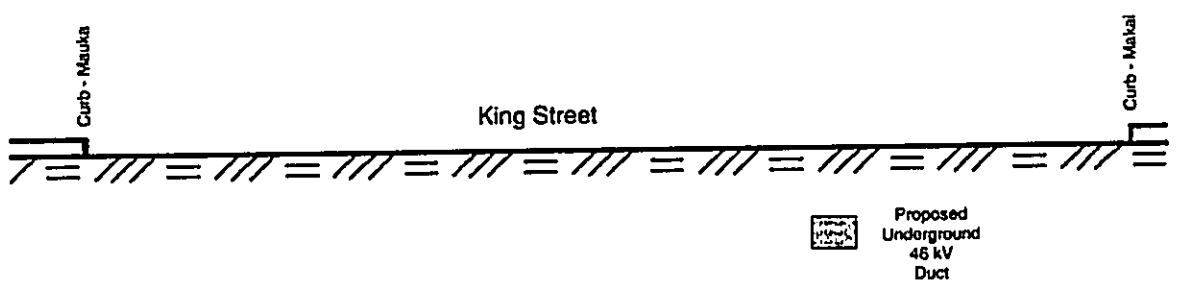


Figure C-9. Magnetic Field Calculations at Segment 'I'

(King Street between Ward Avenue and Victoria Street :
three new 46 kV underground circuits would be installed in a new duct)

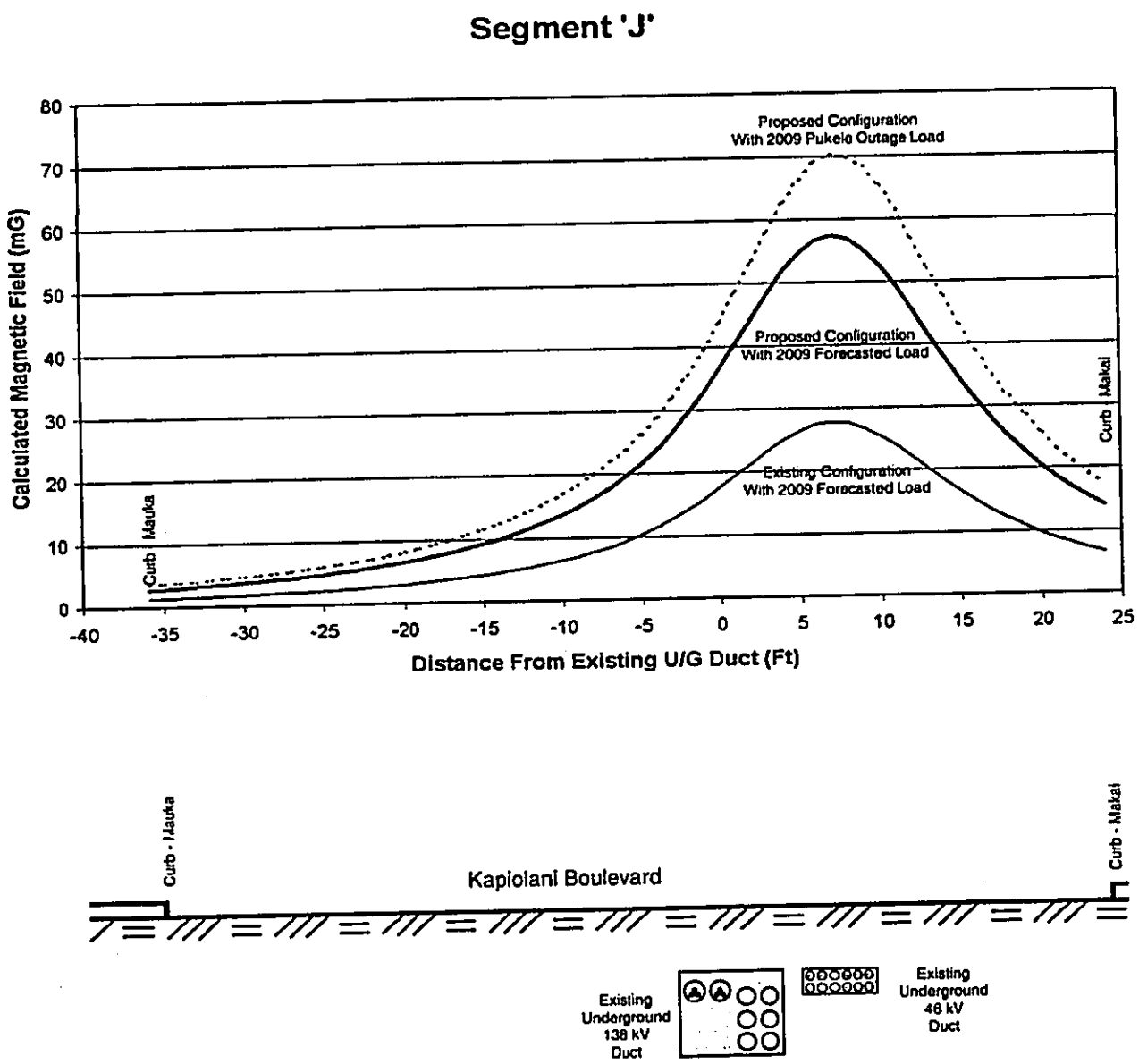
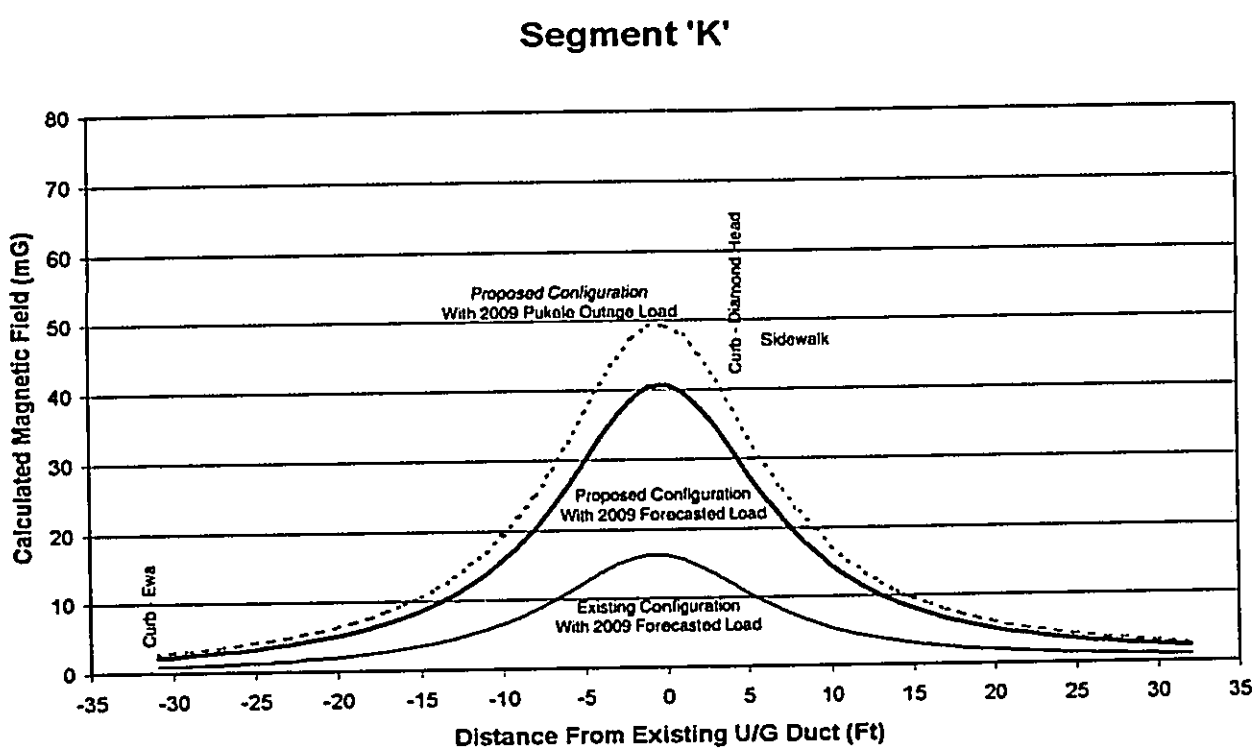


Figure C-10. Magnetic Field Calculations at Segment 'J'

(Kapiolani Boulevard between Clayton Street and Ward Avenue :
three existing 46 kV underground circuits would have increased loading,
two existing 138 kV underground circuits would remain)



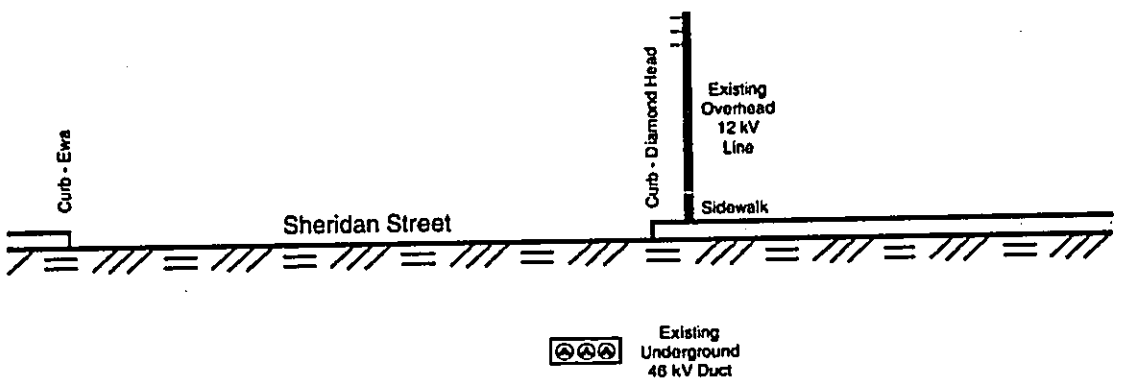


Figure C-11. Magnetic Field Calculations at Segment 'K'

(Sheridan Street between Kapiolani Boulevard and Makaloa Street : three existing 46 kV underground circuits would have increased loading, one existing 12 kV overhead circuit would remain)

APPENDIX D

Segment 'J' Phasing Analysis

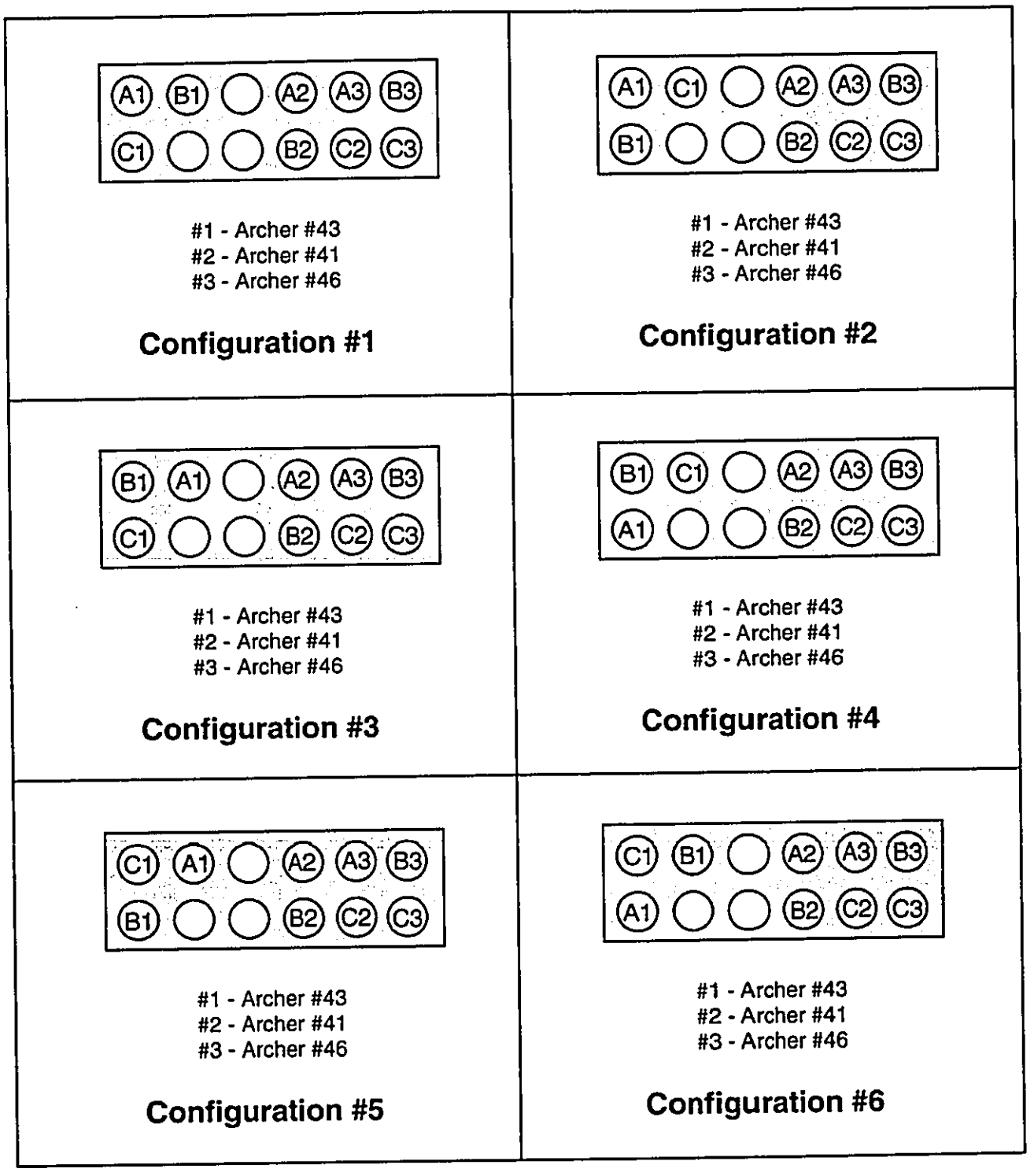


Figure D-1. Segment 'J' Phasing Configurations #1 - #6

Table D-1. Calculated Magnetic Field Versus Measurements at Segment 'J' With Day of Measurement Loading for Phasing Configurations #1 - #6

Location	Distance From 138 kV U/G Duct (Feet)	Field Measurements (mG)	Calculated Magnetic Field					
			Config. #1 (mG)	Config. #2 (mG)	Config. #3 (mG)	Config. #4 (mG)	Config. #5 (mG)	Config. #6 (mG)
North Sidewalk Edge	-36		1.4	1.4	1.3	1.2	1.1	1.1
	-35	2.5	1.5	1.5	1.3	1.3	1.1	1.1
	-34		1.5	1.6	1.4	1.4	1.2	1.2
	-33		1.6	1.6	1.5	1.4	1.3	1.2
	-32		1.7	1.7	1.5	1.5	1.3	1.3
	-31	2.9	1.8	1.8	1.6	1.6	1.4	1.3
	-30		1.9	1.9	1.7	1.7	1.5	1.4
	-29		2.0	2.0	1.8	1.7	1.5	1.5
	-28		2.1	2.1	1.9	1.8	1.6	1.6
	-27	3.0	2.2	2.2	2.0	1.9	1.7	1.6
	-26		2.3	2.4	2.1	2.1	1.8	1.7
	-25		2.5	2.5	2.2	2.2	1.9	1.8
	-24		2.6	2.7	2.4	2.3	2.1	2.0
	-23		2.8	2.8	2.5	2.5	2.2	2.1
	-22	2.6	3.0	3.0	2.7	2.6	2.3	2.2
	-21		3.2	3.2	2.8	2.8	2.5	2.3
	-20		3.4	3.4	3.0	3.0	2.6	2.5
	-19		3.6	3.7	3.2	3.2	2.8	2.7
	-18		3.9	4.0	3.5	3.4	3.0	2.9
	-17		4.2	4.3	3.7	3.6	3.3	3.1
	-16	3.6	4.5	4.6	4.0	3.9	3.5	3.3
	-15		4.9	5.0	4.3	4.2	3.8	3.6
	-14		5.3	5.4	4.7	4.6	4.1	3.9
	-13		5.7	5.8	5.1	4.9	4.4	4.2
	-12		6.2	6.3	5.5	5.3	4.8	4.5
	-11		6.8	6.9	6.0	5.8	5.2	4.9
	-10	6.6	7.4	7.5	6.5	6.3	5.7	5.3
	-9		8.1	8.1	7.1	6.8	6.2	5.8
	-8		8.9	8.9	7.8	7.4	6.8	6.3
	-7		9.8	9.7	8.5	8.1	7.4	6.9
	-6		10.8	10.7	9.4	8.8	8.1	7.6
	-5		11.9	11.7	10.3	9.6	8.9	8.3
	-4	10.8	13.1	12.8	11.5	10.5	9.8	9.1
	-3		14.5	14.1	12.7	11.4	10.9	9.9
	-2		16.1	15.5	14.2	12.5	12.0	10.9
	-1		17.9	17.0	15.8	13.6	13.4	12.0
138 kV U/G Duct	0		19.8	18.7	17.7	14.8	14.9	13.2
	1	17.5	21.8	20.4	19.6	16.1	16.6	14.5
	2		23.9	22.1	21.6	17.5	18.4	15.9
	3		25.8	23.8	23.6	18.8	20.1	17.4
	4		27.6	25.3	25.4	20.0	21.8	18.8
	5		29.0	26.5	26.8	21.1	23.1	20.0
	6		29.9	27.2	27.8	21.9	24.1	21.0
46 kV U/G Duct	7	25.7	30.2	27.4	28.1	22.4	24.4	21.6
	8		29.8	27.1	27.8	22.4	24.2	21.7
	9		28.8	26.3	26.8	22.0	23.5	21.3
	10		27.4	25.1	25.4	21.3	22.3	20.5
	11		25.5	23.5	23.7	20.1	20.8	19.4
	12	14.7	23.5	21.7	21.8	18.8	19.1	18.1
	13		21.4	19.9	19.8	17.4	17.4	16.6
	14		19.4	18.1	17.9	15.9	15.7	15.1
	15		17.5	16.4	16.1	14.5	14.1	13.7
	16		15.7	14.8	14.5	13.1	12.6	12.4
	17		14.1	13.3	13.0	11.9	11.3	11.1
	18	7.7	12.7	12.0	11.7	10.8	10.2	10.0
	19		11.4	10.9	10.5	9.8	9.1	9.0
	20		10.3	9.8	9.4	8.8	8.2	8.2
	21		9.3	8.9	8.5	8.0	7.4	7.4
	22	5.2	8.5	8.1	7.7	7.3	6.7	6.7
	23		7.7	7.4	7.0	6.7	6.1	6.1
South Sidewalk Edge	24		7.0	6.8	6.4	6.1	5.6	5.6
	25							
	26	4.1						

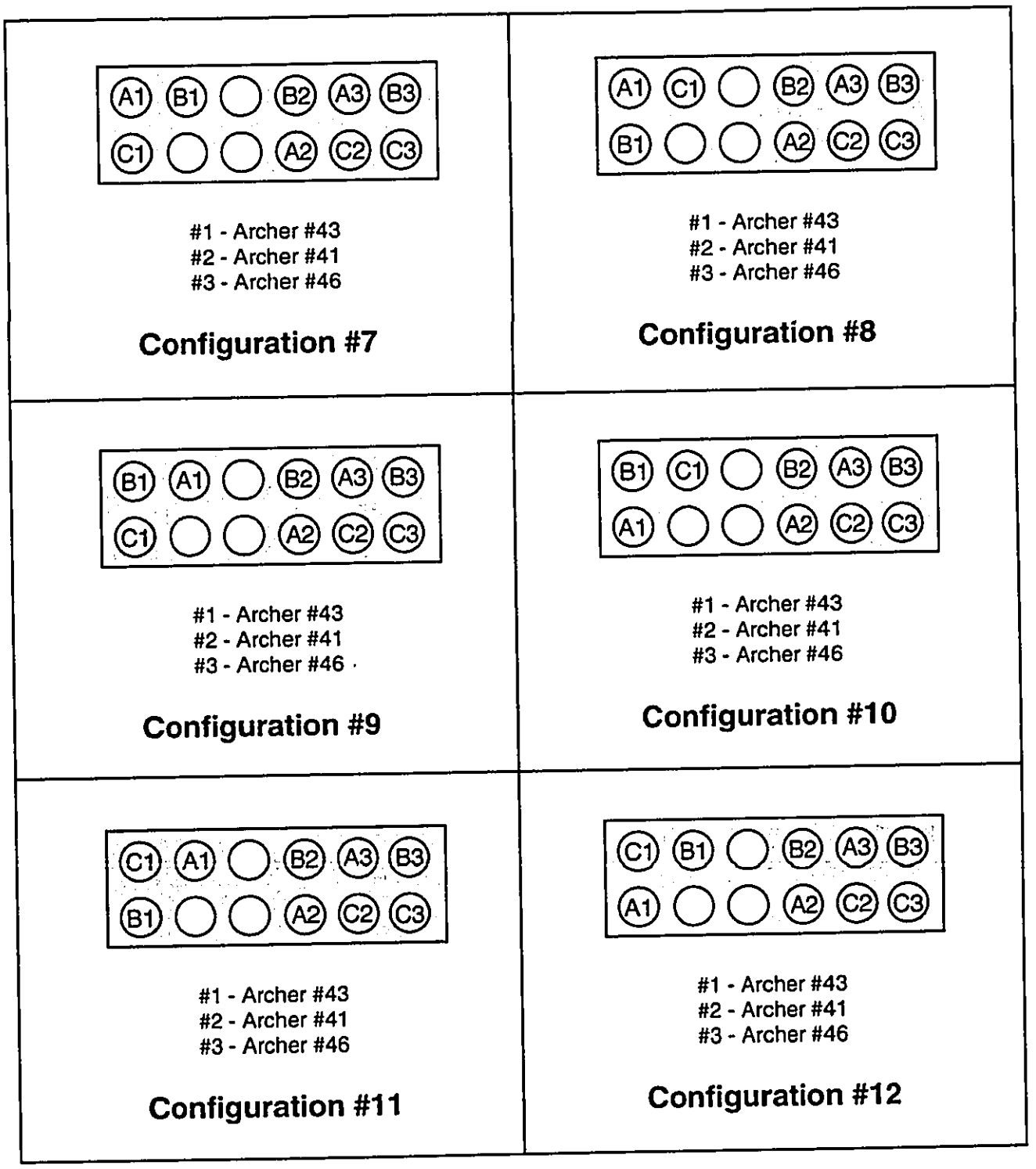
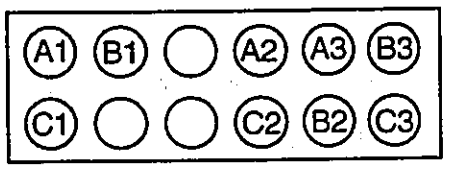


Figure D-2. Segment 'J' Phasing Configurations #7 - #12

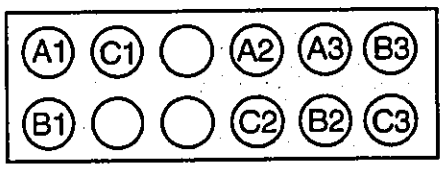
Table D-2. Calculated Magnetic Field Versus Measurements at Segment 'J' With Day of Measurement Loading for Phasing Configurations #7 - #12

Location	Distance From 138 kV U/G Duct (Feet)	Field Measurements (mG)	Calculated Magnetic Field					
			Config. #7 (mG)	Config. #8 (mG)	Config. #9 (mG)	Config. #10 (mG)	Config. #11 (mG)	Config. #12 (mG)
North Sidewalk Edge	-36		1.4	1.2	1.2	1.3	0.8	1.2
	-35	2.5	1.4	1.3	1.3	1.4	0.9	1.2
	-34		1.5	1.3	1.3	1.5	0.9	1.3
	-33		1.6	1.4	1.4	1.5	1.0	1.3
	-32		1.6	1.5	1.5	1.6	1.0	1.4
	-31	2.9	1.7	1.6	1.5	1.7	1.0	1.5
	-30		1.8	1.6	1.6	1.8	1.1	1.5
	-29		1.9	1.7	1.7	1.9	1.2	1.6
	-28		2.0	1.8	1.8	2.0	1.2	1.7
	-27	3.0	2.1	1.9	1.9	2.1	1.3	1.8
	-26		2.2	2.0	2.0	2.2	1.4	1.9
	-25		2.4	2.2	2.1	2.3	1.4	2.0
	-24		2.5	2.3	2.2	2.5	1.5	2.1
	-23		2.7	2.4	2.4	2.6	1.6	2.3
	-22	2.6	2.9	2.6	2.5	2.8	1.7	2.4
	-21		3.0	2.7	2.7	3.0	1.8	2.6
	-20		3.2	2.9	2.8	3.2	1.9	2.7
	-19		3.5	3.1	3.0	3.4	2.1	2.9
	-18		3.7	3.4	3.3	3.6	2.2	3.1
	-17		4.0	3.6	3.5	3.9	2.3	3.4
	-16	3.6	4.3	3.9	3.8	4.2	2.5	3.6
	-15		4.7	4.2	4.0	4.5	2.7	3.9
	-14		5.0	4.5	4.4	4.8	2.9	4.2
	-13		5.5	4.9	4.7	5.2	3.1	4.6
	-12		5.9	5.3	5.1	5.7	3.4	5.0
	-11		6.5	5.8	5.5	6.2	3.6	5.4
	-10	6.6	7.1	6.3	6.0	6.7	3.9	5.9
	-9		7.8	6.9	6.6	7.3	4.2	6.5
	-8		8.5	7.5	7.2	8.0	4.6	7.1
	-7		9.4	8.2	7.9	8.8	5.0	7.8
	-6		10.4	9.0	8.7	9.6	5.4	8.6
	-5		11.5	9.8	9.6	10.5	5.9	9.5
	-4	10.8	12.8	10.8	10.7	11.6	6.5	10.5
	-3		14.3	11.8	11.9	12.7	7.2	11.6
	-2		15.9	13.0	13.2	13.9	8.0	12.9
	-1		17.7	14.2	14.7	15.2	8.9	14.2
138 kV U/G Duct	0		19.6	15.6	16.4	16.6	9.9	15.7
	1	17.5	21.6	17.0	18.1	18.0	11.1	17.3
	2		23.7	18.5	19.9	19.3	12.5	18.8
	3		25.7	19.9	21.6	20.6	13.9	20.4
	4		27.4	21.1	23.2	21.8	15.2	21.8
	5		28.7	22.2	24.5	22.8	16.5	23.0
	6		29.6	22.9	25.3	23.4	17.5	23.8
46 kV U/G Duct	7	25.7	29.8	23.2	25.7	23.7	18.2	24.2
	8		29.4	23.2	25.5	23.7	18.4	24.0
	9		28.5	22.6	24.8	23.2	18.1	23.5
	10		27.0	21.7	23.6	22.3	17.5	22.5
	11		25.2	20.5	22.1	21.2	16.5	21.2
	12	14.7	23.3	19.1	20.5	19.8	15.4	19.6
	13		21.2	17.6	18.7	18.3	14.2	18.0
	14		19.2	16.1	17.0	16.8	12.9	16.4
	15		17.4	14.6	15.4	15.4	11.7	14.9
	16		15.6	13.3	13.9	14.0	10.5	13.5
	17		14.0	12.0	12.5	12.7	9.5	12.2
	18	7.7	12.6	10.8	11.2	11.5	8.5	11.0
	19		11.4	9.8	10.1	10.4	7.7	9.9
	20		10.3	8.9	9.2	9.5	6.9	8.9
	21		9.3	8.1	8.3	8.6	6.3	8.1
	22	5.2	8.4	7.3	7.5	7.8	5.7	7.4
	23		7.7	6.7	6.8	7.2	5.2	6.7
South Sidewalk Edge	24		7.0	6.1	6.2	6.6	4.7	6.1
	25							
	26	4.1						



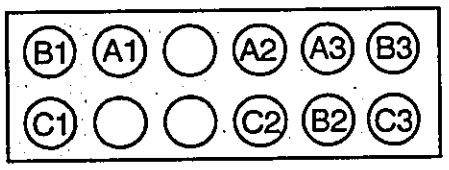
#1 - Archer #43
#2 - Archer #41
#3 - Archer #46

Configuration #13



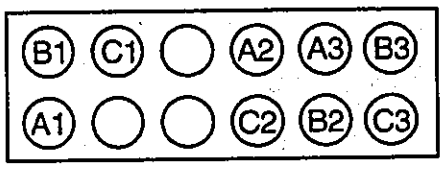
#1 - Archer #43
#2 - Archer #41
#3 - Archer #46

Configuration #14



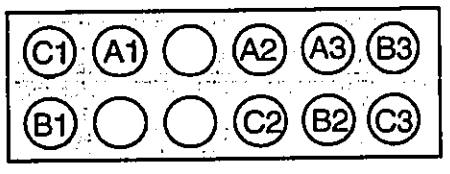
#1 - Archer #43
#2 - Archer #41
#3 - Archer #46

Configuration #15



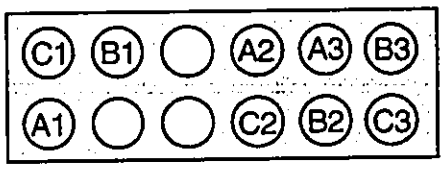
#1 - Archer #43
#2 - Archer #41
#3 - Archer #46

Configuration #16



#1 - Archer #43
#2 - Archer #41
#3 - Archer #46

Configuration #17



#1 - Archer #43
#2 - Archer #41
#3 - Archer #46

Configuration #18

Figure D-3. Segment 'J' Phasing Configurations #13 - #18

Table D-3. Calculated Magnetic Field Versus Measurements at Segment 'J' With Day of Measurement Loading for Phasing Configurations #13 - #18

Location	Distance From 138 kV U/G Duct (Feet)	Field Measurements (mG)	Calculated Magnetic Field					
			Config. #13 (mG)	Config. #14 (mG)	Config. #15 (mG)	Config. #16 (mG)	Config. #17 (mG)	Config. #18 (mG)
North Sidewalk Edge	-36		1.5	1.3	1.2	1.0	1.1	1.2
	-35	2.5	1.6	1.3	1.3	1.1	1.1	1.2
	-34		1.6	1.4	1.3	1.1	1.2	1.3
	-33		1.7	1.4	1.4	1.2	1.2	1.3
	-32		1.8	1.5	1.5	1.3	1.3	1.4
	-31	2.9	1.9	1.6	1.6	1.3	1.3	1.5
	-30		2.0	1.7	1.6	1.4	1.4	1.6
	-29		2.1	1.8	1.7	1.5	1.5	1.6
	-28		2.2	1.9	1.8	1.5	1.6	1.7
	-27	3.0	2.4	2.0	1.9	1.6	1.7	1.8
	-26		2.5	2.1	2.0	1.7	1.8	1.9
	-25		2.6	2.2	2.1	1.8	1.9	2.1
	-24		2.8	2.4	2.3	1.9	2.0	2.2
	-23		3.0	2.5	2.4	2.0	2.1	2.3
	-22	2.6	3.2	2.7	2.6	2.2	2.2	2.5
	-21		3.4	2.8	2.7	2.3	2.4	2.6
	-20		3.6	3.0	2.9	2.5	2.6	2.8
	-19		3.9	3.3	3.1	2.6	2.7	3.0
	-18		4.2	3.5	3.4	2.8	2.9	3.2
	-17		4.5	3.8	3.6	3.0	3.2	3.5
	-16	3.6	4.8	4.1	3.9	3.3	3.4	3.7
	-15		5.2	4.4	4.2	3.5	3.7	4.0
	-14		5.6	4.8	4.5	3.8	4.0	4.4
	-13		6.1	5.2	4.9	4.1	4.4	4.7
	-12		6.7	5.6	5.3	4.5	4.7	5.1
	-11		7.3	6.2	5.8	4.8	5.2	5.6
	-10	6.6	7.9	6.7	6.3	5.3	5.7	6.1
	-9		8.7	7.4	6.9	5.7	6.2	6.7
	-8		9.6	8.1	7.6	6.3	6.8	7.4
	-7		10.6	8.9	8.4	6.8	7.6	8.2
	-6		11.7	9.8	9.2	7.5	8.4	9.0
	-5		12.9	10.8	10.2	8.1	9.3	9.9
	-4	10.8	14.3	11.9	11.4	8.9	10.3	11.0
	-3		15.9	13.1	12.6	9.7	11.6	12.2
	-2		17.6	14.5	14.1	10.6	12.9	13.5
	-1		19.5	16.0	15.7	11.6	14.5	14.9
138 kV U/G Duct	0		21.5	17.7	17.5	12.7	16.3	16.4
	1	17.5	23.7	19.5	19.4	13.9	18.2	18.1
	2		25.8	21.3	21.4	15.1	20.2	19.8
	3		27.9	23.0	23.4	16.4	22.1	21.4
	4		29.7	24.6	25.1	17.6	24.0	23.0
	5		31.1	25.9	26.6	18.8	25.4	24.3
	6		32.0	26.7	27.5	19.8	26.4	25.2
46 kV U/G Duct	7	25.7	32.2	27.0	27.9	20.4	26.7	25.6
	8		31.8	26.7	27.6	20.6	26.4	25.5
	9		30.7	25.9	26.7	20.3	25.4	24.8
	10		29.1	24.5	25.3	19.6	24.0	23.7
	11		27.1	22.9	23.6	18.6	22.2	22.2
	12	14.7	24.9	21.1	21.7	17.3	20.3	20.5
	13		22.7	19.2	19.7	16.0	18.3	18.7
	14		20.6	17.3	17.8	14.6	16.5	17.0
	15		18.5	15.6	16.0	13.2	14.7	15.3
	16		16.6	14.0	14.3	11.9	13.1	13.8
	17		14.9	12.6	12.8	10.8	11.7	12.4
	18	7.7	13.4	11.3	11.5	9.7	10.5	11.1
	19		12.1	10.2	10.3	8.8	9.4	10.0
	20		10.9	9.2	9.3	7.9	8.4	9.1
	21		9.9	8.3	8.4	7.2	7.5	8.2
	22	5.2	9.0	7.5	7.6	6.5	6.8	7.4
	23		8.1	6.8	6.9	5.9	6.2	6.7
South Sidewalk Edge	24		7.4	6.2	6.3	5.4	5.6	6.2
	25							
	26	4.1						

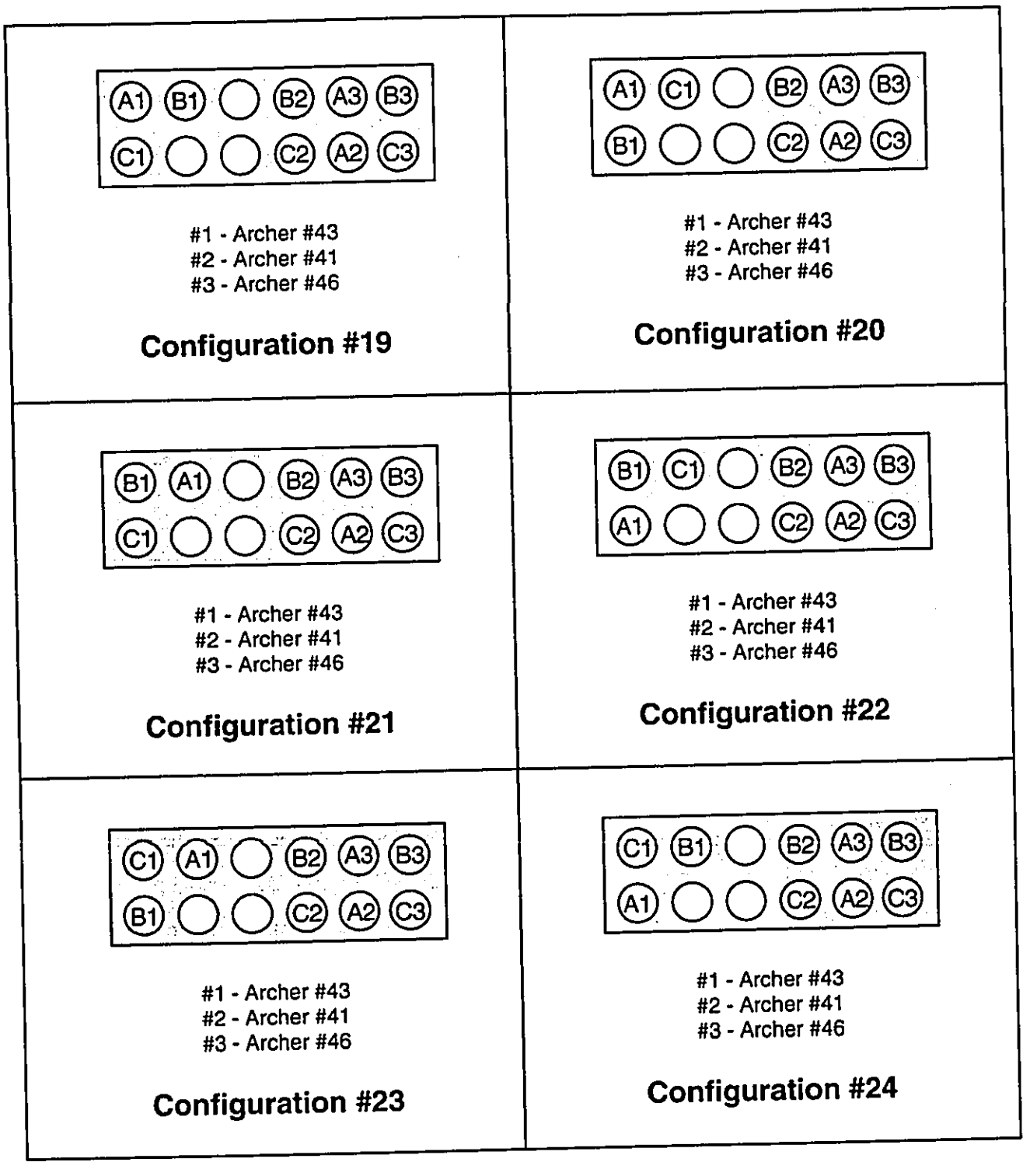


Figure D-4. Segment 'J' Phasing Configurations #19 - #24

Table D-4. Calculated Magnetic Field Versus Measurements at Segment 'J' With Day of Measurement Loading for Phasing Configurations #19 - #24

