SADDLE ROAD (STATE ROUTE 200)
Mamalahoa Highway (State Route 190) to Milepost 42
County of Hawai‘i, State of Hawai‘i
FHWA Project No. 200(00)

SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT

Submitted Pursuant to Section 42 U.S.C. 4332(2)(c)
and Chapter 343, Hawai‘i Revised Statutes by the

U.S. DEPARTMENT OF TRANSPORTATION
Federal Highway Administration (FHWA)
Central Federal Lands Highway Division
and
STATE OF HAWAI‘I
Department of Transportation (HDOT)
Highways Division

Cooperating Agencies
U.S. Army Garrison, Hawai‘i

VOLUME II APPENDICES

LIST OF APPENDICES

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SADDLE ROAD (STATE ROUTE 200)
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U.S. Army Garrison, Hawai‘i

Appendix A
Public Involvement and Agency Coordination
A1: Notice of Intent in Federal Register and EISPN Notice in OEQC Environmental Notice

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877 12/24/07 -PA

foreign nationals begin participation in this program each year.

In February 2004, the Department announced a pilot program whereby Department designated au pair sponsors could request the extension of program participation beyond the original 12-month maximum period afforded au pair participants. In June of 2006, following a review of the two-year pilot program, the Department amended program regulations to permit designated sponsors to submit requests to the Department for consideration of program extensions for six, nine or 12 month durations for first-year au pair participants beyond the maximum duration of participation allowed under the existing regulations.

As the au pair program enters its twentieth year of operation, the Department has been asked to consider amending the age eligibility requirement for au pair participants by increasing the age limitation from 26 to 30. Further, the Department has been asked to consider permitting foreign nationals who previously participated in the au pair program to repeat program participation.

The Department hereby solicits comments from the general public and other interested parties regarding these two issues. This certification will be published in the **Federal Register**.

Dated: November 26, 2007.

Stanley S. Colvin,

Director, Office of Exchange Coordination and Designation, Bureau of Educational and Cultural Affairs, Department of State.

[FR Doc. E7–23883 Filed 12–7–07; 8:45 am]

BILLING CODE 4710–05–P

TENNESSEE VALLEY AUTHORITY

Paperwork Reduction Act of 1995, as Amended by Public Law 104–13; Proposed Collection; Comment Request

AGENCY: Tennessee Valley Authority.

ACTION: Proposed Collection; comment request.

SUMMARY: The proposed information collection described below will be submitted to the Office of Management and Budget (OMB) for review, as required by the Paperwork Reduction Act of 1995 (44 U.S.C. Chapter 35, as amended). The Tennessee Valley Authority is soliciting public comments on this proposed collection as provided by 5 CFR 1320.8(d)(1). Requests for information, including copies of the information collection proposed and supporting documentation should be directed to the Agency Clearance Officer: Alice D. Witt, Tennessee Valley Authority, 1101 Market Street (EB–5B), Chattanooga, TN 37402–2801; (423) 751–6832. (SC: 0003D1Z) Comments should be sent to the Agency Clearance Officer no later than *February 8, 2008.*

SUPPLEMENTARY INFORMATION:

Type of Request: Regular submission; proposal for a reinstatement of a previously approved collection (OMB control number 3316–0009).

Title of Information Collection: Salary Surveys for Engineering Association (EA) and Law Enforcement Employee Association (LEEA) Bargaining Unit Employees.

Frequency of Use: Annually.

Type of Affected Public: State or local governments, Federal agencies, non-profit institutions, businesses, or other for-profit.

Small Businesses or Organizations Affected: EA: 45; LEEA: 30.

Federal Budget Functional Category Code: 999.

Estimated Number of Annual Responses: EA: 30; LEEA: 20.

Estimated Total Annual Burden Hours: EA: 120; LEEA: 60.

Estimated Average Burden Hours Per Response: EA: 4; LEEA: 3.

Need For and Use of Information: TVA conducts an annual salary survey for employee compensation and benefits as a basis for labor negotiations in determining prevailing rates of pay and benefits for represented salary policy employees. TVA surveys firms, and Federal, State, and local governments whose employees perform work similar to that of TVA's salary policy employees.

Steven A. Anderson,

Senior Manager, IT Planning & Governance, Information Services.

[FR Doc. E7–23828 Filed 12–7–07; 8:45 am]

BILLING CODE 8120–08–P

DEPARTMENT OF TRANSPORTATION

Federal Highway Administration

Environmental Impact Statement: Hawai'i County, HI

AGENCY: Federal Highway Administration (FHWA)—Central Federal Lands Highway Division (CFLHD), DOT.

ACTION: Notice of intent.

SUMMARY: FHWA–CFLHD is issuing this notice to advise the public that a supplemental environmental impact statement will be prepared for a proposed highway project in Hawai'i County, Hawai'i.

FOR FURTHER INFORMATION CONTACT: Ricardo Suarez, Division CFLHD Engineer, 12300 West Dakota Avenue, Lakewood, CO 80228 and/or Ronald F. Tsuzuki, State Department of Transportation, Highways Division, Planning Branch, 869 Punchbowl Street, Honolulu, HI 96813.

SUPPLEMENTARY INFORMATION: The FHWA, in consultation with the Hawaii Department of Transportation (HDOT), will prepare a supplemental environmental impact statement (SEIS) for an ongoing project to improve and realign the Saddle Road (State Highway 200), an existing highway in Hawai'i County, Hawai'i. The purpose of the project is to provide a safe and efficient route for access to land uses along Saddle Road and for cross-island traffic between East and West Hawai'i. The ongoing and planned improvements to Saddle Road would also address five general types of needs: Roadway deficiencies, conflicts and hazards with military operations, capacity, safety, and social demand and economic development. The final environmental impact statement (EIS) for the project was completed August 9, 1999, and the Record of Decision (ROD) was signed on October 30, 1999. The project began construction in 2004 and approximately 30% of the project has been completed or is now under construction. In 2006, the Department of the Army (Army) purchased a Parker Ranch property known as the Ke'āmuku parcel. This property included the area planned for the selected alternative (W–3) for western section of the Saddle Road. On September 6, 2006, the U.S. Army Garrison, Hawai'i, requested that HDOT and FHWA consider relocating the highway about a mile southwest towards the southern boundary of Ke'āmuku. This would allow the Army to maximize its training opportunities and minimize conflict with the traveling public. This request meets one of the original purposes of the Saddle Road EIS, which was to minimize conflict between civilian and military uses in the area, and FHWA and HDOT thus have determined that it is prudent to re-examine the alternatives for the western section of the EIS. Alternatives under consideration at this time include (1) taking no action; (2) using the alternative for the western section of the project that was recommended in the Final EIS and selected in the ROD; and (3) relocating this segment of the highway nearer the southern boundary of the Ke'āmuku parcel. The SEIS will also reconfirm the reasons that alternatives for the western section were dropped from consideration in the original EIS, and reconsider them, if appropriate.

Because public scoping meetings for the Saddle Road Improvements project were held in Hilo, Kona and Waimea during the development of the original EIS, no additional scoping is required for an ongoing project, where an SEIS is prepared that does not involve a reassessment of the entire action. However, letters describing the proposed action and soliciting comments will be sent to appropriate Federal, State and local agencies, and to private organizations and citizens who have previously expressed or are known to have interest in this proposal. Public hearings will be held in both West and East Hawai'i. Public notice will be given of the time and place of the hearings. The draft SEIS will be available for public and agency review and comment prior to the public hearing. To ensure that the full range of issues related to this proposed action are addressed and that all significant issues are identified, comments and suggestions are invited from all interested parties. Comments or questions concerning this proposed action and the SEIS should be directed to the FHWA–CFLHD or the HDOT at the addresses provided above.

(Catalog of Federal Domestic Assistance Program Number 20.205, Highway Planning and Construction. The regulations implementing Executive Order 12372 regarding intergovernmental consultation on Federal Programs and activities apply to this program)

Issued on: November 27, 2007.

Ricardo Suarez, P.E.,

Division Engineer, CFLHD.

[FR Doc. 07–5988 Filed 12–7–07; 8:45 am]

BILLING CODE 4910–22–M

DEPARTMENT OF TRANSPORTATION

National Highway Traffic Safety Administration

Denial of Motor Vehicle Defect Petition

AGENCY: National Highway Traffic Safety Administration (NHTSA), Department of Transportation.

ACTION: Denial of petition for a defect investigation.

SUMMARY: This notice sets forth the reasons for the denial of a petition submitted pursuant to 49 U.S.C. 30162 by Mr. Richard H. McSwain of McSwain Engineering Inc. to NHTSA's Office of Defects Investigation (ODI), received June 29, 2007, requesting that the agency commence a proceeding to determine the existence of a defect related to motor vehicle safety with respect to the manual seatback recliner mechanism in model year 1989–1992 Ford Probe vehicles (subject vehicles). After a review of the petition and other information, NHTSA has concluded that further expenditure of the agency's investigative resources on the issues raised by the petition does not appear to be warranted. The agency accordingly has denied the petition. The petition is hereinafter identified as DP07–001.

FOR FURTHER INFORMATION CONTACT: Mr. Steve Chan, Safety Defects Engineer, Defects Assessment Division, Office of Defects Investigation, NHTSA, 1200 New Jersey Avenue, SE., Washington, DC 20590. Telephone: (202) 366–8537.

SUPPLEMENTARY INFORMATION: On June 29, 2007, NHTSA received a petition from Mr. Richard H. McSwain of McSwain Engineering Inc., requesting that the agency investigate the failure of the seatback recliner mechanisms in the subject vehicles. The petition is based on an examination of a passenger side front seat recliner mechanism from a subject vehicle involved in a multi-vehicle collision, of an exemplar seat, as well as mechanical testing of a seat from a subject vehicle. The petitioner identified a failure mode involving bypass of the seatback stop pin (inside the recliner mechanism) during forward movement of the seatback, such as when entering and exiting the rear seat. The petition stated that stop pin bypass allows the recliner mechanism sector gear to over-travel with respect to the pawl. Return of the seatback to the upright position may then bend the first tooth of the pawl, resulting in a false or partial engagement of the sector and pawl teeth. This false engagement condition is transmitted to the opposing recliner mechanism via a mechanical communication cable. According to the petition, the ultimate result is the inability of the recliner mechanism to support the seatback during a collision event. The petitioner concluded that the stop pin bypass that initiated the failure mode is a result of inadequate height of the pin and the resulting inadequate contact between the pin and seatback stop.

The Federal Motor Vehicle Safety Standard (FMVSS) No. 207 "Seating Systems," specifies that seats in passenger cars, multipurpose passenger vehicles, trucks, and buses must meet certain static force test requirements. However, for seats that hinge on folding seatbacks, the restraining device, once engaged, shall not release when a force equal to twenty times the weight of the seatback is applied through the center of gravity for the seat in the direction the seat is facing. It is not uncommon to see the seatbacks of new vehicles moved from their initial positions after a FMVSS simulated vehicular collision.

The identified failure mode may be the result of progressive wear and tear of the seatback stop pin, the seatback stop, and other seat components in vehicles that are, on average, 17 years old. Available data do not suggest that this has occurred with a notable frequency. ODI reviewed its consumer complaint data received over the last nineteen years and found no complaints of seatback collapse (with or without a vehicle collision) in the subject vehicles.

In view of the foregoing, and considering the advanced age of the subject vehicles, it is unlikely that NHTSA would issue an order for the notification and remedy of the alleged defect as defined by the petitioner at the conclusion of the investigation requested in the petition. The statutory requirement that the manufacturer provide a free remedy does not apply if the vehicle was bought by the first purchaser more than 10 calendar years before an order is issued. Therefore, in view of the need to allocate and prioritize NHTSA's limited resources to best accomplish the agency's safety mission, the petition is denied.

Authority: 49 U.S.C. 30162(d); delegations of authority at CFR 1.50 and 501.8.

Issued on: December 4, 2007.

Daniel C. Smith,

Associate Administrator for Enforcement.

[FR Doc. E7–23853 Filed 12–7–07; 8:45 am]

BILLING CODE 4910–59–P

DEPARTMENT OF TRANSPORTATION

National Highway Traffic Safety Administration

[Docket No. NHTSA–2007–0042; Notice 1]

General Motors Corporation, Receipt of Petition for Decision of Inconsequential Noncompliance

General Motors Corporation (GM) has determined that certain model year 2005, 2006 & 2007 Cadillac STS passenger cars equipped with sunroofs do not fully comply with paragraph S4(e) of 49 CFR 571.118, Federal Motor Vehicle Safety Standard (FMVSS) No. 118 Power-Operated Window, Partition, and Roof Panel Systems. GM has filed an appropriate report pursuant to 49 CFR Part 573, Defect and Noncompliance Responsibility and Reports.

Pursuant to 49 U.S.C. 30118(d) and 30120(h), GM has petitioned for an exemption from the notification and

(3) Saddle Road (State Route 200), Mamalahoa Highway (HRS 343 FEA-EISPN)

District: South Kohala
TMK: (3rd): 6-7-001:003
Proposing Agency: State of Hawai‘i, Department of Transportation, Highways Division, 869 Punchbowl Street, Honolulu, Hawai‘i, 96813. Contact: Ronald F. Tsuzuki (808-587-1830)
Accepting Authority: The Honorable Linda Lingle, Governor, State of Hawai‘i, Executive Chambers, State Capitol, Honolulu, Hawai‘i 96813
Consultant: DMT Consultant Engineers, 677 Ala Moana Boulevard, Suite 703, Honolulu, Hawai‘i 96813. Contact: Bruce K. Meyers (808-961-5527)
Status: Final Environmental Assessment and Environmental Impact Statement Preparation Notice, pending 30-day public comment. Address comments to the applicant with copies to the accepting authority, consultant and OEQC.
Public Comment Deadline: January 22, 2008 (Request for 45-day comment period)
Permits Required: Fed Clean Water Act Section 404 Permit*; Section 106 concurrence. State Highways Permit, National Pollutant Discharge Elimination System Permit, Coastal Zone Management Consistency; Conservation District Use Permit* (for portion). County: Grading Grubbing, Excavating and Stockpiling Permits; Subdivision Approval (* - *not yet determined*)

In 1996, Saddle Road was a narrow, two lane road with steep grades, sharp curves, poor pavement, and substandard drainage. The road had become vital for access to the U.S. Army’s Pohakuloa Training Area (PTA), Mauna Kea, Mauna Loa, outdoor recreation areas, ranch lands, and the communities of Waiki‘i Ranch and Kaumana. Its role was increasing as a cross island transportation route linking East and West Hawai‘i for business travel, the transport of goods and services, tourism/recreation, shopping, and commuting. The Saddle Road passed through key training areas of PTA, creating conflicts between motorists and military training units. Roadway deficiencies also hindered the response of emergency vehicles responding to fires and accidents along Saddle Road. A project to improve Saddle Road was initiated by the Federal Highway Administration (FHWA), in cooperation with the State Department of Transportation (HDOT) and the U.S. Army. An EIS was completed in 1999, and since that time 6 miles of the 47-mile road have been built, with another 15 miles now in construction.

In 2006, the Army purchased a Parker Ranch property known as the Ke‘âmuku parcel, which included the area planned for the western section of the Saddle Road. The Army intends to incorporate the property within PTA and use it for military training. In 2006, the Army requested that the HDOT and FHWA consider relocating about 9 miles of the proposed highway about a mile southwest towards the southern boundary of Ke‘âmuku. As this would minimize conflict between military and the traveling public, the agencies have agreed to the request. The joint State-federal SEIS will examine the differences in environmental impact between the originally proposed route and a new route to be identified near the southern boundary of Ke‘âmuku.