Location	Distance From 138 kV U/G Duct (Feet)	Field Measurements (mG)	Calculated Magnetic Field					
			Config. #19 (mG)	Config. #20 (mG)	Config. #21 (mG)	Config. #22 (mG)	Config. #23 (mG)	Config. #24 (mG)
North Sidewalk Edge	-36		1.1	0.7	1.1	0.9	0.6	0.8
	-35	2.5	1.1	0.7	1.1	0.9	0.6	0.9
	-34		1.2	0.8	1.2	1.0	0.7	0.9
	-33		1.2	0.8	1.2	1.0	0.7	0.9
	-32		1.3	0.8	1.3	1.0	0.7	1.0
	-31	2.9	1.4	0.9	1.4	1.1	0.8	1.0
	-30		1.4	0.9	1.4	1.1	0.8	1.1
	-29		1.5	1.0	1.5	1.2	0.9	1.2
	-28		1.6	1.0	1.6	1.3	0.9	1.2
	-27	3.0	1.7	1.1	1.7	1.3	0.9	1.3
	-26		1.8	1.1	1.8	1.4	1.0	1.3
	-25		1.9	1.2	1.9	1.5	1.1	1.4
	-24		2.0	1.3	2.0	1.6	1.1	1.5
	-23		2.1	1.3	2.1	1.7	1.2	1.6
	-22	2.6	2.3	1.4	2.2	1.8	1.2	1.7
	-21		2.4	1.5	2.4	1.9	1.3	1.8
	-20		2.6	1.6	2.5	2.0	1.4	1.9
	-19		2.7	1.7	2.7	2.1	1.5	2.0
	-18		2.9	1.8	2.9	2.3	1.6	2.2
	-17		3.2	2.0	3.1	2.4	1.7	2.3
	-16	3.6	3.4	2.1	3.3	2.6	1.8	2.5
	-15		3.7	2.3	3.5	2.8	1.9	2.7
	-14		4.0	2.4	3.8	3.0	2.0	2.9
	-13		4.3	2.6	4.1	3.3	2.2	3.2
	-12		4.7	2.8	4.4	3.5	2.3	3.5
	-11		5.1	3.0	4.8	3.8	2.5	3.8
	-10	6.6	5.5	3.2	5.2	4.1	2.7	4.2
	-9		6.1	3.5	5.7	4.5	2.9	4.6
	-8		6.7	3.8	6.2	4.9	3.2	5.1
	-7		7.4	4.1	6.9	5.4	3.5	5.7
	-6		8.2	4.4	7.6	5.9	3.8	6.3
	-5		9.1	4.8	8.4	6.5	4.3	7.1
	-4	10.8	10.2	5.2	9.4	7.2	4.8	8.0
	-3		11.4	5.7	10.5	7.9	5.5	9.0
	-2		12.8	6.2	11.7	8.7	6.2	10.1
	-1		14.2	6.8	13.1	9.6	7.1	11.3
138 kV U/G Duct	0		15.9	7.5	14.6	10.5	8.1	12.7
	1	17.5	17.5	8.2	16.1	11.5	9.3	14.1
	2		19.2	9.0	17.6	12.4	10.5	15.5
	3		20.8	9.7	19.0	13.3	11.6	16.9
	4		22.2	10.5	20.3	14.0	12.8	18.1
	5		23.2	11.3	21.3	14.7	13.7	19.1
	6		23.9	11.9	21.9	15.2	14.4	19.7
46 kV U/G Duct	7	25.7	24.0	12.3	22.0	15.4	14.8	19.9
	8		23.6	12.5	21.7	15.5	14.7	19.7
	9		22.8	12.5	21.0	15.2	14.4	19.0
	10		21.6	12.2	19.9	14.7	13.7	18.0
	11		20.1	11.6	18.6	14.0	12.8	16.8
	12	14.7	18.5	10.9	17.2	13.1	11.8	15.5
	13		16.9	10.1	15.7	12.2	10.8	14.1
	14		15.3	9.3	14.3	11.2	9.7	12.8
	15		13.7	8.5	12.9	10.2	8.7	11.5
	16		12.4	7.7	11.6	9.3	7.8	10.3
	17		11.1	7.0	10.5	8.4	7.0	9.3
	18	7.7	10.0	6.3	9.4	7.6	6.3	8.3
	19		9.0	5.7	8.5	6.9	5.7	7.5
	20		8.1	5.2	7.7	6.3	5.1	6.7
	21		7.3	4.7	7.0	5.7	4.6	6.1
	22	5.2	6.6	4.3	6.3	5.2	4.2	5.5
	23		6.0	3.9	5.8	4.8	3.8	5.0
South Sidewalk Edge	24		5.5	3.5	5.3	4.4	3.4	4.6
	25							
	26	4.1						

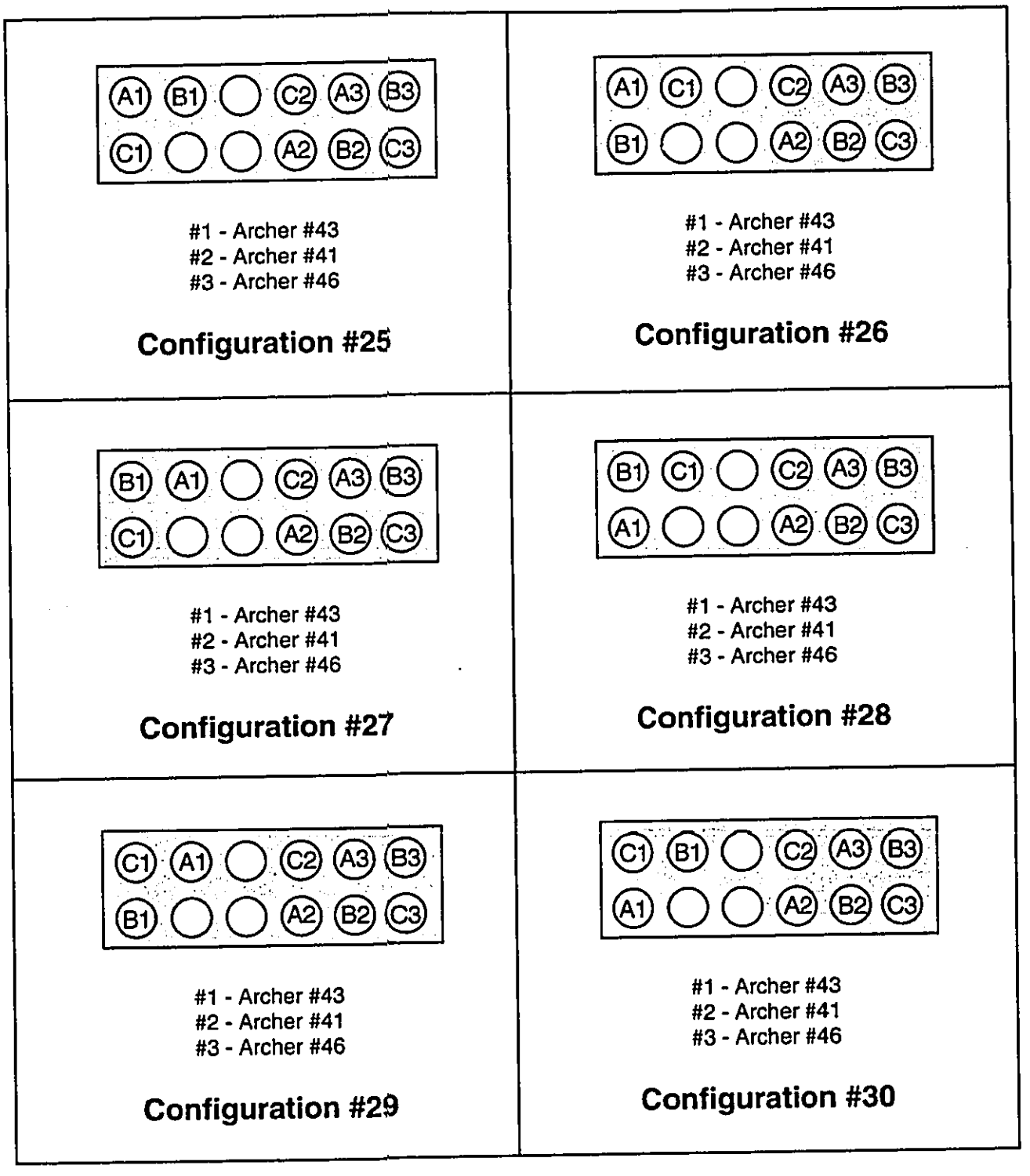
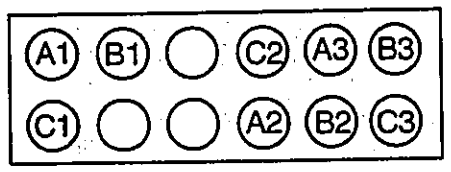


Figure D-5. Segment 'J' Phasing Configurations #25 - #30

CORRECTION

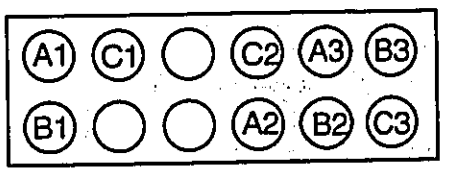
THE PRECEDING DOCUMENT(S) HAS BEEN REPHOTOGRAPHED TO ASSURE LEGIBILITY

SEE FRAME(S) IMMEDIATELY FOLLOWING



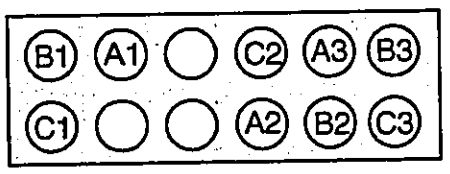
#1 - Archer #43
#2 - Archer #41
#3 - Archer #46

Configuration #25



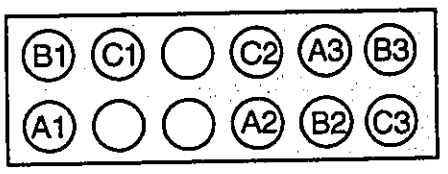
#1 - Archer #43
#2 - Archer #41
#3 - Archer #46

Configuration #26



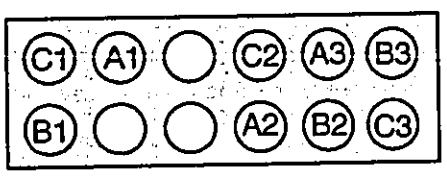
#1 - Archer #43
#2 - Archer #41
#3 - Archer #46

Configuration #27



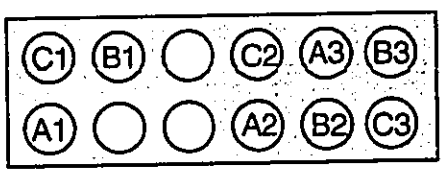
#1 - Archer #43
#2 - Archer #41
#3 - Archer #46

Configuration #28



#1 - Archer #43
#2 - Archer #41
#3 - Archer #46

Configuration #29



#1 - Archer #43
#2 - Archer #41
#3 - Archer #46

Configuration #30

Figure D-5. Segment 'J' Phasing Configurations #25 - #30

Table D-5. Calculated Magnetic Field Versus Measurements at Segment 'J' With Day of Measurement Loading for Phasing Configurations #25 - #30

Location	Distance From 138 kV U/G Duct (Feet)	Field Measurements (mG)	Calculated Magnetic Field Config. #25 (mG)	Config. #26 (mG)	Config. #27 (mG)	Config. #28 (mG)	Config. #29 (mG)	Config. #30 (mG)
North Sidewalk Edge	-36		1.1	0.9	0.6	0.9	0.6	1.0
	-35	2.5	1.1	1.0	0.7	0.9	0.7	1.1
	-34		1.2	1.0	0.7	0.9	0.7	1.1
	-33		1.2	1.1	0.7	1.0	0.7	1.2
	-32		1.3	1.1	0.8	1.0	0.8	1.2
	-31	2.9	1.4	1.2	0.8	1.1	0.8	1.3
	-30		1.4	1.2	0.8	1.2	0.8	1.4
	-29		1.5	1.3	0.9	1.2	0.9	1.4
	-28		1.6	1.4	0.9	1.3	0.9	1.5
	-27	3.0	1.7	1.5	1.0	1.4	1.0	1.6
	-26		1.8	1.6	1.1	1.4	1.1	1.7
	-25		1.9	1.7	1.1	1.5	1.1	1.8
	-24		2.0	1.8	1.2	1.6	1.2	1.9
	-23		2.1	1.9	1.3	1.7	1.3	2.0
	-22	2.6	2.3	2.0	1.3	1.8	1.4	2.2
	-21		2.4	2.1	1.4	1.9	1.5	2.3
	-20		2.6	2.3	1.5	2.1	1.6	2.5
	-19		2.8	2.5	1.6	2.2	1.7	2.6
	-18		3.0	2.7	1.7	2.4	1.8	2.8
	-17		3.2	2.9	1.9	2.6	2.0	3.1
	-16	3.6	3.5	3.1	2.0	2.8	2.2	3.3
	-15		3.8	3.4	2.2	3.0	2.3	3.6
	-14		4.1	3.7	2.4	3.3	2.6	3.9
	-13		4.5	4.0	2.6	3.6	2.8	4.2
	-12		4.9	4.4	2.8	3.9	3.1	4.6
	-11		5.4	4.9	3.1	4.3	3.4	5.1
	-10	6.6	5.9	5.3	3.4	4.7	3.8	5.6
	-9		6.5	5.9	3.7	5.2	4.2	6.2
	-8		7.2	6.5	4.0	5.7	4.6	6.8
	-7		7.9	7.2	4.5	6.3	5.1	7.6
	-6		8.8	7.9	4.9	6.9	5.7	8.4
	-5		9.7	8.8	5.4	7.6	6.4	9.3
	-4	10.8	10.8	9.7	6.0	8.3	7.1	10.3
	-3		12.0	10.7	6.7	9.1	7.9	11.4
	-2		13.3	11.9	7.4	9.9	8.9	12.5
	-1		14.6	13.1	8.3	10.8	9.9	13.7
138 kV U/G Duct	0		16.1	14.4	9.2	11.6	11.1	15.0
	1	17.5	17.7	15.8	10.2	12.5	12.3	16.3
	2		19.2	17.2	11.3	13.4	13.6	17.6
	3		20.6	18.5	12.4	14.3	14.9	18.8
	4		21.9	19.7	13.5	15.0	16.0	19.9
	5		22.9	20.5	14.4	15.6	17.0	20.6
	6		23.5	21.0	15.2	16.1	17.6	21.1
46 kV U/G Duct	7	25.7	23.6	21.0	15.6	16.3	17.8	21.2
	8		23.3	20.6	15.6	16.2	17.5	21.0
	9		22.5	19.8	15.3	15.9	16.8	20.3
	10		21.3	18.7	14.7	15.3	15.8	19.3
	11		19.9	17.3	13.8	14.4	14.6	18.1
	12	14.7	18.3	15.9	12.7	13.5	13.3	16.7
	13		16.7	14.4	11.6	12.4	12.0	15.3
	14		15.1	13.0	10.5	11.4	10.7	13.9
	15		13.6	11.7	9.5	10.3	9.5	12.6
	16		12.3	10.5	8.5	9.4	8.5	11.3
	17		11.0	9.4	7.6	8.5	7.5	10.2
	18	7.7	9.9	8.4	6.8	7.7	6.7	9.2
	19		8.9	7.6	6.1	6.9	6.0	8.3
	20		8.0	6.8	5.5	6.3	5.3	7.5
	21		7.3	6.1	4.9	5.7	4.8	6.8
	22	5.2	6.6	5.6	4.5	5.2	4.3	6.2
	23		6.0	5.0	4.0	4.7	3.9	5.6
South Sidewalk Edge	24		5.5	4.6	3.7	4.3	3.5	5.1
	25							
	26	4.1						

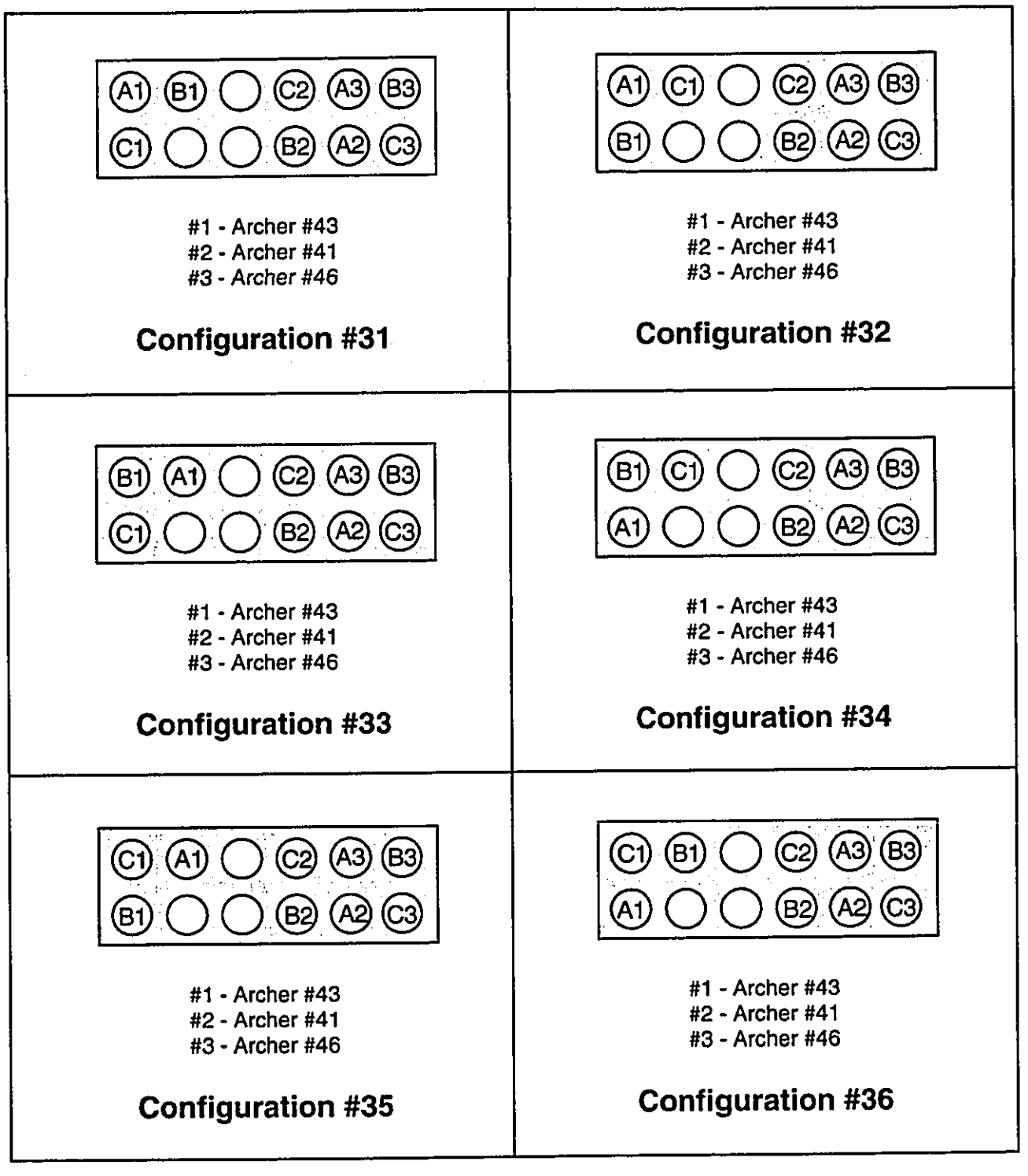


Figure D-6. Segment 'J' Phasing Configurations #31 - #36

Table D-6. Calculated Magnetic Field Versus Measurements at Segment 'J' With Day of Measurement Loading for Phasing Configurations #31 - #36

Location	Distance From 138 kV U/G Duct (Feet)	Field Measurements (mG)	Calculated Magnetic Field					
			Config. #31 (mG)	Config. #32 (mG)	Config. #33 (mG)	Config. #34 (mG)	Config. #35 (mG)	Config. #36 (mG)
North Sidewalk Edge	-36		0.5	0.5	0.4	0.4	0.4	0.3
	-35	2.5	0.5	0.6	0.5	0.4	0.4	0.3
	-34		0.5	0.6	0.5	0.5	0.5	0.4
	-33		0.6	0.6	0.5	0.5	0.5	0.4
	-32		0.6	0.6	0.5	0.5	0.5	0.4
	-31	2.9	0.6	0.7	0.6	0.5	0.5	0.4
	-30		0.6	0.7	0.6	0.6	0.6	0.4
	-29		0.7	0.8	0.6	0.6	0.6	0.5
	-28		0.7	0.8	0.7	0.6	0.6	0.5
	-27	3.0	0.8	0.9	0.7	0.7	0.7	0.5
	-26		0.8	0.9	0.7	0.7	0.7	0.5
	-25		0.9	1.0	0.8	0.8	0.8	0.6
	-24		0.9	1.0	0.8	0.8	0.8	0.6
	-23		1.0	1.1	0.9	0.9	0.9	0.7
	-22	2.6	1.0	1.2	0.9	0.9	0.9	0.7
	-21		1.1	1.3	1.0	1.0	1.0	0.8
	-20		1.2	1.4	1.1	1.1	1.1	0.8
	-19		1.3	1.5	1.1	1.1	1.2	0.9
	-18		1.4	1.6	1.2	1.2	1.3	1.0
	-17		1.5	1.7	1.3	1.3	1.4	1.0
	-16	3.6	1.6	1.9	1.4	1.4	1.5	1.1
	-15		1.7	2.1	1.5	1.5	1.6	1.3
	-14		1.9	2.2	1.6	1.7	1.8	1.4
	-13		2.0	2.4	1.7	1.8	1.9	1.5
	-12		2.2	2.7	1.8	2.0	2.1	1.7
	-11		2.4	2.9	1.9	2.2	2.3	1.9
	-10	6.6	2.7	3.2	2.1	2.4	2.5	2.2
	-9		2.9	3.5	2.2	2.6	2.7	2.4
	-8		3.2	3.8	2.4	2.9	3.0	2.7
	-7		3.6	4.2	2.6	3.2	3.3	3.1
	-6		4.0	4.6	2.9	3.5	3.7	3.5
	-5		4.4	5.0	3.2	3.8	4.1	3.9
	-4	10.8	4.9	5.4	3.6	4.2	4.5	4.4
	-3		5.4	5.9	4.0	4.5	5.1	5.0
	-2		6.1	6.4	4.6	4.9	5.6	5.5
	-1		6.7	7.0	5.2	5.3	6.3	6.1
138 kV U/G Duct	0		7.4	7.5	5.8	5.6	7.0	6.7
	1	17.5	8.1	8.1	6.5	5.9	7.7	7.2
	2		8.8	8.6	7.2	6.1	8.4	7.8
	3		9.5	9.0	7.8	6.1	9.0	8.2
	4		10.1	9.2	8.3	6.1	9.4	8.5
	5		10.5	9.3	8.7	5.8	9.7	8.7
	6		10.7	9.1	8.9	5.5	9.7	8.7
46 kV U/G Duct	7	25.7	10.8	8.8	8.9	5.1	9.4	8.6
	8		10.6	8.3	8.7	4.7	8.9	8.3
	9		10.3	7.7	8.3	4.4	8.2	7.9
	10		9.7	7.1	7.8	4.2	7.3	7.4
	11		9.1	6.4	7.2	4.0	6.5	6.8
	12	14.7	8.3	5.8	6.6	3.8	5.7	6.2
	13		7.6	5.2	6.0	3.6	4.9	5.6
	14		6.8	4.7	5.4	3.5	4.2	5.1
	15		6.1	4.2	4.8	3.3	3.7	4.5
	16		5.5	3.8	4.3	3.0	3.2	4.0
	17		4.9	3.4	3.9	2.8	2.8	3.6
	18	7.7	4.4	3.1	3.5	2.6	2.5	3.2
	19		3.9	2.8	3.1	2.4	2.2	2.9
	20		3.5	2.5	2.8	2.2	1.9	2.6
	21		3.2	2.3	2.6	2.1	1.7	2.3
	22	5.2	2.9	2.1	2.3	1.9	1.6	2.1
	23		2.6	1.9	2.1	1.8	1.4	1.9
South Sidewalk Edge	24		2.4	1.8	1.9	1.6	1.3	1.7
	25							
	26	4.1						

APPENDIX E

Magnetic Field Measurements
of HECO Electrical Facilities

Table E-1. Magnetic Field Measurements of Substation Transformers at Kapiolani Substation

46 kV to 12 kV XFMR at Kapiolani Substation #1

Distance (ft)	Magnetic Field (mG)	Normalized
0	145	1.00
1		
2		
3		
4		
5	28	0.19
6		
7		
8		
9		
10	18.5	0.13
11		
12		
13		
14		
15	17.2	0.12
16		
17		
18		
19		
20	14	0.10
21		
22		
23		
24		
25	11.1	0.08
26		
27		
28		
29		
30	8.4	0.06
31		
32		
33		
34		
35	6.9	0.05
36		
37		
38		
39		
40	6.5	0.04

46 kV to 12 kV XFMR at Kapiolani Substation #2

Distance (ft)	Magnetic Field (mG)	Normalized
0	104	1.00
1		
2		
3		
4		
5	11.7	0.11
6		
7		
8		
9		
10	5.1	0.05
11		
12		
13		
14		
15	1.6	0.02
16		
17		
18		
19		
20	1.2	0.01
21		
22		
23		
24		
25	1	0.01
26		
27		
28		
29		
30	0.9	0.01
31		
32		
33		
34		
35	0.8	0.01

46 kV to 12 kV XFMR at Kapiolani Substation #3

Distance (ft)	Magnetic Field (mG)	Normalized
0	89	1.00
1		
2		
3		
4		
5	29.7	0.33
6		
7		
8		
9		
10	22.9	0.26
11		
12		
13		
14		
15	19.4	0.22

Table E-2. Magnetic Field Measurements of Substation Transformers at McCully Substation

46 kV XFMR at McCully Substation #1

Distance (ft)	Magnetic Field (mG)	Normalized
0	28.1	1.00
1	23.1	0.82
2	18.7	0.67
3	15.7	0.56
4	13.9	0.49
5	12.1	0.43
6	9.9	0.35
7	8.9	0.32
8	8.7	0.31
9	8.0	0.28
10	7.5	0.27
11	7.8	0.28
12	7.2	0.26
13	6.7	0.24
14	6.6	0.24
15	6.1	0.22
16	6.1	0.22
17	5.9	0.21
18	5.9	0.21

46 kV XFMR at McCully Substation #2

Distance (ft)	Magnetic Field (mG)	Normalized
0	119.9	1.00
1	114.1	0.95
2	98.5	0.82
3	72.3	0.60
4	55.7	0.46
5	46.9	0.39
6	40.1	0.33
7	35.3	0.29
8	34.9	0.29
9	31.3	0.26
10	27.3	0.23
11	24.7	0.21
12	24.7	0.21
13	24.9	0.21
14	24.1	0.20
15	14.9	0.12

46 kV XFMR at McCully Substation #3

Distance (ft)	Magnetic Field (mG)	Normalized
0	39.9	1.00
1	39.7	0.99
2	38.5	0.96
3	34.9	0.87
4	32.1	0.80
5	31.1	0.78
6	28.1	0.70
7	23.3	0.58
8	20.1	0.50
9	17.5	0.44
10	15.3	0.38
11	13.3	0.33
12	11.1	0.28
13	9.1	0.23
14	7.5	0.19
15	6.3	0.16
16	5.3	0.13
17	4.3	0.11
18	3.8	0.09
19	3.2	0.08
20	2.9	0.07
21	2.6	0.06
22	2.4	0.06

Between 46 kV XFMR's at McCully Substation

Distance (ft)	Magnetic Field (mG)	Normalized
0	32.5	1.00
1	31.1	0.96
2	28.3	0.87
3	25.9	0.80
4	23.1	0.71
5	20.5	0.63
6	17.7	0.54
7	15.7	0.48
8	14.3	0.44
9	13.5	0.42

Table E-3. Magnetic Field Measurements of Substation Transformers at Moiliili and Kewalo Substations

46 kV to 12 kV XFMR at Moiliili Substation

Distance (ft)	Magnetic Field (mG)	Normalized
0	133	1.00
1		
2		
3		
4		
5	4.7	0.04
6		
7		
8		
9		
10	2.1	0.02
11		
12		
13		
14		
15	1.6	0.01
16		
17		
18		
19		
20	1.4	0.01
21		
22		
23		
24		
25	1.1	0.01
26		
27		
28		
29		
30	1	0.01
31		
32		
33		
34		
35	1	0.01
36		
37		
38		
39		
40	0.9	0.01
41		
42		
43		
44		
45	0.8	0.01

46 kV XFMR at Kewalo Substation

Distance (ft)	Magnetic Field (mG)	Normalized
0	15.9	1.00
1	14.7	0.93
2	14.5	0.91
3	12.9	0.81
4	11.3	0.71
5	10.1	0.64
6	9.3	0.59
7	8.7	0.55
8	8.3	0.52
9	7.5	0.47
10	6.9	0.43

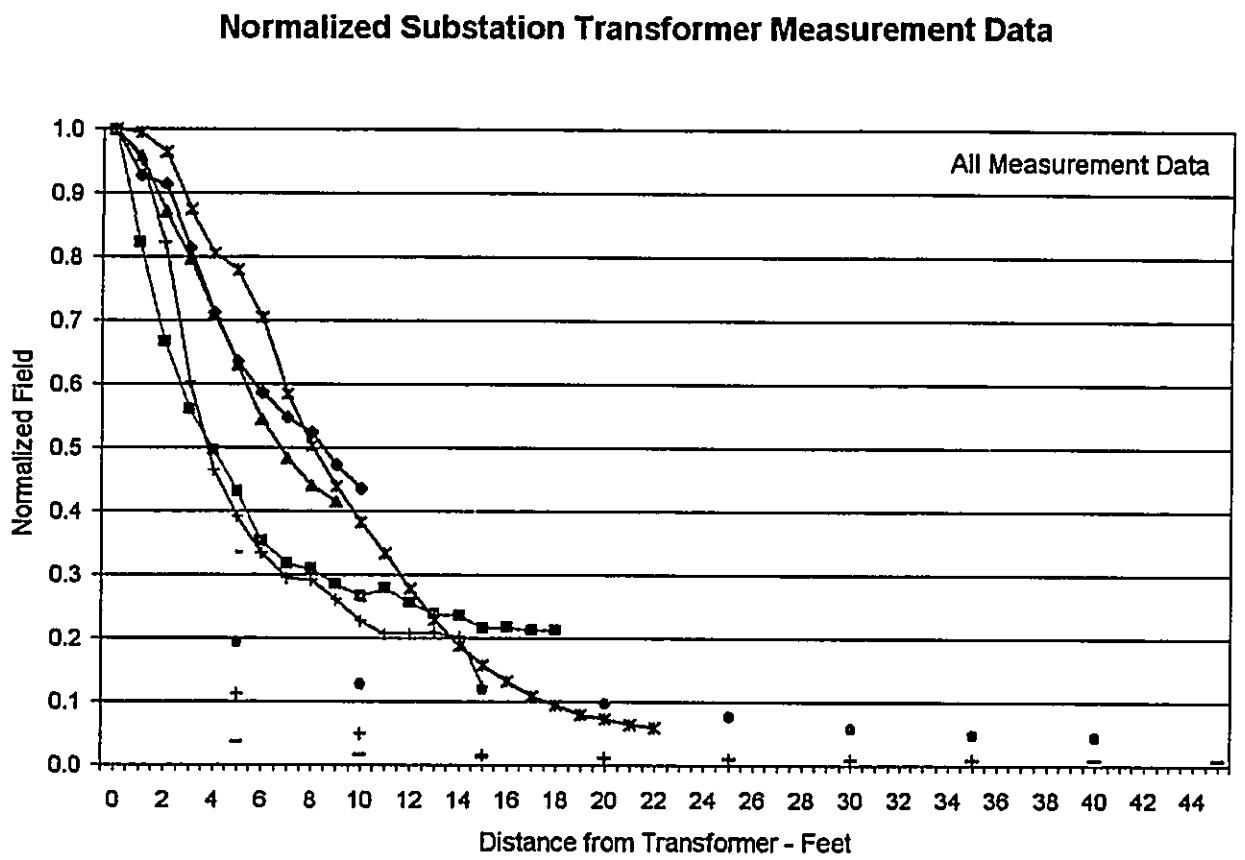


Figure E-1. Normalized Magnetic Field Measurements for HECO Substation Transformers

Table E-4. Average of Normalized Magnetic Field Measurements For HECO Substation Transformers

Average of Normalized Data for HECO Substation Transformers	
Distance (ft)	Normalized
0	1.00
1	0.93
2	0.85
3	0.73
4	0.64
5	0.39
6	0.50
7	0.45
8	0.41
9	0.37
10	0.22
11	0.27
12	0.25
13	0.22
14	0.21
15	0.12
16	0.17
17	0.16
18	0.15
19	0.08
20	0.05
21	0.06
22	0.06
23	
24	
25	0.03
26	
27	
28	
29	
30	0.02
31	
32	
33	
34	
35	0.02
36	
37	
38	
39	
40	0.03
41	
42	
43	
44	
45	0.01

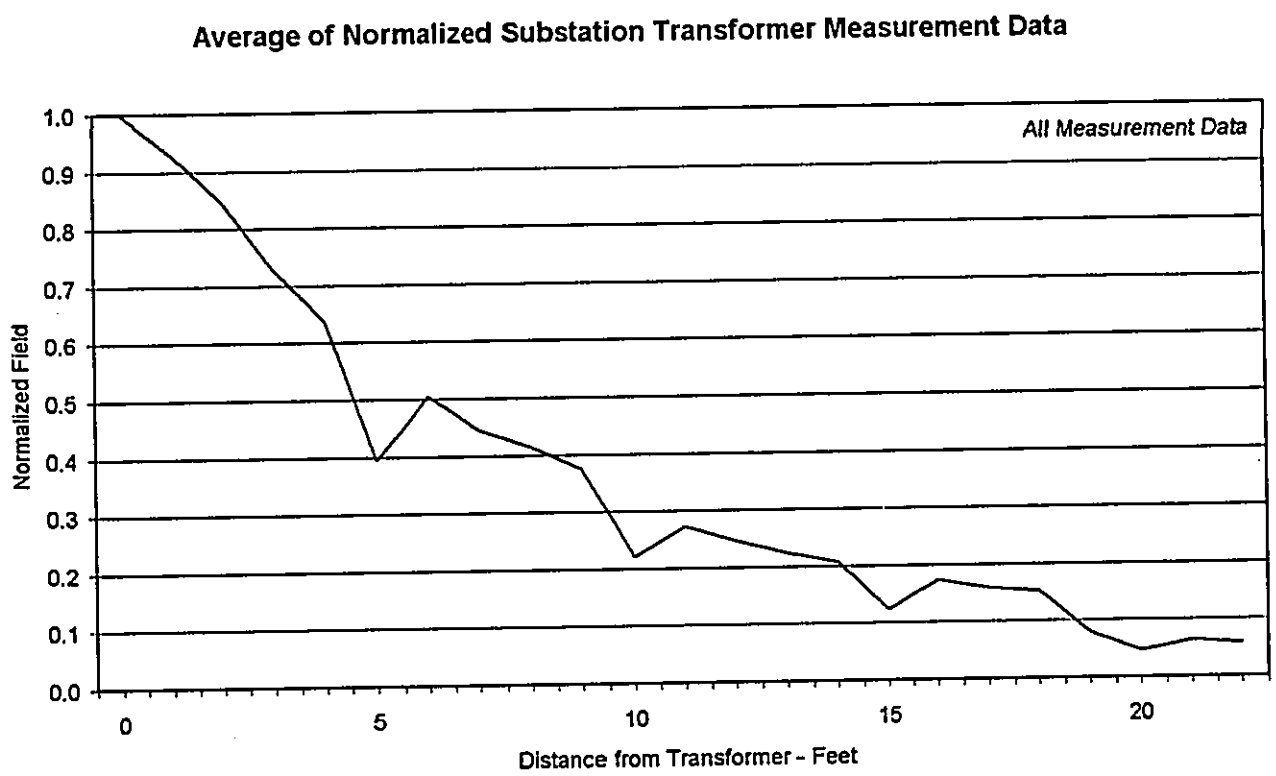


Figure E-2. Average Normalized Magnetic Field Measurements for HECO Substation Transformers

Table E-5. Magnetic Field Measurements of Manholes at Kapiolani Boulevard and Ward Avenue

46 kV Manhole at Kapiolani and Ward #1

Distance (ft)	Magnetic Field (mG)	Normalized
0	17.9	1.00
2	15.3	0.85
4	13.1	0.73
7	12.1	0.68
10	10.1	0.56
12	7.1	0.40
14	5.0	0.28
16	4.2	0.24
19	3.6	0.20
21	3.1	0.17
23	2.8	0.16
25	2.6	0.15
28	2.4	0.14
30	2.1	0.12

46 kV Manhole at Kapiolani and Ward #3

Distance (ft)	Magnetic Field (mG)	Normalized
0	25.3	1.00
2	24.5	0.97
3	21.9	0.87
5	17.3	0.68
7	13.1	0.52
9	10.3	0.41
11	7.1	0.28
13	5.0	0.20
15	4.2	0.17
16	3.8	0.15
18	3.9	0.15
20	3.6	0.14
22	3.4	0.13
23	3.1	0.12
25	2.7	0.11
27	2.4	0.10
29	2.2	0.09
31	2.1	0.08
33	1.9	0.08

46 kV Manhole at Kapiolani and Ward #2

Distance (ft)	Magnetic Field (mG)	Normalized
0	21.9	1.00
2	20.9	0.95
5	15.5	0.71
7	11.5	0.53
9	9.1	0.42
11	6.9	0.32
13	4.7	0.22
16	3.8	0.17
18	3.4	0.16
20	3.1	0.14
22	2.9	0.13
24	2.6	0.12
26	2.5	0.11
27	2.3	0.11
29	2.2	0.10
31	2.1	0.09
33	2.0	0.09
34	1.9	0.09
35	1.8	0.08

46 kV Manhole at Kapiolani and Ward #4

Distance (ft)	Magnetic Field (mG)	Normalized
0	27.3	1.00
1	25.9	0.95
3	21.7	0.79
5	17.1	0.63
7	12.5	0.46
9	9.3	0.34
11	6.5	0.24
13	5.4	0.20
15	5.0	0.18
16	4.6	0.17
19	4.2	0.15
21	3.7	0.14
23	3.2	0.12
25	2.8	0.10
27	2.5	0.09
29	2.3	0.08
30	2.2	0.08
31	2.1	0.08

Table E-6. Magnetic Field Measurements of Manholes at Kapiolani Boulevard and Ward Avenue

46 kV Manhole at Kapiolani and Ward #5

Distance (ft)	Magnetic Field (mG)	Normalized
0	23.9	1.00
1	21.5	0.90
3	20.1	0.84
5	18.5	0.77
7	15.5	0.65
9	11.3	0.47
11	7.7	0.32
14	5.5	0.23
16	4.5	0.19
17	3.9	0.16
19	3.4	0.14
20	3.2	0.13
22	2.9	0.12
24	2.9	0.12
25	2.8	0.12
27	2.7	0.11
29	2.7	0.11
31	2.4	0.10
33	2.4	0.10
35	2.3	0.10
36	2.2	0.09

46 kV Manhole on Kapiolani near Ward

Distance (ft)	Magnetic Field (mG)	Normalized
0	9.1	1.00
1	8.2	0.90
3	7.7	0.85
6	6.8	0.75
8	5.8	0.64
10	5.3	0.59
13	5.0	0.55
16	4.4	0.49
19	4.3	0.47
22	4.1	0.45
25	3.8	0.42
29	2.7	0.29
31	1.7	0.19
34	1.2	0.13
37	1.0	0.11
40	0.9	0.10
42	0.8	0.09
44	0.7	0.08

46 kV Manhole at Kapiolani and Ward #6

Distance (ft)	Magnetic Field (mG)	Normalized
0	54.3	1.00
4	29.3	0.54
8	14.5	0.27
12	7.7	0.14
16	5.7	0.11
19	4.6	0.08
21	3.8	0.07
23	3.3	0.06
26	2.7	0.05
29	2.2	0.04
31	2.0	0.04
34	1.8	0.03
37	1.6	0.03
40	1.5	0.03
43	1.3	0.02
46	1.2	0.02
48	1.1	0.02
49	1.0	0.02

138 kV Manhole on Kapiolani near Ward

Distance (ft)	Magnetic Field (mG)	Normalized
0	3.1	1.00
2	2.5	0.82
4	2.0	0.64
7	1.5	0.48
9	1.1	0.36
11	0.9	0.30

Table E-7. Magnetic Field Measurements of Manholes at Kapiolani Boulevard and Ward Avenue

46 kV Manhole on Sheridan

Distance (ft)	Magnetic Field (mG)	Normalized
0	18.5	1.00
2	17.5	0.95
3	14.9	0.81
5	11.9	0.64
7	9.3	0.50
10	6.9	0.37
12	5.4	0.29
14	4.5	0.24
16	3.9	0.21
18	3.5	0.19
20	3.3	0.18
22	3.0	0.16
24	2.8	0.15
26	2.5	0.14
27	2.6	0.14
29	2.5	0.13
31	2.4	0.13
32	2.5	0.13
34	2.4	0.13
36	2.1	0.12
37	2.0	0.11
40	1.8	0.10
41	1.6	0.08
43	1.4	0.08
45	1.4	0.07
47	1.3	0.07
49	1.1	0.06
51	1.0	0.06

46 kV Manhole on Pumehana #1

Distance (ft)	Magnetic Field (mG)	Normalized
0	33.3	1.00
2	32.1	0.96
3	28.1	0.84
5	20.9	0.63
6	14.7	0.44
8	11.1	0.33
10	8.3	0.25
12	6.2	0.18
14	4.2	0.13
16	3.3	0.10
18	2.3	0.07
20	1.8	0.05
22	1.5	0.05
24	1.2	0.04
26	1.0	0.03
28	0.9	0.03
30	0.8	0.02

46 kV Manhole on Pumehana #2

Distance (ft)	Magnetic Field (mG)	Normalized
0	28.1	1.00
1	26.9	0.96
2	22.3	0.79
3	18.1	0.64
4	15.9	0.57
5	13.9	0.49
6	11.5	0.41
8	8.1	0.29
10	5.9	0.21
12	3.8	0.14
14	2.6	0.09
16	2.0	0.07
18	1.4	0.05
20	1.1	0.04
22	1.0	0.04
24	0.8	0.03
26	0.7	0.03

46 kV Manhole on Makaloa Street

Distance (ft)	Magnetic Field (mG)	Normalized
0	4.2	1.00
2	3.9	0.93
4	3.4	0.82
6	2.8	0.68
8	2.2	0.53
11	1.7	0.41
13	1.4	0.34
15	1.2	0.28
17	1.0	0.25
19	0.9	0.21
21	0.8	0.18
23	0.7	0.17
25	0.7	0.16

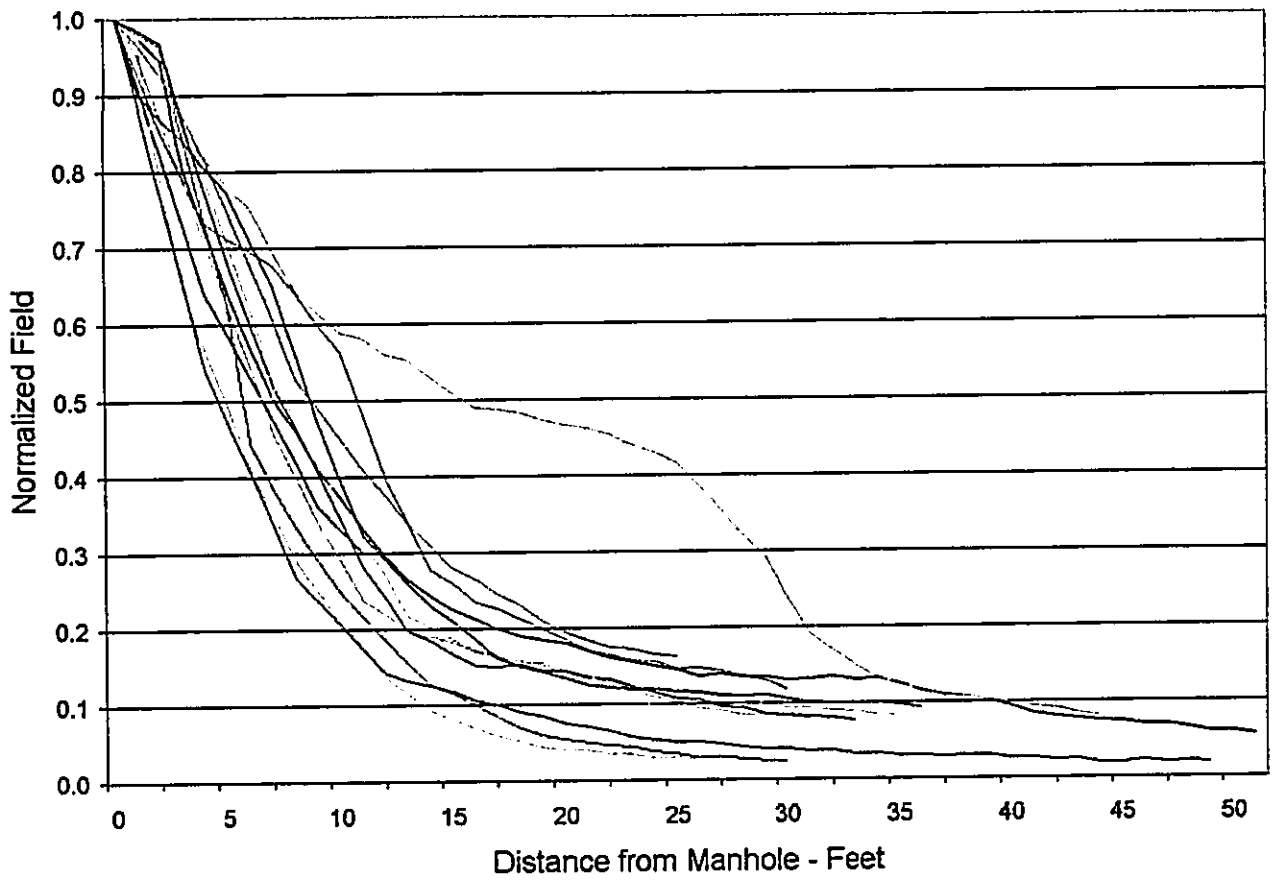


Figure E-3. Normalized Magnetic Field Measurements for HECO Manholes

Table E-8. Average of Normalized Magnetic Field Measurements For HECO Manholes

Average of Normalized Data for HECO Manholes	
Distance (ft)	**Normalized**
0	1.00
1	0.93
2	0.90
3	0.81
4	0.66
5	0.65
6	0.57
7	0.54
8	0.41
9	0.40
10	0.40
11	0.31
12	0.23
13	0.30
14	0.19
15	0.21
16	0.19
17	0.20
18	0.12
19	0.21
20	0.12
21	0.14
22	0.16
23	0.13
24	0.09
25	0.18
26	0.07
27	0.11
28	0.08
29	0.12
30	0.07

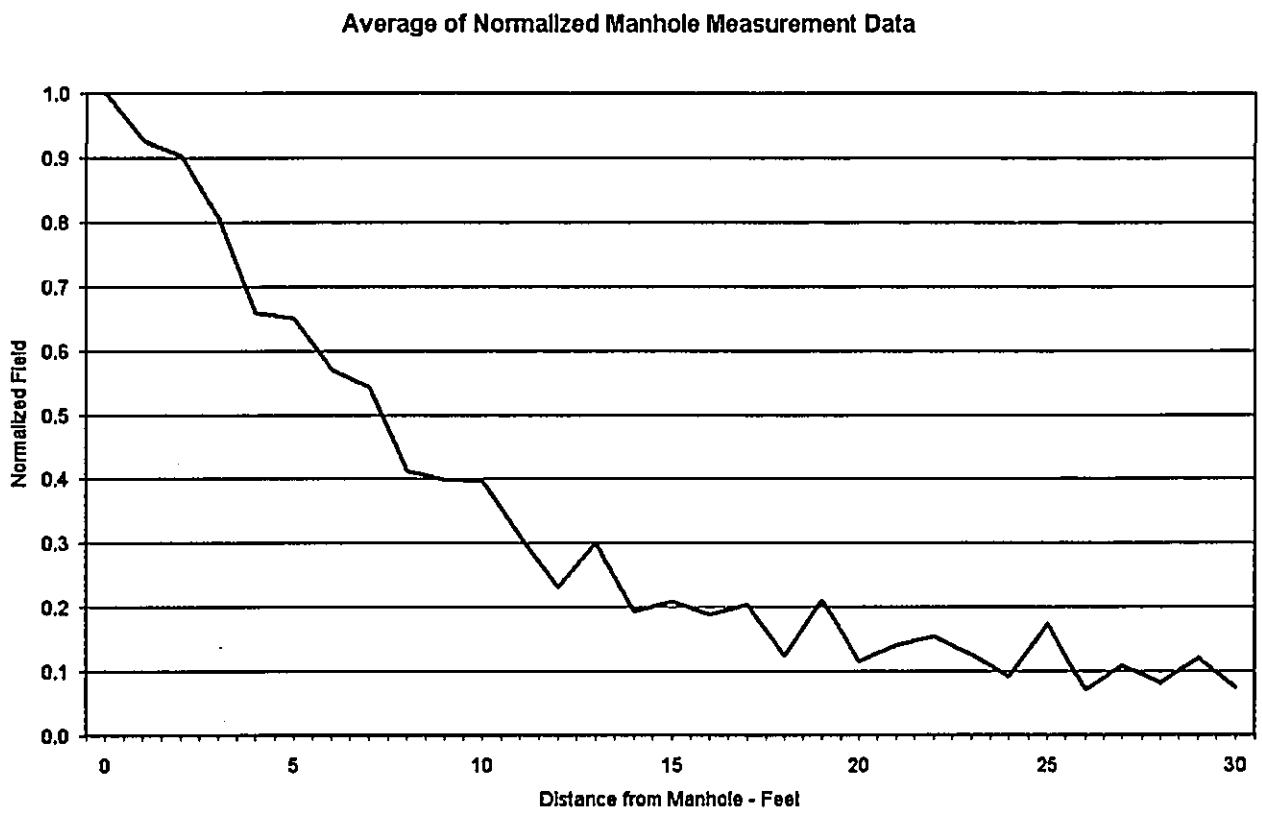


Figure E-4. Average Normalized Magnetic Field Measurements for HECO Manholes

Table E-9. Magnetic Field Measurements of Risers at Various Honolulu Locations

Riser Pole #8 (Near Alexander) - #1

Distance (ft)	Magnetic Field (mG)	Normalized
0	13.0	1.00
1	2.6	0.20
2	2.0	0.15
3	2.1	0.16
4	1.8	0.14

Riser Pole #8 (Near Alexander) - #2

Distance (ft)	Magnetic Field (mG)	Normalized
0	14.0	1.00
1	2.4	0.17
2	2.2	0.16
3	2.0	0.14
4	1.6	0.11

46 kV Riser Pole - 1 (Pukele 2 Circuit)

Distance (ft)	Magnetic Field (mG)	Normalized
0	64.3	1.00
1	12.1	0.19
2	9.2	0.14
3	8.8	0.14

Riser Pole - Pukele 2 Circuit to SW 5397

Distance (ft)	Magnetic Field (mG)	Normalized
0	36.4	1.00
1	12.5	0.34
2	9.8	0.27

Riser Pole - Pukele 2 Circuit (T-Tap)

Distance (ft)	Magnetic Field (mG)	Normalized
0	249.6	1.00
1	23.2	0.09
2	4.9	0.02
3	1.8	0.01
4	1.3	0.01

46 kV Riser Pole at McCully and Kapiolani

Distance (ft)	Magnetic Field (mG)	Normalized
0	24.8	1.00
1	4.0	0.16
2	2.5	0.10
3	2.2	0.09

Note : Background = 1.8 mG

46 kV Riser Pole - Pokele 4 Circuit

Distance (ft)	Magnetic Field (mG)	Normalized
0	1417	1.00
1	745.6	0.53
2	182.4	0.13
3	75.4	0.05
4	41.2	0.03
5	25.6	0.02
6	16.8	0.01
7	11.6	0.01
8	9.0	0.01
9	7.4	0.01
10	6.1	0.00
11	5.2	0.00
12	4.6	0.00

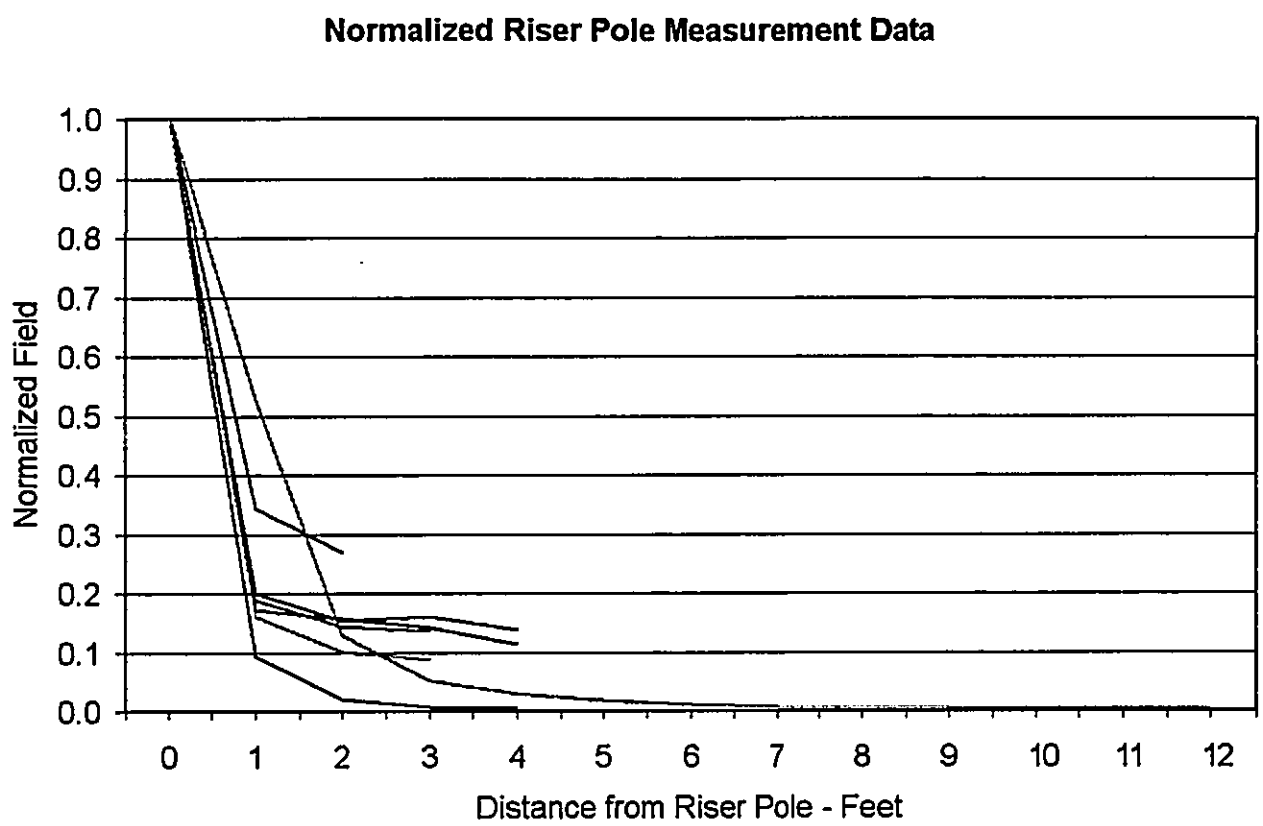


Figure E-5. Normalized Magnetic Field Measurements for HECO Risers

Table E-10. Average of Normalized Magnetic Field Measurements For HECO Risers

Average of Normalized Data for HECO Risers	
Distance (ft)	Normalized
0	1.00
1	0.24
2	0.14
3	0.10
4	0.07
5	0.02
6	0.01
7	0.01
8	0.01
9	0.01
10	0.00
11	0.00
12	0.00

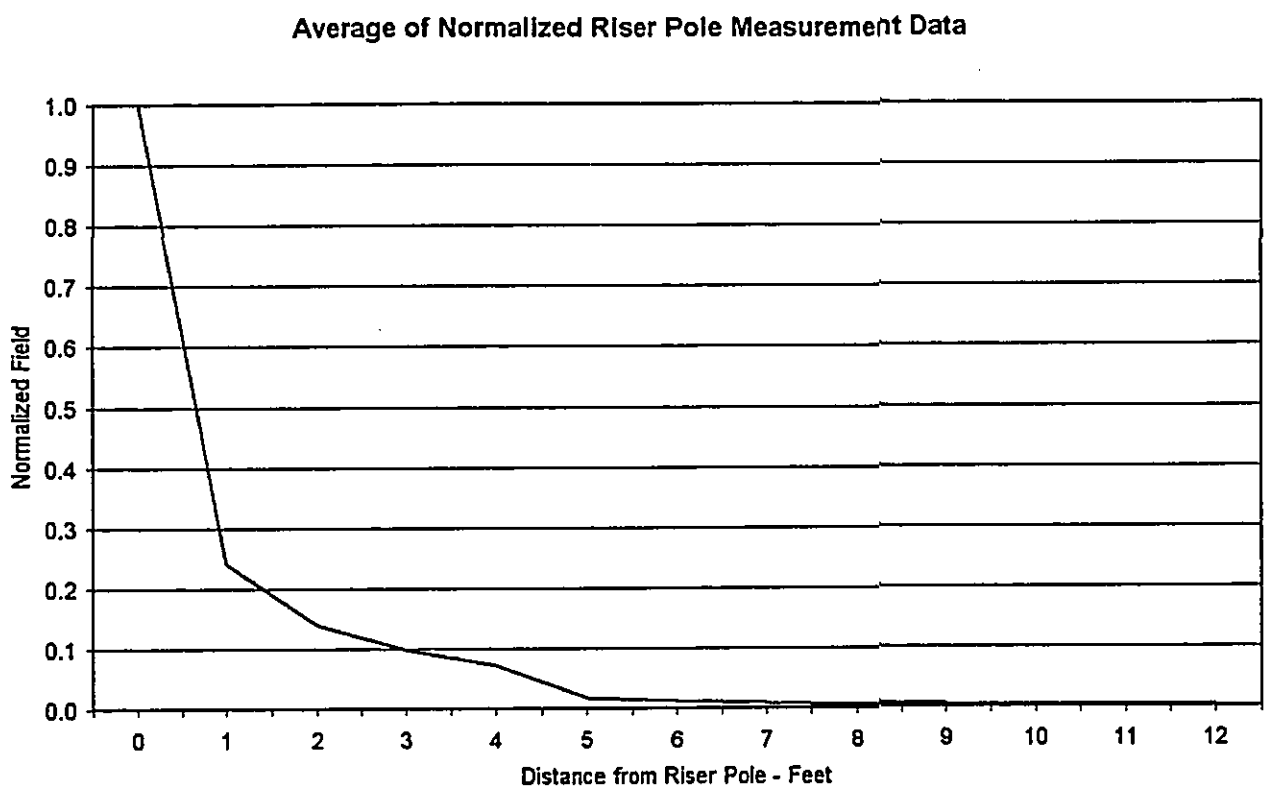


Figure E-6. Average Normalized Magnetic Field Measurements for HECO Risers

APPENDIX F

Magnetic Field Measurements
at Public Locations

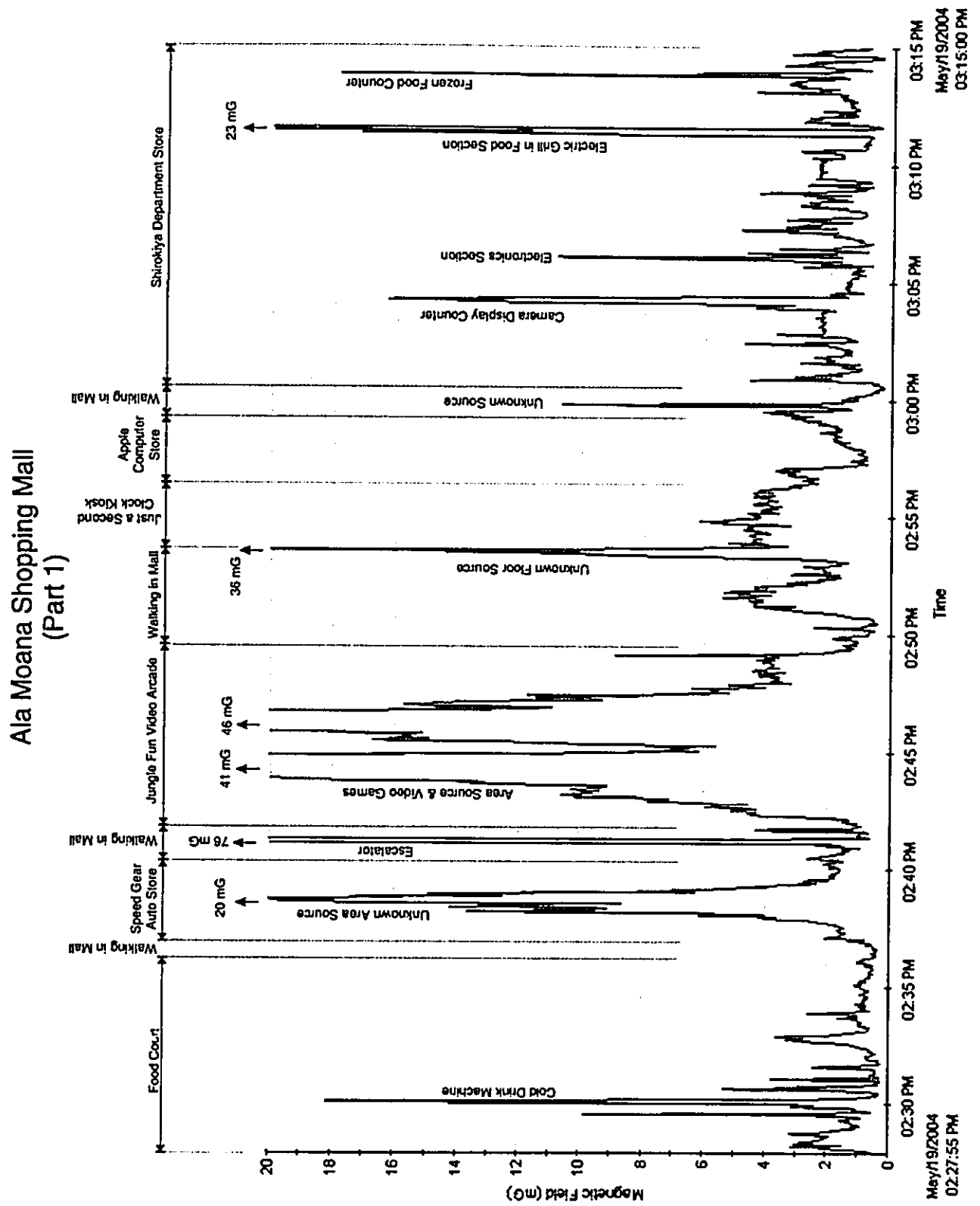


Figure F-1. Magnetic Field Measurements at Ala Moana Shopping Mall (Part 1)

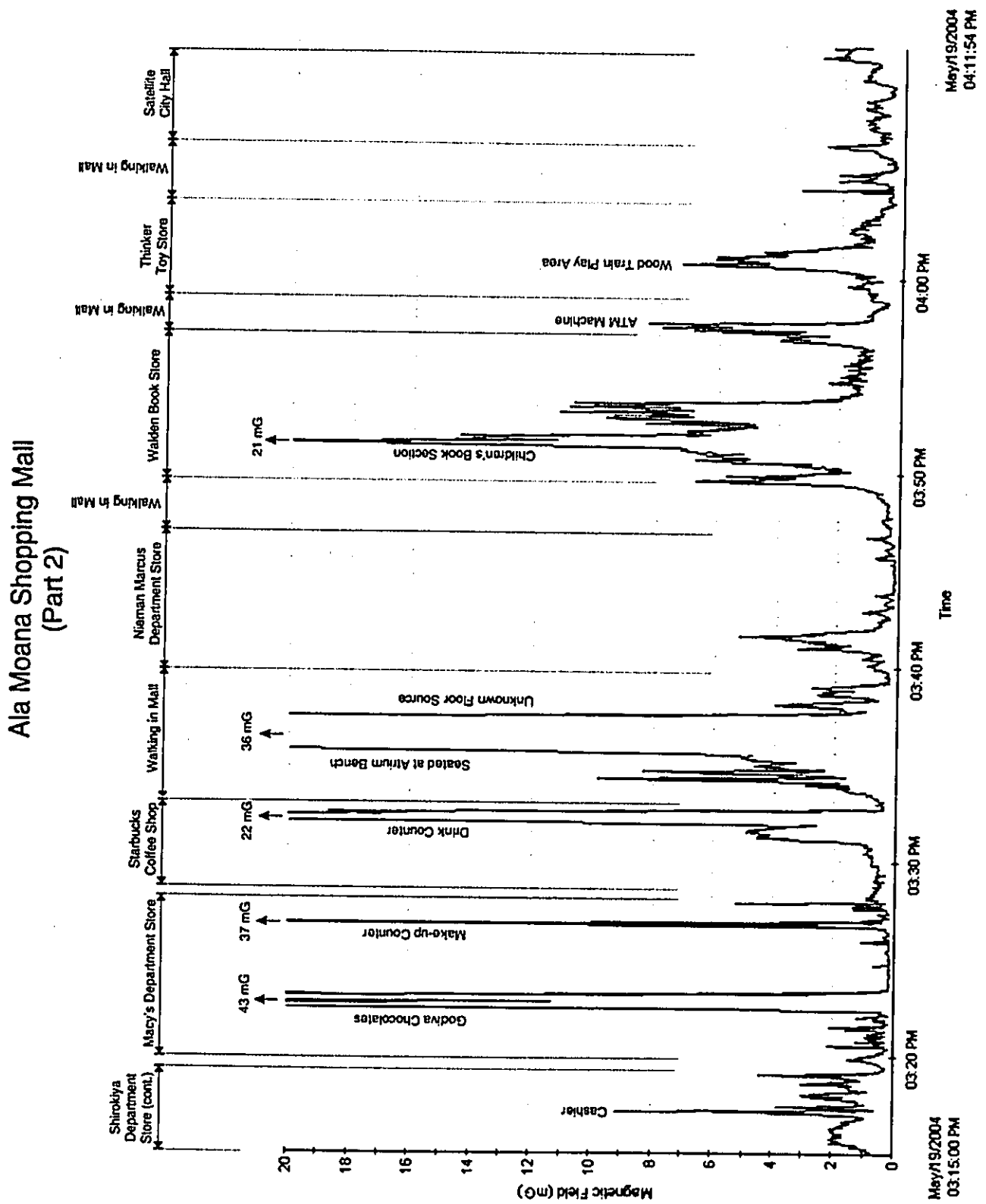


Figure F-2. Magnetic Field Measurements at Ala Moana Shopping Mall (Part 2)

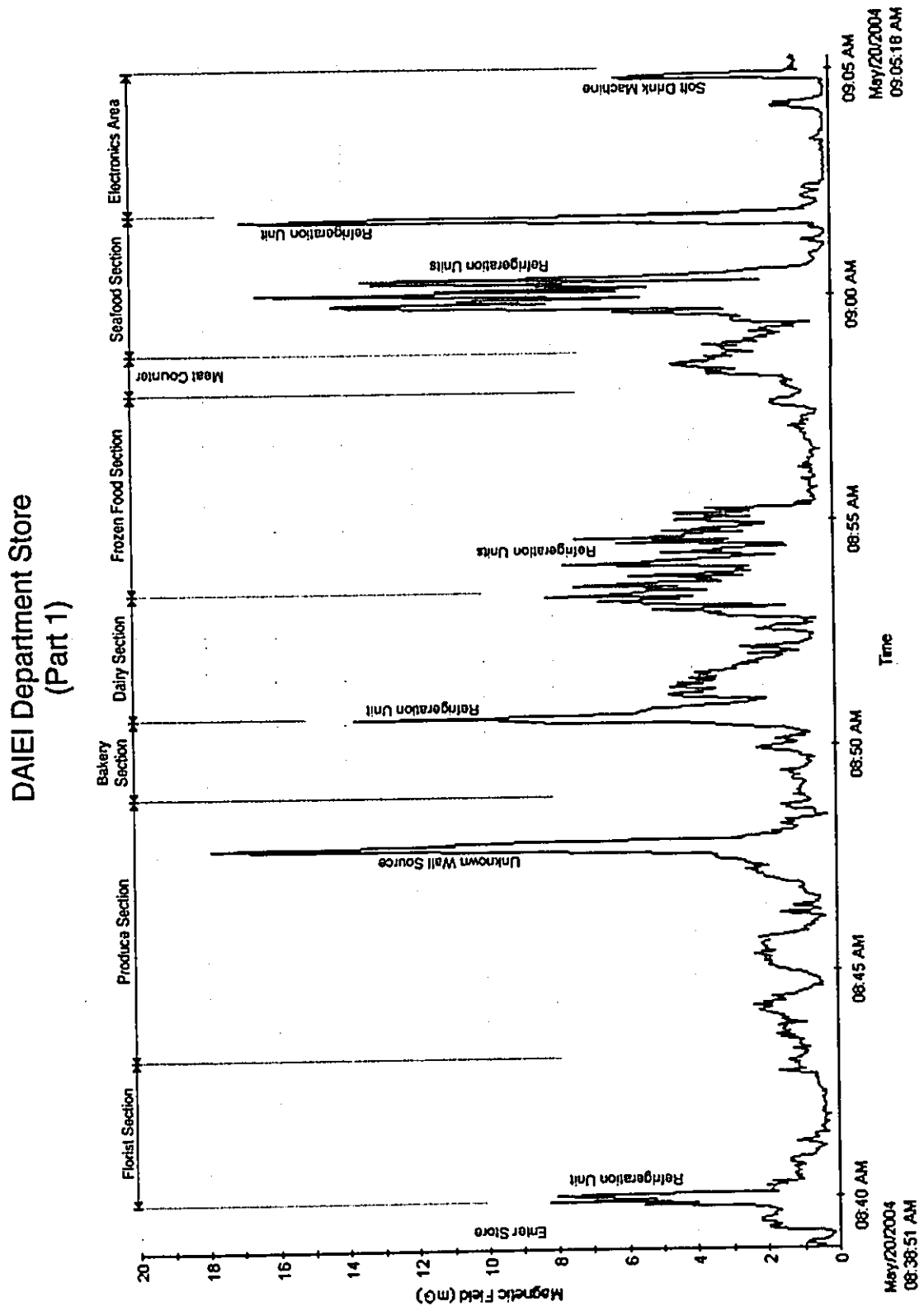


Figure F-3. Magnetic Field Measurements at Daiei Department Store (Part 1)