(4) University of Hawai‘i, Hilo College of Hawaiian Language Facilities (HRS 343 DEA)

District: South Hilo
TMK: (3rd): 2-4-01:07
Proposing Agency: University of Hawai‘i, Office of Capital Improvements, 1960 East West Road, Biomed Sci. Bld. Ctyd. B-102, Honolulu, Hawai‘i 96822. Contact: Maynard G.. P. Young (808-956-4071)
Determination Agency: Same as above.
Consultant: Geometrician Associates, PO Box 396, Hilo Hawai‘i 96721. Contact: Ron Terry (808-969-7090)
Public Comment Deadline: January 7, 2008
Status: Draft environmental assessment (DEA) notice pending 30-day public comment. Address comments to the proposing agency with copies to the consultant and OEQC.
Permits Required: Hawai‘i County: Planning Department Approval Plan Approval and Building Permit; Planning Commission Height Variance; Public Works Grading Permit, Driveway Permit and Drainage Approval; State: DOH NPDES

The University of Hawai‘i at Hilo proposes to develop facilities to house Ka Haka ‘Ula O Ke‘elikôlani, the College of Hawaiian Language. The facilities will expand educational opportunities and help revitalize Hawaiian language and culture. The College was established at UH Hilo in 1997 and includes the Hawaiian Studies Division, the Hawaiian Language Center Division, the Laboratory School Division and an Outreach Program. The College’s facilities are currently spread among five existing buildings at UH Hilo and another building located six miles from campus. The new facility will accommodate the current programs as well as future growth. Phase 1 is currently in design and will include a two-story building for administrative offices and classrooms and two one-story daycare/preschool structure, connected by covered walkways, with associated parking, utilities, and landscaping. Later phases will accommodate the teacher training program, media/telecommunications services, and graduate students. The College is being developed within the Leadership in Energy and Environmental Design (LEED) Program. It will incorporate many environmentally sustainable features and will meet standards for a silver certificate in this “green building” rating system. Construction would have a minor and easily mitigable effect on traffic. Long-term traffic impacts would be minimal and mitigated through proper design of entry/exit points. Short-term noise, air, and water quality impacts associated with grading and landscaping would be mitigated. A Storm Water Pollution Prevention Plan (SWPPP) to contain sediment and storm water runoff during grading and construction will be developed and implemented. The site has been mostly graded or otherwise disturbed

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SADDLE ROAD (STATE ROUTE 200)
Mamalahoa Highway (State Route 190) to Milepost 42
County of Hawai‘i, State of Hawai‘i
FHWA Project No. 200(00)

SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT

Submitted Pursuant to Section 42 U.S.C. 4332(2)(c)
and Chapter 343, Hawai‘i Revised Statutes by the

U.S. DEPARTMENT OF TRANSPORTATION
Federal Highway Administration (FHWA)
Central Federal Lands Highway Division
and
STATE OF HAWAI‘I
Department of Transportation (HDOT)
Highways Division

Cooperating Agencies
U.S. Army Garrison, Hawai‘i

Appendix A
Public Involvement and Agency Coordination
A2: Comments to NOI/EISPN and HDOT Responses

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Harry Kim
Mayor

Christopher J. Yuen
Director

Brad Kurokawa, ASLA
LEED® AP
Deputy Director

County of Hawaii
PLANNING DEPARTMENT
101 Pauahi Street, Suite 3 • Hilo, Hawaii 96720-4224
(808) 961-8288 • FAX (808) 961-8742

January 22, 2008

Mr. Ron Terry
Geometrician Associates
PO Box 396
Hilo, HI 96721

Dear Mr. Terry:

Subject: Consultation for the Preparation of a Supplemental Environmental Impact Statement (SEIS)
Project: Saddle Road (SR 200) between Mile Post 42 and Mamalahoa Highway
Tax Map Key: (3) 6-7-1: portion of 3; Ke'āmuku, South Kohala, Hawaii

We have reviewed the Environmental Impact Statement Preparation Notice dated December 6, 2007 for the construction of Saddle Road (SR 200) on the Ke'āmuku parcel between Mile Post 42 and Mamalahoa Highway and have the following comments to offer.

The Bike Plan Hawaii lists bicycle lanes on Saddle Road between Mamalahoa Highway and Hilo as a long-term priority that could be implemented with minor improvements to the existing roadway. Although bicycle lanes are not discussed in the EIS Preparation Notice, the SEIS should discuss the feasibility of incorporating bicycle lanes into the proposed project.

Due to the topography in the project area it is likely that with construction of the selected alignment a new scenic view plane will be created for motorists. To enhance the experience of tourism travelers, HDOT should consider constructing roadside turnouts for scenic viewing purposes.

To reduce conflicts between civilian and military vehicles, grade-separated structures such as overpass or underpass crossings should be constructed at all intersections of the selected Saddle Road alignment with the former tank road, which the Army proposed using in their EIS to transport Stryker vehicles from Kawaihae Harbor to PTA. Please provide an illustration in the SEIS of the W-7 and W-3 alignments in relation to the military trail that will be used to transport Stryker vehicles.

Please provide this office with a copy of the draft EA upon its publication. Should you have questions, please contact Maija Cottle of my staff at 961-8288 extension 253.

Sincerely,

CHRISTOPHER J. YUEN
Planning Director

MJC:cs
P:\wpwin60\Maija\EA-EIS\Pre-Consult Comments\Saddle Road MP 42 to Mamalahoa 6-7-1-3 Pre-cmnts doc

xc: Mr. Nelson Sagum
Hawai'i State Department of Transportation
Highways Division
869 Punchbowl Street
Honolulu, HI 96813

Director
Office of Environmental Quality Control
235 South Beretania Street, Suite 702
Honolulu, HI 96813

LINDA LINGLE
GOVERNOR

BRENNON T. MORIOKA
INTERIM DIRECTOR

Deputy Directors
MICHAEL D. FORMBY
FRANCIS PAUL KEENO
BRIAN H. SEKIGUCHI

STATE OF HAWAII
DEPARTMENT OF TRANSPORTATION
869 PUNCHBOWL STREET
HONOLULU, HAWAII 96813-5097

IN REPLY REFER TO:

HWY-PA
2.7123

FEB 21 2008

Mr. Christopher J. Yuen
Director
Planning Department
County of Hawaii
101 Pauahi Street, Suite 3
Hilo, Hawaii 96720

Dear Ms. Yuen:

Subject: Saddle Road (State Route 200)
Mamalahoa Highway (State Route 190) to Milepost 42
Supplemental EIS Preparation Notice (EISPN)

Thank you for your letter, dated January 22, 2008, in which you provided us with your comments regarding the subject project. A brief statement from your comments and our tentative responses are provided below:

1. *The SEIS should discuss the feasibility of incorporating bicycle lanes into the proposed project.*

   Bicycle lanes along the proposed highway will be further evaluated during the development of the project's Supplemental EIS. However, at the moment, the typical section of the proposed highway will definitely include 8-foot shoulders on each side of the highway, which may be used by bicyclists and are favored by the State Department of Transportation (DOT).

2. *. . . DOT should consider constructing roadside turnouts . . .*

   The project's Supplemental EIS will include a discussion of the scenic turnouts along the proposed highway and will consider several possible locations for these facilities. Although there seems to be widespread support of scenic turnouts, these facilities may be costly to construct and operate.

3. *To reduce conflicts between civilian and military vehicles, grade-separated structures such as overpass or underpass crossings should be constructed at all intersections of the selected Saddle Road alignment with the former tank road . . .*

HWY-PA
2.7123

One of the primary reasons in favor of the relocation of the proposed Saddle Road involves the reduction of conflicts with military vehicles and the necessity to construct such grade-separated structures. We are very hopeful that military training maneuvers will be confined to areas north of the proposed highway and crossings will be infrequent; at locations where multiple or frequent crossings are anticipated, grade-separated structures will be considered.

Please also note, upon its completion, a copy of the draft Supplemental EIS will be forwarded to your office for your review and comments.

If you have any other questions or issues concerning this project, please contact Nelson Sagum, our project manager, at (808) 587-1834.

Very truly yours,

BRENNON T. MORIOKA, Ph.D., P.E.
Interim Director of Transportation

bc: HWY-PA

NS:th

LINDA LINGLE
GOVERNOR

RUSS K. SAITO
COMPTROLLER

BARBARA A. ANNIS
DEPUTY COMPTROLLER

(P)1022.8

STATE OF HAWAII
DEPARTMENT OF ACCOUNTING AND GENERAL SERVICES
P.O. BOX 119, HONOLULU, HAWAII 96810

JAN 22 2008

Mr. Ron Terry
Geometrician Associates
P.O. Box 396
Hilo, Hawaii 96721

Dear Mr. Terry:

Subject: Supplemental Environmental Impact Statement Preparation Notice
Saddle Road (Route 200), Mamalahoa Hightway (State Route 190)
Island of Hawaii, Kohala
TMK: (3) 6-7-001:003

Thank you for the opportunity to review the information regarding the subject project. The project does not impact any of the Department of Accounting and General Services' projects or existing facilities and we have no comments to offer.

If there are any questions regarding the above, please have your staff call Mr. David DePonte of the Planning Branch at 586-0492.

Sincerely,

Ralph Morita
for ERNEST LAU
Public Works Administrator

DD:vca
c: Mr. Laurence K. Lau, Director, OEQC
Mr. Nelson Sagum, DOT - Highways
Mr. Glenn Okada, DAGS Hawaii District Office

LINDA LINGLE
GOVERNOR

STATE OF HAWAII
DEPARTMENT OF TRANSPORTATION
869 PUNCHBOWL STREET
HONOLULU, HAWAII 96813-5097

BRENNON T. MORIOKA
INTERIM DIRECTOR

Deputy Directors
MICHAEL D. FORMBY
FRANCIS PAUL KEENO
BRIAN H. SEKIGUCHI

IN REPLY REFER TO:

HWY-PA
2.7130

FEB 21 2008

Mr. Ernest Lau
Public Works Administrator
State of Hawaii
Department of Accounting and General Services
P.O. Box 119
Honolulu, Hawaii 96810

Dear Mr. Lau:

Subject: Saddle Road (State Route 200)
Mamalahoa Highway (State Route 190) to Milepost 42
Supplemental EIS Preparation Notice (EISPN)

Thank you for your letter, dated January 22, 2008, in which you stated that our proposed highway project would not impact any of the Department of Accounting and General Services' projects or existing facilities.

If you have any questions or issues concerning this project, please contact Nelson Sagum, our project manager, at (808) 587-1834.

Very truly yours,

BRENNON T. MORIOKA, ~~Ph.D.~~, P.E.
Interim Director of Transportation

bc: HWY-PA

NS:th

Harry Kim
Mayor

Jane H. Testa
Director

Diane L. Ley
Deputy Director

County of Hawaii

DEPARTMENT OF RESEARCH AND DEVELOPMENT

25 Aupuni Street, Room 109 • Hilo, Hawaii 96720-4252
(808) 961-8366 • Fax (808) 935-1205
E-mail: chresdev@co.hawaii.hi.us

January 11, 2008

Ron Terry
Geometrician Associates
P. O. Box 396
Hilo, Hawai`i 96721

RE: Environmental Impact Statement Preparation Notice
Saddle Road (State Route 200), Mamalahoa Highway (State Route 190) to Milepost 42
Kohala District, Hawai`i Island

Dear Mr. Terry:

Thank you for providing the County of Hawai`i's Department of Research and Development with an opportunity to review and provide comments on the Environmental Impact Statement Preparation Notice for the proposed realignment of Saddle Road (State Route 200), Mamalahoa Highway (State Route 190) to Milepost 42, Kohala District, Hawai`i Island. Our Department has no comments or concerns at this time.

Sincerely,

Diane Ley
Deputy Director

C: Director, Office of Environmental Quality Control
Nelson Sagum, Highways Division, Hawai`i Department of Transportation

LINDA LINGLE
GOVERNOR

STATE OF HAWAII
DEPARTMENT OF TRANSPORTATION
869 PUNCHBOWL STREET
HONOLULU, HAWAII 96813-5097

BRENNON T. MORIOKA
INTERIM DIRECTOR

Deputy Directors
MICHAEL D. FORMBY
FRANCIS PAUL KEENO
BRIAN H. SEKIGUCHI

IN REPLY REFER TO:

HWY-PA
2.7133

FEB 21 2008

Ms. Diane Ley
Deputy Director
Department of Research and Development
County of Hawaii
25 Aupuni Street, Room 109
Hilo, Hawaii 96720

Dear Ms. Ley:

Subject: Saddle Road (State Route 200)
Mamalahoa Highway (State Route 190) to Milepost 42
Supplemental EIS Preparation Notice (EISPN)

Thank you for your letter, dated January 11, 2008, in which you stated that you had no comments to offer regarding the Supplemental EISPN for this project. We appreciate your review of this document.

If you have any questions or issues concerning this project, we encourage you to contact Nelson Sagum, our project manager, at (808) 587-1834.

Very truly yours,

BRENNON T. MORIOKA, Ph.D., P.E.
Interim Director of Transportation

bc: HWY-PA

NS:th

DEPARTMENT OF WATER SUPPLY • COUNTY OF HAWAI'I
345 KEKUANAO'A STREET, SUITE 20 • HILO, HAWAI'I 96720
TELEPHONE (808) 961-8050 • FAX (808) 961-8657

January 28, 2008

Mr. Ron Terry
Geometrician Associates, LLC
P.O. Box 396
Hilo, HI 96721

**SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT PREPARATION NOTICE
SADDLE ROAD (STATE ROUTE 200) MAMALAHOA HIGHWAY (STATE ROUTE 190) TO MILEPOST 42
TAX MAP KEY 6-7-001:003**

This is in response to the subject Supplemental EIS Prepration Notice.

Please be informed that there are no existing Department of Water Supply facilities within the project area. Therefore, we will not need to review the Draft Supplemental EIS for this project when it is completed.

Should there be any questions, please contact Mr. Finn McCall of our Water Resources and Planning Branch at 961-8070, extension 255.

Sincerely yours,

Milton D. Pavao, P.E.
Manager

FM:dfg

copy - Office of Environmental Quality Control
State of Hawai'i, Department of Transportation, Highways Division

... *Water brings progress*...

LINDA LINGLE
GOVERNOR

BRENNON T. MORIOKA
INTERIM DIRECTOR

Deputy Directors
MICHAEL D. FORMBY
FRANCIS PAUL KEENO
BRIAN H. SEKIGUCHI

STATE OF HAWAII
DEPARTMENT OF TRANSPORTATION
869 PUNCHBOWL STREET
HONOLULU, HAWAII 96813-5097

IN REPLY REFER TO:

HWY-PA
2.7132

FEB 21 2008

Mr. Milton D. Pavao
Manager
Department of Water Supply
County of Hawaii
345 Kekuanao'a Street, Suite 20
Hilo, Hawaii 96720

Dear Mr. Pavao:

Subject: Saddle Road (State Route 200)
Mamalahoa Highway (State Route 190) to Milepost 42
Supplemental EIS Preparation Notice (EISPN)

Thank you for your letter, dated January 28, 2008, in which you stated that there are no County of Hawaii, Department of Water Supply facilities in the project area, and consequently, your subsequent review of the draft Supplemental EIS will not be necessary.

We appreciate receiving this information, and at this time, we will not be forwarding a copy of the draft Supplemental EIS to your office.

If you have any questions or issues concerning this project, please contact Nelson Sagum, our project manager, at (808) 587-1834.