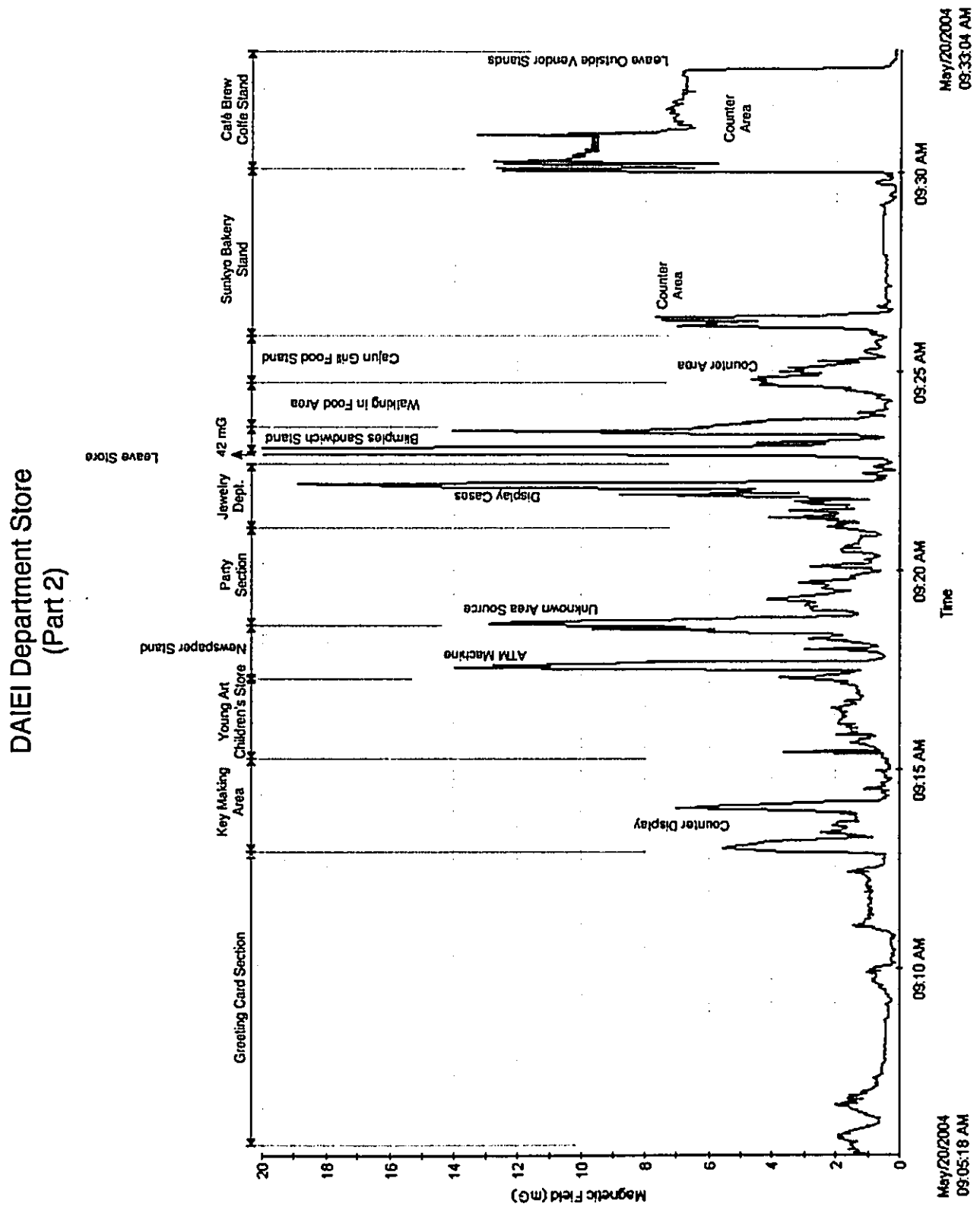


Figure F-4. Magnetic Field Measurements at Daiei Department Store (Part 2)

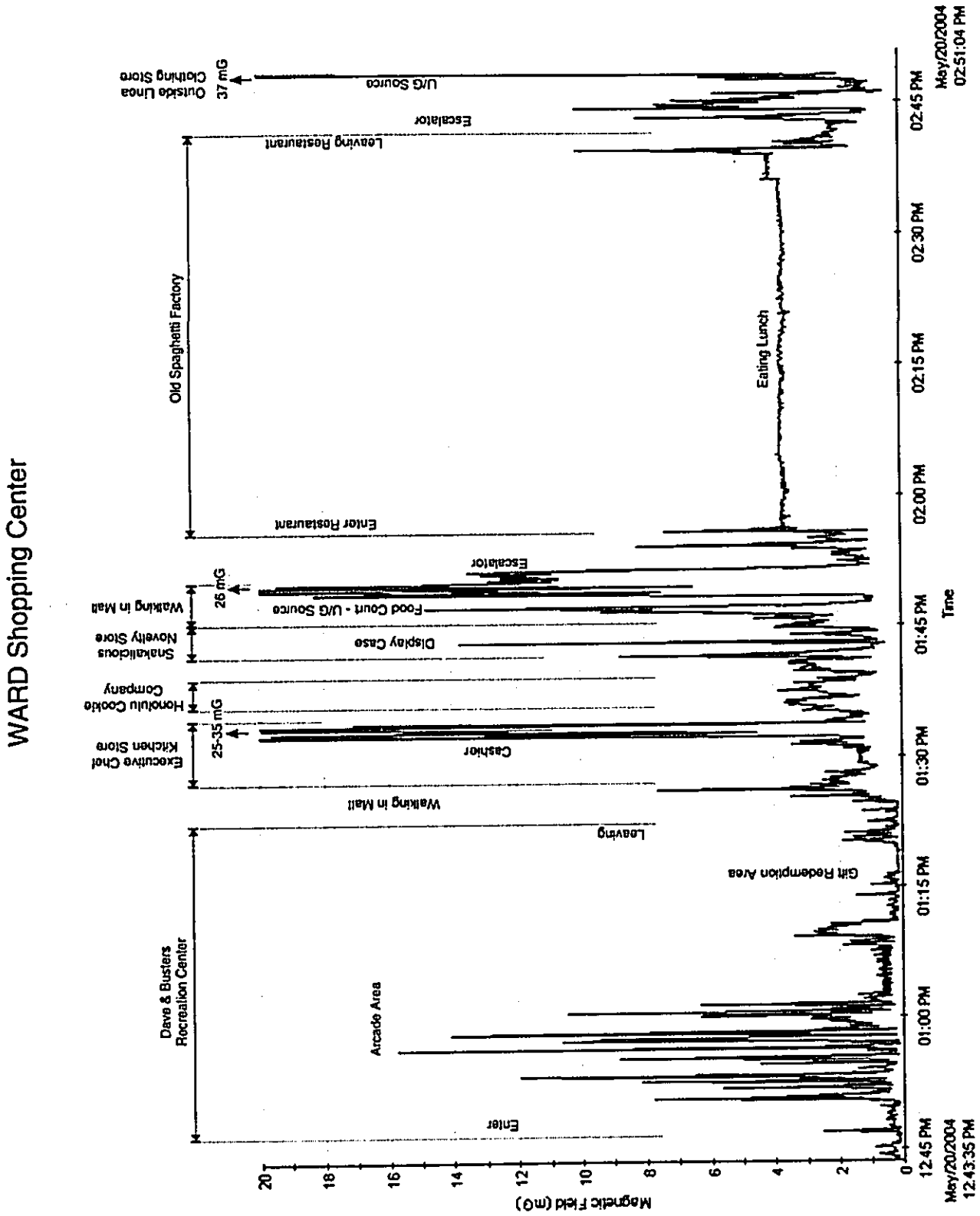


Figure F-5. Magnetic Field Measurements at Ward Shopping Center

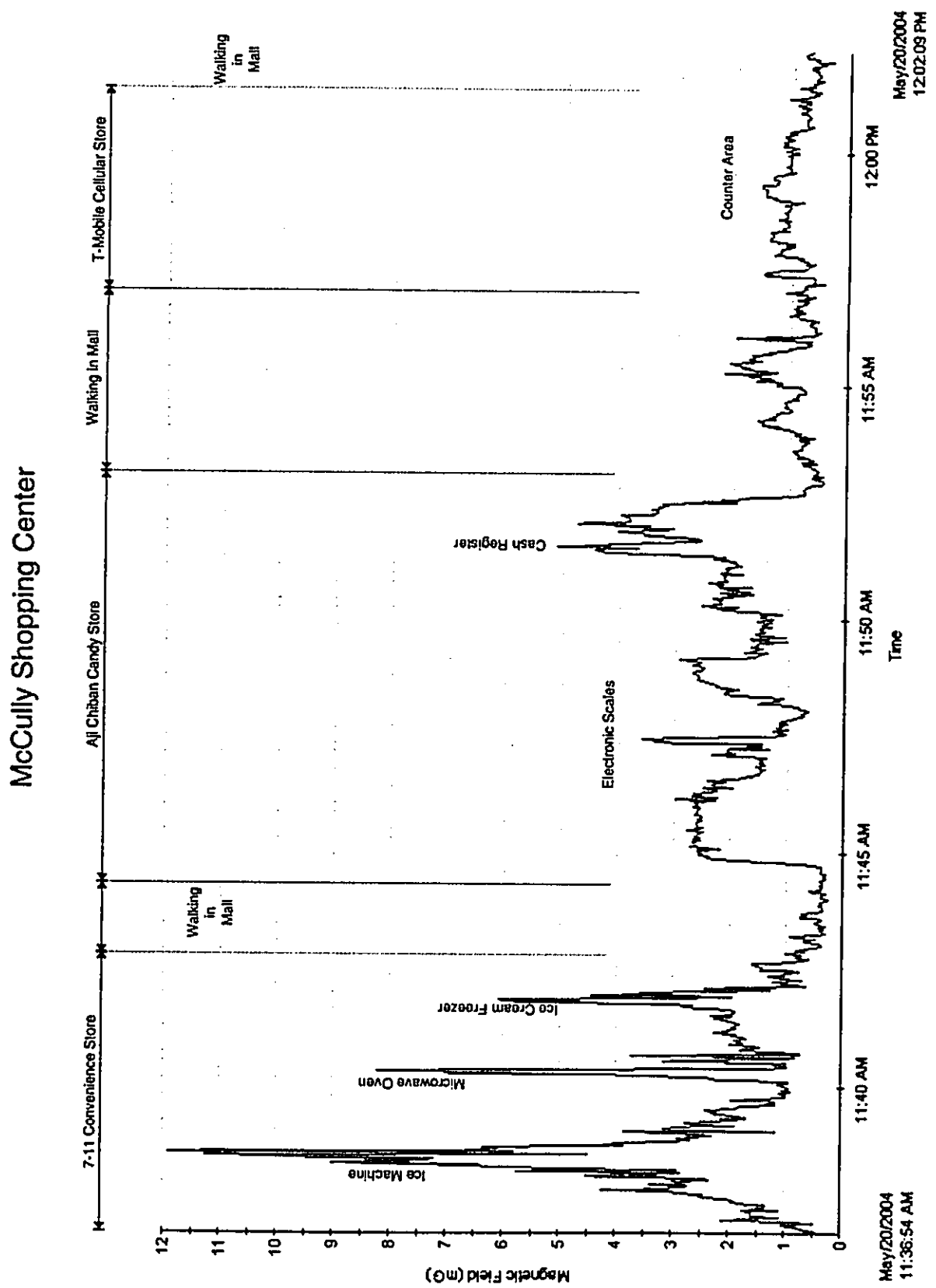


Figure F-6. Magnetic Field Measurements at McCully Shopping Center

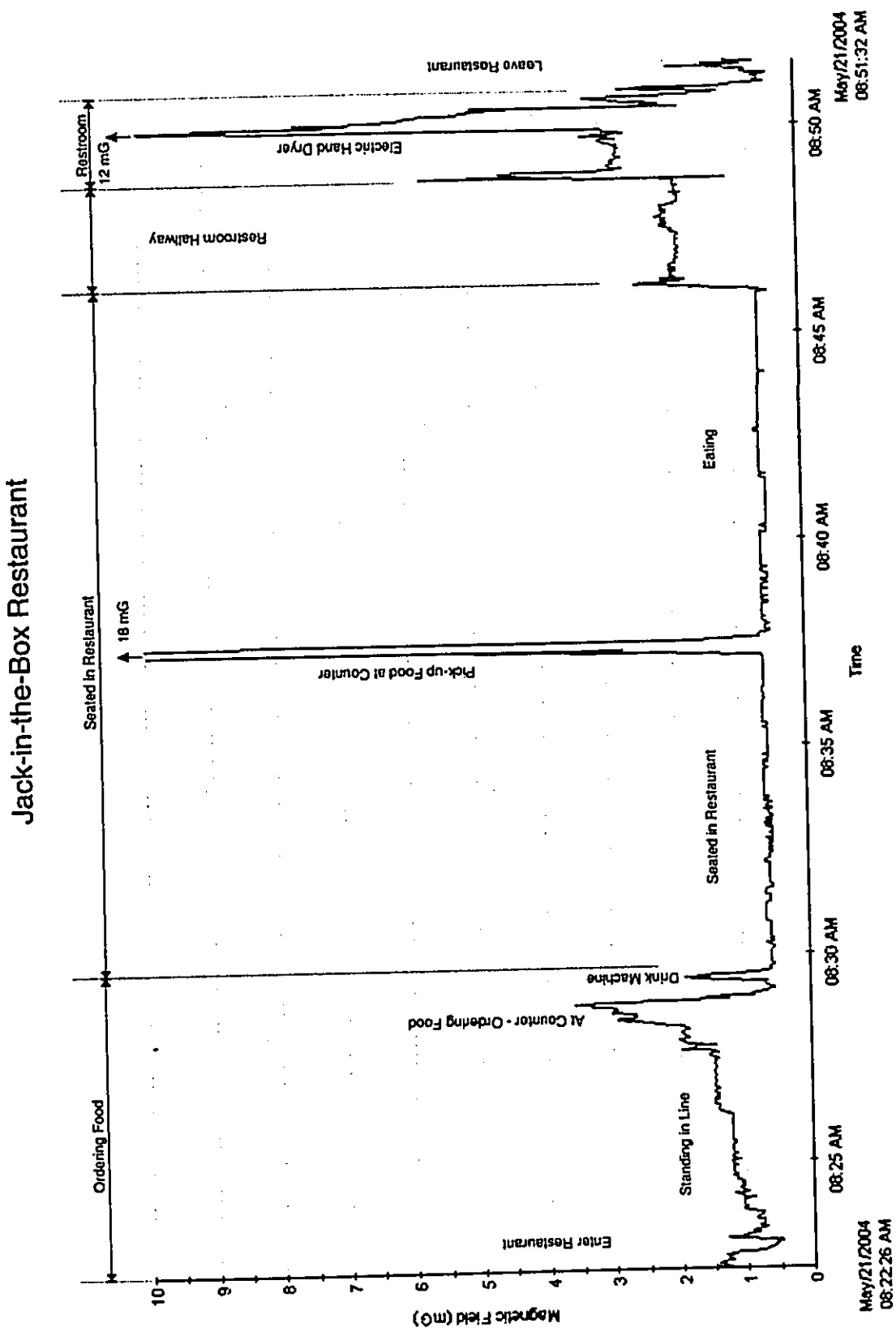


Figure F-7. Magnetic Field Measurements at Jack-In-The-Box Restaurant

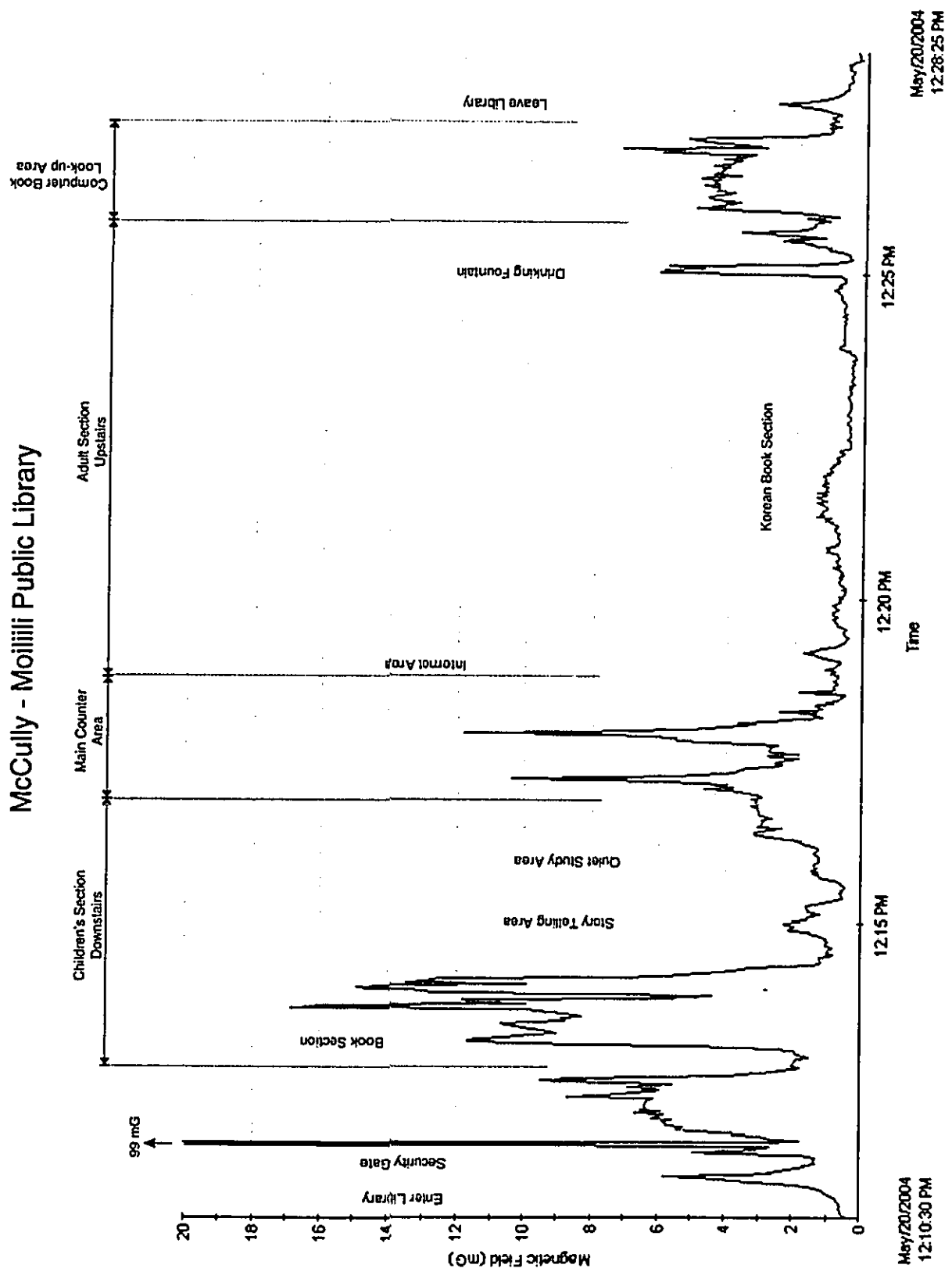


Figure F-8. Magnetic Field Measurements at McCully – Moiliili Public Library

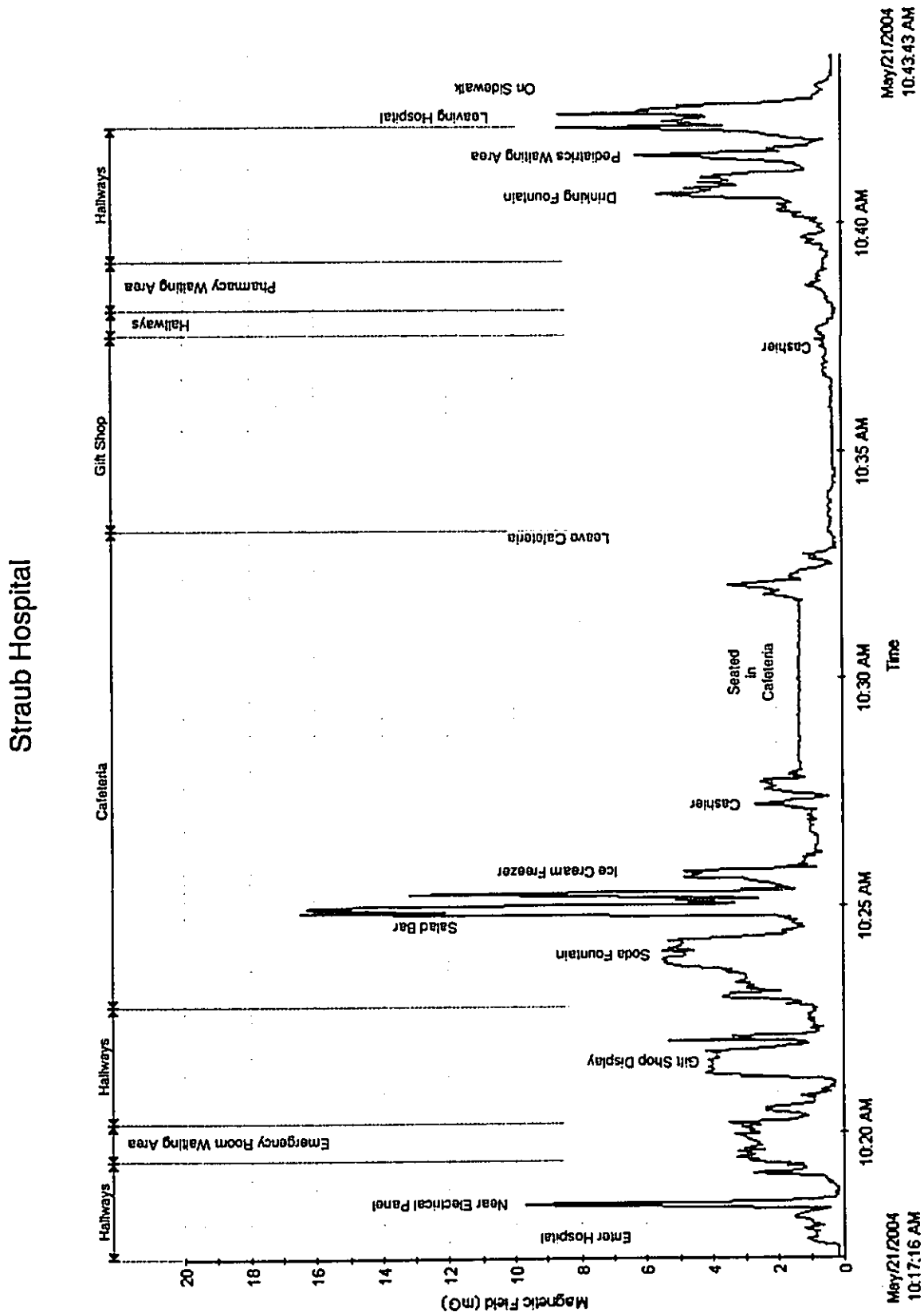


Figure F-9. Magnetic Field Measurements at Straub Hospital

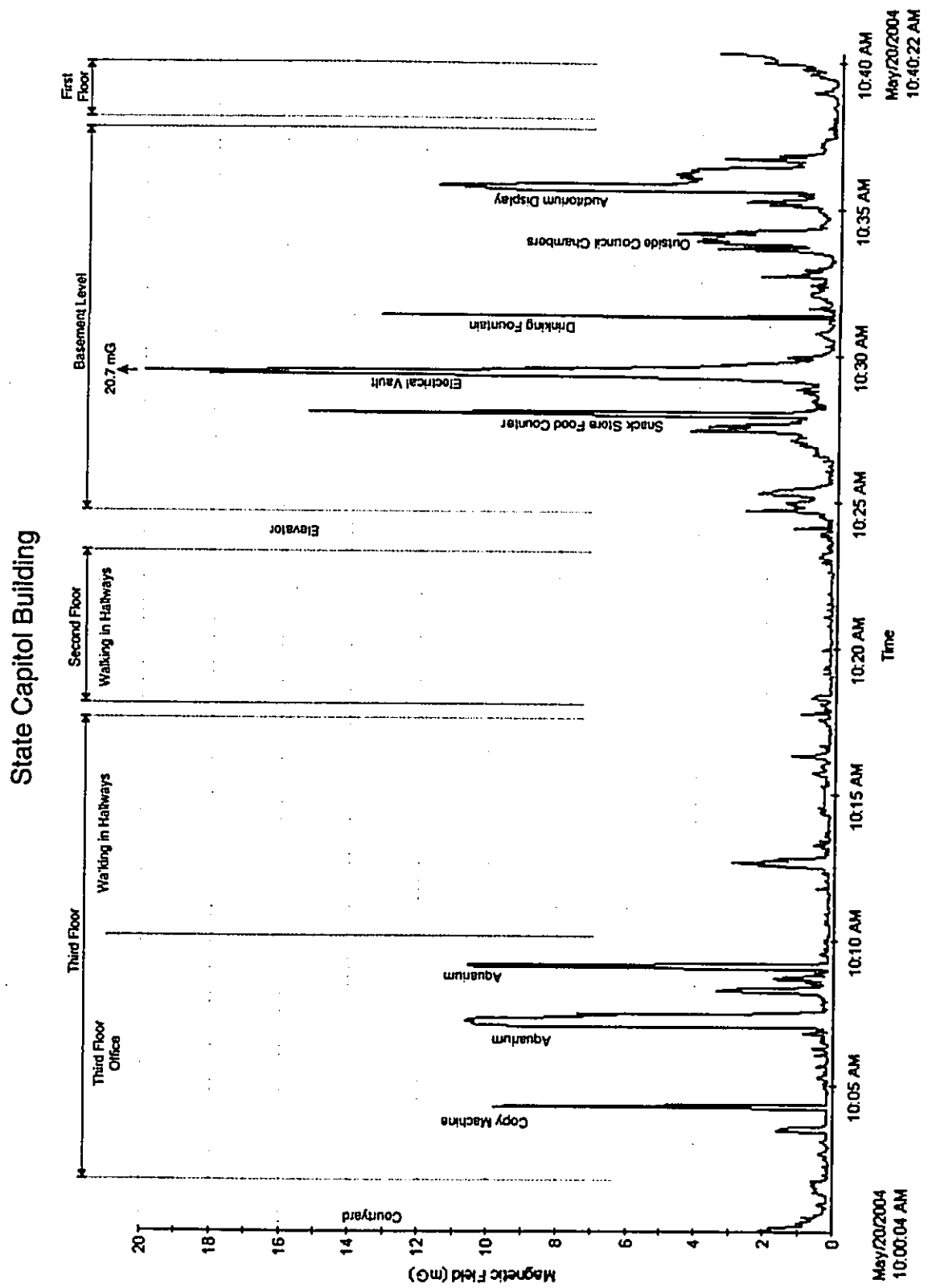


Figure F-10. Magnetic Field Measurements at State Capitol Building

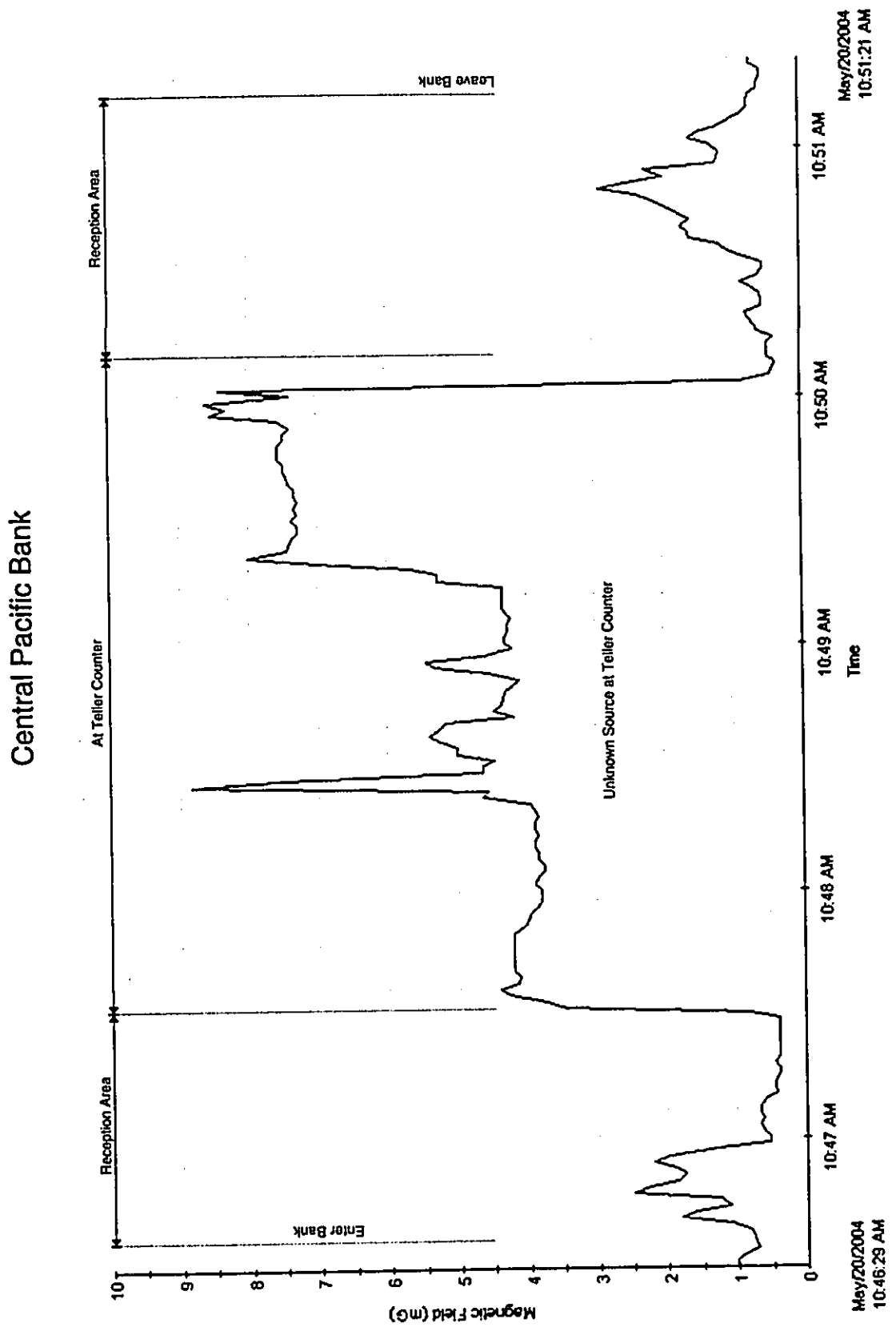


Figure F-11. Magnetic Field Measurements at Central Pacific Bank

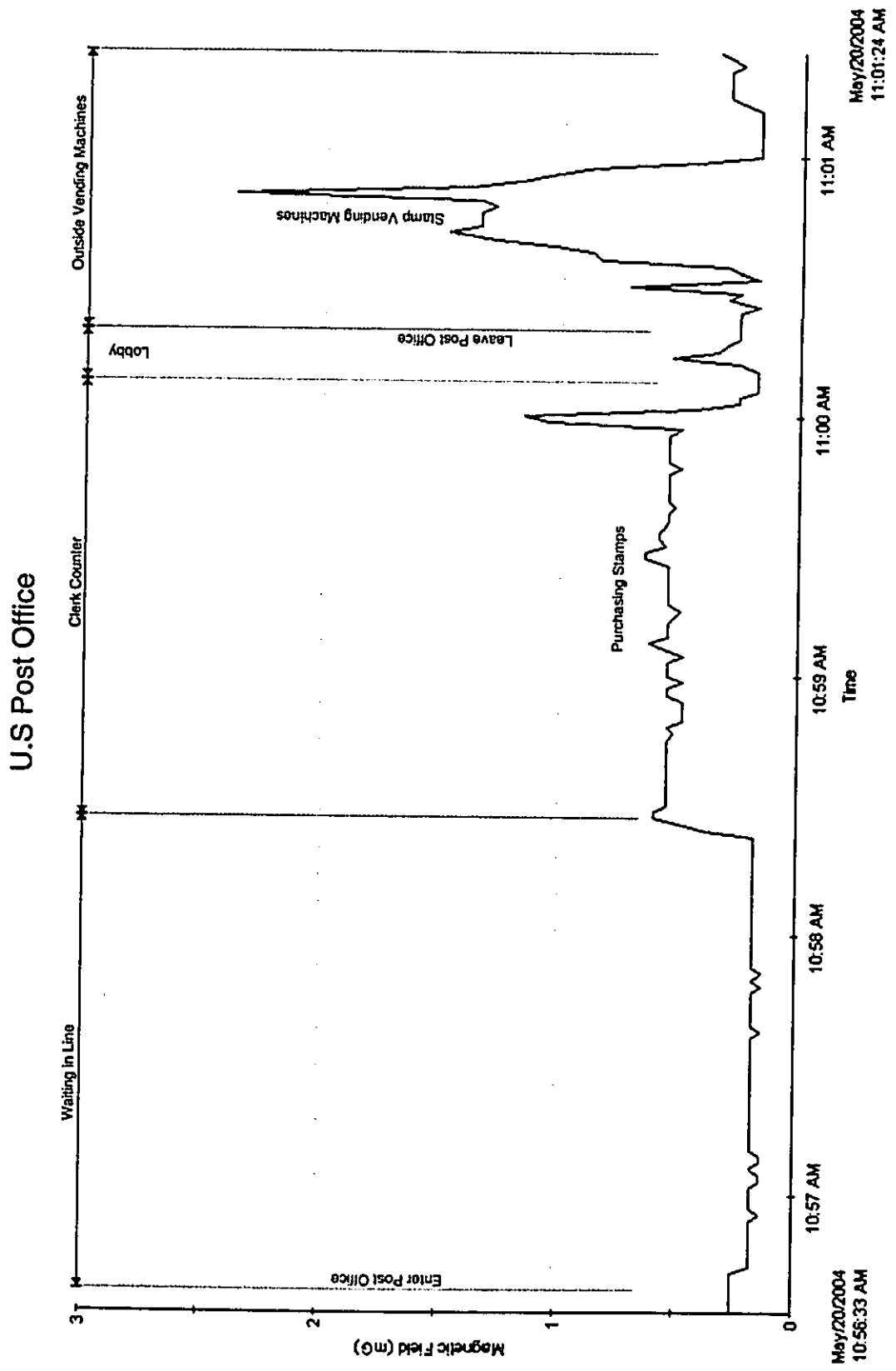


Figure F-12. Magnetic Field Measurements at U.S. Post Office

APPENDIX G

HECO Documentation of Electrical Facilities,
Loading, and Selection of Segment Locations

INTEROFFICE CORRESPONDENCE

Hawaiian Electric Co., Inc.

July 21, 2004

To: K. J. Wong

From: E. F. Oshiro

Subject: East Oahu Transmission Project (EOTP) – Phase 1 & 2
Line Loadings for EMF Analysis

Since magnetic fields are a function of line current, an increase in line loading can increase the magnetic fields in an area. HECO evaluated projected power line loadings in 2009 to determine which segments had the greatest increase in current flow after the installation of the EOTP. Enertech Consultants evaluated magnetic field levels at these segments, as well as the segments in which construction would take place. This memo describes the methodology used to determine the line current loadings used in the EMF analysis and the selection of EMF measurement locations.

Load Flow Simulation

Power System Simulator for Engineering (PSS/E) is an integrated, interactive program for simulating, analyzing, and optimizing power system performance. PSS/E is the most comprehensive, technically advanced, and widely used power system simulation computer program. Using electrical system characteristics and forecasted area loads, PSS/E simulates current flow in power lines.

Forecasted Normal Loads

The 2009 normal load is based on the 2003 recorded load demand escalated to 2009. To be more specific, the 2003 load demand for the substations in the study area at the time of the annual system day peak is multiplied by the day peak load growth factor in the HECO August 2002 Long Term Sales and Peak Forecast.

Areas with Line Current Increases

Four areas were determined to have the greatest line current increases although no new lines are planned for construction. These areas are as follows:

- Kapiolani Boulevard between Clayton and Kamakee Streets – Loads currently fed from Pukele Substation are transferred to Archer Substation by the EOTP. The result is an increase in current flow in the 46kV circuits exiting Archer Substation.
- Sheridan Street between Kapiolani Boulevard and Makaloa Substation – Loads currently fed from Pukele Substation are transferred to Archer Substation by the EOTP. The result is an increase in current flow in the 46kV circuits exiting Archer Substation.
- Kapiolani Boulevard between Kamoku and Pumehana Streets – Loads currently fed from Pukele Substation are also transferred to the new transformer at Kamoku

Substation by the EOTP. The result is an increase in line current in the circuit from Kamoku Substation feeding loads in the Ewa direction.

- Date Street near Pumehana Street – The section of 46kV line along Date Street is presently at the end of a circuit. As a result, the load in the circuit is close to zero. With the construction of the EOTP, the connection of the Archer #46 to the Pukele #2 circuit near Date Street makes this segment of subtransmission line the middle of a circuit fed from Archer Substation.

On the HECO system, 138kV transmission lines originate from generating stations and feed 138kV transmission substations. In a radial configuration, such as in the proposed EOTP, 46kV subtransmission lines emanate from 138kV transmission substations and feed transformers at 46kV subtransmission substations downstream. Typically the current loading in these 46kV subtransmission lines is highest closest to the 138kV transmission substation and decreases downstream as loads are fed. Based on this, the identified locations of greatest increase in current flow are reasonable.

25 kV and 12 kV distribution loads were calculated based on the total connected load of service transformers on the circuit at the location where measurements and modeling would be done. Since loading on service transformers is not recorded, it was assumed that all transformers were loaded to their rated values. This represents the most conservative assumption for the EMF analysis.