Very truly yours,

BRENNON T. MORIOKA, Ph.D., P.E.
Interim Director of Transportation

bc: HWY-PA

NS:th

Harry Kim
Mayor

Bobby Jean Leithead-Todd
Director

Nelson Ho
Deputy Director

County of Hawai'i
DEPARTMENT OF ENVIRONMENTAL MANAGEMENT
25 Aupuni Street • Hilo, Hawai'i 96720
(808) 961-8083 · Fax (808) 961-8086
http://co.hawaii.hi.us/directory/dir_envmng.htm

December 13, 2007

Mr. Ron Terry
Geometrician Associates
P. O. Box 396
Hilo, HI 96720

SUBJECT: ENVIRONMENTAL IMPACT STATEMENT PREPARATION NOTICE SADDLE ROAD (STATE ROUTE 200), MAMALAHOA HIGHWAY (STATE ROUTE 190) TO MILEPOST 42 TMK: 6-7-001:003

We have reviewed the subject request and have no comments to offer.

Thank you for allowing us to comment on this project.

Bobby Jean Leithead Todd
DIRECTOR

cc: Director, OEQC
Hawai'i State DOT, Highways Division

102√3A

LINDA LINGLE
GOVERNOR

STATE OF HAWAII
DEPARTMENT OF TRANSPORTATION
869 PUNCHBOWL STREET
HONOLULU, HAWAII 96813-5097

BRENNON T. MORIOKA
INTERIM DIRECTOR

Deputy Directors
MICHAEL D. FORMBY
FRANCIS PAUL KEENO
BRIAN H. SEKIGUCHI

IN REPLY REFER TO:

HWY-PA
2.7134

FEB 21 2008

Ms. Bobby Jean Leithead-Todd
Director
Department of Environmental Management
County of Hawaii
25 Aupuni Street, Room 210
Hilo, Hawaii 96720

Dear Ms. Leithead-Todd:

Subject: Saddle Road (State Route 200)
Mamalahoa Highway (State Route 190) to Milepost 42
Supplemental EIS Preparation Notice (EISPN)

Thank you for your letter, dated December 13, 2007, in which you stated that you had no comments to offer regarding the Supplemental EISPN for this project. We appreciate your review of this document.

If you have any questions or issues concerning this project, we encourage you to contact Nelson Sagum, our project manager, at (808) 587-1834.

Very truly yours,

BRENNON T. MORIOKA, Ph.D., P.E.
Interim Director of Transportation

bc: HWY-PA

NS:th

LINDA LINGLE
GOVERNOR

MAJOR GENERAL ROBERT G. F. LEE
DIRECTOR OF CIVIL DEFENSE

EDWARD T. TEIXEIRA
VICE DIRECTOR OF CIVIL DEFENSE

PHONE (808) 733-4300
FAX (808) 733-4287

STATE OF HAWAII
DEPARTMENT OF DEFENSE
OFFICE OF THE DIRECTOR OF CIVIL DEFENSE
3949 DIAMOND HEAD ROAD
HONOLULU, HAWAII 96816-4495

January 3, 2008

Mr. Ron Terry
Geometrician Associates, LLC
P. O. Box 396
Hilo, Hawaii 96721

Dear Mr. Terry:

Supplemental Environmental Impact Statement
Saddle Road, Mamalahoa Highway to Milepost 42
TMK (3rd): 6-7-001:003

Thank you for the opportunity to comment on this Supplemental Environmental Impact Statement (SEIS). After careful review of the documents for this Saddle Road realignment, State Civil Defense (SCD) recommends that the developer not be required to install an outdoor warning siren. SCD already has a siren simulator installed at the Pohakuloa Training Area Military Police office.

If you have any questions, please call Mr. Norman Ogasawara, Assistant Telecommunications Officer, at (808) 733-4300, ext. 531.

Sincerely,

EDWARD T. TEIXEIRA
Vice Director of Civil Defense

Enc.

c: Hawaii Civil Defense Agency
SCD Radio Shop

LINDA LINGLE
GOVERNOR

STATE OF HAWAII
DEPARTMENT OF TRANSPORTATION
869 PUNCHBOWL STREET
HONOLULU, HAWAII 96813-5097

BRENNON T. MORIOKA
INTERIM DIRECTOR

Deputy Directors
MICHAEL D. FORMBY
FRANCIS PAUL KEENO
BRIAN H. SEKIGUCHI

IN REPLY REFER TO:

HWY-PA
2.7124

FEB 27 2008

Mr. Edward T. Teixeira
Vice Director of Civil Defense
State of Hawaii
Department of Defense
3949 Diamond Head Road
Honolulu, Hawaii 96816-4495

Dear Mr. Teixeira:

Subject: Saddle Road (State Route 200)
Mamalahoa Highway (State Route 190) to Milepost 42
Supplemental EIS Preparation Notice (EISPN)

Thank you for your January 3, 2008 letter that advises us that the State Civil Defense has installed a siren simulator at the Pohakuloa Training Area. Therefore, our contractor will not be required to install an outdoor warning siren.

If you have any questions or issues concerning this project, please contact Nelson Sagum, our project manager, at 587-1834.

Very truly yours,

BRENNON T. MORIOKA, Ph.D., P.E.
Interim Director of Transportation

bc: HWY-PA

NS:th

LINDA LINGLE
GOVERNOR OF HAWAII

CHIYOME L. FUKINO, M.D
DIRECTOR OF HEALTH

STATE OF HAWAII
DEPARTMENT OF HEALTH
P.O. Box 3378
HONOLULU, HAWAII 96801-3378

In reply, please refer to:
EPO-07-228

January 22, 2008

Mr. Ron Terry
Geometrician Associates
P.O. Box 396
Hilo, Hawaii 96721

Dear Mr. Terry:

SUBJECT: Supplemental Environmental Impact Statement Preparation Notice for Saddle Road (State Route 200), Mamalahoa Highway (State Route 190) to Milepost 42 Project
Keamuku, South Kohala, Island of Hawaii, Hawaii
TMK: (3) 6-7-001: 003

Thank you for allowing us to review and comment on the subject document. The document was routed to the various branches of the Department of Health (DOH) Environmental Health Administration. We have the following Clean Water Branch and General comments.

Clean Water Branch

Please note that our review is based solely on the information provided in the subject document and its compliance with Hawaii Administrative Rules (HAR), Chapters 11-54 and 11-55. You may be responsible for fulfilling additional requirements related to our program. We recommend that you also read our standard comments on our website at
http://www.hawaii.gov/health/environmental/env-planning/landuse/CWB-standardcomment.pdf.

1. Any project and its potential impacts to State waters must meet the following criteria:

   a. Antidegradation policy (HAR, Section 11-54-1.1), which requires that the existing uses and the level of water quality necessary to protect the existing uses of the receiving State water be maintained and protected.

   b. Designated uses (HAR, Section 11-54-3), as determined by the classification of the receiving State waters.

   c. Water quality criteria (HAR, Sections 11-54-4 through 11-54-8).

2. The project was granted a National Pollutant Discharge Elimination System (NPDES) individual permit for the section of the project from Milepost 28-42 and Phase 3. This permit is set to expire on November 29, 2009. NPDES general permit coverage for the portion of the project from MP 19-28 expired on November 6, 2007. The CWB has not received a Notice of Intent to renew this coverage and if construction is ongoing as stated in the subject document, then it is considered to be a violation of HAR, Chapter 11 -55.

3. Please note that all discharges related to the project construction or operation activities, whether or not NPDES permit coverage and/or Section 401 Water Quality Certification are required, must comply with the State's Water Quality Standards. Noncompliance with water quality requirements contained in HAR, Chapter 11-54, and/or permitting requirements, specified in HAR, Chapter 11-55, may be subject to penalties of $25,000 per day per violation.

If you have any questions, please visit our website at http://www.hawaii.gov/health/environmental/water/cleanwater/index.html, or contact the Engineering Section, CWB, at 586-4309.

General

We strongly recommend that you review all of the Standard Comments on our website: www.state.hi.us/health/environmental/env-planning/landuse/landuse.html. Any comments specifically applicable to this project should be adhered to.

If there are any questions about these comments please contact Jiacai Liu with the Environmental Planning Office at 586-4346.

Sincerely,

KELVIN H. SUNADA, MANAGER
Environmental Planning Office

c: EPO
CWB
EH-Hawaii

LINDA LINGLE
GOVERNOR

BRENNON T. MORIOKA
DIRECTOR

Deputy Directors
MICHAEL D. FORMBY
FRANCIS PAUL KEENO
BRIAN H. SEKIGUCHI

STATE OF HAWAII
DEPARTMENT OF TRANSPORTATION
869 PUNCHBOWL STREET
HONOLULU, HAWAII 96813-5097

IN REPLY REFER TO:

HWY-PA
2.7279

MAR 19 2008

Mr. Kevin H. Sunada, Manager
State of Hawaii
Department of Health
Environmental Planning Office
P.O. Box 3378
Honolulu, Hawaii 96801-3378

Dear Mr. Sunada:

Subject: Saddle Road (State Route 200)
Mamalahoa Highway (State Route 190) to Milepost 42
Supplemental EIS Preparation Notice (EISPN)

Thank you for your letter, dated January 22, 2008, which commented on the Supplemental EIS Preparation Notice based on Hawaii Administrative Rules (HAR), Chapters 11-54 and 11-55. Your letter also provided us with a website containing your standard comments for projects and we are indeed grateful for this information.

Brief statements from the comments of your letter, along with our tentative responses, are provided below:

1. *Anti-degradation policy, designated uses as determined by classification of the receiving waters, and water quality criteria.*

   This project will fully comply with the Consent Decree, dated January 2006, in regards to requirements of Clean Water Act and the regulations developed in accordance with this Act. At this point, it appears that the project will not affect any State waters, and consequently, efforts to comply with Consent Decree may be minimal.

2. *The National Pollutant Discharge Elimination System (NPDES) general permit coverage for the portion of the project from MP 19-28 expired on November 6, 2007.*

   According to our records, the Federal Highway Administration, Central Federal Lands Highway Division, filed a Notice of Intent (NOI) to develop a NPDES general permit with your agency in September 2007. A Department of Health letter, dated October 4, 2007, granted an administrative extension of NPDES general permit, until your agency is able to complete its processing of the NOI.

3. *. . . all discharges related to the project construction or operation activities, . . . must comply with the State's Water Quality Standards.*

   Again, we do not anticipate that this project will affect any waters of the State of Hawaii. In the event that State waters may be impacted, appropriate construction methods will be utilized to control discharges from the project site, which should assure compliance with the State's Water Quality Standards and the Consent Decree, as prepared pursuant to the Clean Water Act.

We appreciate your assistance. If any questions or problems arise, please feel free to contact Nelson Sagum, Project Manager, at 587-1834.

Very truly yours,

BRENNON T. MORIOKA, Ph.D., P.E.
Director of Transportation

bc: HWY-PA

NS:th

LINDA LINGLE
GOVERNOR

CHAD K. TANIGUCHI
EXECUTIVE DIRECTOR

STATE OF HAWAII

DEPARTMENT OF HUMAN SERVICES
HAWAII PUBLIC HOUSING AUTHORITY
1002 NORTH SCHOOL STREET
P.O. BOX 17907
Honolulu, Hawaii 96817

IN REPLY REFER TO

07:CMS/0291

December 14, 2007

Mr. Ron Terry
Geometrician Associates, LLC
P.O. Box 396
Hilo, Hawai 96721

Dear Mr. Terry:

Thank you for your letter dated December 6, 2007 regarding the Saddle Road (State Route 200), Mamalahoa Highway (State Route 190) to Milepost 42 Project in the County of Hawai'i.

We have no comments on the Environmental Impact Statement Preparation Notice for the above project.

Should you have any questions, please call me at 832-6020.

Sincerely,

Derek H. Fujikami
Construction Management Section Chief

c: Director, Office of Environmental Quality Control
Mr. Nelson Sagum, Hawaii State Dept. of Transportation

LINDA LINGLE
GOVERNOR

STATE OF HAWAII
DEPARTMENT OF TRANSPORTATION
869 PUNCHBOWL STREET
HONOLULU, HAWAII 96813-5097

BRENNON T. MORIOKA
DIRECTOR

Deputy Directors
MICHAEL D. FORMBY
FRANCIS PAUL KEENO
BRIAN H. SEKIGUCHI

IN REPLY REFER TO:

HWY-PA
2.7278

March 25, 2008

Mr. Derek H. Fujikami
Construction Management Section Chief
State of Hawaii, Department of Human Services
Hawaii Public Housing Authority
P.O. Box 17907
Honolulu, Hawaii 96817

Dear Mr. Fujikami:

Subject: Saddle Road (State Route 200)
Mamalahoa Highway (State Route 190) to Milepost 42
Supplemental EIS Preparation Notice (EISPN)

Thank you for your letter, dated December 14, 2007, in which you stated that you had no comments to offer regarding the Supplemental EISPN for this project. We appreciate your review of this document.

In the future, if you have any questions or issues concerning this project, we encourage you to contact Nelson Sagum, Project Manager, at 587-1834.

Very truly yours,

for

BRENNON T. MORIOKA, Ph.D., P.E.
Director of Transportation

bc: HWY-PA

NS:th

PHONE (808) 594-1888 FAX (808) 594-1865

STATE OF HAWAI'I
OFFICE OF HAWAIIAN AFFAIRS
711 KAPI'OLANI BOULEVARD, SUITE 500
HONOLULU, HAWAI'I 96813

HRD07/3273C

January 25, 2008

Ron Terry
Geometrician Associates LLC
P.O. Box 396
Hilo, HI 96721

RE: Request for comments on the preparation notice for the Supplemental Environmental Impact Statement for the Saddle Road (State Route 200), Māmalahoa Highway (State Route 190) to Milepost 42

Dear Ron Terry,

The Office of Hawaiian Affairs (OHA) is in receipt of the above-referenced request. The federal and state departments of transportation are planning to develop a new alternative path for a section of the Saddle Road improvement project. The 1999 Saddle Road EIS analyzed two alternative routes for the Saddle Road improvement project. That study will now be revisited by the Supplemental EIS because both alternative routes from the 1999 EIS run through a large property that the U.S. Army purchased from Parker Ranch in 2006 for the Stryker Transformation Project. The Supplemental EIS will investigate a new alignment located near the southern boundary of the Army's newly-acquired, 23,977-acre Ke'āmuku parcel. The new route is expected to lower the frequency of interactions between military training that will occur in the Ke'āmuku parcel and Saddle Road motorists. OHA offers the following comments.

OHA looks forward to participating in all consultations for this project that are conducted in compliance with Section 106 of the National Historic Preservation Act. We also request to be involved in any consultations that occur relating to the 2004 Programmatic Agreement regarding the Section 106 responsibilities for the Army's proposed transformation of the 2^{nd} Brigade, 25^{th} Infantry Division to a Stryker Brigade Combat Team. OHA is a concurring party to that agreement. We also anticipate that the Supplemental EIS will address the impacts the project will have on Native Hawaiian traditional and customary practices and rights, as well as any Traditional Cultural Properties, as defined by National Register Bulletin 38 (National Park Service 1990).

Finally, OHA asks to be informed on future public meetings regarding this issue in advance so that we may attend. We look forward to reviewing the Supplemental EIS, when it becomes available. Thank you for the opportunity to comment. If you have further questions, please contact Sterling Wong (808) 594-0248 or e-mail him at sterlingw@oha.org.

Sincerely,

Clyde W. Nāmu'o
Administrator

C: Nelson Sagum
State Department of Transportation
Highways Division
869 Punchbowl Street #301
Honolulu, HI 96813

Director
Office of Environmental Quality Control
235 South Beretania Street, Suite 702
Honolulu, HI 96813

Ruby McDonald
Office of Hawaiian Affairs
75-5706 Hanama Pl., Ste. 107
Kailua-Kona, HI 96740

Lukela Ruddle
Office of Hawaiian Affairs
162 A Baker Avenue
Hilo, HI 96720-4869

LINDA LINGLE
GOVERNOR

BRENNON T. MORIOKA
DIRECTOR

Deputy Directors
MICHAEL D. FORMBY
FRANCIS PAUL KEENO
BRIAN H. SEKIGUCHI

STATE OF HAWAII
DEPARTMENT OF TRANSPORTATION
869 PUNCHBOWL STREET
HONOLULU, HAWAII 96813-5097

IN REPLY REFER TO:

HWY-PA
2.7277

MAR 1 9 2008

Mr. Clyde W. Namuo
Administrator
State of Hawaii
Office of Hawaiian Affairs
711 Kapolei Boulevard, Suite 500
Honolulu, Hawaii 96813

Dear Mr. Namuo:

Subject: Saddle Road (State Route 200)
Mamalahoa Highway (State Route 190) to Milepost 42
Supplemental EIS Preparation Notice (EISPN)

Thank you for your letter, dated January 25, 2008, which commented on the proposed Saddle Road and its potential impact on both Native Hawaiian practices and rights and traditional cultural properties in the project area.

We appreciate your willingness to participate in the consultation processes for this project, which will be conducted in compliance with Section 106 of the National Historic Preservation Act. Our archaeological/cultural consultants will be contacting you in order to properly schedule this meeting.

We have not been directly involved in the 2004 Programmatic Agreement regarding the U.S. Army's transformation of the 2nd Brigade, 25th Infantry Division to a Stryker Brigade Combat Team. A copy of your letter will be forwarded to the U.S. Army, Corps of Engineers, for their information and further action.

In addition, we assure you that every effort will be made to notify the Office of Hawaiian Affairs of our future public meetings for this project.

If any other questions or issues arise regarding this project, please contact Nelson Sagum, Project Manager, at 587-1834.

Very truly yours,

BRENNON T. MORIOKA, Ph.D., P.E.
Director of Transportation

bc: HWY-PA
NS:th

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Pacific Islands Fish and Wildlife Office
300 Ala Moana Boulevard, Room 3-122, Box 50088
Honolulu, Hawaii 96850

In Reply Refer To:
2008-TA-0087
(ER 07/1059)

JAN 14 2008

Mr. Ricardo Suarez, P. E.
Division CFLHD Engineer
12300 West Dakota Avenue
Lakewood, Colorado 80228

Subject: Preparation of a Supplemental Environmental Impact Statement for the Proposed Realignment of Saddle Road (Keamuku Parcel), Hawaii

Dear Mr. Suarez:

The U. S. Fish and Wildlife Service reviewed the Federal Highway Administration notice in the Federal Register dated December 10, 2007 (Volume 72, Number 236, Page 69726-69727). The following information is to assist you and the Hawaii Department of Transportation, in preparing the Supplemental Environmental Impact Statement (SEIS) for the realigned portion of Saddle Road. The purpose of the project is to provide a safe and efficient route for access to land uses along Saddle Road and for cross-island traffic between East and West Hawaii. We have reviewed the information in the Record of Decision (ROD) (October 30, 1999) and pertinent information in our files, including data compiled by the Hawaii Biodiversity and Mapping Program, the Hawaii Geographic Analysis Program, and the interagency West Hawaii Wildfire Management Group's wildland fire history.

We offer the following recommendations as potential issues to be reviewed and addressed in the SEIS.

1. The southwestern portion of the Keamuku parcel harbors a significant concentration of plant species that are federally listed as threatened or endangered including *Haplostachys haplostachya, Silene lanceolat* and *Stenogyne angustifolia*. If alternative three from the Federal Register Notice is chosen, "relocating this segment of the highway nearer the southern boundary of the Keamuku parcel" the highway could directly impact listed plants species. We recommend current botanical survey information (i.e., within the last year) be included in the SEIS.

2. The proposed project is located on the dry leeward side of West Hawaii, where wildland fires may affect endangered species and critical habitat. Since the time the original ROD for was finalized in 1999, the threat of wildland fire has increased significantly in West

Hawaii. Measures for wildland fire prevention and suppression should be addressed in the SEIS.

3. We have taken a broad look at the general area of influence for this project, including areas that may potentially be impacted by wildland fires interdependent with the realigned Saddle Road. The following is a list of threatened and endangered species that could be impacted by this project (Table 1).

We hope this information assists you in drafting the Saddle Road SEIS. If you have questions regarding these comments, please contact Dr. Jeff Zimpfer, Fish and Wildlife Biologist, Technical Assistance and Consultation Program (phone: 808/792-9400; fax: 808/792-9581).

Sincerely,

for Patrick Leonard
Field Supervisor

Enclosure

cc: OEPC, Vijai N. Rai

Table 1. Threatened and endangered species within the area of potential influence of Saddle Road.

Scientific Name	Common Name	Status
Plants		
Argyroxiphium sandwicense subsp. *sandwicense*	ahinahina, silversword	Endangered
Asplenium peruvianum var. *insulare*	no common name	Endangered
Clermontia lindseyana	oha, oha wai	Endangered
Clermontia peleana subsp. *singuliflora*	oha, oha wai	Endangered
Haplostachys haplostachya	no common name	Endangered
Isodendrion hosakae	aupaka	Endangered
Melanthera venosa	nehe	Endangered
Portulaca sclerocarpa	ihi	Endangered
Silene hawaiiensis	no common name	Threatened
Silene lanceolata	no common name	Endangered
Solanum incompletum	popolo ku mai	Endangered
Stenogyne angustifolia	no common name	Endangered
Tetramolopium arenarium var. *confertum*	no common name	Endangered
Vigna o-wahuensis	no common name	Endangered
Birds		
Branta sandvicensis	nene, Hawaiian goose	Endangered
Buteo solitarius	Hawaiian hawk, io	Endangered
Hemignathus munroi	akiapolaau	Endangered
Loxioides bailleui	palila	Endangered
Loxops coccineus coccineus	Hawaii akepa	Endangered
Oreomystis mana	Hawaii creeper	Endangered
Pterodroma sandwichensis	Hawaiian dark-rumped petrel, uau	Endangered
Mammals		
Lasiurus cinereus semotus	Hawaiian hoary bat, opeapea	Endangered
Critical Habitat		
Loxioides bailleui	palila	
Isodendrion hosakae	aupaka	
Vigna o-wahuensis	no common name	

LINDA LINGLE
GOVERNOR

BRENNON T. MORIOKA
DIRECTOR

Deputy Directors
MICHAEL D. FORMBY
FRANCIS PAUL KEENO
BRIAN H. SEKIGUCHI

STATE OF HAWAII
DEPARTMENT OF TRANSPORTATION
869 PUNCHBOWL STREET
HONOLULU, HAWAII 96813-5097

IN REPLY REFER TO:

HWY-PA
2.7276

MAR 19 2008

Mr. Patrick Leonard
Field Supervisor
Fish and Wildlife Service
U.S. Department of Interior
300 Ala Moana Boulevard, Room 3-122
Honolulu, Hawaii 96850

Dear Mr. Leonard:

Subject: Saddle Road (State Route 200)
Mamalahoa Highway (State Route 190) to Milepost 42
Supplemental EIS Preparation Notice (EISPN)

Thank you for your letter, dated January 14, 2008, which provided us with your recommendations and requirements for this project's Supplemental Environmental Impact Statement (EIS). Your letter also provided us with a listing of threatened and endangered species in the vicinity of this project, and we appreciate receiving this information.

In accordance with Section 7, of the Endangered Species Act, botanical surveys will be conducted along the proposed corridors of this project and the results of these surveys will be included in the project's Supplemental EIS. At the moment, we are proposing that these surveys extend 250 feet from the centerline of each alternative alignment, with an expanded width in the southwestern portion of Keamuku.

As stated in your letter, fire risk and wildfire mitigation and suppression will be discussed in the Supplemental EIS. The development of this highway will also be coordinated with the State Department of Land and Natural Resources, Division of Forestry and Wildlife, as they share your concerns on the growing frequency of wildfires in the project area. We assure you that every effort will be made, to reduce wildfires along the proposed highway and minimize the effects of these fires on our protected wildlife in the project area.

If you have any other questions or comments regarding this project, please feel free to contact Nelson Sagum, Project Manager, at 587-1834.

Very truly yours,

BRENNON T. MORIOKA, Ph.D., P.E.
Director of Transportation
bc: HWY-PA
NS:th

United States Department of the Interior

U. S. GEOLOGICAL SURVEY
Hawaiian Volcano Observatory
P.O. Box 51
Hawaii National Park, HI 96718-0051
(808) 967-8824
FAX (808) 967-8890
E-MAIL: jimk@usgs.gov

USGS
science for a changing world

To: Geometrician Associates
From: Jim Kauahikaua, SIC
Date: December 28, 2007
Subject: comments on Supplemental Environmental Impact Statement Preparation Notice, Saddle Road (State Route 200) . . . FHWA Project No. 200(00)

There is a misunderstanding about earthquake shaking probabilities in the following section:

2.1.1 Geologic Resource and Hazards

The Uniform Building Code (UBC) is not a "seismic probability rating," but is a set of minimum construction standards intended to ensure that a building be located, designed, and constructed so that any threat to life, health, and welfare of its occupants and the public is minimized or prevented. Its provisions specify ways to make buildings resistant to damage from earthquakes and are based on expected shaking intensities. The Island of Hawai'i is in UBC Zone 4 in which construction is intended to resist a 10% chance of shaking equivalent to 0.4g within 50 years, where g is the acceleration of gravity.

Recent work shows that maximum shaking on areas of Hawai'i island south of Waikoloa Village (including this study area) have a 10% chance of exceeding accelerations of 0.4g within 50 years (Klein and others, 2001; also see http://pubs.usgs.gov/imap/i-2724/). If designers want to utilize the best estimates on probable future shaking, they should consult these references.

Klein F. W., Frankel A. D., Mueller C. S., Wesson R. L. and P. G. Okubo, 2001. Seismic Hazard in Hawaii: High Rate of Large Earthquakes and Probabilistic Ground-Motion Maps. Bulletin of the Seismological Society of America, 91, 3, pp. 479-498.

Cc: Director, Office of Environmental quality Conrol

Hawai'i State Department of Transportation, Highways Division

LINDA LINGLE
GOVERNOR

BRENNON T. MORIOKA
DIRECTOR

Deputy Directors
MICHAEL D. FORMBY
FRANCIS PAUL KEENO
BRIAN H. SEKIGUCHI

STATE OF HAWAII
DEPARTMENT OF TRANSPORTATION
869 PUNCHBOWL STREET
HONOLULU, HAWAII 96813-5097

IN REPLY REFER TO:

HWY-PA
2.7275

MAR 20 2008

Dr. James Kauahikaua
Scientist-In-Charge
Hawaii Volcano Observatory
U. S. Geological Survey
P. O. Box 51
Hawaii National Park, Hawaii 96718-0051

Dear Dr. Kauahikaua:

Subject: Saddle Road (State Route 200)
Mamalahoa Highway (State Route 190) to Milepost 42
Supplemental EIS Preparation Notice (EISPN)

Thank you for your memorandum, dated December 28, 2007, which commented on the the Supplemental EISPN and minimum design standards as stated in the Uniform Building Code (UBC).

Our statements regarding the UBC will be corrected in the draft Supplemental Environmental Impact Statement (EIS) and this information will be passed on to our project design engineers.

We appreciate your concern for your community. If any other issues or problems arise, please feel free to contact Nelson Sagum, our project manager, at 587-1834.

Very truly yours,

BRENNON T. MORIOKA, Ph.D., P.E.
Director of Transportation

bc: HWY-PA

NS:th

LINDA LINGLE
GOVERNOR

STATE OF HAWAII
DEPARTMENT OF TRANSPORTATION
869 PUNCHBOWL STREET
HONOLULU, HAWAII 96813-5097

BRENNON T. MORIOKA
DIRECTOR

Deputy Directors
MICHAEL D. FORMBY
FRANCIS PAUL KEENO
BRIAN H. SEKIGUCHI

IN REPLY REFER TO:

HWY-PA
2.7490

March 25, 2008

Ms. Susan Sturges, Life Scientist
Environmental Review Office
U.S. Environmental Protection Agency
Region IX
75 Hawthorne Street
San Francisco, California 94105-3901

Dear Ms. Sturges:

Subject: Saddle Road (State Route 200)
Mamalahoa Highway (State Route 190) to Milepost 42
Notice of Intent

Thank you for your letter, dated January 9, 2008, which provided scoping comments pursuant to our Notice of Intent to prepare a Supplemental Environmental Impact Statement (EIS) for this project.

The EPA comments, essentially involved four (4) major issues, which will be addressed in the project's draft Supplemental EIS and/or in the development of this document, and the final Supplemental EIS. These critical issues include the Memorandum of Understanding of National Environmental Policy Act and Section 404 of the Clean Water Act; Invasive Species; Air Quality; Indirect and Cumulative Impacts; and Environmental Justice. As recommended, we will be coordinating with appropriate governmental agencies to obtain their input to these processes.

We believe that the proposed highway is highly desired by our residential and visitor commuters on the island of Hawaii, and consequently, we appreciate your support of this project.

If any questions or problems arise, please contact Nelson Sagum, Project Manager, at (808) 587-1834.

Very truly yours,

for
BRENNON T. MORIOKA, Ph.D., P.E.
Director of Transportation

bc: HWY-PA
NS:th

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IX
75 Hawthorne Street
San Francisco, CA 94105-3901

January 9, 2008

Richard Suarez
Federal Highway Administration
Central Federal Lands Highway Division
12300 West Dakota Avenue
Lakewood, CO 80228

Ronald F. Tsuzuki
Hawaii Department of Transportation
Highways Division - Planning Branch
869 Punchbowl Street, Room 301
Honolulu, Hawai'i 96813

Subject: Scoping Comments for Saddle Road (State Route 200), Mamalahoa Highway (State Route 190) to Milepost 42, Hawai'i County, Hawai'i

Dear Mr. Suarez and Mr. Tsuzuki:

The U.S. Environmental Protection Agency (EPA) has reviewed the Federal Register Notice published on December 10, 2007, and associated project materials submitted to our agency requesting comments on the Federal Highway Administration (FHWA) and Hawaii Department of Transportation (HDOT) decision to prepare a Draft Supplemental Environmental Impact Statement (Draft SEIS) for Saddle Road (State Route 200), Mamalahoa Highway (State Route 190) to Milepost 42.

In 1999, the FHWA published a Final Environmental Impact Statement (FEIS) for Saddle Road, from Mamalahoa Highway to Milepost 6. In 2006, The U.S. Army Garrison, Hawai'i, acquired the Keamuku parcel which is traversed by the proposed western section of Saddle Road (W-3). The SEIS will evaluate western alignment alternatives to maximize army training opportunities on the parcel and minimize conflict with the traveling public.

EPA commented on the original Saddle Road Draft Environmental Impact Statement and FEIS. EPA also provided feedback on the original project through the interagency 1995 *National Environmental Policy Act and Clean Water Act Section 404 Integration Process for Surface Transportation Projects in the State of Hawaii Memorandum of Understanding* (NEPA/404 MOU). To ensure that a revised alignment is the least environmentally damaging and practicable alternative (LEDPA) and to streamline resource and regulatory agency feedback on the supplemental NEPA analysis, EPA recommends following the NEPA/404 MOU process as applicable. We encourage FHWA and HDOT to contact the NEPA/404 signatory agencies so that the appropriate concurrence points can be addressed as early as possible in the NEPA process.

EPA scoping comments are provided pursuant to the National Environmental Policy Act (NEPA), Council on Environmental Quality (CEQ) regulations (40 CFR Parts 1500-1508) and Section 309 of the Clean Air Act.