Pukele Outage Load

If the EOTP is implemented, in the event of the loss of Pukele Substation, all 46kV loads fed from Pukele Substation are transferred to Archer or Kamoku Substations. Current flow for this scenario is represented as the "Pukele Outage Load". 25 kV and 12 kV distribution loads remained the same in the Pukele Outage Load since this already represented the most conservative assumption for the EMF analysis.

Loads at the Time of EMF Measurements

Enertech Consultants measured existing magnetic fields on May 17-18, 2004. 46kV subtransmission line loading at the time of the EMF measurements was determined using recorded data at the hour nearest to the time of measurement. These values were obtained from the ammeter charts located in the substation switchgear or the Energy Management System (EMS) located in the HECO load dispatch center.

Knowing the current reading at the 138kV transmission substations, the source side of the circuit, and the current loading at the connected 46kV subtransmission substations, the current flow in each line segment was calculated.

Similar to the forecasted loads, 25 kV and 12 kV distribution loads were calculated based on the total connected load from service transformers on the circuit at the location where measurements were taken.

Conclusion

The method used to determine forecasted current loading and at the time of the EMF measurements was reasonable and conservative.

Appendix D2

Addendum to Magnetic Field Evaluation

Hawaiian Electric Company

Addendum to
Magnetic Field Evaluation
East Oahu Transmission Project

Prepared for
Hawaiian Electric Company
Honolulu, Hawaii 96840

Prepared by
Enertech Consultants of Santa Clara, Inc.
300 Orchard City Drive, Suite 132
Campbell, California 95008

December 22, 2004

NOTICE

This report was prepared by the organization(s) named below as an account of work sponsored by Hawaiian Electric Company (HECO). Neither Hawaiian Electric Company (HECO), Enertech Consultants, nor any person acting on their behalf: (a) makes any warranty, express or implied, with respect to the use of any information, apparatus, method, or process disclosed in this report or that such use may not infringe privately owned rights; or (b) assumes any liabilities with respect to the use of or for damages resulting from the use of any information, apparatus, method, or process disclosed in this report.

Prepared by
Enertech Consultants of Santa Clara, Inc.
Campbell, California

TABLE OF CONTENTS

Section	Page
Executive Summary	vi
Introduction	1
Description of Alternative Alignments	1
Units of Measure	3
Measurement Equipment	4
Instrumentation Calibration	4
Magnetic Field Measurements at Selected Project Locations	4
Magnetic Field Calculations at Selected Project Locations	5
Computer Modeling Assumptions	11
Review of Selected Institutions Near Proposed Project	11
Magnetic Field Standards	11
Summary and Conclusions	12
References	14

Appendix	Page
A - Diagram of Electrical Facilities at Alternative Alignment Segment Locations	A-1
B - Magnetic Field Measurements at Alternative Alignment Segment Locations	B-1
C - Magnetic Field Profile Calculations at Alternative Alignment Segment Locations	C-1

TABLES

Appendix Table **Page**

Table A-1. Summary of Existing Transmission Line Facilities and Loading Information for Each Alternative Alignment Segment of the Proposed Project A-12

Table A-2. Summary of Proposed Transmission Line Facilities and Loading Information for Each Alternative Alignment Segment of the Proposed Project A-13

Table B-1. Summary of Line Loading for Each Alternative Alignment Segment During Field Measurements B-6

FIGURES

Report Figure **Page**

Figure 1. Diagram of Alternative Alignment Segment Locations 2

Figure 2. Projected Magnetic Field for Segment 'M' Under 2009 Forecasted Normal Loading (Kaheka Street between Makaloa Street and Kapi'olani Boulevard) 6

Figure 3. Projected Magnetic Field for Segment 'N' Under 2009 Forecasted Normal Loading (Kapi'olani Boulevard between Kaheka Street and Kalauokalani Way) 7

Figure 4. Projected Magnetic Field for Segment 'P' Under 2009 Forecasted Normal Loading (Kalauokalani Way between Makaloa Street and Kapi'olani Boulevard) 8

Figure 5. Projected Magnetic Field for Segment 'Q' Under 2009 Forecasted Normal Loading (Kapi'olani Boulevard between Hauoli and Pumehana Streets) 9

Figure 6. Projected Magnetic Field for Segment 'R' Under 2009 Forecasted Normal Loading (Pumehana Street between Kapi'olani Boulevard and Lime Street) 10

FIGURES

Appendix Figure **Page**

Figure A-1. Diagram for the HECO East Oahu Transmission Project With Associated Alternative Alignment Segment Locations A-1
Figure A-4. Measurement Location at Alternative Alignment Segment 'M' A-2
Figure A-5. Diagram of Electrical Facilities at Alternative Alignment Segment 'M' A-3
Figure A-6. Measurement Location at Alternative Alignment Segment 'N' A-4
Figure A-7. Diagram of Electrical Facilities at Alternative Alignment Segment 'N' A-5
Figure A-8. Measurement Location at Alternative Alignment Segment 'P' A-6
Figure A-9. Diagram of Electrical Facilities at Alternative Alignment Segment 'P' A-7
Figure A-10. Measurement Location at Alternative Alignment Segment 'Q' A-8
Figure A-11. Diagram of Electrical Facilities at Alternative Alignment Segment 'Q' A-9
Figure A-12. Measurement Location at Alternative Alignment Segment 'R' A-10
Figure A-13. Diagram of Electrical Facilities at Alternative Alignment Segment 'R' A-11

Appendix Figure **Page**

Figure B-1. Magnetic Field Measurements at Alternative Alignment Segment 'M' B-1
Figure B-2. Magnetic Field Measurements at Alternative Alignment Segment 'N' B-2
Figure B-3. Magnetic Field Measurements at Alternative Alignment Segment 'P' B-3
Figure B-4. Magnetic Field Measurements at Alternative Alignment Segment 'Q' B-4
Figure B-5. Magnetic Field Measurements at Alternative Alignment Segment 'R' B-5

Figure C-1. Magnetic Field Calculations at Alternative Alignment Segment 'M' C-1
Figure C-2. Magnetic Field Calculations at Alternative Alignment Segment 'N' C-2
Figure C-3. Magnetic Field Calculations at Alternative Alignment Segment 'P' C-3
Figure C-4. Magnetic Field Calculations at Alternative Alignment Segment 'Q' C-4
Figure C-5. Magnetic Field Calculations at Alternative Alignment Segment 'R' C-5

EXECUTIVE SUMMARY

Hawaiian Electric Company (HECO) has proposed the construction of a new transmission system project, entitled the East Oahu Transmission Project. This project involves the installation of several new underground 46 kV subtransmission lines and transformers. As a result of this proposed installation, some existing electrical facilities (such as 12 kV, 25 kV and 46 kV underground and overhead distribution lines) may be eliminated, remain unchanged, or may increase or decrease in loading. The results of this evaluation are presented in a main report entitled "East Oahu Transmission Project - Magnetic Field Evaluation", dated July 22, 2004 (the "Magnetic Field Evaluation").

This addendum to the Magnetic Field Evaluation evaluates magnetic field levels associated with two alternative alignments for Phase 1 of the East Oahu Transmission Project. Based upon this evaluation of the two alternative alignments, the following conclusions were reached:

Existing magnetic field levels from HECO facilities along the two alternative alignments are typical of levels from similar facilities throughout the State of Hawaii.

Magnetic field measurements were conducted at five selected segments along the two alternative alignments to characterize field strengths due to existing electrical facilities. Existing magnetic field levels along these segments range from a few tenths of a mG to about 4.3 mG, depending upon location. Existing electric facilities surveyed included 12 kV, 25 kV, 46 kV, and 138 kV power line facilities.

Along the two alternative alignments, the difference in projected magnetic field levels between the existing and proposed power line configurations under 2009 forecasted loading will increase for each segment evaluated.

In addition to field measurements, magnetic field levels were also calculated for 2009 forecasted normal and Pukele outage conditions for five different project segments along the two alternative alignments. The difference in projected magnetic field levels between the existing and proposed power line configurations under forecasted 2009 normal loading will increase due to the two additional 46 kV underground circuits along each alternate segment. Under proposed 2009 normal load conditions, the maximum calculated magnetic field on the two alternative alignments occurs directly above the two proposed 46 kV underground circuits for each segment. Under proposed 2009 Pukele outage conditions, the projected magnetic field on the two alternative alignments again increases at all segment locations. While magnetic field increases typically occur within street locations, projected magnetic field levels can also increase at sidewalk locations (depending upon the proposed project location within the street).

There are no institutions along the two alternative alignments which would experience an effect on EMF levels from the proposed underground circuits if the project is implemented.

In the Magnetic Field Evaluation, Enertech evaluated present and future magnetic field levels at various institutions along the proposed project. Institutions which were reviewed included day care centers, pre-schools and schools, hospitals, churches, and retirement homes. No such institutions have been identified along the two alternative alignments evaluated in this addendum report.

There are no Federal or State of Hawaii health standards for 60 Hertz magnetic fields.

Although there are no Federal health standards in the United States specifically for 60 Hertz magnetic fields, two organizations have developed guidelines or limits: the International Commission on Non-Ionizing Radiation Protection and the American Conference of Governmental Industrial Hygienists. The measured and projected magnetic field levels associated with the two alternative alignments evaluated in this addendum are far below these guidelines or limits.

There are at least two states that have adopted "status quo" engineering standards for magnetic fields. The purpose of most of these standards is to make the field levels from new power lines similar to the field levels from existing overhead transmission lines. The measured and projected magnetic field levels associated with the two alternative alignments evaluated in this addendum are well below these other state standards.

INTRODUCTION

Hawaiian Electric Company (HECO) has proposed the construction of a new power line[1] project, entitled the East Oahu Transmission Project. This project involves the installation of several new underground 46 kV power lines and transformers. This proposed action would allow HECO to transfer electrical loads between substations serving high-demand areas of the island, addressing existing and future transmission problems. As a result of this proposed installation, some existing electrical facilities (such as 12 kV, 25 kV and 46 kV underground and overhead power lines) along portions of the project and beyond may be eliminated, remain unchanged, or may increase or decrease their loading.

HECO retained Enertech Consultants to evaluate the magnetic field levels associated with this proposed project. This evaluation included magnetic field measurements along selected segments of the proposed project line, magnetic field calculations for these segments for both existing and proposed power line configurations, assessment of existing HECO facilities, identification of nearby environments to the proposed project, and magnetic field measurements in common, everyday locations around the Honolulu project area. The results of this evaluation are presented in a main report entitled "East Oahu Transmission Project - Magnetic Field Evaluation", dated July 22, 2004 (the "Magnetic Field Evaluation").

Enertech Consultants prepared this addendum report to evaluate magnetic field levels associated with the two alternative alignments considered for a portion of Phase 1 of the East Oahu Transmission Project. This addendum evaluates both existing and proposed power line configurations along the two alternative alignments. The evaluation in this addendum uses the same measurement equipment, instrumentation calibration and computer modeling assumptions as were used in the Magnetic Field Evaluation. These evaluation results are presented in this addendum report.

DESCRIPTION OF ALTERNATIVE ALIGNMENTS

The East Oahu Transmission Project is described on page one of the Magnetic Field Evaluation. The two alternative alignments for "Phase 1" of the East Oahu Transmission Project, which are the subject of this addendum report, are described below.

Alternative Alignment 1

From the Makaloa Substation, the circuits in new ductline would exit the substation to Makaloa Street, proceed in the Diamond Head direction until Kaheka Street, continue on Kaheka Street in the makai direction to Kapi'olani Boulevard and proceed in the Diamond Head direction on Kapi'olani Boulevard to Pumehana Street. At Pumehana Street, the circuits in new ductline would then proceed in the mauka direction to Lime Street at the McCully Substation. This alignment is depicted by the purple line in Figure 1.

[1] The term "power lines" is used generically to describe transmission, subtransmission and distribution lines.

Alternative Alignment 2

From the Makaloa Substation, the circuits in new ductline would exit the substation to Makaloa Street, proceed in the Diamond Head direction to Kalauokalani Way, continue on Kalauokalani Way in the makai direction to Kapi'olani Boulevard, and then proceed in the Diamond Head direction on Kapi'olani Boulevard to Pumehana Street. At Pumehana Street, the circuits in new ductline would then proceed in the mauka direction to Lime Street at the McCully Substation. This alignment is depicted by the red line in Figure 1.

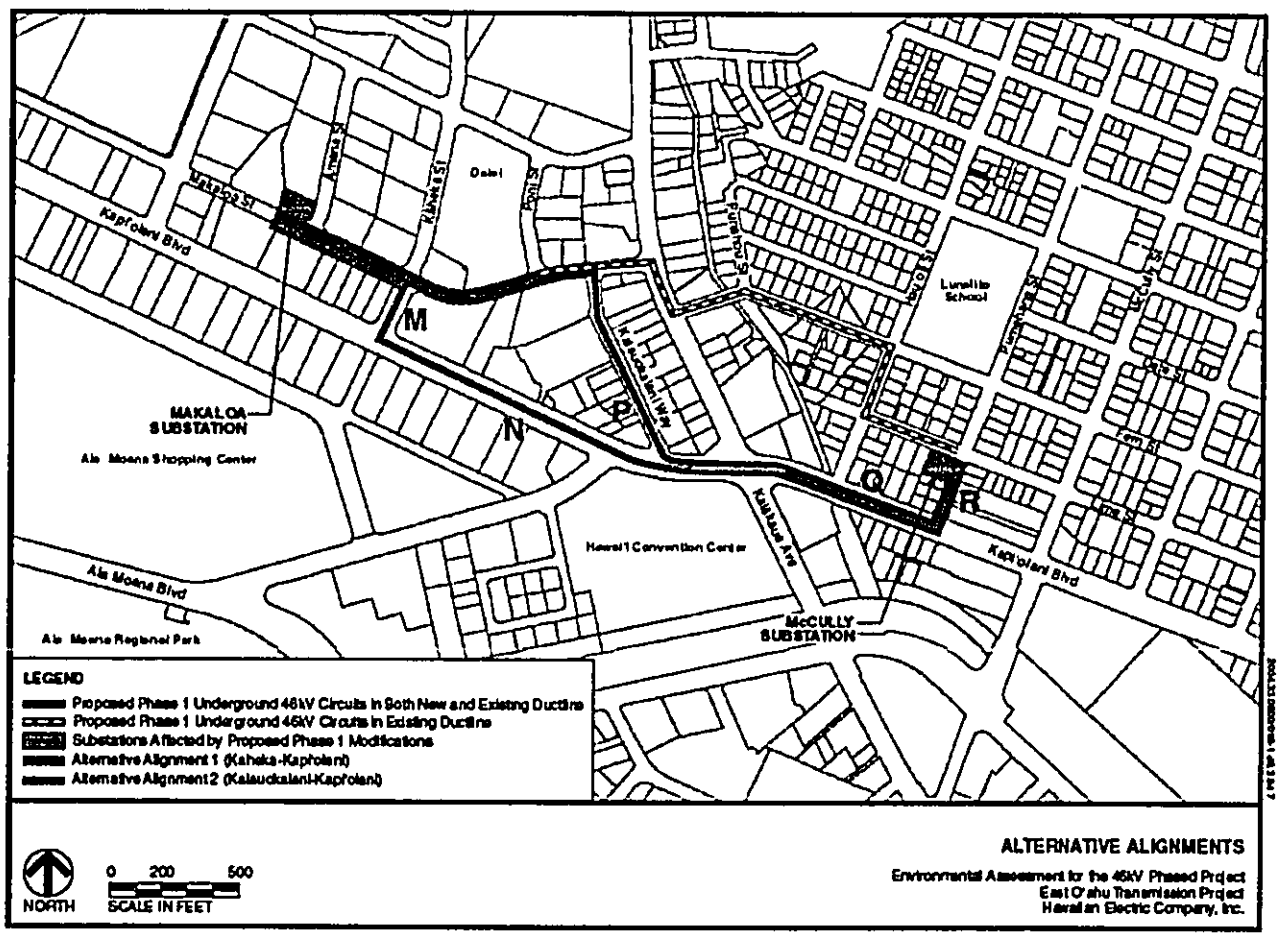


Figure 1. Diagram of Alternative Alignment Segment Locations

This addendum report evaluates five specific segments along Alternative Alignment 1 and Alternative Alignment 2. These five segment locations, identified as segments 'M' through 'R', are shown on Figure 1. The proposed electrical modifications which would be implemented for the alternative alignments are further described below.

- Segment 'M' – Kaheka Street between Makaloa Street and Kapi'olani Boulevard: Two new 46 kV underground power lines would be installed in a new duct, while five existing 12 kV underground power lines would remain.
- Segment 'N' – Kapi'olani Boulevard between Kaheka Street and Kalauokalani Way: Two new 46 kV underground power lines would be installed in a new duct, while three existing 12 kV and one existing 138 kV and four existing 25 kV underground power lines would remain.
- Segment 'P' - Kalauokalani Way between Makaloa Street and Kapi'olani Boulevard: Two new 46 kV underground power lines would be installed in a new duct, while an existing 12 kV overhead power line would remain.
- Segment 'Q' – Kapi'olani Boulevard between Hauoli and Pumehana Streets: Two new 46 kV underground power lines would be installed in a new duct, while four existing 12 kV and one existing 138 kV and two existing 25 kV underground power lines would remain, one existing 46 kV overhead circuit and one existing 12 kV overhead circuit would also remain.
- Segment 'R' – Pumehana Street between Kapi'olani Boulevard and Lime Street: Two new 46 kV underground power lines would be installed in a new duct, while six existing 12 kV underground power lines would remain, one existing 46 kV overhead circuit and one existing 12 kV overhead circuit would also remain.

Maps of the various alternate project segments (identified by its respective letter) are presented in Appendix A. A detailed diagram of each segment, showing the existing and proposed electrical facilities at each segment, is also included in Appendix A.

UNITS OF MEASURE

This addendum report evaluates magnetic fields using the milligauss (mG), equal to one-thousandth of a gauss (i.e., 1 mG = 0.001 G), as the unit of measure. This same unit of measure was also used in the Magnetic Field Evaluation.

MEASUREMENT EQUIPMENT

An EMDEX II Magnetic Field Digital Exposure Meter was used to record power-frequency (60 Hertz) magnetic field levels of the overhead and underground power lines and substation electrical equipment. The EMDEX II is a computer-controlled, three-axis, AC exposure meter. Each of the three-axis sensors measures the magnetic field and the on-board computer calculates a resultant field value (the resultant is comparable to a maximum field value and is calculated as the square root of the sum of the squares for all three orthogonal axes (B_r=SQRT[$B_x^2 + B_y^2 + B_z^2$]). The data are stored in the computer's memory and downloaded to a personal computer for analysis following the measurement session. In addition, an LCD digital display on the EMDEX II allows the user to see the magnetic field data, as they are stored in the computer's memory. The EMDEX II meter has a range of 0.1 milliGauss (mG) up to 3,000 mG (3 Gauss). The EMDEX II recorded the magnetic field at a sample rate of once every 1.5 seconds. The accuracy of the EMDEX II meter is $\pm$ 2%.

INSTRUMENTATION CALIBRATION

All magnetic field instruments were calibrated using a 91-centimeter (cm) diameter Helmholtz coil in the Enertech research laboratory. Vertical magnetic fields are generated with magnitudes ranging from 0.5 mG to 1,000 mG and with absolute accuracy of $\pm$2 percent above 10 mG and $\pm$15 percent at 1 mG. Meters were calibrated in accordance with 1994 IEEE/ANSI Standards (IEEE 1994).

MAGNETIC FIELD MEASUREMENTS AT SELECTED PROJECT LOCATIONS

This addendum evaluates five segments along the two alternative alignments for Phase 1 of the East Oahu Transmission Project, which were selected to represent various changes which would result from construction of the project along the two alternative alignments. Magnetic field measurements were conducted at each of these five segments to characterize existing field strengths due to existing electrical facilities. Measurements were conducted as lateral profile measurements (from curb to curb) across each of the five locations on November 16, 2004. Appendix B presents graphs of the measured magnetic fields as a function of distance for each segment location.

Existing magnetic field levels range from a few tenths of a mG to about 4.3 mG, depending upon location. Existing electric facilities surveyed included overhead and underground 12 kV distribution lines, underground 25 kV distribution lines, overhead 46 kV subtransmission lines, and underground 138 kV transmission lines along the two alternative alignments. For street and sidewalk locations with overhead power lines, measured magnetic fields typically ranged from about 1.5 mG to about 2.5 mG. Street and sidewalk locations with underground power lines typically ranged from about 0.5 mG to 4.3 mG directly above the underground power line in the street.

MAGNETIC FIELD CALCULATIONS AT SELECTED PROJECT LOCATIONS

In addition to field measurements, magnetic field calculations were also performed for each of the five segments along the two alternative alignments. Transmission line computer models were developed using the software program "ENVIRO", which is a module within EPRI's EMFWorkstation program. ENVIRO models the magnetic fields in and around transmission and distribution lines. The ENVIRO software allows the user to enter transmission line configuration information and other parameters into the program and then calculates lateral profiles for power-frequency magnetic fields at designated locations. Results obtained with computer models have been compared with measurement data for operating power lines and calculation accuracy has been evaluated. Typically, the computer model will calculate field values to within ±5% of actual field measurements.

HECO provided existing power line geometry and loading information. Circuit routing for the existing and proposed underground lines were provided as HECO drawings. Overhead line geometry was provided by HECO standard power line drawings. Magnetic field calculations were performed for the existing power line configuration (if the proposed project were not constructed), as well as for the proposed power line configuration. For the existing power line configuration, calculations were performed using a forecasted 2009 normal loading condition. For the proposed project power line configuration, calculations were performed using two forecasted 2009 loading conditions: normal and Pukele outage condition. As defined by HECO, "normal load" means the power line loads at the time of the forecasted system peak load with the HECO transmission system under normal, all lines in-service, state. "Pukele outage condition" means the power line loads at the time of the forecasted system peak load with the Pukele Substation out of service. Details for determining the loading values for power lines within each segment were determined by HECO. Calculations were performed for each line configuration and load condition at a calculation height of 1 meter above ground level (3.28 feet), in accordance with IEEE Standards (IEEE 1994). Calculations were performed assuming that both Phase 1 and Phase 2 of the proposed project are implemented.

The difference in projected magnetic field levels between the existing and proposed power line configurations under forecasted 2009 normal loading will increase due to the two additional 46 kV underground circuits along each of the five segments evaluated in this addendum report. Figures 2 through 6 present the calculated magnetic field results for each segment under normal loading conditions for both the existing and proposed power line configurations. Under proposed 2009 normal load conditions, the maximum calculated magnetic field (of about 23 mG) occurs directly above the two proposed 46 kV underground circuits for each of the five segments evaluated. While magnetic field increases typically occur within street locations, projected magnetic field levels can also increase at sidewalk locations. The location of the proposed 46 kV underground duct within the street for each segment influences the amount of field increase at sidewalk locations. Under proposed 2009 Pukele outage conditions, the projected magnetic field increases (to about 57 mG) for each of the five segments evaluated. Again, the magnetic field increases primarily occur within street locations but can also influence projected magnetic field levels at sidewalk locations

(depending upon the proposed 46 kV duct location within the street). Appendix C presents graphs of the projected magnetic field as a function of distance for each segment location. Appendix A contains a summary table of the projected 2009 loading values used for each of the power lines at each segment.

SEGMENT 'M'

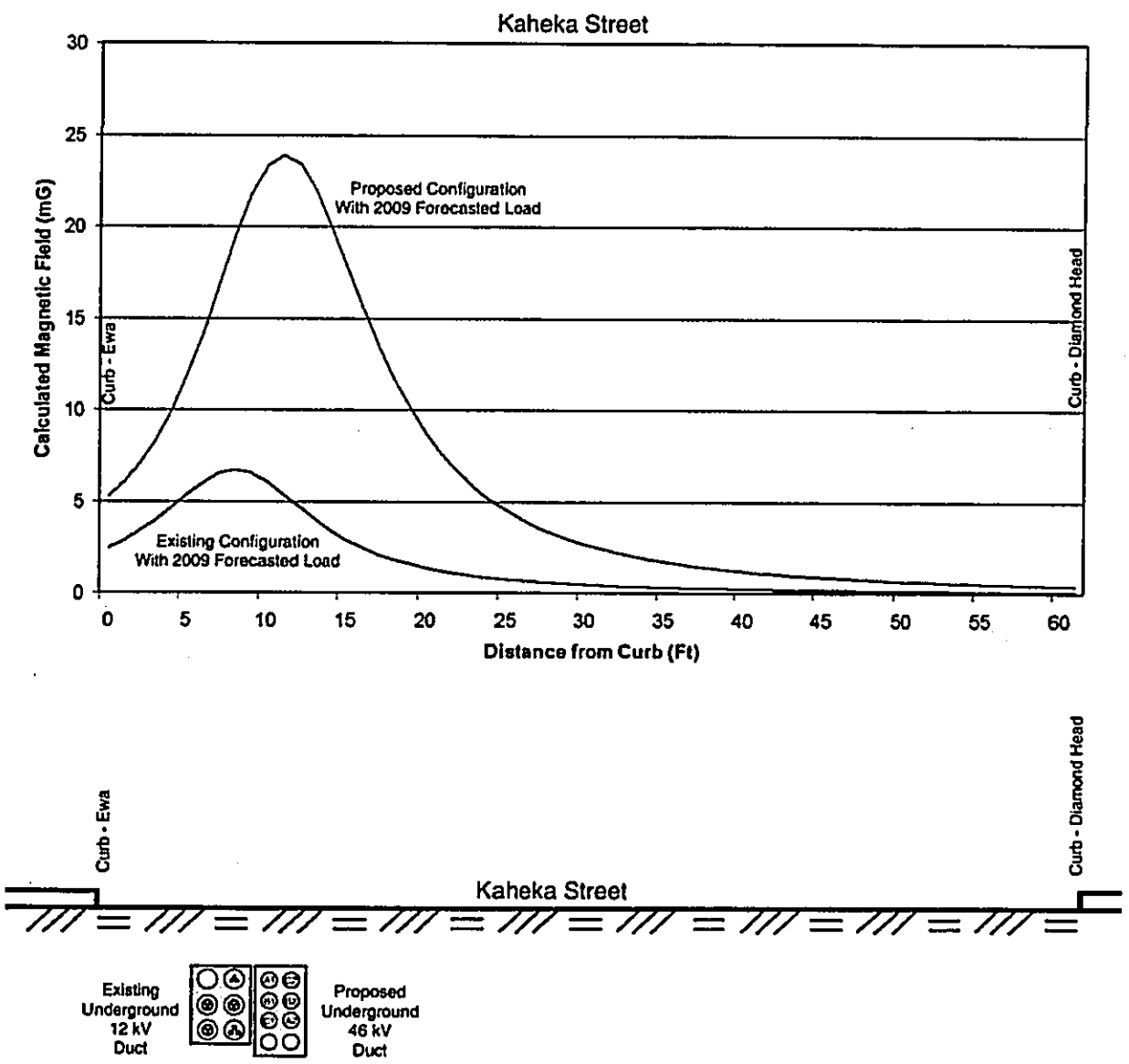


Figure 2. Projected Magnetic Field for Segment 'M' Under 2009 Forecasted Normal Loading (Kaheka Street between Makaloa Street and Kapi'olani Boulevard)

SEGMENT 'N'

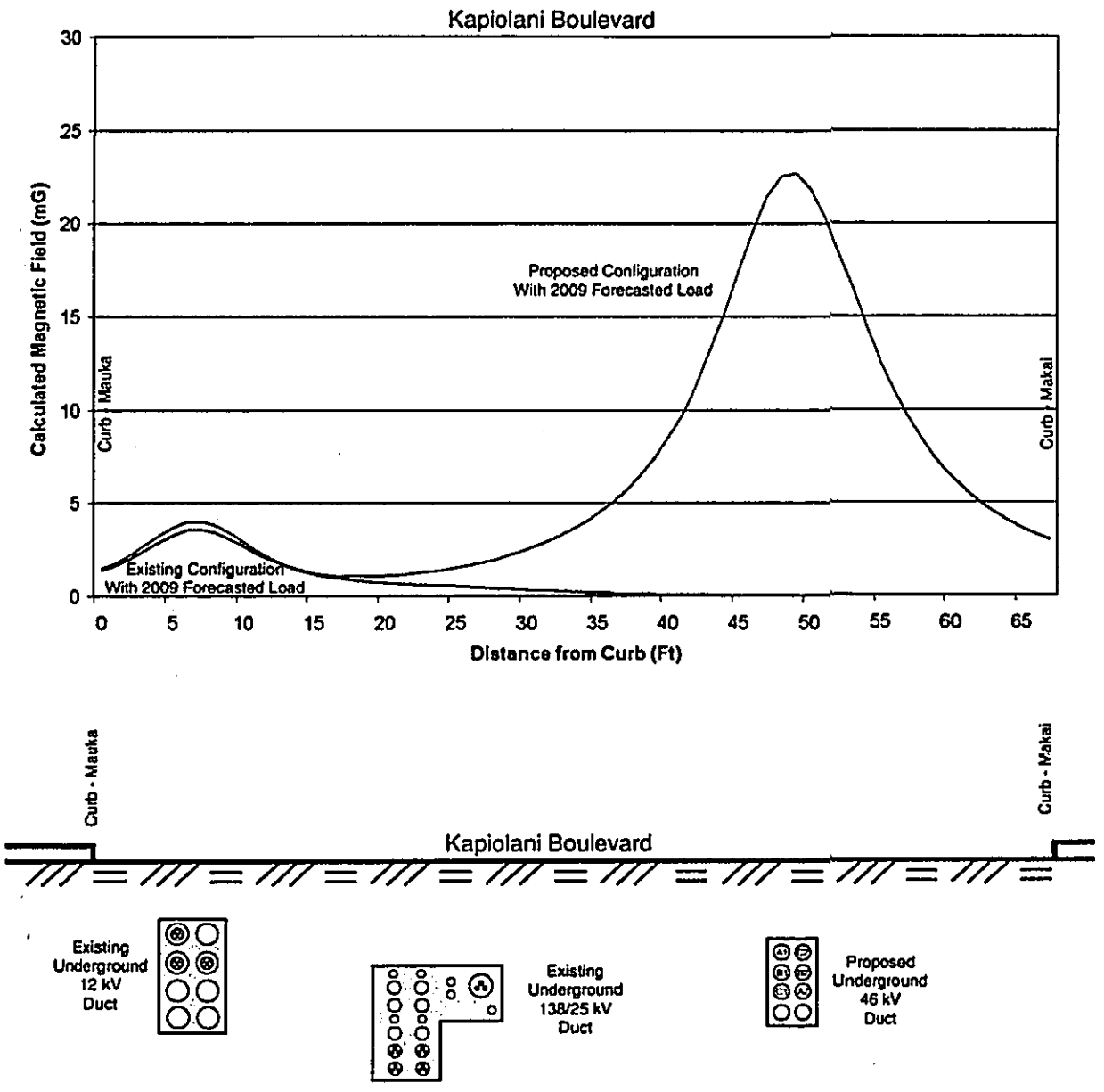


Figure 3. Projected Magnetic Field for Segment 'N' Under 2009 Forecasted Normal Loading (Kapi'olani Boulevard between Kaheka Street and Kalauokalani Way)

SEGMENT 'P'

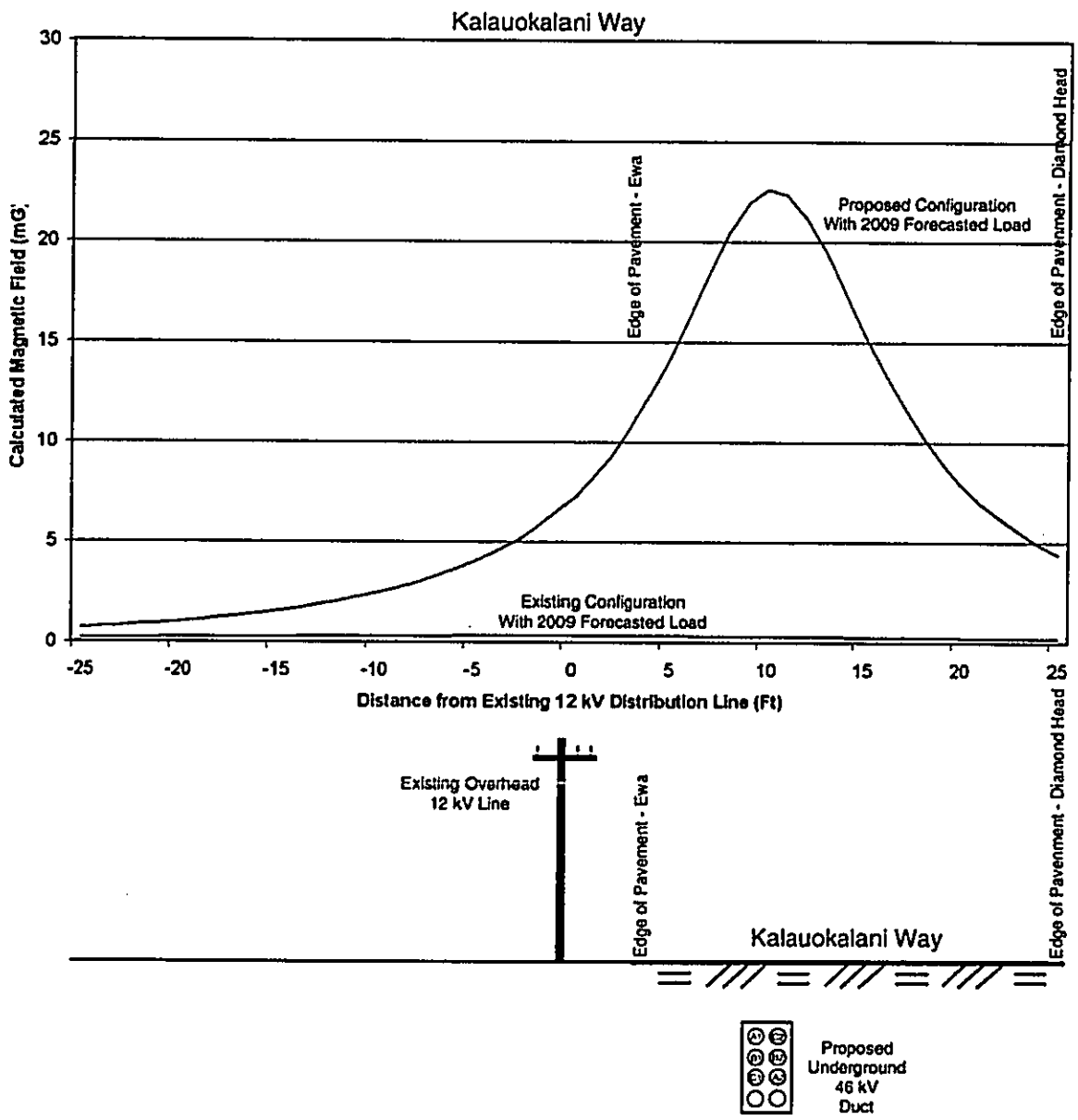


Figure 4. Projected Magnetic Field for Segment 'P' Under 2009 Forecasted Normal Loading (Kalauokalani Way between Makaloa Street and Kapi'olani Boulevard)

SEGMENT 'Q'