Clean Water Act Section 404

Avoidance and Minimization of Impacts to Waters

The Draft SEIS should disclose the approximate area of waters of the United States that occur within the study area of the proposed project, including intermittent and ephemeral streams and wetlands. The Clean Water Act (CWA) Section 404(b)(1) Guidelines (Guidelines) at 40 CFR Part 230.10(a) state that "... no discharge of dredged or fill material shall be permitted if there is a practicable alternative to the proposed discharge which would have less adverse impact on the aquatic ecosystem, so long as the alternative does not have other significant adverse environmental consequences." FHWA and HDOT will have to demonstrate that potential impacts to waters of the United States have been avoided and minimized to the maximum extent practicable prior to obtaining a CWA Section 404 permit (40 CFR 230.10(a) and 230.10(d)) from the U.S. Army Corps of Engineers (Corps). We urge FHWA and HDOT, in planning alternative designs for the project, to incorporate the following recommendations into the Draft SEIS:

- Demonstrate that all potential impacts to waters of the United States have been avoided and minimized. If these resources cannot be avoided, the project-level analyses should clearly demonstrate how cost, logistical, or technological constraints preclude avoidance and minimization of impacts. Propose mitigation to offset impacts to waters of the United States.

- Quantify the benefits from measures and modifications designed to avoid and minimize impacts to water resources for each alternative studied; for example, number of stream crossings avoided, acres of waters of the United States avoided, etc.

- Identify all protected resources with special designations and all special aquatic sites[1] and waters within state, local, and federal protected lands. Additional steps should be taken to avoid and minimize impacts to these areas.

Rapanos Guidance

In light of the recent Supreme Court decision in the consolidated cases Rapanos v. United States, and Carabell v. United States, 126 S. Ct. 2208 (2006) (jointly hereafter Rapanos), EPA and the Corps are required to coordinate on Jurisdictional Determinations (JDs) under CWA Section 404 in certain situations under joint agency guidance issued on June 5, 2007 (See http://www.usace.army.mil/cw/cecwo/reg/cwa_guide/rapanos_moa_06-05-07.pdf). EPA recommends HDOT and FHWA involve the Corps and EPA as early as practicable in your review of potentially jurisdictional waters to facilitate their coordination on waters subject to the guidance. For Section 404 coordination, please contact Wendy Wiltse of EPA's Region 9 Hawaii Field Office at 808-541-2752 or wiltse.wendy@epa.gov.

[1] Special aquatic sites are defined at 40 CFR 230.40 – 230.45 and include wetlands, mud flats, vegetated shallows, coral reefs, and riffle and pool complexes.

Invasive Species

In accordance with Executive Order 13112, EPA recommends that the Draft SEIS identify proposed methods to minimize the spread of invasive species and utilize native plant and tree species where revegetation is planned. The islands of Hawai`i are particularly vulnerable to invasive species, and construction associated with the project has the potential to aid in the establishment of invasive plants along any newly disturbed corridors. EPA recommends that FHWA and HDOT coordinate invasive species management with local agencies and organizations to stop established invasive species from spreading on Hawai`i. Measures to reduce the potential for the spread of invasive species will be more effective when they are coordinated with other ongoing planning efforts. Resources related to Federal and State programs to address invasive species can be found at: http://www.invasivespeciesinfo.gov/

Air Quality

Construction activities may result in short and long-term impacts on air quality – particularly emissions of nitrogen oxides (NOx - an ozone precursor), particulate matter less than 10 microns in size (PM10), and carbon monoxide. The Draft SEIS should discuss the general air quality impacts of the project and discuss options for mitigating these impacts. To reduce construction-related air quality impacts, EPA recommends that the Draft SEIS address the feasibility of implementing air quality-related mitigation to reduce emissions of Diesel Particulate Matter (DPM) and other pollutants from construction, including:

Fugitive Dust Source Controls:

- Stabilize open storage piles and disturbed areas by covering and/or applying water or chemical/organic dust palliative where appropriate. This applies to both inactive and active sites, during workdays, weekends, holidays, and windy conditions.
- Install wind fencing and phase grading operations where appropriate, and operate water trucks for stabilization of surfaces under windy conditions.
- When hauling material and operating non-earthmoving equipment, prevent spillage and limit speeds to 15 miles per hour (mph). Limit speed of earth-moving equipment to 10 mph.

Mobile and Stationary Source Controls:

- Reduce use, trips, and unnecessary idling from heavy equipment.
- Maintain and tune engines per manufacturer's specifications to perform at EPA certification levels and to perform at verified standards applicable to retrofit technologies. Employ periodic, unscheduled inspections to limit unnecessary idling and to ensure that construction equipment is properly maintained, tuned, and modified consistent with established specifications.
- Prohibit any tampering with engines and require continuing adherence to manufacturer's recommendations
- If practicable, lease new, clean equipment meeting the applicable Federal Standards. In general, only Tier 2 or newer engines should be employed in the construction phase.

- Utilize EPA-registered particulate traps and other appropriate controls where suitable to reduce emissions of diesel particulate matter and other pollutants at the construction site.

Analysis of Indirect and Cumulative Impacts

NEPA requires evaluation of indirect and cumulative effects which are caused by the action (40 CFR Parts 1508.8(b) and 1508.7). "Indirect effects may include growth inducing effects related to induced changes in the pattern of land use, population density or growth rate, and related effects on air and water and other natural systems, including ecosystems." CEQ regulations also state that an EIS should include the "means to mitigate adverse environmental effects." (40 CFR 1502.16(h)). This provision applies to indirect effects as well as direct effects. Induced commercial, recreational, and residential growth can adversely affect water quality, wetlands, and other natural resources.

The Draft SEIS should evaluate the increased rates of growth for commercial, recreational, or residential purposes indirectly caused by the proposed changes to the project. Specifically, the Draft SEIS should estimate reasonably foreseeable changes in land use patterns, as well as the increased number of automobile and truck trips associated with new land uses. Impacts to cultural, water, socioeconomic, and community resources associated with new development and increased vehicle miles traveled should be specifically addressed in the Draft SEIS. Appropriate mitigation to minimize impacts should be included.

Cumulative impacts are defined in the CEQ NEPA regulations as the impact on the environment that results from the incremental impact of the action when added to the other past, present, and reasonably forseeable future actions, regardless of what agency (Federal or non-Federal) or person undertakes such actions (40 CFR 1508.7). These actions include both transportation and non-transportation activities. The cumulative impact analysis should consider all nearby projects such as adjacent roadway improvements, military initiatives, residential development, and other projects that are reasonably foreseeable and are identified in the surrounding area, including those that have occurred or are planned since the 1999 FEIS. Where adverse cumulative impacts are identified, the Draft SEIS should identify appropriate mitigation measures, even if the mitigation is the responsibility of other entities. Disclose the parties that would be responsible for avoiding, minimizing, and mitigating those adverse impacts (CEQ's Forty Most Frequently Asked Questions #19).

EPA recommends using the California Department of Transportation Indirect and Cumulative Impacts Analyses, which are co-authored by EPA and FHWA and are applicable to impact analyses for projects outside of California. This guidance can be found at [http://www.dot.ca.gov/ser/cumulative_guidance/purpose.htm] and [http://www.dot.ca.gov/ser/Growth-related_IndirectImpactAnalysis/gri_guidance.htm].

Environmental Justice

Executive Order 12898 addresses Environmental Justice in minority and low income populations, and the Council on Environmental Quality has developed guidance concerning how to address Environmental Justice in the environmental review process (http://ceq.eh.doe.gov/nepa/regs/ej/justice.pdf). Community involvement activities supporting the project should include opportunities for incorporating public input into the facility area design and location process, especially from any members of the community who may benefit or be adversely affected by the project. The Draft SEIS should identify whether the proposed changes may disproportionately and adversely affect low income or minority populations in the surrounding area and should provide appropriate mitigation measures for any adverse impacts.

We appreciate the opportunity to provide comments on the preparation of the Draft SEIS, and look forward to continued participation in this process as more information becomes available. Please send hard copies of materials to the address above (mail code CED-2) and email information to the email addresses provided above. If you have any questions, please contact me, the lead reviewer for this project. I can be reached at 415-947-4188 or sturges.susan@epa.gov.

Sincerely,

Susan Sturges, Life Scientist
Environmental Review Office

CC: Susan Meyer, Army Corps of Engineers
Michael Molina, US Fish and Wildlife Service

BIG ISLAND BIRD HUNTERS

17-124 Palaai Street
Keaau, HI 96749

December 7, 2007

Geometrician Associates
PO Box 396
Hilo, HI 96721

Attn: Ron Terry

Subject: SEISPN
Saddle Road (State Route 200)
Mamalahoa Highway (State Route 190) to Milepost 42
County of Hawaii, State of Hawaii
FHWA Project No. 200(00)

Due to the preliminary nature of the information included in the SEISPN, we wish to reserve our comments until more definitive information becomes available. However, we do have a definite interest in the project and request informal meetings to establish dialogue and input before the Draft EIS is compiled. Further, we ask to be included on a mailing list to receive all publicly issued documents and announcements related to the project.

We also petition to become a CONSULTED PARTY for this project as allowed in the state Department of Health Administrative Rules (11-200-15B). We base this request on the following.

- Our members have had historical hunting use of the Kaohe Game Management Area (GMA) and the Puuanahulu GMA. The Kaohe GMA is adjacent to the extension of the proposed Saddle Road near mile post 42, and the Puuanahulu GMA immediately abuts the Keamuku land corridor proposed for route W-7. Should the final realignment of Saddle Road from mile post 42 to Mamalahoa Highway infringe on the use of any part of the Kaohe or Puuanahulu GMA, it would deny our members access to our accepted cultural practices and resources.
- Our organization has worked cooperatively with the state DLNR, Division of Forestry and Wildlife and voluntarily installed rain catchment structures and water storage tanks within both Kaohe and Puuanahulu GMA with the intent of

supplying water for the wildlife population. Additionally, we want to eventually establish tree and brush outplantings, aided in growth by the water from these catchment systems. These outplantings could then potentially collect dew from fog in the area to further increase moisture collection and serve as windbreaks to create a more hospitable environment for flora and fauna.

Thank you for providing this opportunity to correspond with you, and we look forward to establishing dialogue with you.

Sincerely,

Steven Hurt
President

LINDA LINGLE
GOVERNOR

STATE OF HAWAII
DEPARTMENT OF TRANSPORTATION
869 PUNCHBOWL STREET
HONOLULU, HAWAII 96813-5097

BRENNON T. MORIOKA
DIRECTOR

Deputy Directors
MICHAEL D. FORMBY
FRANCIS PAUL KEENO
BRIAN H. SEKIGUCHI

IN REPLY REFER TO:

HWY-PA
2.7493

April 1, 2008

Mr. Steven Hurt, President
Big Island Bird Hunters
17-124 Palani Street
Keaau, Hawaii 96749

Dear Mr. Hurt:

Subject: Saddle Road (State Route 200)
Mamalahoa Highway (State Route 190) to Milepost 42
Supplemental EIS Preparation Notice (EISPN)

Thank you for your letter, dated December 7, 2007, which provided us with your comments pursuant to the Supplemental EIS Preparation Notice for this project.

Your organization will be included in our listing of consulted parties for this project, and consequently, you should be furnished with a copy of our draft Supplemental EIS and other project documents and notices.

In addition, we do not anticipate any infringement of the Kaohe Game Management Area (GMA) and the proposed highway is just northerly of the Puuanahulu GMA as it approaches Mamalahoa Highway. In the vicinity of Mamalahoa Highway, the proposed highway was located as far south as possible in order to intersect Mamalahoa Highway at an appropriate angle.

We appreciate the efforts of your organization regarding the preservation of your hunting areas. We will conscientiously evaluate any impacts and propose mitigation, if these impacts will have an adverse effect on the game management areas for the island of Hawaii.

If you have any questions, please call Nelson Sagum, Project Manager, at (808) 587-1834.

Very truly yours,

BRENNON T. MORIOKA, Ph.D., P.E.
Director of Transportation

bc: HWY-PA
NS:th

Hawaii Island Chamber of Commerce

106 Kamehameha Avenue
Hilo, Hawaii 96720
Phone: (808) 935-7178
Fax: (808) 961-4435
E-mail: admin@hicc.biz
www.hicc.biz

January 19, 2008

Nelson Sagum
Hawai'i State Department of Transportation
Highways Division
869 Punchbowl Street
Honolulu, Hawai'i 96813

Director
Office of Environmental Quality Control
235 S. Beretania, Suite 702
Honolulu, Hawai'i 96813

Ron Terry
Geometrician Associates
PO Box 396
Hilo, Hawai'i 96721

Aloha.

On behalf of the Hawaii Island Chamber of Commerce, our leadership has considered the Supplemental Environmental Impact Statement Preparation Notice for the Saddle Road (State Route 200) Mamalahoa Highway (State Route 190) to Milepost 42, FWA Project No. 200(00).

It has been clear for some time that improvements are needed to the Saddle Road. The improvements will make the road safer for trans-island traffic, and make it easier for a growing number of commuters, including shortening the drive time.

An improved Saddle Road will be good for our workforce, many who find affordable housing on the East Side, but find employment on the West Side. Nor can we discount that reduced travel time also means fuel energy savings in terms of fewer miles driven for these commuters.

While we support careful planning and consideration of all impacts, we urge a timely completion of improvements to this road. It remains one of the most dangerous rural roads in our state.

The 109-year-old Hawaii Island Chamber of Commerce represents more than 330 businesses and nearly 700 members.

Sincerely,

Barbara A. Hastings

Barbara A. Hastings
Chair, Government Affairs

LINDA LINGLE
GOVERNOR

STATE OF HAWAII
DEPARTMENT OF TRANSPORTATION
869 PUNCHBOWL STREET
HONOLULU, HAWAII 96813-5097

BRENNON T. MORIOKA
DIRECTOR

Deputy Directors
MICHAEL D. FORMBY
FRANCIS PAUL KEENO
BRIAN H. SEKIGUCHI

IN REPLY REFER TO:

HWY-PA
2.7492

March 25, 2008

Ms. Barbara A. Hastings
Chair, Government Affairs
Hawaii Island Chamber of Commerce
106 Kamehameha Avenue
Hilo, Hawaii 96720

Dear Ms. Hastings:

Subject: Saddle Road (State Route 200)
Mamalahoa Highway (State Route 190) to Milepost 42
Supplemental EIS Preparation Notice (EISPN)

Thank you for your letter, dated January 19, 2008, which provided us with your comments for this project pursuant to this project's Supplemental EISPN. We are appreciative of your review of this document.

We are also deeply appreciative of the support of the Hawaii Island Chamber of Commerce for the proposed Saddle Road, and indeed, we are very hopeful of the timely completion of this study.

If you have any questions or comments, please feel free to contact Nelson Sagum, Project Manager, at (808) 587-1834.

Very truly yours,

for BRENNON T. MORIOKA, Ph.D., P.E.
Director of Transportation

bc: HWY-PA

NS:th

----- Original Message -----
From: Paul Normann
To: rterry@hawaii.rr.com
Sent: Tuesday, January 22, 2008 3:35 PM
Subject: Comments on Saddle Road Project

Ron Terry,

Here are my comments concerning the Saddle Road realignment.

There are serious health concerns for anyone working on road construction in the area of Pohakuloa Training Area (PTA). Of primary concern at this time are the potential risks posed by airborne Depleted Uranium dust, something neither the Hawaii health department nor the military have tested for in any methodological way.

I strongly urge that air monitoring stations, testing for airborne Depleted Uranium dust particles, be set up along the proposed route of the Saddle Road realignment. The monitoring should start before construction begins and continue throughout the duration of the project. The data from these air monitors should published both in paper form and on the internet where they should be accessible to the general public in real time, 24 / 7. Further, the contractors or engineers working on this project should work with Dr. Lorrin Pang to design and scientifically sound sampling methodology to test for the presence of DU.