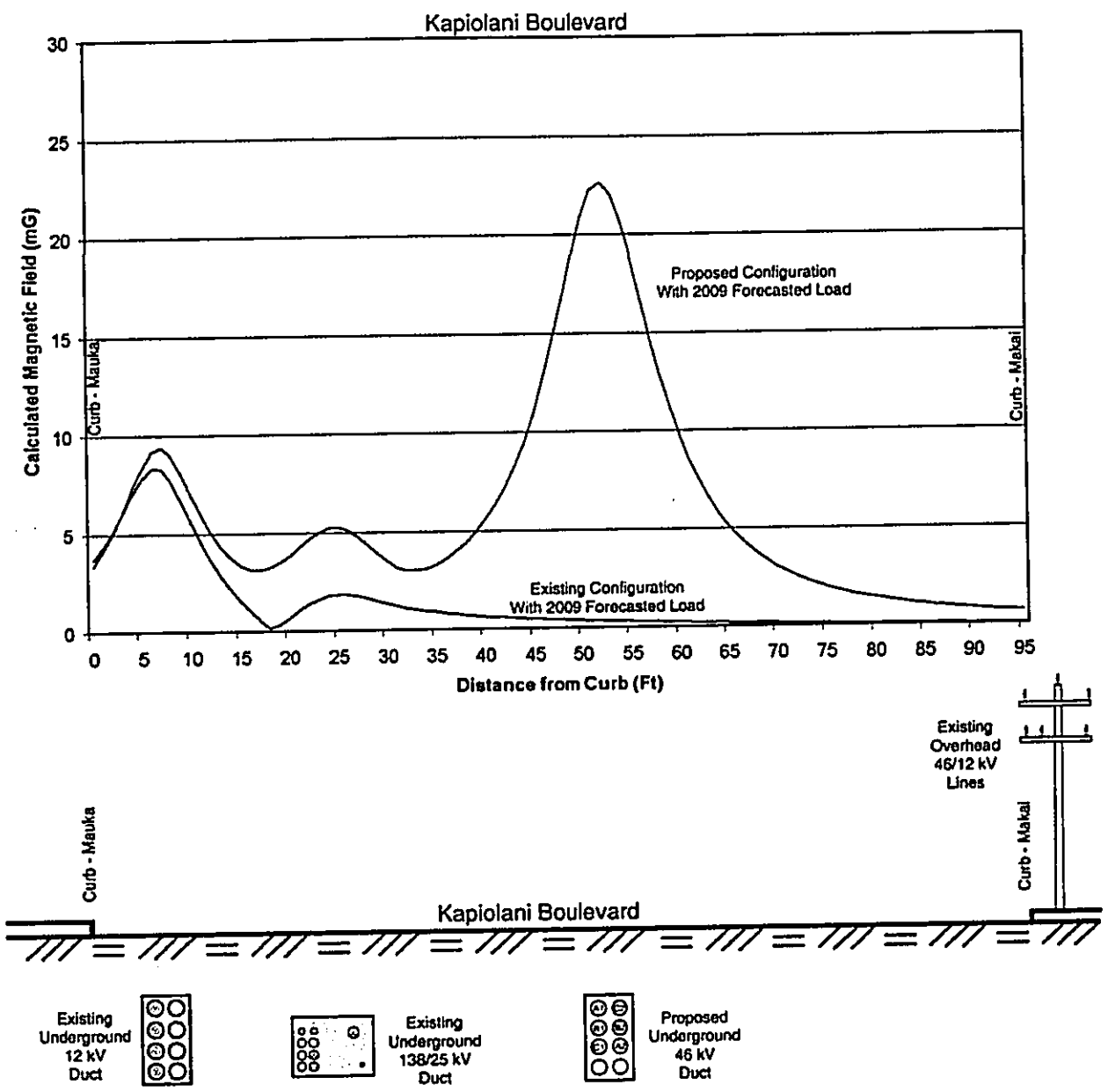


Figure 5. Projected Magnetic Field for Segment 'Q' Under 2009 Forecasted Normal Loading (Kapi'olani Boulevard between Hauoli and Pumehana Streets)

SEGMENT 'R'

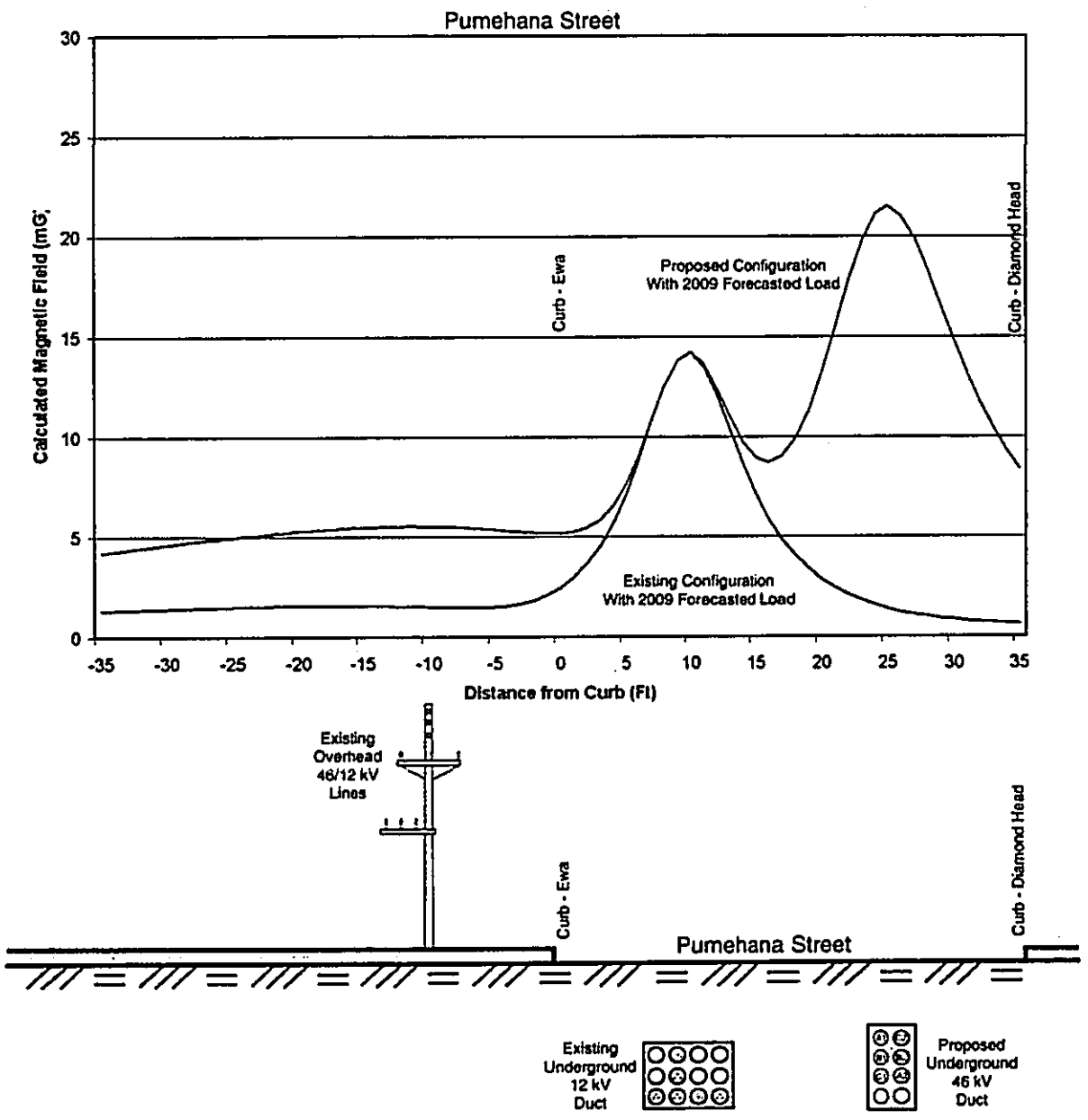


Figure 6. Projected Magnetic Field for Segment 'R' Under 2009 Forecasted Normal Loading (Pumehana Street between Kapi'olani Boulevard and Lime Street)

COMPUTER MODELING ASSUMPTIONS

Projected magnetic field levels are based upon computer modeling of the line design for the existing and proposed HECO electrical equipment which simulate a real world environment. Enertech has assumed that both Phase 1 and Phase 2 of the East Oahu Transmission Project will be implemented.

While computer modeling is very accurate in calculating magnetic field levels, the computer model contains certain assumptions. For example, the computer model assumes balanced three-phase currents on all of the underground and overhead transmission and distribution circuits. However, there may be some load unbalance or net current on a circuit. An unbalanced current (or net current) can create higher magnetic field levels than projected, and can attenuate much more slowly than magnetic fields from balanced sources. Ground currents can also exist, where electrical current can flow along metallic objects, such as underground steel conduits or pipes. Specific magnitudes for phase angles on a circuit are assumed to be exactly 120-degrees out of phase from each other, and are also assumed to be uniform across circuits. Many of these parameters can vary or are unknown (such as the presence of small load-carrying underground conductors), and therefore may not be included within the computer model. The methods used for the computer modeling are reasonable for a practical characterization of magnetic field levels.

REVIEW OF SELECTED INSTITUTIONS NEAR PROPOSED PROJECT

In the Magnetic Field Evaluation, Enertech evaluated present and future magnetic field levels at various institutions along the proposed project. Institutions which were reviewed included day care centers, pre-schools and schools, hospitals, churches, and retirement homes. No such institutions have been identified along the two alternative alignments evaluated in this addendum report.

MAGNETIC FIELD STANDARDS

As discussed on page 36 and as summarized in Table 14 of the Magnetic Field Evaluation, there are at least two states that have adopted "status quo" engineering standards for magnetic fields (NIEHS 2002). The purpose of most of these standards is to make the field levels from new power lines similar to the field levels from existing overhead transmission lines. The measured and projected magnetic field levels associated with each of the five segments along the two alternative alignments are well below these standards.

As discussed on pages 36 - 37 and as summarized in Tables 15 and 16 of the Magnetic Field Evaluation, there are no Federal health standards in the United States specifically for 60 Hertz magnetic fields. Two organizations have developed guidelines or limits: the International Commission on Non-Ionizing Radiation Protection (ICNIRP 1998) and the American Conference of Governmental Industrial Hygienists (ACGIH 2003). The measured and projected magnetic field

levels associated with each of the five segments along the two alternative alignments are far below the guidelines or limits.

SUMMARY AND CONCLUSIONS

Hawaiian Electric Company (HECO) has proposed the construction of a new transmission system project, entitled the East Oahu Transmission Project. This project involves the installation of several new underground 46 kV subtransmission lines and transformers. As a result of this proposed installation, some existing electrical facilities (such as 12 kV, 25 kV and 46 kV underground and overhead distribution lines) may be eliminated, remain unchanged, or may increase or decrease in loading. The results of this evaluation are presented in a main report entitled "East Oahu Transmission Project - Magnetic Field Evaluation", dated July 22, 2004 (the "Magnetic Field Evaluation").

This addendum to the Magnetic Field Evaluation evaluates magnetic field levels associated with two alternative alignments for Phase 1 of the East Oahu Transmission Project. Based upon this evaluation of the two alternative alignments, the following conclusions were reached:

Existing magnetic field levels from HECO facilities along the two alternative alignments are typical of levels from similar facilities throughout the State of Hawaii.

Magnetic field measurements were conducted at five selected segments along the two alternative alignments to characterize field strengths due to existing electrical facilities. Existing magnetic field levels along these segments range from a few tenths of a mG to about 4.3 mG, depending upon location. Existing electric facilities surveyed included 12 kV, 25 kV, 46 kV, and 138 kV power line facilities.

Along the two alternative alignments, the difference in projected magnetic field levels between the existing and proposed power line configurations under 2009 forecasted loading will increase for each segment evaluated.

In addition to field measurements, magnetic field levels were also calculated for 2009 forecasted normal and Pukele outage conditions for five different project segments along the two alternative alignments. The difference in projected magnetic field levels between the existing and proposed power line configurations under forecasted 2009 normal loading will increase due to the two additional 46 kV underground circuits along each alternate segment. Under proposed 2009 normal load conditions, the maximum calculated magnetic field on the two alternative alignments occurs directly above the two proposed 46 kV underground circuits for each segment. Under proposed 2009 Pukele outage conditions, the projected magnetic field on the two alternative alignments again increases at all segment locations. While magnetic field increases typically occur within street locations, projected magnetic field levels can also increase at sidewalk locations (depending upon the proposed project location within the street).

There are no institutions along the two alternative alignments which would experience an effect on EMF levels from the proposed underground circuits if the project is implemented.

In the Magnetic Field Evaluation, Enertech evaluated present and future magnetic field levels at various institutions along the proposed project. Institutions which were reviewed included day care centers, pre-schools and schools, hospitals, churches, and retirement homes. No such institutions have been identified along the two alternative alignments evaluated in this addendum report.

There are no Federal or State of Hawaii health standards for 60 Hertz magnetic fields.

Although there are no Federal health standards in the United States specifically for 60 Hertz magnetic fields, two organizations have developed guidelines or limits: the International Commission on Non-Ionizing Radiation Protection and the American Conference of Governmental Industrial Hygienists. The measured and projected magnetic field levels associated with the two alternative alignments evaluated in this addendum are far below these guidelines or limits.

There are at least two states that have adopted "status quo" engineering standards for magnetic fields. The purpose of most of these standards is to make the field levels from new power lines similar to the field levels from existing overhead transmission lines. The measured and projected magnetic field levels associated with the two alternative alignments evaluated in this addendum are well below these other state standards.

REFERENCES

ACGIH 2003. "Threshold Limit Values for Chemical Substances and Physical Agents", American Conference of Governmental Industrial Hygienists (ACGIH), Cincinnati, 2003.

ICNIRP 1998. "Guidelines for Limiting Exposure to Time-Varying Electric, Magnetic, and Electromagnetic Fields (Up To 300 Hz)", International Commission on Non-Ionizing Radiation Protection (ICNIRP), Health Physics, 74: 494-522, 1998.

IEEE 1994. "IEEE Standard Procedures for Measurement of Power Frequency Electric and Magnetic Fields from AC Power Lines", IEEE Std 644-1994, Institute of Electrical and Electronics Engineers, 1994.

NIEHS 2002. "EMF Questions and Answers", EMF Rapid Program Booklet, NIEHS, 2002.

APPENDICES

APPENDIX A

Diagram of Electrical Facilities
at Alternative Alignment Segment Locations

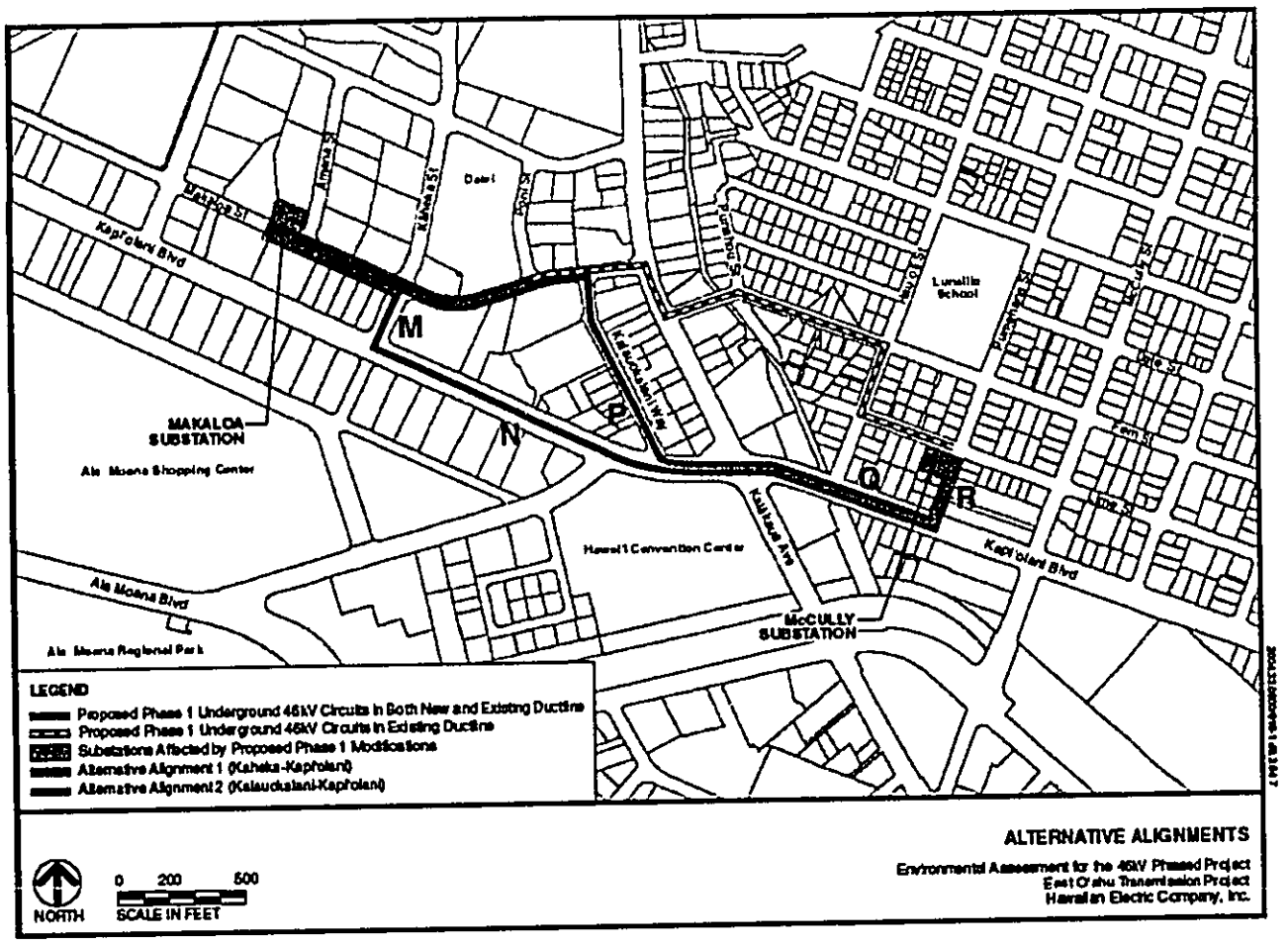


Figure A-1. Diagram for the HECO East Oahu Transmission Project
With Alternative Alignment Segment Locations

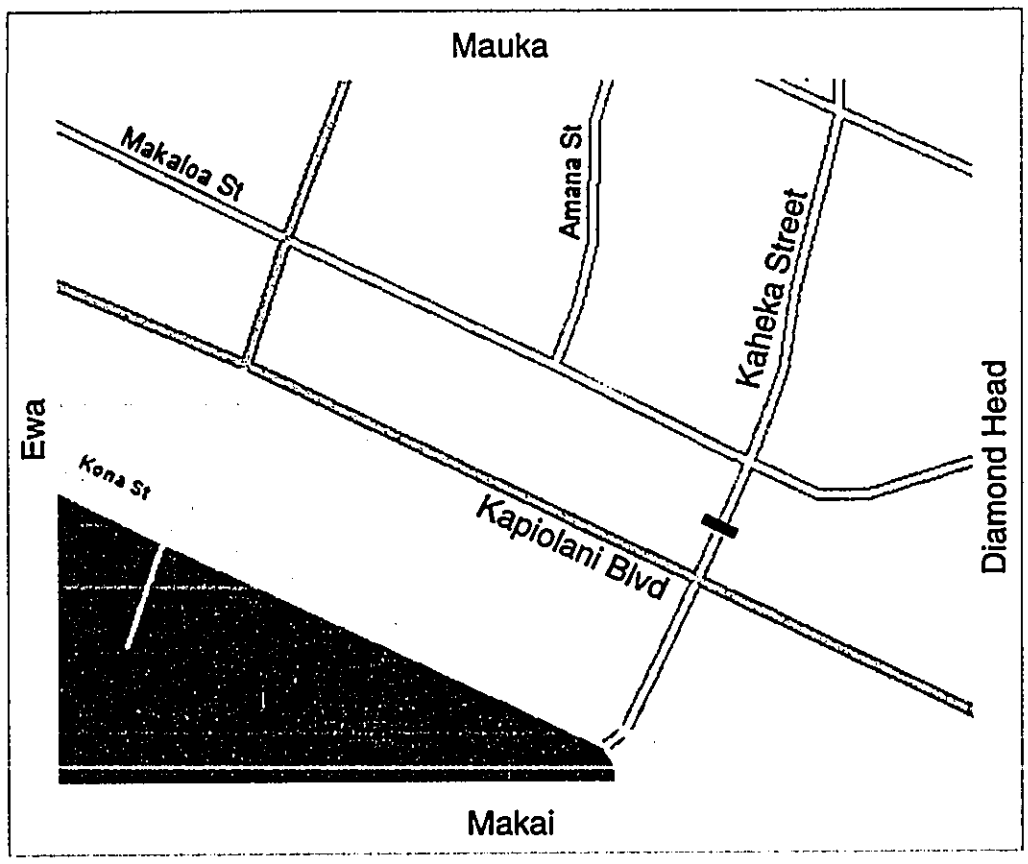
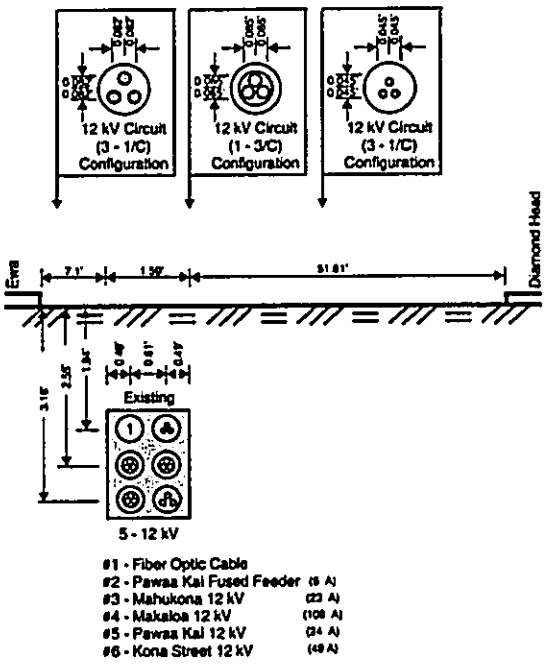
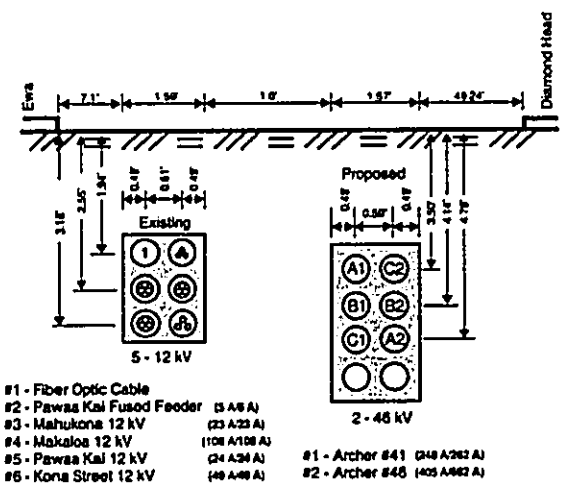


Figure A-2. Measurement Location at Alternative Alignment Segment 'M'
(Kaheka Street between Makaloa Street and Kapi'olani Boulevard)



Note : Phase A = 0 Degrees, Phase B = -120 Degrees, Phase C = 120 Degrees
Loading : Black = Normal Load
Bold = Pukele Outage Load
+ Value = Load Flow Toward Viewer (Out of Page)
- Value = Load Flow Away From Viewer (Into Page)



EXISTING **PROPOSED**

SEGMENT 'M'

Kaheka Street between Makaloa Street & Kapiolani Boulevard

Figure A-3. Diagram of Electrical Facilities at Alternative Alignment Segment 'M'
(Kaheka Street between Makaloa Street and Kapi'olani Boulevard)

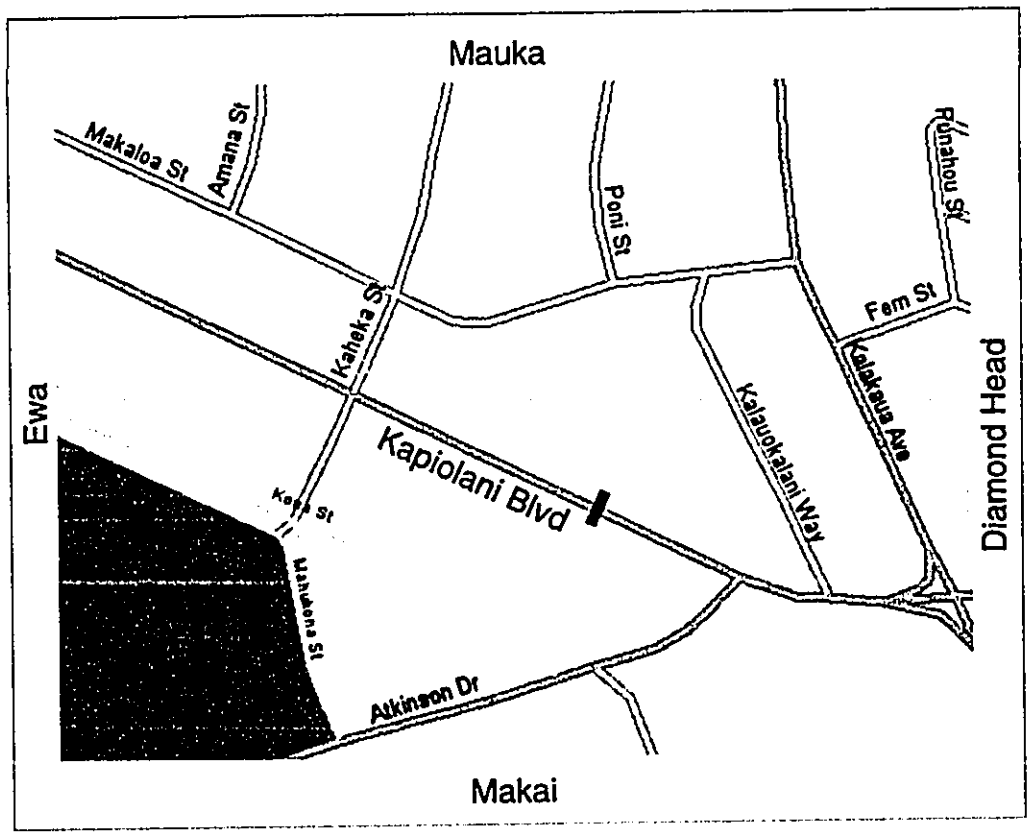
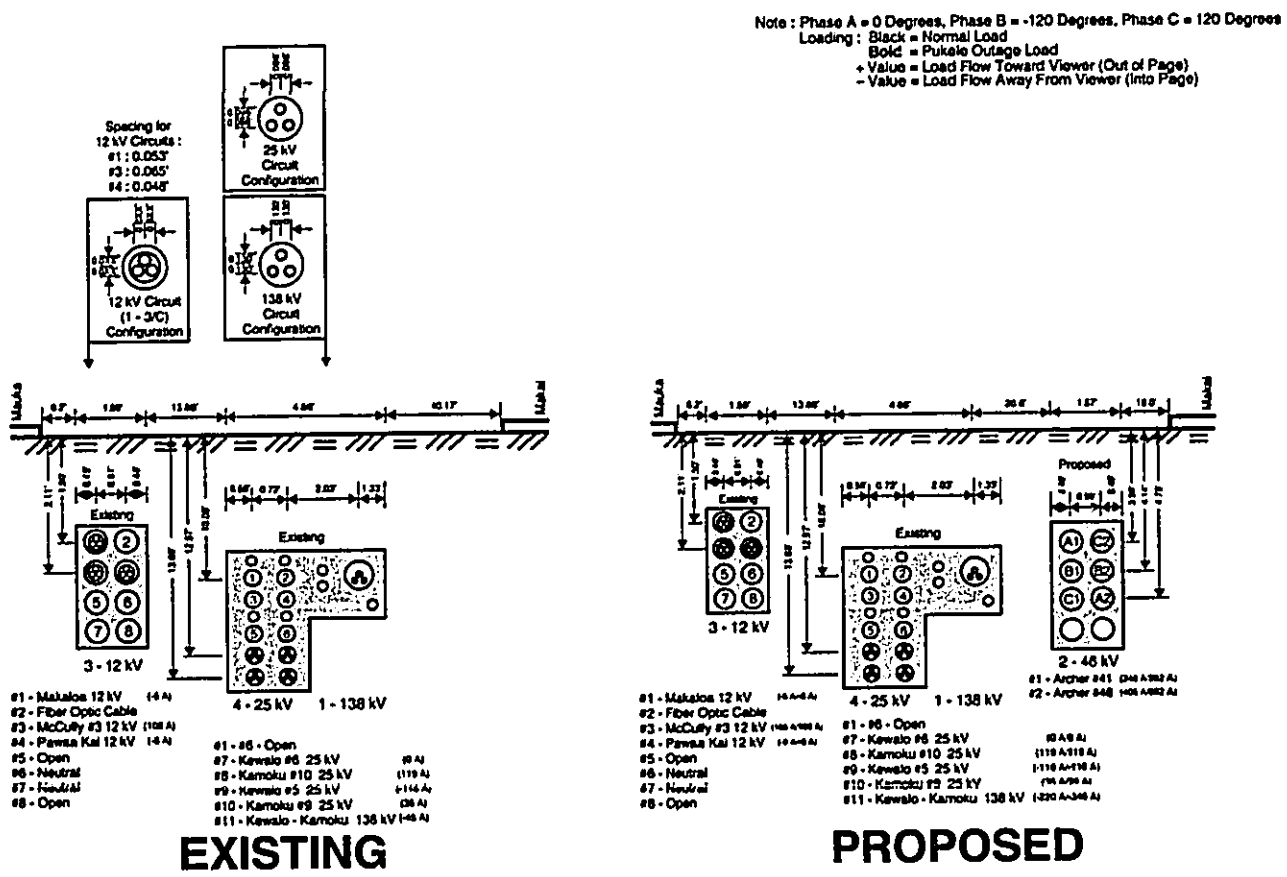


Figure A-4. Measurement Location at Alternative Alignment Segment 'N' (Kapi'olani Boulevard between Kaheka Street and Kalauokalani Way)



SEGMENT 'N'

Kapiolani Boulevard between Kaheka Street and Kalauokalani Way

Figure A-5. Diagram of Electrical Facilities at Alternative Alignment Segment 'N' (Kapi'olani Boulevard between Kaheka Street and Kalauokalani Way)

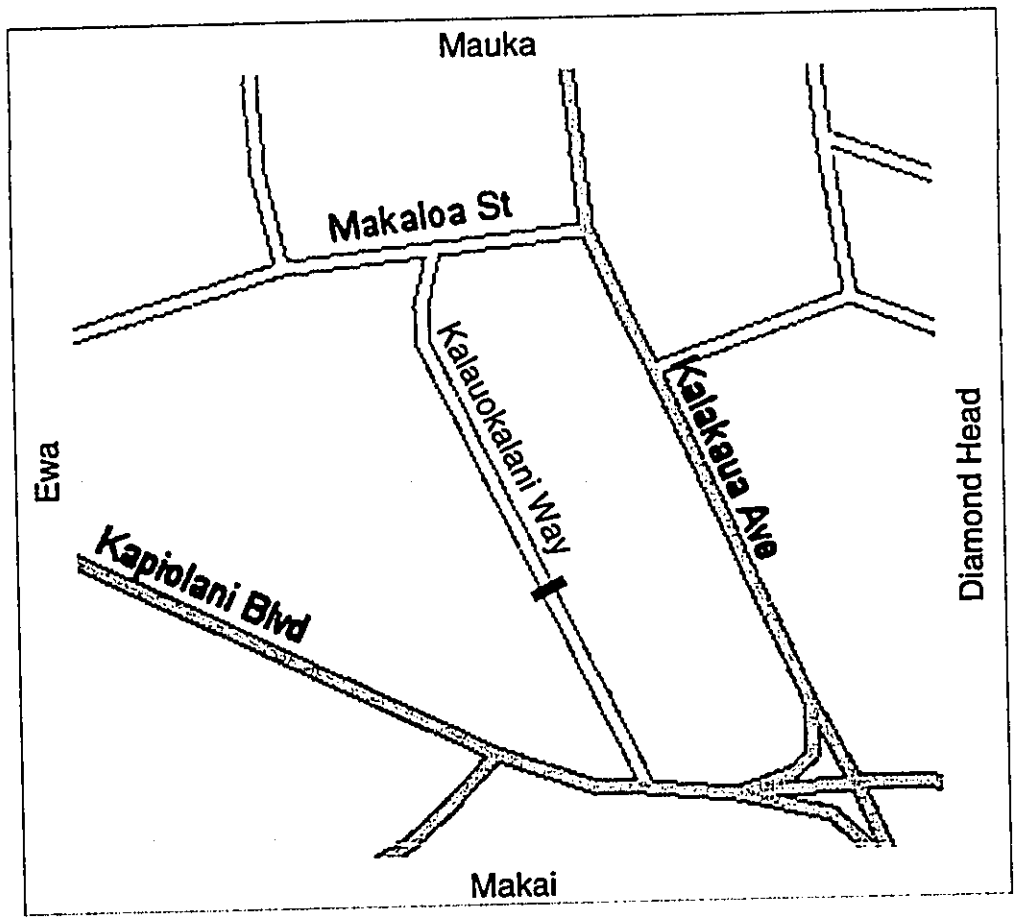
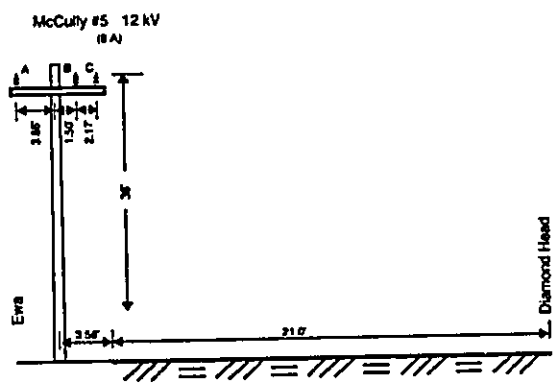
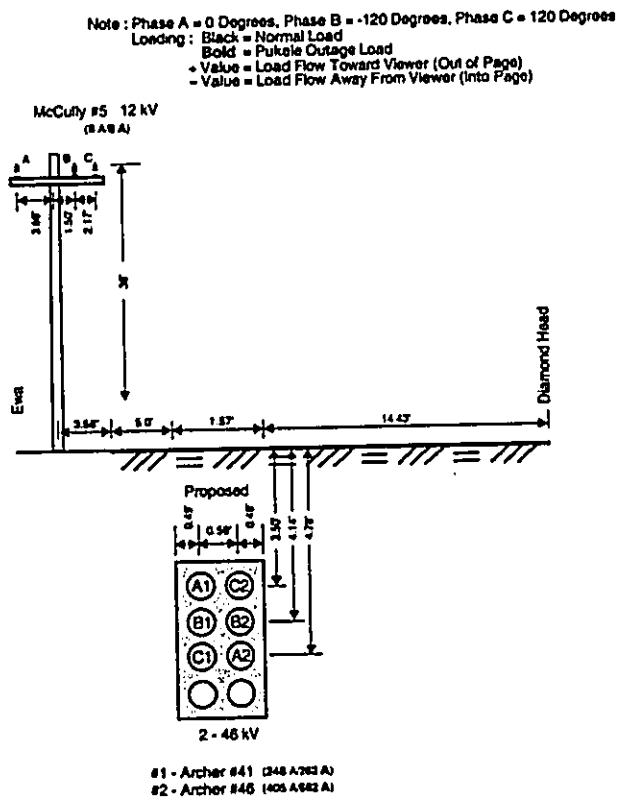


Figure A-6. Measurement Location at Alternative Alignment Segment 'P' (Kalauokalani Way between Makaloa Street and Kapi'olani Boulevard)





EXISTING **PROPOSED**

SEGMENT 'P'

Kalauokalani Way between Makaloa Street and Kapiolani Boulevard

Figure A-7. Diagram of Electrical Facilities at Alternative Alignment Segment 'P' (Kalauokalani Way between Makaloa Street and Kapi'olani Boulevard)

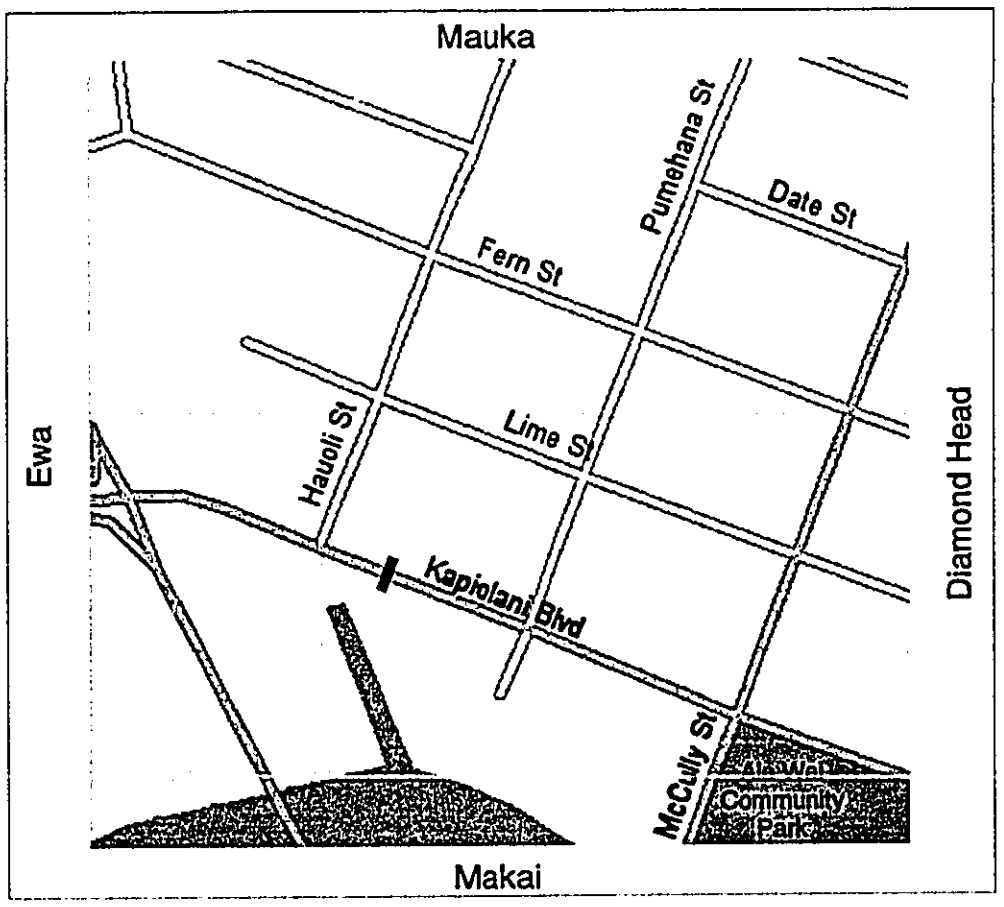
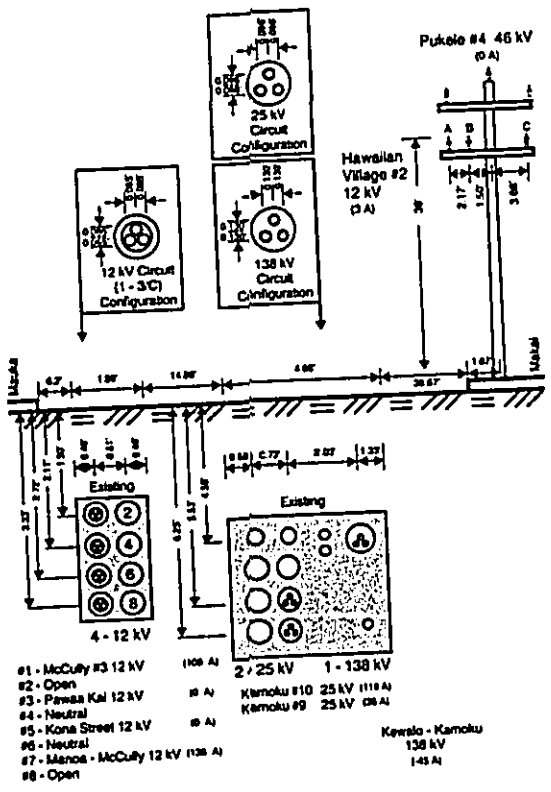
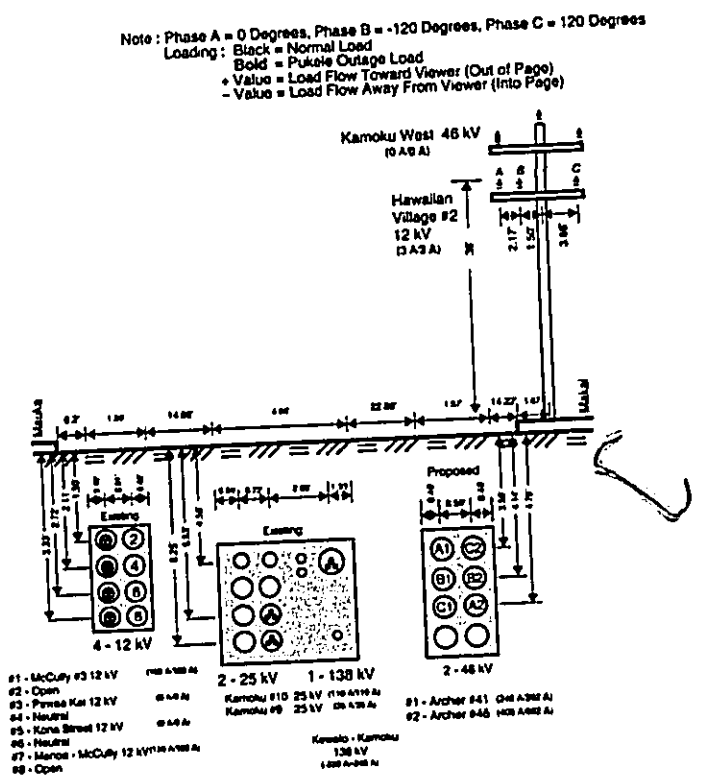


Figure A-8. Measurement Location at Alternative Alignment Segment 'Q' (Kapi'olani Boulevard between Hauoli and Pumehana Streets)



EXISTING



PROPOSED

SEGMENT 'Q'

Kapiolani Boulevard between Hauoli and Pumehana Streets

Figure A-9. Diagram of Electrical Facilities at Alternative Alignment Segment 'Q' (Kapi'olani Boulevard between Hauoli and Pumehana Streets)

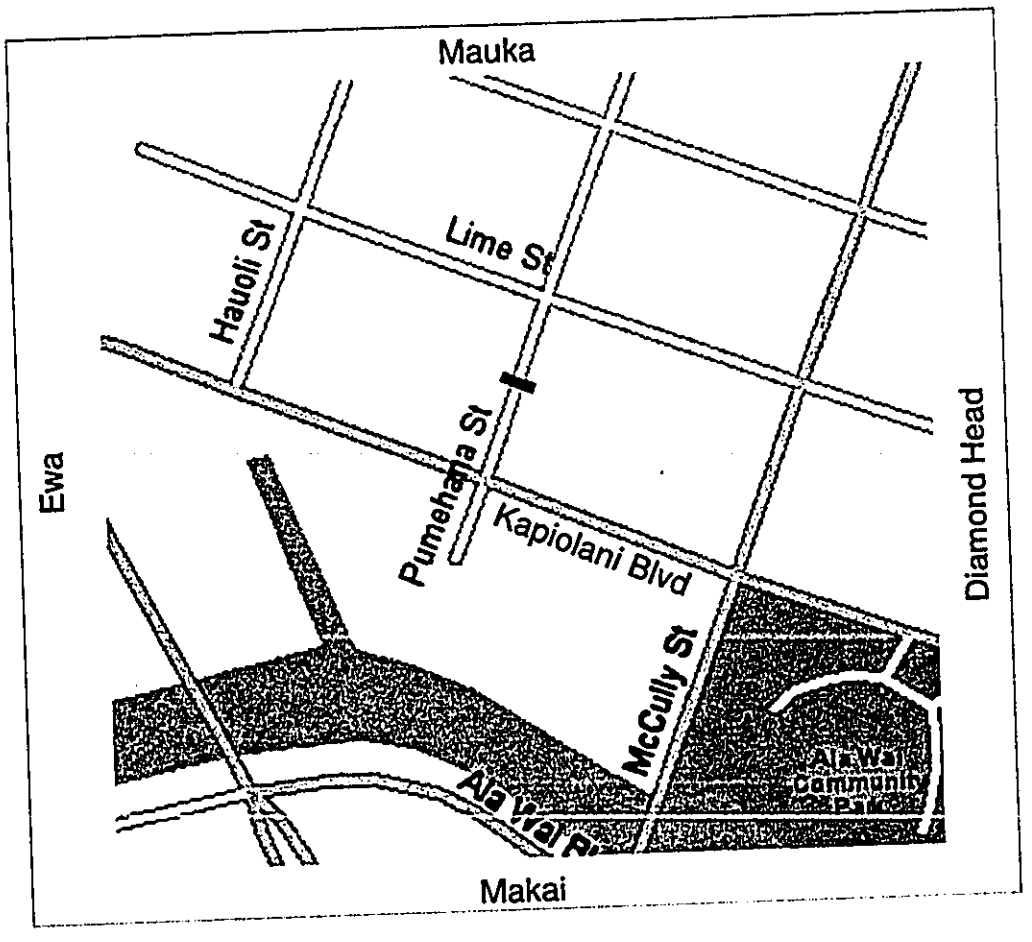
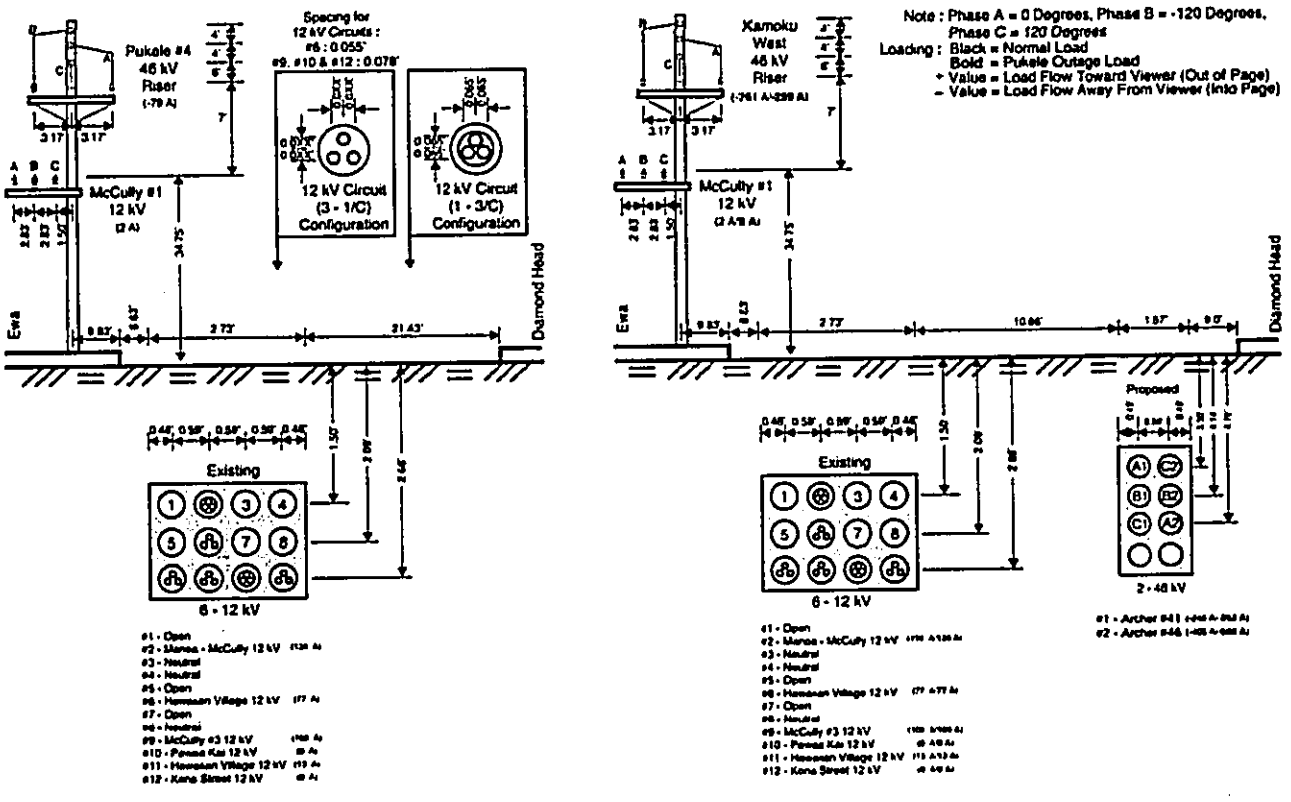


Figure A-10. Measurement Location at Alternative Alignment Segment 'R' (Pumehana Street between Kapi'olani Boulevard and Lime Street)



EXISTING **PROPOSED**

SEGMENT 'R'

Pumehana Street between Kapiolani Boulevard and Lime Street

Figure A-9. Diagram of Electrical Facilities at Alternative Alignment Segment 'R' (Pumehana Street between Kapi'olani Boulevard and Lime Street)

Table A-1. Summary of Existing Transmission Line Facilities and Loading Information for Each Alternative Alignment Segment of the Proposed Project

HECO : EAST OAHU TRANSMISSION PROJECT - 46 kV PHASED PROJECT

Filename	Phase	Segment	Segment Location/Description	Specific Location	Existing Line Configuration				
					Line Type	Line Voltage	Circuit Name	Amp	Conductor Size
HECO_1ME HECO_1MP	1	M	Kaheka Street	Between Makaloa and Kapiolani	U/G	12 kV	Pawaa Kai FF	5	3-1/C #4 PEILC-PJ
					U/G	12 kV	Mahukona	23	1-3/C 750 PILC-PJ
					U/G	12 kV	Makaloa	108	1-3/C 750 PILC-PJ
					U/G	12 kV	Pawaa Kai	24	1-3/C 750 PILC-PJ
					U/G	12 kV	Kona Street	49	3-1/C 750 PEILC-PJ
HECO_1NE HECO_1NP	1	N	Kapiolani Boulevard	Between Kaheka and Kalaiokalani Way	U/G	138 kV	Kewalo-Kamoku	45	3000 CU HPFF
					U/G	12 kV	Makaloa	5	1-3/C 350 PILC-PJ
					U/G	12 kV	McCully #3	108	1-3/C 4/0 PILC-PJ
					U/G	12 kV	Pawaa Kai	8	1-3/C 750 PILC-PJ
					U/G	25 kV	Kewalo 5	116	1000 PEICN
					U/G	25 kV	Kamoku 9	35	1000 PEICN
					U/G	25 kV	Kamoku 10	119	1000 PEICN
HECO_1PE	1	P	Kalaiokalani Way	Between Makaloa and Kapiolani	O/H	12 kV	McCully #5	6	#4
HECO_1QE HECO_1QP	1	Q	Kapiolani Boulevard	Between Hauoli and Pumehana	U/G	138 kV	Kewalo-Kamoku	45	3000 CU HPFF
					O/H	46 kV	Pukele 4	0	556 AAC
					U/G	12 kV	McCully #3	108	1-3/C 750 PILC-PJ
					U/G	12 kV	Pawaa Kai	0	1-3/C 750 PILC-PJ
					U/G	12 kV	Kona Street	0	1-3/C 750 PILC-PJ
					U/G	12 kV	Manoa-McCully	138	1-3/C 750 PILC-PJ
					O/H	12 kV	Hawaiian Village #2	3	336 Al
					U/G	25 kV	Kamoku 9	35	1000 PEICN
					U/G	25 kV	Kamoku 10	119	1000 PEICN
HECO_1RE HECO_1RP	1	R	Pumehana Street	Between Kapiolani and Lime	O/H	46 kV	Pukele 4	79	556 AAC
					U/G	12 kV	McCully #3	108	3-1/C 750 PEILC-PJ
					U/G	12 kV	Pawaa Kai	0	3-1/C 750 PEILC-PJ
					U/G	12 kV	Kona Street	0	3-1/C 750 PEILC-PJ
					U/G	12 kV	Manoa-McCully	138	1-3/C 750 PILC-PJ
					U/G	12 kV	Hawaiian Village #2	13	1-3/C 4/0 PILC-PJ
					U/G	12 kV	Hawaiian Village #2	77	1-3/C 750 PILC-PJ
					O/H	12 kV	McCully #1	2	1/0

Table A-2. Summary of Proposed Transmission Line Facilities and Loading Information for Each Alternative Alignment Segment of the Proposed Project

HECO : EAST OAHU TRANSMISSION PROJECT - 46 kV PHASED PROJECT										
					Proposed Line Configuration					
Filename	Phase	Segment	Segment Location/Description	Specific Location	Line Type	Line Voltage	Circuit Name	Amp	Emerg Amp	Conductor Size
HECO_1ME HECO_1MP	1	M	Kaheka Street	Between Makaloa and Kapiolani	U/G	12 kV	Pawaa Kai FF	5	5	3-1/C #4 PEILC-PJ
					U/G	12 kV	Mahukona	23	23	1-3/C 750 PILC-PJ
					U/G	12 kV	Makaloa	108	108	1-3/C 750 PILC-PJ
					U/G	12 kV	Pawaa Kai	24	24	1-3/C 750 PILC-PJ
					U/G	12 kV	Kona Street	49	49	3-1/C 750 PEILC-PJ
					U/G	46 kV	Archer 41	248	262	1500 kcm
					U/G	46 kV	Archer 46	405	682	1500 kcm
HECO_1NE HECO_1NP	1	N	Kapiolani Boulevard	Between Kaheka and Kalauokalani Way	U/G	138 kV	Kewalo-Kamoku	220	348	3000 CU HPFF
					U/G	12 kV	Makaloa	5	5	1-3/C 350 PILC-PJ
					U/G	12 kV	McCully #3	108	108	1-3/C 4/0 PILC-PJ
					U/G	12 kV	Pawaa Kai	8	8	1-3/C 750 PILC-PJ
					U/G	25 kV	Kewalo 5	116	116	1000 PEICN
					U/G	25 kV	Kamoku 9	35	35	1000 PEICN
					U/G	25 kV	Kamoku 10	119	119	1000 PEICN
					U/G	46 kV	Archer 41	248	262	1500 kcm
					U/G	46 kV	Archer 46	405	682	1500 kcm
HECO_1PE	1	P	Kalauokalani Way	Between Makaloa and Kapiolani	O/H	46 kV	McCully #5	8	8	#4
					U/G	46 kV	Archer 41	248	262	1500 kcm
					U/G	46 kV	Archer 46	405	682	1500 kcm
HECO_1QE HECO_1QP	1	Q	Kapiolani Boulevard	Between Hauoli and Pumehana	U/G	138 kV	Kewalo-Kamoku	220	348	3000 CU HPFF
					O/H	46 kV	Kamoku West	0	0	556 AAC
					U/G	12 kV	McCully #3	108	108	1-3/C 750 PILC-PJ
					U/G	12 kV	Pawaa Kai	0	0	1-3/C 750 PILC-PJ
					U/G	12 kV	Kona Street	0	0	1-3/C 750 PILC-PJ
					U/G	12 kV	Manoa-McCully	138	138	1-3/C 750 PILC-PJ
					O/H	12 kV	Hawaiian Village #2	3	3	336 Al
					U/G	25 kV	Kamoku 9	35	35	1000 PEICN
					U/G	25 kV	Kamoku 10	119	119	1000 PEICN
					U/G	46 kV	Archer 41	248	262	1500 kcm
					U/G	46 kV	Archer 46	405	682	1500 kcm
HECO_1RE HECO_1RP	1	R	Pumehana Street	Between Kapiolani and Lime	O/H	46 kV	Kamoku West	261	259	556 AAC
					U/G	12 kV	McCully #3	108	108	3-1/C 750 PEILC-PJ
					U/G	12 kV	Pawaa Kai	0	0	3-1/C 750 PEILC-PJ
					U/G	12 kV	Kona Street	0	0	3-1/C 750 PEILC-PJ
					U/G	12 kV	Manoa-McCully	138	138	1-3/C 750 PILC-PJ
					U/G	12 kV	Hawaiian Village #2	13	13	1-3/C 4/0 PILC-PJ
					U/G	12 kV	Hawaiian Village #2	77	77	1-3/C 750 PILC-PJ
					O/H	12 kV	McCully #1	2	2	1/0
					U/G	46 kV	Archer 41	248	262	1500 kcm
					U/G	46 kV	Archer 46	405	682	1500 kcm

APPENDIX B

Magnetic Field Measurements
at Alternative Alignment Segment Locations

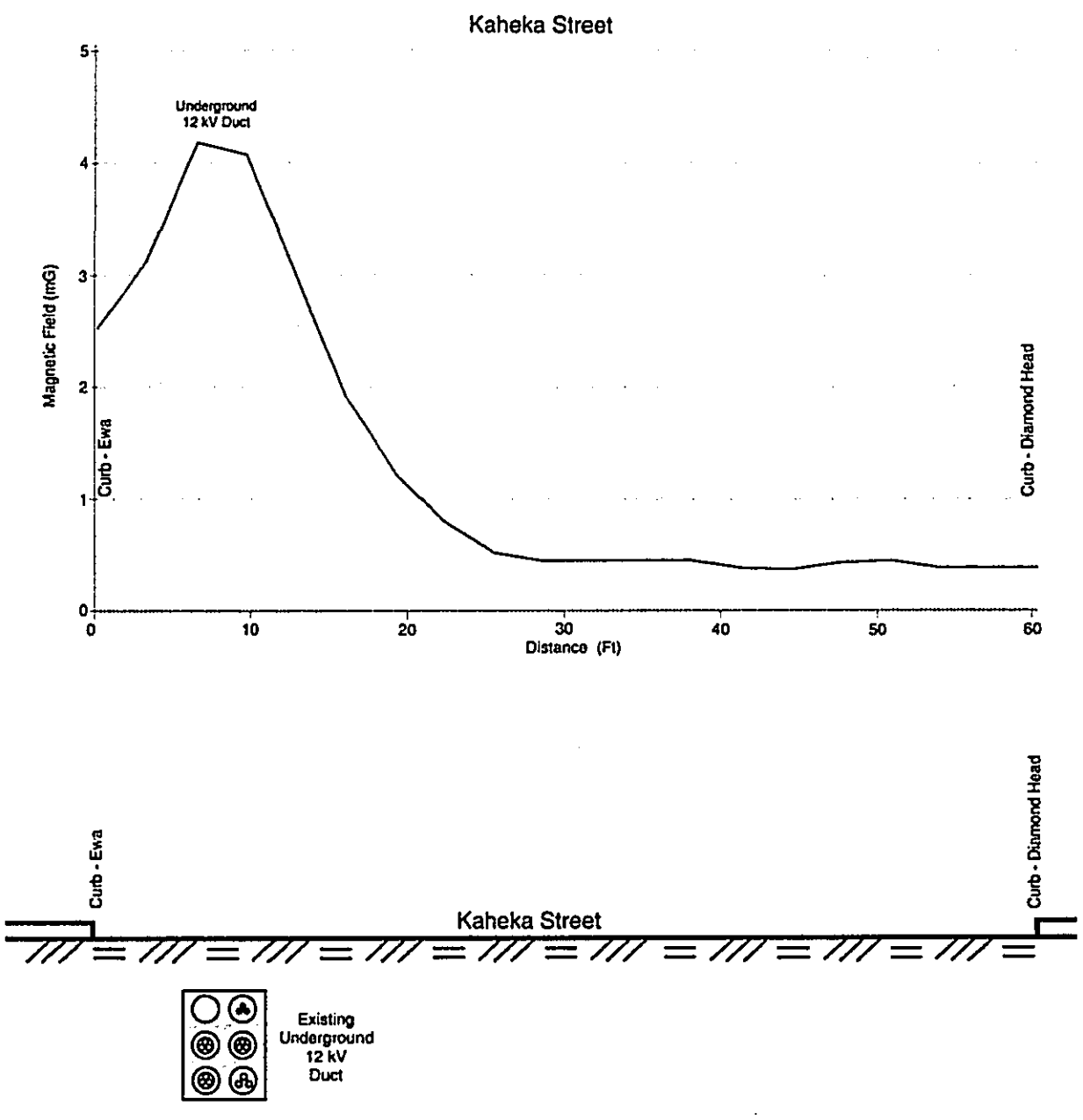


Figure B-1. Magnetic Field Measurements at Alternative Alignment Segment 'M'
(Kaheka Street between Makaloa Street and Kapi'olani Boulevard)

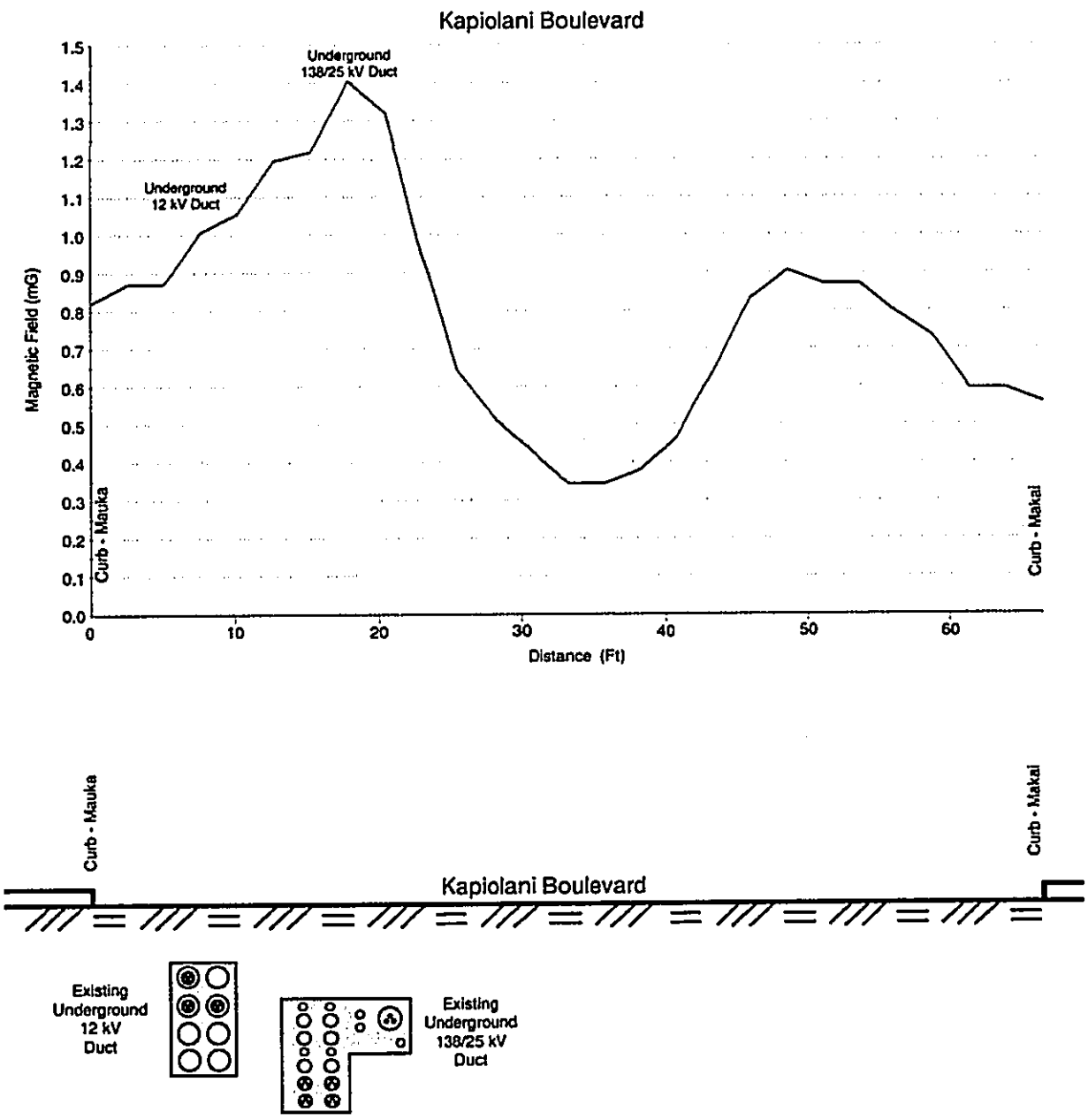


Figure B-2. Magnetic Field Measurements at Alternative Alignment Segment 'N' (Kapi'olani Boulevard between Kaheka Street and Kalauokalani Way)

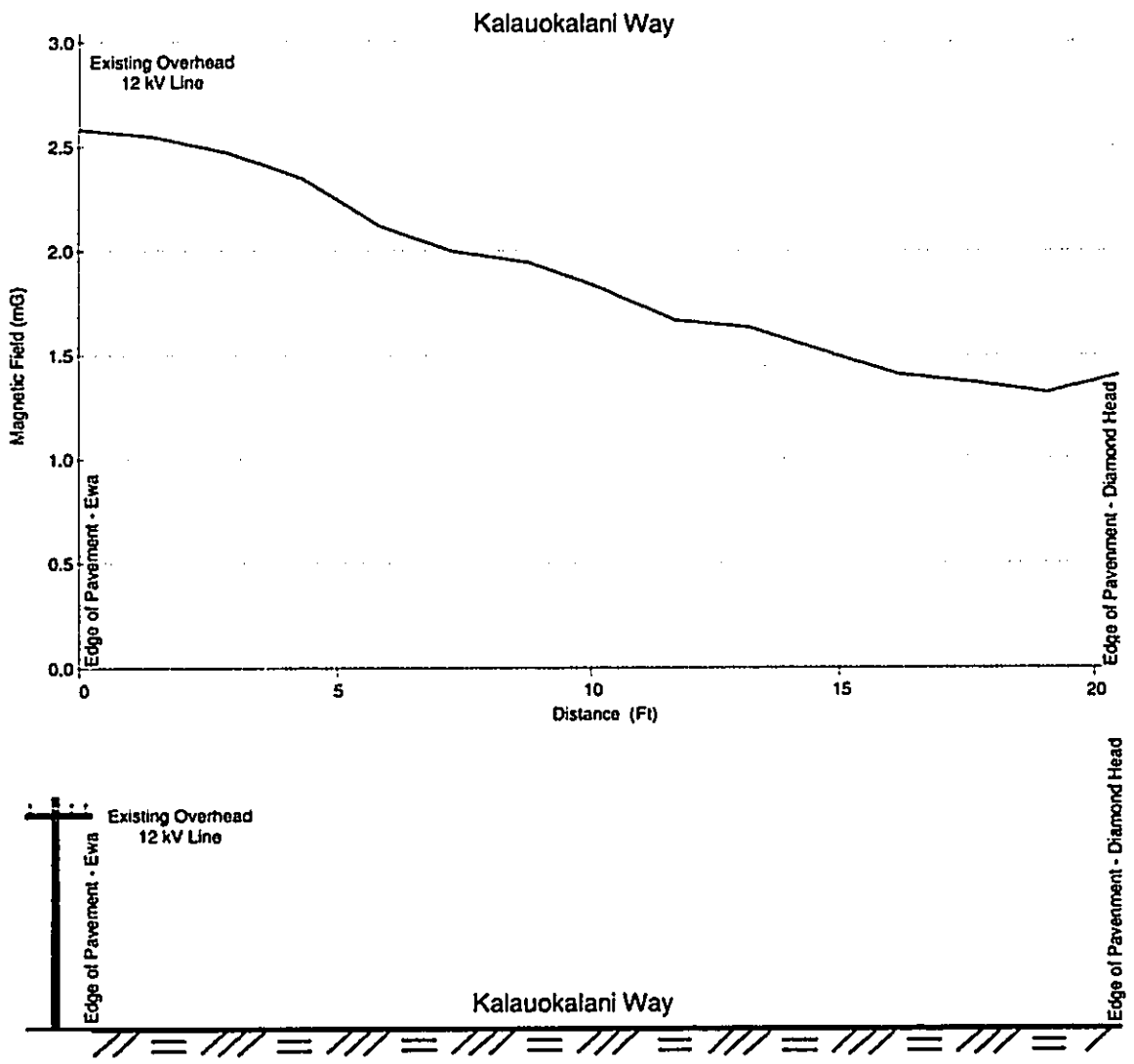


Figure B-3. Magnetic Field Measurements at Alternative Alignment Segment 'P' (Kalauokalani Way between Makaloa Street and Kapi'olani Boulevard)

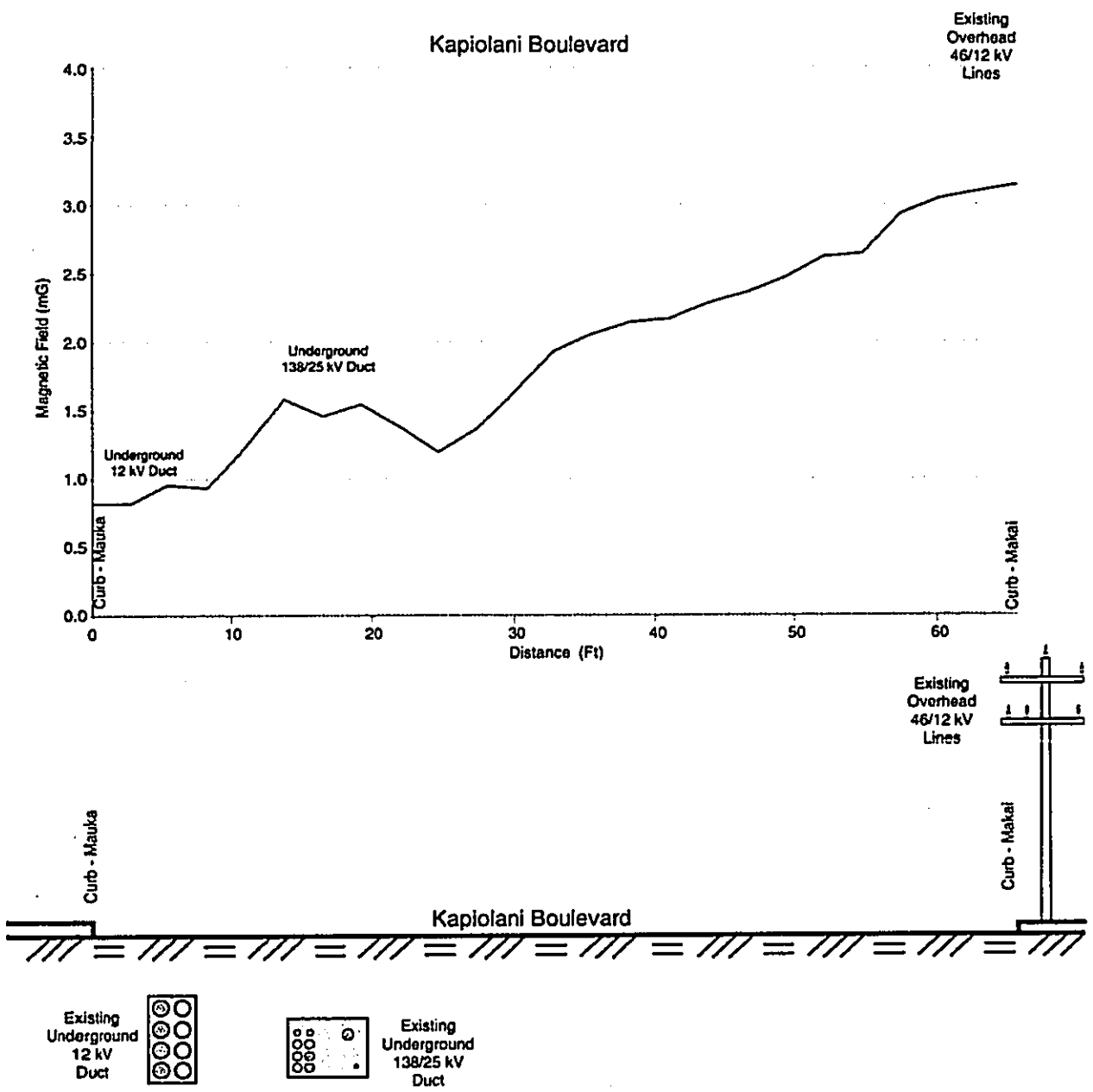


Figure B-4. Magnetic Field Measurements at Alternative Alignment Segment 'Q' (Kapi'olani Boulevard between Hauoli and Pumehana Streets)

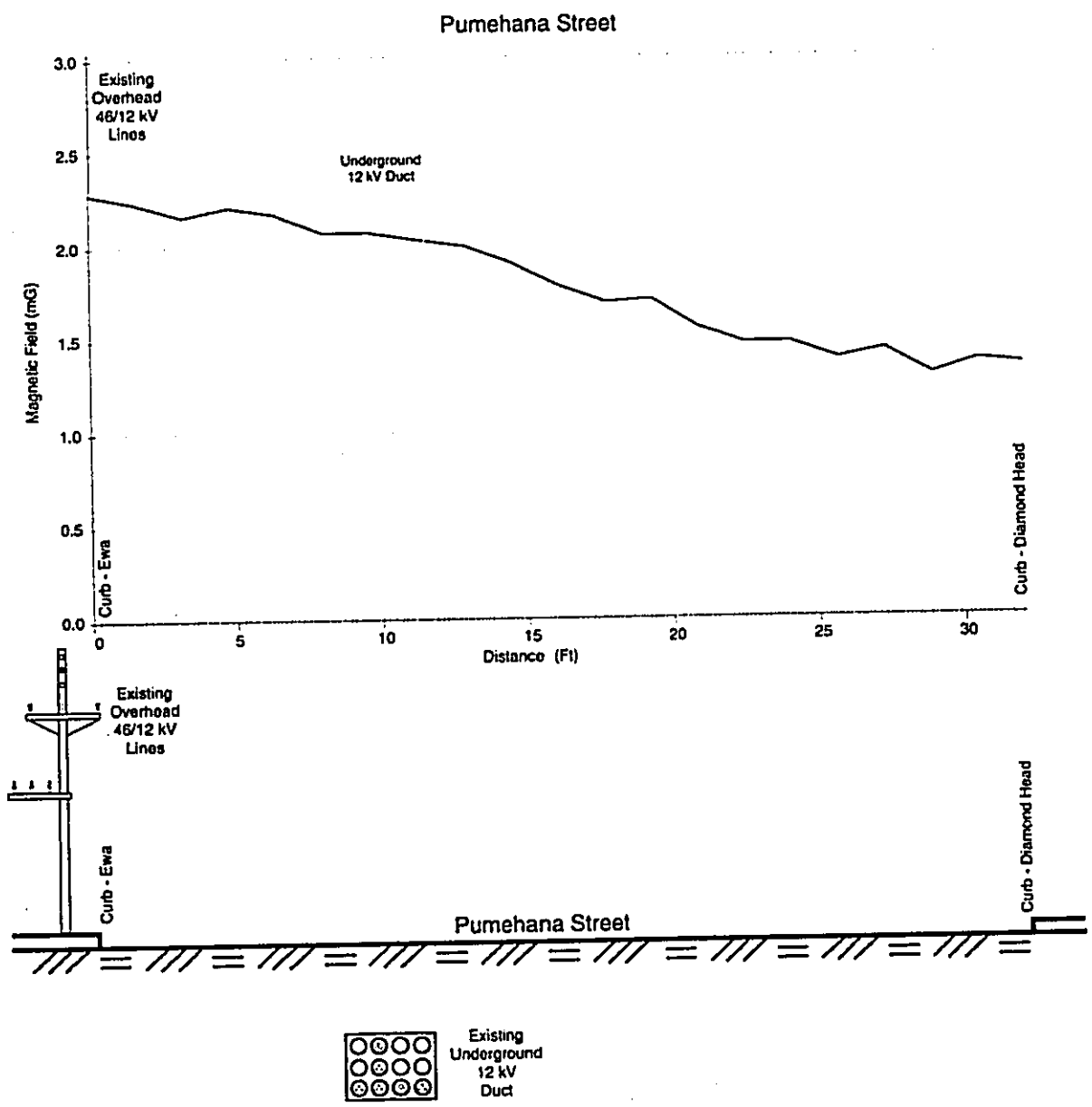


Figure B-5. Magnetic Field Measurements at Alternative Alignment Segment 'R' (Pumehana Street between Kapi'olani Boulevard and Lime Street)