Such monitoring will help protect the safety of the workers who will be exposed to windblown dust throughout the project.

Paul Normann
Kurtistown, HI
966-7622

Nelson Sagum/HWY/HIDOT
02/29/2008 03:46 PM

To "Paul Normann" <paulwnormann@yahoo.com>
cc Brennon Morioka/ADMIN/HIDOT@HIDOT, Glenn Yasui/HWY/HIDOT@HIDOT, Dina Lau/HWY/HIDOT, rterry@hawaii.rr.com, bmeyers@okahara.com,
bcc
Subject Saddle Road, Mamalahoa Highway to Milepost 42

Dear Mr. Normann:

Your email to Mr. Ron Terry, dated January 22, 2008, has been forwarded to the State Department of Transportation (DOT), for our consideration and response.

We are certainly aware of the depleted uranium (DU) issue in the project area, and we appreciate your concern for our construction workers in this vicinity. Undoubtedly, we would be seeking the assistance of the U.S. Army in regards to a satisfactory resolution this problem; however, the U.S. Army has been proactively engaged in gathering information on the level and effects of DU in the vicinity of the Pohakuloa Training Area. According to their records, approximately "$5.5 million and countless manhours" have been spent in this study, and we are hopeful that the U.S. Army will continue to monitor the radioactivity in the project area throughout the construction period of the proposed Saddle Road.

For your information, the State DOT will also be preparing an independent study which will focus on a risk assessment involving the probable adverse effects from DU at Pohakuloa. This study will be included in the Supplemental Environmental Impact Study for this project and will be available for review by Dr. Lorrin Pang and other interested parties.

We appreciate your participation in this project. If you have any other comments or questions, please contact me at *nelson.sagum@hawaii.gov*, or (808) 587-1834.

Aloha, Nelson Sagum

Department of Transportation, Highways Division
Attn: Ronald F. Tsuzuki
869 Punchbowl Street
Honolulu, HI 96813

DMT Consultant Engineers
Attn. Bruce K. Meyers
677 Ala Moana Boulevard, Suite 703
Honolulu, HI 96813

Office of Environmental Quality Control
Attn: Leiopapa A Kamehameha
235 South Beretania Street, Suite 702
Honolulu, HI 96813

SUBJECT: Saddle Road (State Route 200), Mamalahoa Highway (HRS 343 FEA-EISPN)

I am a member of the Hawai'i County Transportation Commission, the Hawai'i County Highway Safety Council, and the Hawai'i County Bicycle/Pedestrian Advisory Committee. I am providing the following comments on the proposed supplemental Environmental Impact Statement for the realignment of Saddle Road, not on behalf of these boards but as an individual seeking the best solutions to accommodate all modes of travel

Sincerely,

Robert Ward 01/21/08

Robert Ward
77-6526 Ho'olaupa'i Street
Kailua Kona, HI 96740

SUBJECT: Saddle Road (State Route 200), Mamalahoa Highway (HRS 343 FEA-EISPN)

I would like to take the time to offer a few comments on the proposed supplemental Environmental Impact Statement for the realignment of Saddle Road. Regional transportation is an important issue today and will become even more important in the future as we explore other opportunities including increased transit operations and freight hauling (perhaps including solid waste). Because of the heavy potential use, the design of this transportation corridor will have a significant impact on its users Other ancillary functions of the corridor including vegetation management, fire breaks and emergency access are important considerations as well.

Commencing with the Federal Highway Administration's edicts issued at the beginning of this millennium, moving through the State DOT level with Bike Plan Hawai'i, and all the way to the County of Hawai i General Plan, the need to include facilities for all modes of travel in roadway design is essential Conventional highway travel lanes with paved shoulders can accommodate motor vehicles and the shoulder bikeways may be used by bicyclists that can negotiate the 8% gradients. Something more is required if we want to accommodate all modes of interurban transportation.

Improving the right-of-way corridors adjacent to the central highway cross-section could provide a low cost solution and ultimately create a "complete highway" The portion of corridor laying northerly of the highway cross-section could be lightly graded with major collision hazards removed. This could become a dedicated travel route for "off-road vehicles". Occupying the space between a major highway and a live-fire training facility would be ideal strategic placement and provide compatible land use. This would essentially widen the corridor to provide a much needed expanded fire break.

The second supplemental corridor would include a paved Shared-Use Path and unpaved equestrian trail. These could be curvilinear in design (particularly in areas where the highway maximum grade approach 8%) to achieve a 5 percent grade that is more desirable for cyclists and would also be fully ADA compliant. These paths would closely follow the route of the highway but could more closely follow the natural terrain. The path would further expand the fire break but some trees could remain as a wind break and provide shade for the users as well, without increasing roadside hazards.

Future options could include extending the supplemental corridors along the current Mamalahoa Highway between the existing saddle road and the new intersection with the relocated Saddle Road This would specifically conform to the DOT Bike Plan Hawai'i which intended to utilize the remnants of the old Mamalahoa Highway. The Bike Plan element was planned as a Shared-Use Path with construction in 2013 or later (which could coincide with the proposed Saddle Road realignment)

Total construction costs and phasing are concerns that must be evaluated. Certain elements of the supplemental corridors might lag behind that actual highway construction for various reasons, and could require some funding from alternative sources. However, it is imperative that the planning, right-of-way and design phases incorporate all facilities.

Robert Ward
Kailua Kona, HI

LINDA LINGLE
GOVERNOR

STATE OF HAWAII
DEPARTMENT OF TRANSPORTATION
869 PUNCHBOWL STREET
HONOLULU, HAWAII 96813-5097

BRENNON T. MORIOKA
INTERIM DIRECTOR

Deputy Directors
MICHAEL D. FORMBY
FRANCIS PAUL KEENO
BRIAN H. SEKIGUCHI

IN REPLY REFER TO:

HWY-PA
2.7121

FEB 25 2008

Mr. Robert Ward
Commissioner
Hawai'i County Transportation Commission
77-6526 Ho'olaupa'i Street
Kailua-Kona, Hawaii 96740

Dear Mr. Ward:

Subject: Saddle Road, Mamalahoa Highway to Milepost 42, Project No. DP-HI-0200(5)
Supplemental Environmental Impact Statement Preparation Notice

Thank you for your letter and comments, which indicated your concern for bicyclists and other modes of transportation that may be using the proposed Saddle Road, from Mamalahoa Highway (SR 190) to Milepost 42.

Your letter stated that our proposed right-of-way width and the design of the highway should consider its use by off-road vehicles, recreational bicyclists and equestrians. Please note that the proposed minimum right-of-way width is 200 feet which should be sufficient to accommodate various facilities for these modes of transportation. However, our participation in the construction of adjacent facilities is very dependent on the results of our studies, which should be developed pursuant to the Supplemental Environmental Impact Statement for this project. Furthermore, if you have any records or surveys, or if you know of the availability of any information which would be of assistance to us, please provide them to us or let us know of its location.

As you have also indicated, the proposed typical section for the highway will include 8-foot shoulders, which will also be available to island bicyclists.

We sincerely appreciate your participation in this project. If you have any other comments or questions, please contact us at your earliest opportunity.

Very truly yours,

BRENNON T. MORIOKA, Ph.D., P.E.
Interim Director of Transportation

bc: HWY-PA
NS:th

Share the road with aloha!

PATH ~ PEOPLES ADVOCACY FOR TRAILS HAWAI`I

PO BOX 62 ◆ KAILUA-KONA, HAWAI`I 96745 ◆ 808 -329-9718 ◆ sharetheroad@pathhawaii.org

Department of Transportation, Highways Division
Attn: Ronald F. Tsuzuki
869 Punchbowl Street
Honolulu, HI 96813

DMT Consultant Engineers
Attn: Bruce K. Meyers
677 Ala Moana Boulevard, Suite 703
Honolulu, HI 96813

Office of Environmental Quality Control
Attn: Leiopapa A Kamehameha
235 South Beretania Street, Suite 702
Honolulu, HI 96813

January 22, 2008

Regarding: **Saddle Road (State Route 200), Mamalahoa Highway (HRS 343 FEA-EISPN)**

PATH, a grassroots bicycle and pedestrian advocacy organization, wishes to bring to the attention of the DOT and OEQC the tremendous opportunity to create safe inter-modal regional transportation facilities with the realignment of the Saddle Road in Keamuku.

The mission of the State of Hawaii's Department of Transportation Highway Division is to: "provide a safe, and efficient and accessible highway system through the utilization of available resources in the maintenance, enhancement and support of land transportation facilities."

The Saddle Road and connecting Mamalahoa Highway represent two HDOT assets that encapsulate this mission with the potential to become a "complete highway" serving all users through this region of the island.

Similar to the notion of 'Complete Streets 'designed for all users, including motorists, transit, pedestrians and bicyclists, a Complete Highway would provide access, safety and efficiency to all users of the transportation system. It would also serve the very necessary functions of fire control, vegetation management and emergency access. Such a complete highway draws upon available resources within DOT and results in a value-added transportation facility that contributes to quality of life and sustainability for the island.

'Complete Highway' design for Saddle Road is supported at the Federal level through FHWA's flexible design guidelines, the State of Hawaii's Bike Plan and the Hawaii County General Plan and emerging Roadway Standards and Community Development Plans.

We urge DOT to envision Saddle Road as a "Complete Highway" with the following components:

- **Shoulder Bikeways.** Just as the mission states, use of existing resources within DOT provides the most efficient and cost effective solution in providing safe, accessible and efficient transportation facilities. The new sections of Saddle road that are completed from Mauna Kea State Park to the Mauna Kea Access Road include shoulder bikeways suitable for bicycling, emergency breakdown and shoulder stabilization for long term roadway maintenance. We urge the continuation of this design for the west side sections. This provides bicycle facilities within the existing highway right of way and adds tremendous value to the transportation facility with minimal additional investment in the form of signage and striping.

- **Shared Use Path System.** That being said, conventional highway travel lanes with paved shoulders can accommodate motor vehicles and the shoulder bikeways may be used by bicyclists that can negotiate the 8% gradients. Something more is required if we want to accommodate all modes of interurban transportation up the 3,000 ascent from Mamalahoa Hwy to Kilohana (Girl Scout Camp). This section would require a curvilinear path to meet AASHTO bicycle guidelines and ADA requirements for pedestrians on the 3,000 ascent from Mamalahoa Highway.

  Such a shared use pathway along Saddle Road would then connect with several Bike Plan Hawaii projects that identify old remnants of Mamalahoa Highway. This stretches from Parker Ranch's rodeo grounds in Waimea to the new Saddle Road realignment in Keamuku. From there sections of Old Mamalahoa as well as fire break roads continue to Puu Waawaa and Puu Anahulu and on to Kona.

  The Shared-Use Path serves a broader spectrum of potential users (and can provide both emergency access and firebreaks). Conventional paved Shared-Use Paths can accommodate most bicyclists and pedestrians. Optional "green drainage" sections provide a unique equestrian opportunity. Even the growth of motorized off-road users could be accommodated on some segments (specifically the portion of the corridor laying northerly of the highway cross-section could be lightly graded with major collision hazards removed. This could become a dedicated travel route for "off-road vehicles". Occupying the space between a major highway and a live-fire training facility would be ideal strategic placement and provide compatible land use.)

  These paths would closely follow the route of the highway but could more closely follow the natural terrain. The path would further expand the fire break but some trees could remain as a wind break and provide shade for the users as well, without increasing roadside hazards.

  In order to move forward with a "Complete Highway" concept, it is critical that planning, right-of-way acquisition and design incorporate shoulder bikeways and shared use paths as identified in Bike Plan Hawaii. We urge DOT to take these steps now to insure the best chance of success in creating a "Complete Highway" for Hawaii Island.

Kind Regards,

Laura Dierenfield
Executive Director
PATH Peoples Advocacy for Trails Hawaii

LINDA LINGLE
GOVERNOR

STATE OF HAWAII
DEPARTMENT OF TRANSPORTATION
869 PUNCHBOWL STREET
HONOLULU, HAWAII 96813-5097

BRENNON T. MORIOKA
DIRECTOR

Deputy Directors
MICHAEL D. FORMBY
FRANCIS PAUL KEENO
BRIAN H. SEKIGUCHI

IN REPLY REFER TO:

HWY-PA
2.7491

APR - 1 2008

Ms. Laura Dierenfield
Executive director
PATH Peoples Advocacy for Trails Hawaii
P. O. Box 62
Kailua-Kona, Hawaii 96745

Dear Ms. Dierenfield:

Subject: Saddle Road (State Route 200)
Mamalahoa Highway (State Route 190) to Milepost 42
Supplemental EIS Preparation Notice (EISPN)

Thank you for your letter, dated January 22, 2008, which provided us with your comments regarding the proposed Saddle Road, pursuant to the Supplemental EISPN for this project. We appreciate your review of the Supplemental EISPN, and we have the following responses in regards to each of your comments:

The proposed typical section for the highway will include 8-foot shoulders. The use of these 8-foot shoulders will be shared by both island bicyclists and motorists.

In addition, your letter stated that our proposed right-of-way width and the design of the "complete highway" should consider its use by off-road vehicles and recreational bicyclists. Please note that the proposed minimum right-of-way width is 200 feet which should be sufficient to accommodate various facilities for these modes of transportation. However, our participation in the construction of "shared use pathways" is very dependent on the results of our studies, which should be developed in sequence with the Supplemental EIS for this project. Hence, if you have any records or surveys, or if you know of the availability of any information which could be of assistance to us, please provide them to us or let us know of its location.

We sincerely appreciate your participation in this project. If you have any other comments or questions, please contact Nelson Sagum, Project Manager, at (808) 587-1834.

Very truly yours,

BRENNON T. MORIOKA, Ph.D., P.E.
Director of Transportation

bc: HWY-PA
NS:th

PRESS RELEASE

IMMEDIATE RELEASE
Contact person: Cory Harden
Sierra Club, Moku Loa group
P.O Box 1137
Hilo, Hawai'i 96721
808-968-8965 mh@interpac.net
http://www.hi.sierraclub.org

January 15, 2008, Hilo, Hawai'i

Sierra Club, citing risks of dispersing depleted uranium at Pohakaloa, called on the Army to halt both a planned February training, and practice bombing with 2000-pound inert bombs

"We are extremely concerned," said Cory Harden of the Club's Moku Loa group, "because minute amounts of DU can impact health, DU can be transported for miles in the air, and DU can be dispersed by rodents."

The Army does not yet know the exact locations of all the DU, or whether it can be completely cleaned up.

Sierra Club is also calling for air monitoring funded by the Army and designed to detect intermittent spikes in radiation, with results immediately available on the Internet; investigation for decay products of DU; and an information meeting in Hilo by mid-February.

###

Ron - please use as comments on Stryker the EIS
thx
Cory

LINDA LINGLE
GOVERNOR

STATE OF HAWAII
DEPARTMENT OF TRANSPORTATION
869 PUNCHBOWL STREET
HONOLULU, HAWAII 96813-5097

BRENNON T. MORIOKA
DIRECTOR

Deputy Directors
MICHAEL D. FORMBY
FRANCIS PAUL KEENO
BRIAN H. SEKIGUCHI

IN REPLY REFER TO:

HWY-PA
2.7507

April 7, 2008

Ms. Cory Harden
Sierra Club, Moku Loa Group
P. O. Box 1137
Hilo, Hawaii 96721

Dear Ms. Harden:

Subject: Saddle Road (State Route 200)
Mamalahoa Highway (State Route 190) to Milepost 42
Supplemental EIS Preparation Notice (EISPN)

Thank you for a copy of your press release and its enclosures, dated January 15, 2008, regarding military activities and the existence of depleted uranium (DU) in the Pohakuloa Training Area (PTA) of the U.S. Army.

For your information, the State Department of Transportation also has several questions regarding the DU in PTA, and consequently, we have initiated an independent study which would develop a risk assessment regarding the adverse effects of the DU that may occur as a consequence of the construction and operation of the proposed Saddle Road. All of our studies and its findings will be included in the Supplemental Environmental Impact Statement (EIS) for this project.

In addition, your comments have been forwarded to our environmental and risk assessment subconsultants, who will evaluate them during the preparation of their studies for the project's Supplemental EIS. We intend to include your press release in the Supplemental EIS; however, because of our copyright concerns, your enclosures will not be duplicated in this document.

If you have any questions or issues concerning this project, please contact Nelson Sagum, Project Manager, at (808) 587-1834.

Very truly yours,

BRENNON T. MORIOKA, Ph.D., P.E.
Director of Transportation

bc: HWY-PA
NS:dn

----- Original Message -----
From: "Aaron Stene" <aaron@hawaiiantel.net>
To: "Ron Terry" <rterry@hawaii.rr.com>
Sent: Saturday, December 15, 2007 9:32 AM
Subject: Re: Saddle Road

Aloha Ron,
>
I'm not sure if the supplemental EIS (for the m.m 41 to Mamalahoa highway) would address this. But I'll give it a shot.
>
I assume the alignment of this segment of roadway would be addressed in the SEIS. So I'd like to put my .02 in.

I think the alignment that would minimize the the civilian/Army interaction and not impact the alignment of the Saddle Road extension would be the best alignment. I tried looking for the map of the different alignments (in WHT). I couldn't find it. But I believe this is the W-7 alignment.
>
Would you suggest I e-mail I e-mail the QEQC and DOT my thoughts too.
>
> Aaron
>
> ********************************
> Aaron Stene
> Kailua-Kona, Hawaii
> http://thekonablog.wordpress.com/
> ********************************

Nelson Sagum/HWY/HIDOT
02/27/2008 03:57 PM

To "Aaron Stene" <aaron@hawaiiantel.net>
cc Brennon Morioka/ADMIN/HIDOT@HIDOT, Glenn Yasui/HWY/HIDOT@HIDOT, Dina Lau/HWY/HIDOT, rterry@hawaii.rr.com
bcc
Subject Saddle Road, Mamalahoa Hwy to Milepost 42

Dear Mr. Stene:

Your email to Mr. Ron Terry, dated December 15, 2007, has been forwarded to the State Department of Transportation, for our consideration and response.

First of all, we appreciate your interest in the proposed Saddle Road, from Mamalahoa Highway to Milepost 42. We believe that island residents and tourists should indeed benefit from the construction of this facility.

Secondly, we are grateful for your support of alignment W-7, and we also believe that this alignment will minimize civilian and military interaction. It should also be noted that at least one grade-separated military crossing will be provided for this highway section.

If you have any additional comments or questions, please forward them to me at *nelson.sagum@hawaii.gov* or call me at (808) 587-1834.

Aloha, Nelson Sagum

WAIKI'I · RANCH
HOMEOWNERS' ASSOCIATION

January 16, 2008

Mr. Ron Terry
Geometrician Associates
PO Box 396
Hilo, HI 96721

Dear Mr. Terry:

These are the comments of the Waiki'i Ranch Homeowners' Association regarding the Environmental Impact Statement Preparation Notice for the Saddle Road, Mamalahoa Highway to Milepost 42 Project.

The Waiki'i Ranch Homeowners' Association (WRHOA) supports the W-7 Proposed SEIS Alignment of the New Saddle Road.

A correction needs to be made on page 14 of the SEIS Preparation Notice. There are two wells at Waiki'i Ranch. The depth is 4,300 feet below ground elevation of 4,260 feet. The water level is 2,730 feet below ground elevation.

Sincerely yours,

J.J. McAniff

Vice President, WRHOA

Copies to:

Director
Office of Environmental Quality Control
235 South Beretania St., Suite 702
Honolulu, HI 96813

Nelson Sagum
Hawaii State Dept. of Transportation
Highways Division
869 Punchbowl St
Honolulu, HI 96813

P.O. Box 6389 · Kamuela, HI 96743 · (808) 885-4884 · FAX (808) 885-0433

LINDA LINGLE
GOVERNOR

STATE OF HAWAII
DEPARTMENT OF TRANSPORTATION
869 PUNCHBOWL STREET
HONOLULU, HAWAII 96813-5097

BRENNON T. MORIOKA
DIRECTOR

Deputy Directors
MICHAEL D. FORMBY
FRANCIS PAUL KEENO
BRIAN H. SEKIGUCHI

IN REPLY REFER TO:

HWY-PA
2.7505

April 1, 2008

Mr. T. J. McAniff
Vice President
Waiki'i Ranch Homeowners' Association
P. O. Box 6389
Kamuela, Hawaii 96743

Dear Mr. McAniff:

Subject: Saddle Road (State Route 200)
Mamalahoa Highway (State Route 190) to Milepost 42
Supplemental EIS Preparation Notice (EISPN)

Thank you for your letter, dated January 16, 2008, which commented on the Supplemental EIS Preparation Notice for this project. We appreciate your review of this document.

We are also grateful for your indication of the support of the Waiki'i Ranch Homeowners' Association (WRHA) for alignment W-7 and for your efforts involved in correcting the misinformation contained in this Supplemental EISPN, regarding the number of wells at Waiki'i Ranch.

We look forward to hearing from you and the WRHA as this project develops. If you have any questions or comments concerning this project, please contact Nelson Sagum, Project Manager, at (808) 587-1834.

Very truly yours,

BRENNON T. MORIOKA, Ph.D., P.E.
Director of Transportation

bc: HWY-PA

NS:dn

South Kohala Traffic Safety Committee
P.O. Box 383375
Waikoloa, HI 96738

January 15, 2008

Mr. Nelson Sagum
State of Hawaii Department of Transportation
Highways Division, Planning Branch
869 Punchbowl Street
Honolulu, HI 96813

Mr. Ron Terry
Geometrician Associates
P.O. Box 396
Hilo, HI 96721

Director
Office of Environmental Quality Control
235 South Beretania Street, Suite 702
Honolulu, HI 96813

RE: Saddle Road, Mamalahoa to Milepost 42 to Queen Ka'ahumanu Highway Project Comments

Dear Mr. Sagum;

At the January 8, 2008 Meeting of South Kohala Traffic Safety Committee safety and other concerns related to the Saddle Road, Mamalahoa to Milepost 42 to Queen Ka'ahumanu Highway Project were discussed by the membership. A major concern is that this new road will be a heavily used connector between East and West Hawai'i. As the Island population grows, future traffic on this road will increase substantially. Many members remember the light use at first of the Queen Ka'ahumanu Highway. Today this is a heavily used congested 2 lane route with many safety issues. Most members feel strongly that this project should be designed for the future potential and planned growth. Procurement of a wide Right of Way now will avoid rising procurement costs and access problems in the future. The current situation with the State Waimea Bypass Project is a good example of the problems that can be avoided by establishing a ROW adequate for the future. If funding is not available to build a "super highway now", design and procure the necessary ROW now is the point.

The following comments were made by the membership for your review and consideration;

1. Interchanges:

    a. Grade separated interchanges are preferred. Right of Way and design should be for future needs.

    b. Waikoloa Village, Waikoloa Beach Resort Node and other future subdivision development and the existing Saddle Road are along the route. These properties need interchange access now and accommodation for future growth. None of these mentioned subdivisions are built out at present. Future expanded growth should be in the design.

    c. Design and coordinate with Hawaii County Dept. of Public Works an interchange for a proposed future County Road extension of Paniolo Avenue or KilaKila Street in Waikoloa Village, to run south and connect to the Saddle Road Extension.

    d. Design an interchange for connecting the existing Saddle Road to the new proposed Saddle Road alignment.

2. Slow traffic lane for trucks to pull off on steep grades.

3. Runaway truck ramps designed and constructed concurrently with roadway.

4. Pull offs for tourists to look at views, or tired drivers to rest. Design for future rest stop with restrooms.

5. Need for smooth flow of commercial and military traffic. Road will traverse some steep terrain. No stop lights are preferred to keep trucks and buses moving. Keep traffic moving with separated grade interchange ramps for smooth transition of commercial trucks and other vehicles into and out of traffic flow.

6. Divided highway. Build two lanes now. Eventually build two more as a divided highway with planted medians so that two lanes will be westbound, and two eastbound. This will provide slow and turn lanes while maintaining a free flow lane. Queen Ka'ahumanu Highway design has resulted in too many head on collisions.

7. ROW width should be at least 250 to 300 Feet wide like the present Queen Ka'ahumanu HWY improvement project alignment.

8. **Build the highway beyond present needs - triple what we seem to need now. Build for future needs and expansion.**

9. Accentuate SAFETY in designing grade, and for mix of use: workers, residents, tourists, bicyclists and commercial trucks including trucks hauling fuel.

We appreciate the opportunity to comment on this long awaited project and hope you will keep South Kohala Traffic Safety Committee informed as the project progresses. Hopefully the end result will be a well designed, safe roadway that serves present and future needs. Mahalo for your consideration of these comments.

Sincerely,

Mike Price

Mike Price-Chair South Kohala Traffic Safety Committee

CC: State Representative Cindy Evans
Councilman Pete Hoffmann
Brennon Morioka-Interim Director DOT Highways Division
Stanley Tamura-District Engineer DOT Highways Division
Bruce McClure-Director County Department of Public Works
Galen Kuba-Division Chief County Department of Public Works Engineering Division
Bruce Tsuchida-Townscape-SKCDP
Andrew Choy-Townscape-SKCDP

LINDA LINGLE
GOVERNOR

BRENNON T. MORIOKA
DIRECTOR

Deputy Directors
MICHAEL D. FORMBY
FRANCIS PAUL KEENO
BRIAN H. SEKIGUCHI

STATE OF HAWAII
DEPARTMENT OF TRANSPORTATION
869 PUNCHBOWL STREET
HONOLULU, HAWAII 96813-5097

IN REPLY REFER TO:

HWY-PA
2.7504

April 7, 2008

Mr. Mike Price, Chair
South Kohala Traffic Safety Committee
P. O. Box 383375
Waikoloa, Hawaii 96738

Dear Mr. Price:

Subject: Saddle Road (State Route 200)
Mamalahoa Highway (State Route 190) to Milepost 42
Supplemental EIS Preparation Notice (EISPN)

Thank you for your letter, dated January 15, 2008, which compiled the comments made by your membership regarding the proposed Saddle Road, from Mamalahoa Highway to Milepost 42, EISPN. For each of these comments we have the following:

1. *Purchase additional right-of-way to accommodate future growth. The proposed right-of-way width should be at least 250 to 300 feet wide.*

   At the moment, our proposed minimum right-of-way width is 200 feet, which should be sufficient for anticipated traffic growth. It should be noted that the U.S. Army currently owns the land which may be acquired for the highway, and they are very mindful about preserving an adequate training area and the lessening of the effects of this training on the proposed highway.

2. *Interchanges are preferred.*

   Interchanges are very costly to construct, and consequently, such facilities will usually be implemented only where they may be feasible or significantly improve highway safety. Currently, an interchange will be considered for the Saddle Road/Mamalahoa Highway crossing; however, this interchange will be evaluated as part of the proposed Saddle Road Extension, from Queen Kaahumanu Highway to Mamalahoa Highway. We also believe that an interchange at the junction of the proposed Saddle Road and the old Saddle road may be infeasible; however, additional right-of-way may be acquired in the vicinity of the old Saddle Road intersection in the event that an interchange may be needed.

Interchanges for Waikoloa Village, Waikoloa Beach Resort and Paniola Avenue will also be considered during the development of the proposed Saddle Road Extension, from Queen Kaahumanu Highway to Mamalahoa Highway.

3. *A truck climbing lane is needed.*

We agree with your statement and are proposing that a truck climbing lane be provided for the length of this project.

4. *Emergency escape ramps are needed.*

At least one (1) emergency ramp will be constructed along the proposed Saddle Road Extension, from Queen Kaahumanu Highway to Mamalahoa Highway. Additional emergency ramps may be installed, should more of these ramps be necessary.

5. *Scenic turnouts or rest stops should also be provided.*

The Supplementary EIS will have a discussion regarding rest stops, which will include a diagram of possible locations for these facilities. We also agree that a rest stop is needed; however, there may be issues regarding the availability of adequate infrastructure and the concerns of the U.S. Army.

6. *When four (4) lanes are being proposed for Saddle Road, the proposed facility should be a divided highway.*

We agree with this statement; however, we believe that this discussion is more likely to occur during the development of another project in the near future.

7. *Accentuate safety, and its use by bicyclists and commercial trucks, during your layout of the proposed grade of this highway.*

The proposed maximum grade of this highway is 7 percent, which should be suitable for all travelers along this highway. One of the primary purposes of this project is to improve travel safety for all users, and the design of the highway will be reflective of this.

In addition, the proposed minimum right-of-way width for this highway may be able to accommodate an adjacent facility in the event that recreational bicyclists or off-road enthusiasts also express an avid interest in traveling alongside this highway.

We trust that we have satisfactorily addressed your concerns and the concerns of the South Kohala Traffic Safety Committee, and we appreciate your continuing interest in our highway projects. If you have any other questions or comments, please contact Nelson Sagum, Project Manager, at (808) 587-1834.

Very truly yours,

BRENNON T. MORIOKA, Ph.D., P.E.
Director of Transportation

bc: HWY-PA

NS:dn

Aloha Ron,
Please include the material below in the record for the Saddle Rd. EIS. The Keamuku parcel where the road is intended to go is normally directly downwind of the PTA impact area and may be contaminated with radiation from uranium weapons training. Radiation has been confirmed at PTA on August 20, 2007.

The most serious health hazard involves the inhalation of uranium oxide particles.

I'll include comments by Dr. Lorrin Pang, MD of Maui who I recommend as a consultant on the medical effects issue. He has given me permission to circulate his comments about the military's position on radiation. Lorrin Pang is highly critical of the military and the Hawaii State Dept. of Health not addressing the serious issue of uranium oxide.

Jim Albertini
Malu `Aina Center For Non-violent Education & Action
P.O. Box AB
`Ola`a (Kurtistown), Hawaii 96760
Phone 808-966-7622
email ja@interpac.net
www.malu-aina.org

Comments by Dr. Lorrin Pang, MD January 19, 2008
I have offered to constructively contribute to this effort by joining the investigative committee but this was denied by the Gov. I can now only criticize what has transpired but will try to remain constructive.

It has repeatedly been the community request that a survey be done which will detect markers for all forms of uranium weaponry, both Davey Crocketts(ballast) and penetrators (ballistic, as Army defines). It has always been pointed out that the ballistic type are far more dangerous - releasing far traveling plumes of oxides and nano-particles, which become inhaled then very slowly cleared from the body with a distinct type of distribution (macrophage/lymphatic system). Nano toxicity remains unknown. In contrast the ballast forms released metallic U shrapnel of limited migration, risk of inhalation, with rapid clearance (unless permanently imbedded shrapnel) and more of a blood borne distribution in the body.