Table B-1. Summary of Line Loading for Each Alternative Alignment Segment During Field Measurements

Segment	Date	Time	Power Line Name	Load Range (Amps)
M	November 16, 2004	9:05 AM	Pawaa Kai FF	5
			Mahukona	23
			Makaloa	101 - 108
			Pawaa Kai	23 - 24
			Kona Street	49
N	November 16, 2004	9:25 AM	Makaloa	5
			McCully #3	108
			Pawaa Kai	8
			Kewalo #6	0
			Kamoku #10	114 - 119
			Kewalo #5	116
			Kamoku #9	35
			Kewalo - Kamoku	36 - 41
P	November 16, 2004	9:15 AM	McCully #5	3 - 8
Q	November 16, 2004	9:35 AM	McCully #3	108
			Pawaa Kai	0
			Kona Street	0
			Manoa – McCully	119 - 138
			Kamoku #10	114 - 119
			Kamoku #9	35
			Kewalo – Kamoku	36 - 41
			Pukele #4	0
			Hawaiian Village	2 - 3
R	November 16, 2004	9:45 AM	Manoa – McCully	119 - 138
			Hawaiian Village	12 - 13
			McCully #3	108
			Pawaa Kai	0
			Hawaiian Village	73 - 77
			Kona Street	0
			Pukele #4	0
			McCully #1	2

APPENDIX C

Magnetic Field Profile Calculations
at Alternative Alignment Segment Locations

SEGMENT 'M'

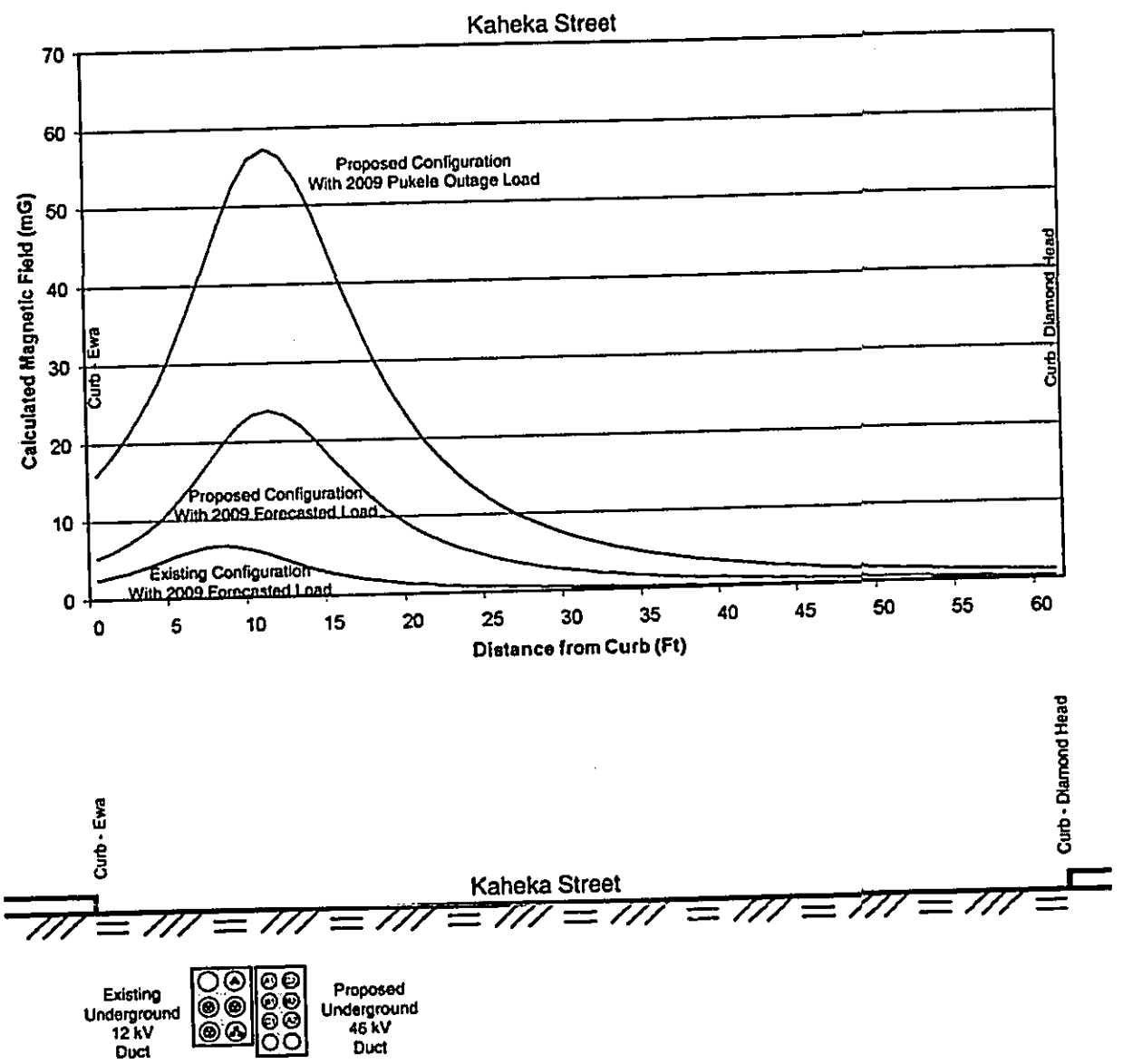


Figure C-1. Magnetic Field Calculations at Alternative Alignment Segment 'M'

(Kaheka Street between Makaloa Street and Kapi'olani Boulevard :
two new 46 kV underground circuits would be installed in new duct,
five existing 12 kV underground circuits would remain)

SEGMENT 'N'

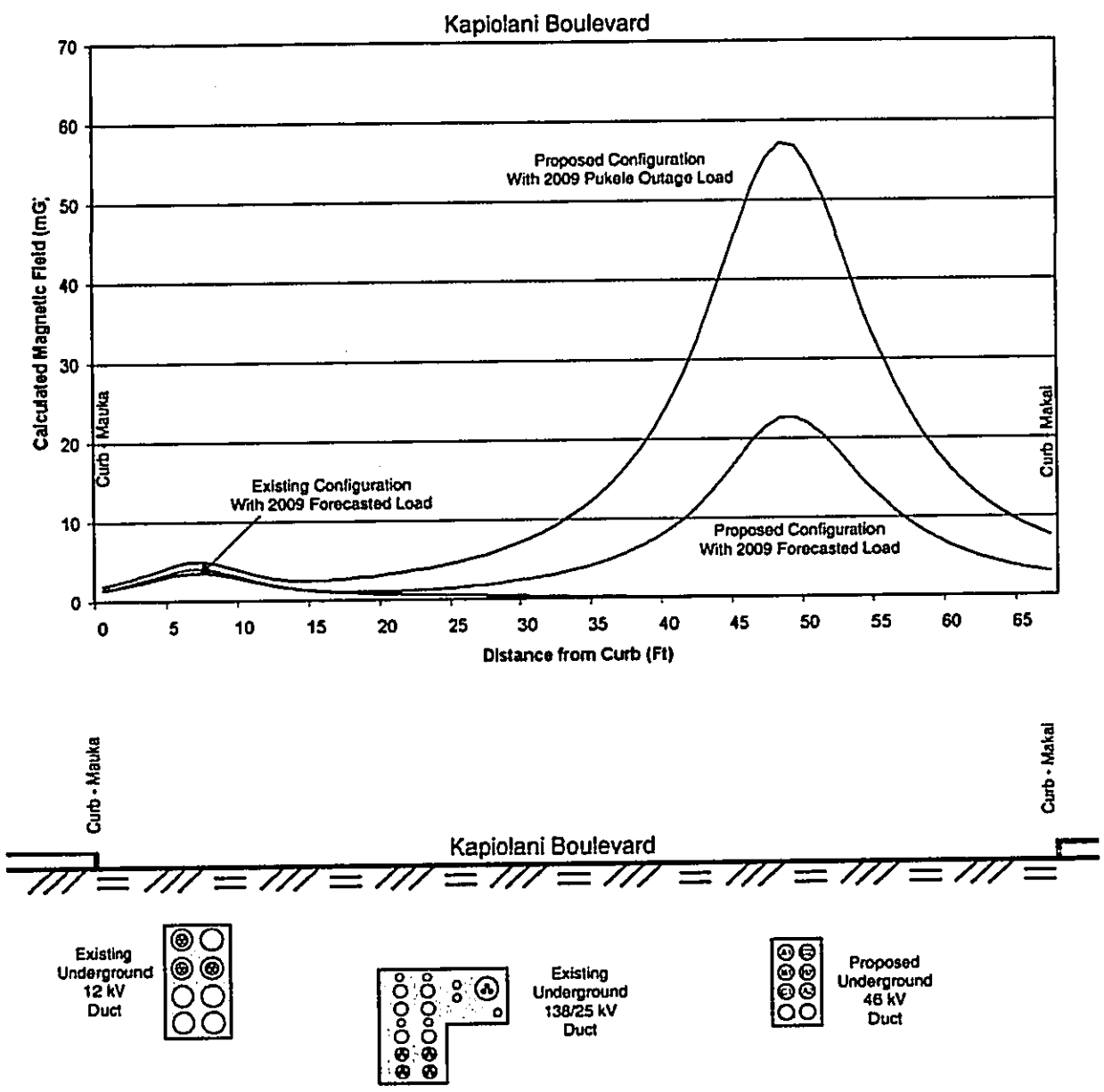


Figure C-2. Magnetic Field Calculations at Alternative Alignment Segment 'N'

(Kapi'olani Boulevard between Kaheka Street and Kalauokalani Way :
two new 46 kV underground circuits would be installed in new duct,
three existing 12 kV underground circuits and one existing 138 kV underground circuit
and four existing 25 kV underground circuits would remain)

SEGMENT 'P'

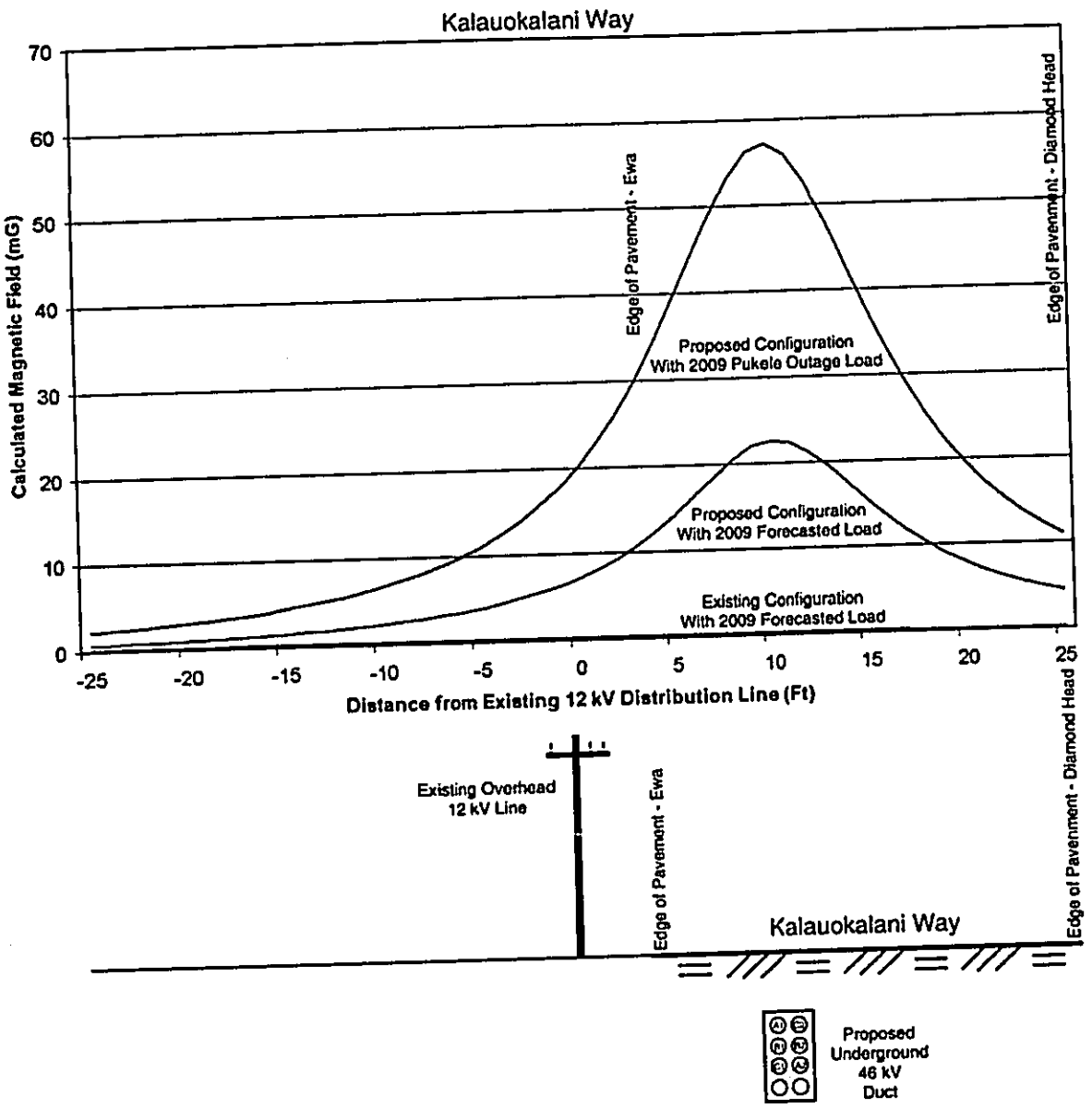


Figure C-3. Magnetic Field Calculations at Alternative Alignment Segment 'P'

(Kalauokalani Way between Makaloa Street and Kapi'olani Boulevard :
two new 46 kV underground circuits would be installed in new duct,
one existing 12 kV overhead power line would remain)

SEGMENT 'Q'

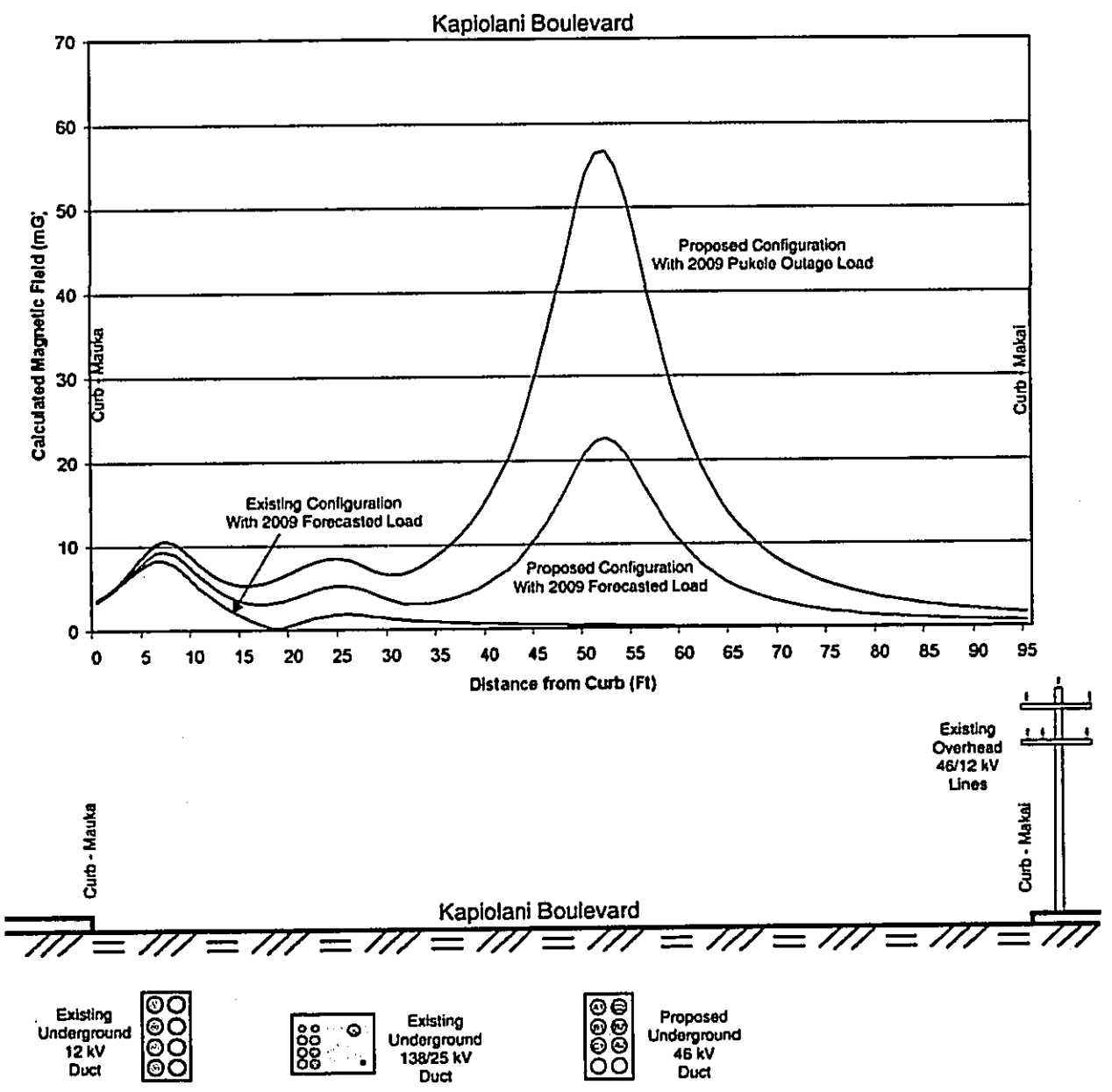


Figure C-4. Magnetic Field Calculations at Alternative Alignment Segment 'Q'

(Kapi'olani Boulevard between Hauoli and Pumehana Streets :
two new 46 kV underground circuits would be installed in new duct,
four existing 12 kV underground circuits and one existing 138 kV underground circuit
and two existing 25 kV underground circuits would remain,
one existing 46 kV overhead circuit and one existing 12 kV overhead circuit would also remain)

SEGMENT 'R'

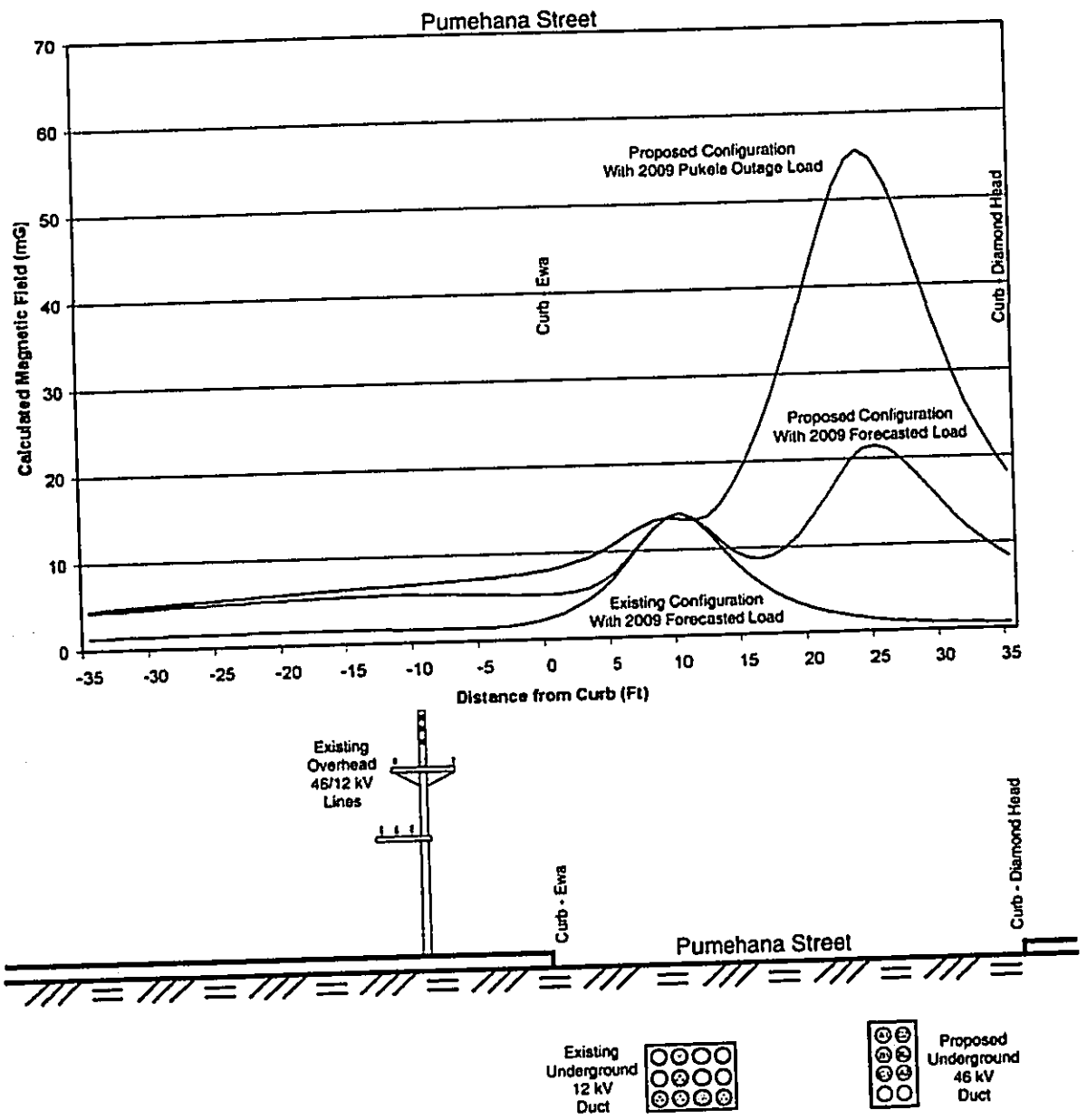


Figure C-5. Magnetic Field Calculations at Alternative Alignment Segment 'R'

(Pumehana Street between Kapi'olani Boulevard and Lime Street :
two new 46 kV underground circuits would be installed in new duct,
six existing 12 kV underground circuits would remain,
one existing 46 kV overhead circuit and one existing 12 kV overhead circuit would also remain)

ALREADY
REDUCED
AND
PLACED
IN FILE

RECEIVED AS FOLLOWS

Tabl
Overview of T

Phase/Corridor	Affected Street	No. of Days Traffic Impacted	No. of N Traffic In
Phase 1 Work Areas			
Makaloa-Kapiolani Corridor			
Proposed Action	Makaloa St. – Amana St. to Poni St. (Trenching)	11-14	10-1
	Work at existing manholes along Kalakaua Ave. and Fern, Hauoli, Lime Sts.	2-3 at each manhole	0
Alternative 1 Kaheka-Kapiolani Alignment	Makaloa St. – Amana St. to Kaheka St.	11-14	2+
	Kaheka St. – Makaloa St. to Kapiolani Blvd.	3-4	1
	Kapiolani Blvd. – Kaheka St. to Pumehana St.	37-42	2-3
	Pumehana St. – Kapiolani Blvd. to Lime St.	4-5	
Alternative 2 Kalauokalani-Kapiolani Alignment	Makaloa St. – Amana St. to Kalauokalani Way.	11-14	15+
	Kalauokalani Way – Makaloa to Kapiolani Blvd.	12-14	1
	Kapiolani Blvd. – Kalauokalani to Pumehana St.	17-18	1-2
	Pumehana St. – Kapiolani Blvd. to Lime St.	4-5	1
Pumehana St. Area			
Proposed Action Closure by Block	Lime St. – Substation to Pumehana St.	6-7	0
	Pumehana St. - Lime St. to Date St.	33-35	0
Single-Lane Option	Lime St. – Substation to Pumehana St.	6	0
	Pumehana St - Lime St. to Date St.	6 Closed 50-55 Flagman	0
Date St. Area			1-2
Proposed Action	Date St. – Kapiolani Blvd. to Laau St.	22-26	
Winam Ave. Area			
Proposed Action	Mooheau Ave. – Winam Ave. to Paliuli St.	9-10	0
	Winam Ave. Mooheau Ave. to Hoolulu St.	10-11	0
Single-Lane Option	Mooheau Ave. – Winam Ave. to Paliuli St.	9-10	0
	Winam Ave. Mooheau Ave. to Hoolulu St.	21+	0

No. Days/Nights Traffic Impact = Days during which trenching, drilling, or repaving closes one or more lanes
Local Only = Street would be closed to through traffic but would allow access to driveways.

RECEIVED AS FOLLOWS

Table S-1
rview of Traffic Impacts

No. of Nights Traffic Impacted	Estimated Daily Traffic	Minimum Lanes Open to Traffic	No. Cross Streets Impacted	Problem Intersection Locations
10-13	7,000	1 with Flagman at Amana St.	3	Amana St., Kaheka St.
0	2,000-4,000	2	1	Kalakaua Ave.
2+	7,000	1 with Flagman at Amana St.	2	Amana St., Kaheka St.
1	14,000	4	0	
2-3+	39,000	4	4	Kalakaua Ave., Atkinson Dr.
	2,900		0	
15+	7,000	1 with Flagman at Amana St.	3	Amana St., Kaheka St.
1	No Counts	4	0	
1-2+	39,000	4	2	Kalakaua Ave., Atkinson Dr.
1	2,900		0	
0	No Counts	Local only	1	
0	2,900	Local only	2	
0	No Counts	1 with flagman	1	
0	2,900	1 with flagman	2	
1-2				
	16,000	2	1	Kapiolani Blvd. (limited stacking distance at signal)
0	8,200	1 with flagman	0	
0	3,650	Local only	1	
0	8,200	1 with flagman	0	
0	3,650	1 with flagman	1	

re lanes

Wilbur Smith Associates; July 22, 2004

RECEIVED AS FOLLOWS

Table S-1 (
Overview of T

Phase/Corridor	Affected Street	No. of Days Traffic Impacted	No. of N Traffic In
Phase 2 Work Area			
King Street Corridor			
Proposed Action (Nighttime Trenching)	Cooke St. – Archer Substation Exit to King St.	0	10-1
	King St. – Cooke St. to Kaheka St.	0	120-1
	King St. – Kaheka St. to McCully St.	0	61-7
	McCully St. – King St. to Beretania St.	0	11-1
Daytime Trenching Option	Cooke St. – Archer Substation Exit to King St.	9-11	1
	King St. – Cooke St. to Kaheka St.	114-125	6
	King St. – Kaheka St. to McCully St.	58-70	3
	McCully St. – King St. to Beretania St.	10-12	1
Partial Horizontal Directional Drilling Option	Cooke St. – Archer Substation Exit to King St.	0	10-1
	King St. – Cooke St. to Elsie Ln.	152 work days plus weekends	9-1
	King St. – Elsie Ln. to McCully St.	0	61-7
	McCully St. – King St. to Beretania St.	0	11-1

RECEIVED AS FOLLOWS

Table S-1 (Continued)
erview of Traffic Impacts

No. of Nights Traffic Impacted	Estimated Daily Traffic	Minimum Lanes Open to Traffic	No. Cross Streets Impacted	Problem Intersection Locations
10-12	6,400	Closed to through traffic	0	
120-131	30,000	4	7	
61-73	31,000	4	1	
11-13	17,000	4	1	
1	6,400	1 lane with flagman	0	
6	30,000	4	7	Ward Ave., Keeaumoku St.
3	31,000	4	1	McCully St.
1	17,000	4	1	
10-12	6,400	Closed to through traffic	0	
9-10	30,000	4	0	Ward Ave., Kalakaua Ave. Keeaumoku Ave.
61-73	31,000	4	1	McCully St.
11-13	17,000	4	1	

Wilbur Smith Associates; August 8, 2004

RECEIVED AS FOLLOWS

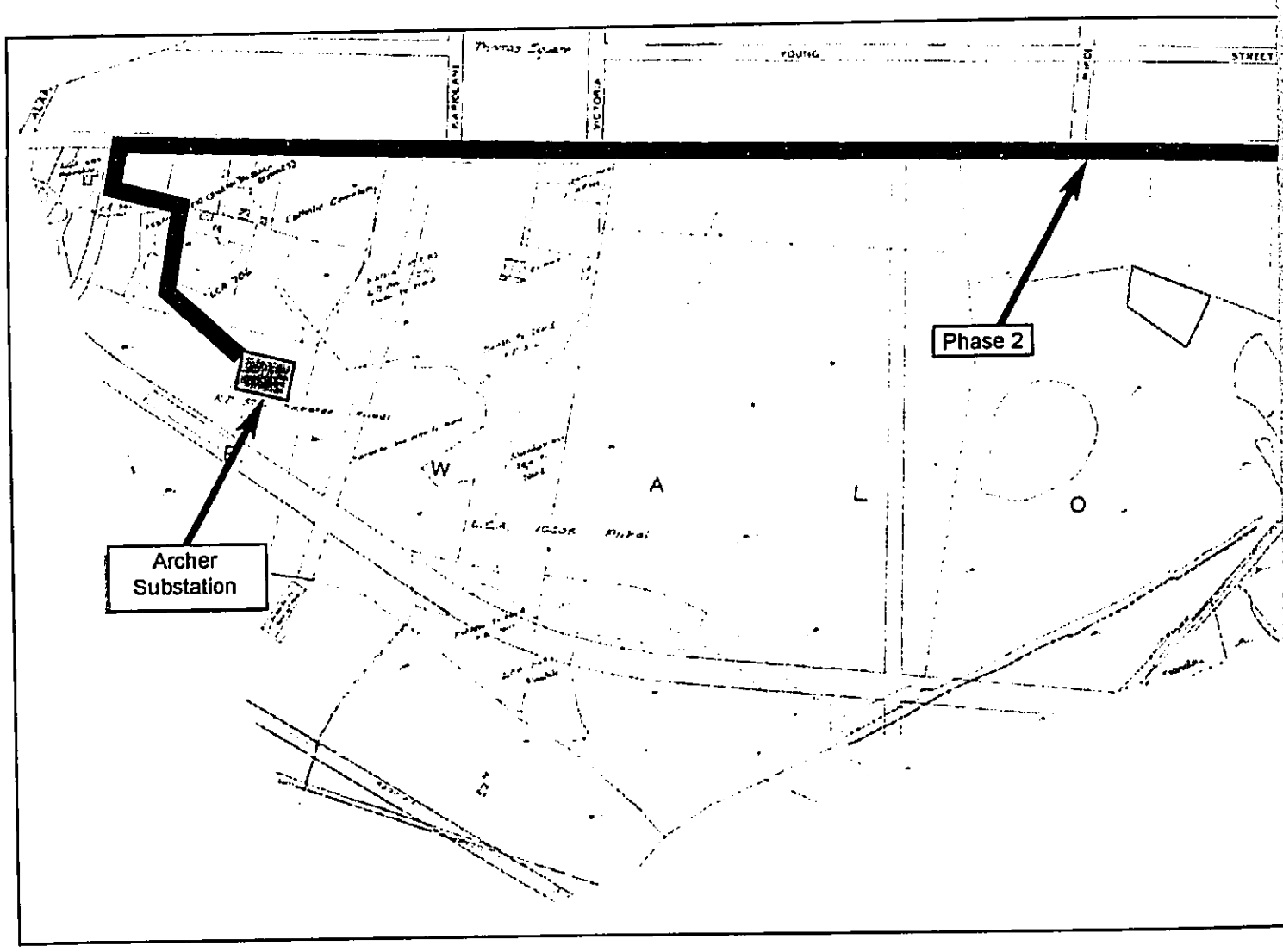
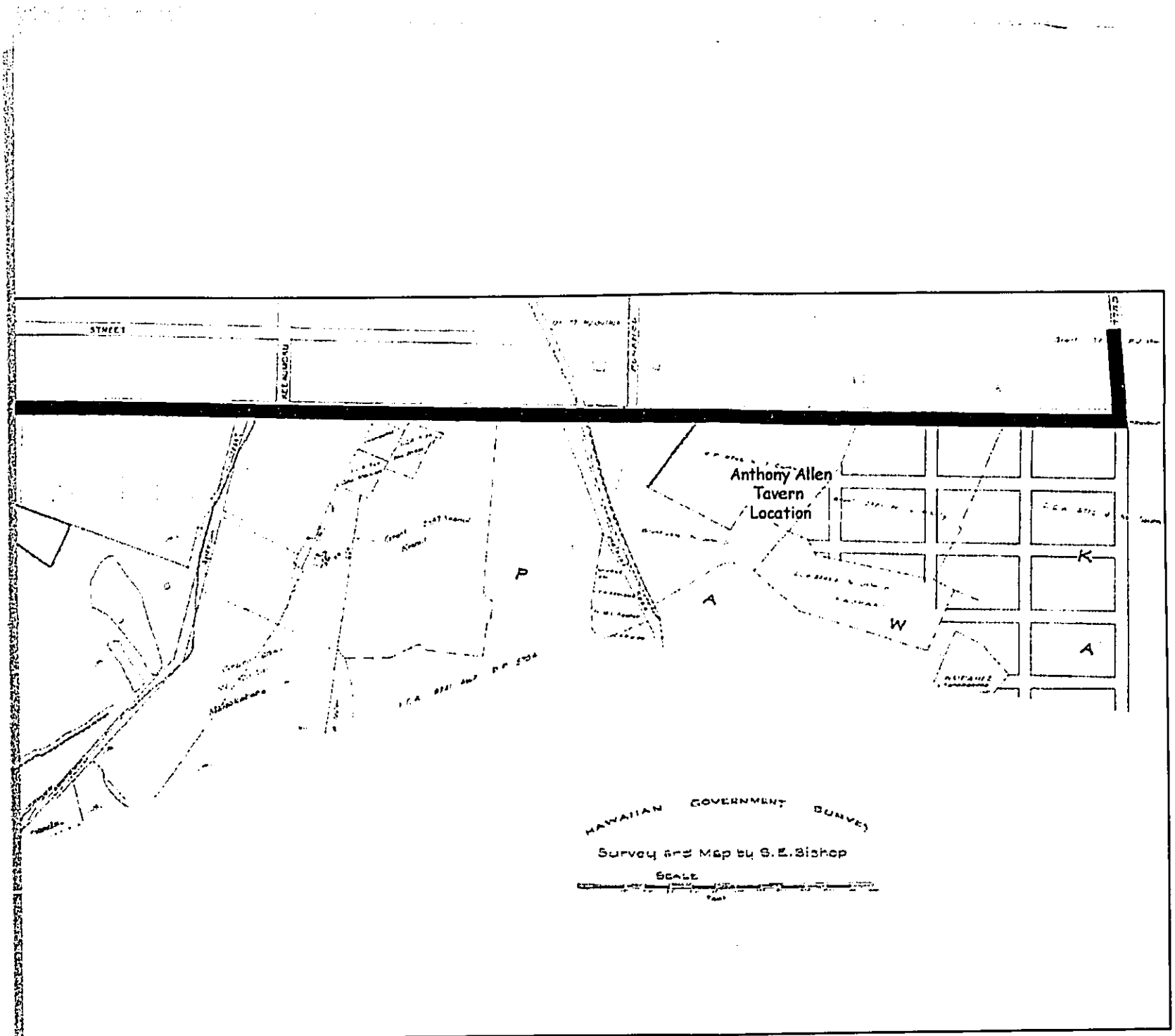


Figure 10. Kewalo-Kuhua-Pāwa'a Lands Showing Approximate Location of the Proposed Action (Source: S.

RECEIVED AS FOLLOWS



1 (Source: S.E. Bishop Map 1881, 1884).

Pacific Legacy Incorporated