Initially the Army said they knew of AT LEAST ballast weaponry but now their latest brochure (Information Booklet - Depleted Uranium in Hawaii, no date but distributed at the JUan 2008 Hawaii legislative meeting) implies that they ONLY address ballast, page 12.. I am rather disappointed that the Army is not willing to address the more dangerous from of U radiation based on the "best of their knowledge" which initially proved incorrect with even ballast usage. A good (epidemiologic and statistically sound) survey for ballistic markers (oxides) at ballistic distances would go a long way to appease the critics. Is this intended in the final report (item 4 page 10)? Many of the brochure's claims about minimal migration of U contamination, heavier non migrating particles, claims of safety based on extrapolation from other U experiences, detection at points far from the target zones, etc. etc seem erroneous until it is pointed out near the end of the brochure they only address ballast weaponry (page 12 last item). That only ballast weaponry is addressed should be in the title of the brochure. The justification for this limited search should be on page 2 - as it is contrary to Army policy for procedures to survey for contamination (which is based on survey rather than the more fallible historical knowledge).

Even IF only ballast weaponry was used - the decades' subsequent conventional explosives used on the target sites could have rendered the initially ballast forms of U airborne with conversion to the more dangerous plumes and oxides.

The public should only be satisfied with comprehensive surveys which will include the search for U Oxides contamination and at distances beyond conventional ballast scattering. The dust samples form the particulate survey could be used for that. If oxides or evidence of extensive migration of ANY U compounds are found, regardless of the pruported source, one must set the objective of the survey as one of contamination (comparison to control sites, IAW Army regulation) rather than health threshold set by the NRC (since these may not be extrapolable to nano U or U oxide toxicity).

Some to the responses to public concerns are misleading and unscientific - for example page 10 item 5: If there is a questions of the high reading one should question the specificity (possibility of false positive) instead the Army makes the argument that the detectors are insensitive (false negatives). For a high reading the correct response should have been to see if the reading could be repeated at the same site with more sensitive equipment and greater statistical sensitivity. Community volunteers perfomed this at the Kona site with tens of thousands of air samples (counts or decays per minute, CPM readings) using the best detectors available to them. At my own expense and as a private citizen I presented on the Big Island a written analysis with statistical interpretation to the public, Sen Inouye's representative and the media (Army and DOH were invited, though not personally by me, but did not attend). Most importantly I answered questions from the public on the spot (in contrast to the recent legislative hearing). The results were reassuring. There is an Army/DOH claim that repeated sampling was done with sophisticated equipment. We have repeatedly asked for details to examine analysis (for example, means vs frequencies of CPM data), statistical power and scheme to insure sensitive (for example wind/dust conditions) sampling sites. To date this has not been made availabe to the public, hopefully it will be presented in the final report. We seem to always be arguing that it would be wrong to only run the analysis on means. As cited above this would base the risk on the NRC recommendations for health risks based largely on non oxide U forms from other situations. But of course if one chooses to ignore the U oxides based on the presumption that only ballast forms were used then we have a self fulfilling "confirmation" of safety. The argument that General Lee was so concerned seems a bit odd. No one from the Army attended my presentation of the community survey which I presented in Hilo. He would have been happy with my conclusions and could have presented his survey methods and results at the same time. Maybe we might have disagreed on how to proceed, maybe not.

To me it seems very strange that all the collaborators (especially the CDC and NRC) would not have raised the above concerns with the brochure.

Again I offered to collaborate up front but was denied this. As I understand it Sec Davis was willing but not Gov Lingle thought there was enough expertise elsewhere. Allow me at least this constructive criticism before the final report, as I too am a land owner (small vacant plot) on the Big Island. Finally, I am a stakeholder with no conflict of interest who is trying to uphold federal regulations of safety. I have been warned by colleagues to "watch my back" that I am a "marked" man but have told them that whistle blower laws protect me against retaliation. I have confidence in Sec Davis on this point.

Lorrin Pang, MD, MPH
(as private citizen)
Retired Army Medical Corp
Best Doctors of America list 2006-8
Consultant WHO (since 1985)
Consultant Glaxo Smith Kline

Below are comments by Jim Albertini and dialogue with Russ Takata of the Hawaii Dept. of Health.
Jim,

Russ,
Mahalo for your answers.
The truth is you don't have the facts. You do not know how much DU has been used at PTA. You do not have comprehensive monitoring data.
Show us the data about no radioactivity above background levels. How many readings did you take, for what time frame, and where, under what wind conditions. We have obtained 75 counts per minute (3-4 times background levels) at Mauna Kea State park on May 29, 2007 with dust devils coming right off the PTA impact area. Normally you will get background level readings. Averaging won't cut it. **It is the spikes that concerns us. All that it takes are small particles, carried by the winds, of inhalled DU to cause health problems. That's why we need 360 degress monitoring around PTA with a paper trail and the data available to citizens via home computers. Put the heat on Dan Inouye to come up with the funding for first class monitoring of the military radiation contamination on our Island home. Then we'll have the facts.**

Mahalo.
Jim Albertini
Malu `Aina Center For Non-violent Education & Action
P.O. Box AB
`Ola`a (Kurtistown), Hawaii 96760
Phone 808-966-7622
email ja@interpac.net
www.malu-aina.org
----- Original Message -----
From: Takata, Russell S.
To: Jim Albertini ; imcom-pacific-du@hawaii.army.mil
Cc: Faye Hanohano ; Dwight Takamine ; Cindy Evans ; Robert N. Herkes ; Jerry L. Chang ; Russell S. Kokubun ; Lorrainne R. Inouye ; Harry Kim ; Alan McNarie ; PCRC ; A P ; advertiser ; Garden Ise ; Garden Island ; Hawaii Island Journal ; Hilo Trib ; Hono Weekly ; Honolulu Star-Bulletin ; Ian Lind ; KBOO ; Kevin Dayton ; kgmb tv9 ; khnl tv8 ; KPUA ; Maui news ; namaka@interpac.net ; Rod Thompson ; Audrey McAvoy ; WestHawaii Today ; Honolulu Advertiser ; Pacific Business News ; j Yoshimoto ; Brenda Ford ; Emily Naeole ; Dominic Yagong ; Bob Jacobson ; Angel Pilago ; Donald Ikeda ; Pete Hoffmann ; Stacy K. Higa ; Andy Levin ; Janet Snyder ; Barbara Bell ; Nelson Ho ; Chris Yuen ; Charmaine Shigemura
Sent: Wednesday, January 16, 2008 1:43 PM
Subject: RE: No answers to DU questions

Jim,
Here are my answers: See below in blue.
Russ

From: Jim Albertini [mailto:ja@interpac.net]
Sent: Wed 1/16/2008 12:06 PM
To: Takata, Russell S.; imcom-pacific-du@hawaii.army.mil
Cc: Faye Hanohano; Dwight Takamine; Cindy Evans; Robert N. Herkes; Jerry L. Chang; Russell S. Kokubun; Lorrainne R. Inouye; Harry Kim; Alan McNarie; PCRC; A P; advertiser; Garden Ise; Garden Island; Hawaii Island Journal; Hilo Trib; Hono Weekly; Honolulu Star-Bulletin; Ian Lind; KBOO; Kevin Dayton; kgmb tv9; khnl tv8; KPUA; Maui news; namaka@interpac.net; Rod Thompson; Audrey McAvoy; WestHawaii Today; Honolulu Advertiser; Pacific Business News; j Yoshimoto; Brenda Ford; Emily Naeole; Dominic Yagong; Bob Jacobson; Angel Pilago; Donald Ikeda; Pete Hoffmann; Stacy K. Higa; Andy Levin; Janet Snyder; Barbara Bell; Nelson Ho; Chris Yuen; Charmaine Shigemura
Subject: No answers to DU questions

It's been nearly two months since these questions were presented Nov. 18, 2007 to Army Col. Killian, DOH Russ Takata, Cindy Evans, etc. No answers. How come?

Questions for Meetings on Depleted Uranium Nov. 2007

STATE ONLY ANSWERS

1. Why have you (State & military) refused balanced forums with presenters including Dr. Lorrin Pang, MD, Peace activist Jim Albertini and others?

I will not debate the facts.

2. You have downplayed the health hazards of DU. Isn't that misleading the public?

No, I have not downplayed the health effects. In fact, health effects were covered in my Powerpoint presentation.

3. Where is the data to support your claims minimizing DU health risks?

No evidence of radioactivity above background levels.

4. Did any DU particles on-the-ground become airborne and blow off-base on Oct. 23, 2007 when several 2000-pound bombs were dropped on Pohakuloa (PTA) by B-2 bombers.

There has been no change in background levels in populated areas outside of PTA.

5. Disclose all live-fire weapons and number of rounds fired at PTA, and other training there since DU has been confirmed at PTA on Aug. 20, 2007.

Army

6. Isn't it time we start operating on the precautionary principle. Stop all live-fire at PTA for the following reasons: 1. we have a reasonable suspicion of harm from the possible spread of DU particles; 2. there is uncertainty about the full extent and nature of the DU contamination at PTA; 3. we have a duty to take action to prevent harm to human health and the environment; 4 the cause and effect relationships are not fully known and established scientifically concerning DU.

There has been no radioactivity over normal background levels.

7. Is Army Regulation 700-48 being violated? AR 700-48 ...2-4 Handling of RCE (radiologically contaminated equipment)...During peacetime or soon as operational risk permits, the Corps/JTF/Division Commander's RSP (Radiation Safety Officer) will identify, segregate, isolate, secure, and label all RCE. **Procedures to minimize the spread of radioactivity will be implemented as soon as possible.**

Army

8. Is there any use of DU (past, present, and/or planned) and/ or other activities such as Stryker training at Pohakuloa that could result in the spread of aerosolized DU, and/or DU compounds?

Army

9. Summarize the results of research -past, present and/or planned - on health risks from 1. live munitions exploding on top of DU left on the ground in Hawaii, during forty years of training; 2. vaporized and/or aerosolized DU; 3. DU nanotoxicity. Nanoparticles of a substance may have properties different from those of the original substance, such as becoming toxins or super-catalysts; 4. DU oxides which are insoluble and so are not excreted from the body.

Army

10. Describe past, present, and/or planned use of radioactive substances at PTA.

Army

11. Large areas of PTA and Makua are off-limits because of ICM)Improved Conventional Munitions) which are cluster bombs. Some type of cluster bombs such as ADAM (Area Denial Anti-personnel Mine) contain DU. Is there any use (past, present, and/or planned) at PTA and/or Makua of cluster bombs containing DU

Army

12. The Davy Crockett spotting rounds containing DU used at PTA was one of approximately 60 different nuclear weapons in the U.S. nuclear arsenal during the 1960s and 70s. Have other spotting rounds involving other weapon systems been used at PTA that contain DU? News reports (7/4/07 Big Is. Weekly, p.5) said 714 Davy Crockett DU spotting rounds were shipped to Hawaii. How many remain unaccounted for? Where else have DU Davy Crockett spotting rounds been shipped around the U.S. and outside of the U.S? Identify the sites and the numbers shipped.

Army

13. Will the military pay for 24 hour mass spectrometer independent testing for DU exposure for military and civilian personnel, and/or private contractors at PTA, Schofield, and civilians around such bases who believe they may have been exposed?

Army

14. Have tree bark, animal droppings, and vehicle air filters been tested for DU presence at PTA?

Not by State

15. Why did the Army deny the use of DU in Hawaii for years? Why did the Army fail to publicize the 2005 discovery of DU at Schofield until after citizen groups made the facts known?

Army

16. If State incursion on Federal property is illegal how is it the State is involved in ongoing DU testing?

The State was invited by the Army to participate in activities to obtain a human health risk assessment. The State is not independently conducting DU testing on military property.

17. If the State, CDC, NRC and Army disagree on what should be told to the public, will one party be allowed to speak independently?

The State speaks independently.

Military Clean-Up NOT Build Up!

Contact: Malu `Aina Center For Non-violent Education & Action P.O. Box AB Ola`a (Kurtistown), Hawai`i 96760. Phone (808) 966-7622. Email ja@interpac.net <mailto:ja@interpac.net> http://www.malu-aina.org

"Assuming the machinery is accurate and that the sampling site is truly down wind of the traget site, how many samples (CPM or DPM) will be done? The sampling number should be based on the statistical power to detect the frequency of high CPM above some threshold (say 2 SD's above the mean of background). That frequency based on what Jim first saw in Waikii (4/500) would be quite a bit smaller than 1%. To use the means of CPM is misleading if a one time inhalation exposure is not cleared from the body for such a long time (U oxides with 5 half lives approx several decades) and if the distribution in the body is fixed to a few selected cells."

Lorrin Pang, MD

----- Original Message -----
From: Jim Albertini
To: Takata, Russell S.
Cc: Bob Jacobson ; Clifton Tsuji ; congresswomanmaziehirono@congressionalemaildispatcher.com ; Harry Kim ; Josh Green ; Cindy Evans ; Alan McNarie ; PCRC ; A P ; advertiser ; Garden Ise ; Garden Island ; Hawaii Island Journal ; Hilo Trib ; Hono Weekly ; Honolulu Star-Bulletin ; Ian Lind ; KBOO ; Kevin Dayton ; kgmb tv9 ; khnl tv8 ; KPUA ; Maui news ; namaka@interpac.net ; Bod Thompson ; Audrey McAvoy ; WestHawaii Today ; Honolulu Advertiser ; Pacific Business News ; shannon rudolph ; Dr. Lorrin Pang
Sent: Wednesday, January 16, 2008 11:00 PM
Subject: Re: Action on DU

Russ,
We are not dealing with radiation from a nuclear blast of cold war nuclear weapon testing. DU is much more sinister. It is the inhalation of small DU oxide particles that is of greatest concern. Alpha particles breathed in, not external exposure. You just can't go around and check for an hour here and there and conclude nothing above background therefore PTA can continue business as usual with DU contamination present.
We know the DU is there. We do not know the full extent of the contamination. Likely there are hundreds of Davy Crockette spotting rounds given what was shipped to Hawaii and perhaps other DU rounds as well. The only way to tell if it is going off base (and we have readings to suggest it is) is to encircle the base with high tech 24/7 air monitors with a paper trail and citizen computer access to the data at all times. Otherwise we simply are not going to buy your claims, and the

military claims, of no problem. The cost of such monitors is peanuts to the **$2 billion the military spends PER DAY! waging war and spreading opala like they're doing at PTA.**
The scientific reason for you to pursue cessation of activity at PTA is the DU present could be spread off base by live-fire, and other activities that puts dust into the air. We have already sent you material by radiation expert Dr. Rosalie Bertell strongly critiquing the Army's 6 page DU November 2007 handout. We also sent you material by Dr. Leonard Dietz and DU being carried more than 26 miles from a plant that simply manufactured 30-mm DU rounds near Albany, N.Y. That plant has been shut down because it exceeded a NY state radioactivity limit of 150 microcuries (387 g of DU metal) for airborne emissions in a given month. One DU aircraft 30-mm round contains 272 g of DU metal. By the way, what is Hawaii's radioactivity limit for airborne emissions in a given month? Is there a federal standard as well?

You have plenty of scientific material to call for a halt to B-2 bombing at PTA and the upcoming major live-fire in February 2008.
From the Dept. of the Army, sadly, we expect very little. From the Dept. of HEALTH, we expect more.
Mahalo.
Jim Albertini
Malu `Aina Center For Non-violent Education & Action
P.O. Box AB
`Ola`a (Kurtistown), Hawaii 96760
Phone 808-966-7622
email ja@interpac.net
www.malu-aina.org

----- Original Message -----
From: Takata, Russell S.
To: Jim Albertini
Cc: Bob Jacobson ; Clifton Tsuji ; congresswomanmaziehirono@congressionalemaildispatcher.com ; Harry Kim ; Josh Green ; Cindy Evans ; Alan McNarie ; PCRC ; A P ; advertiser ; Garden Ise ; Garden Island ; Hawaii Island Journal ; Hilo Trib ; Hono Weekly ; Honolulu Star-Bulletin ; Ian Lind ; KBOO ; Kevin Dayton ; kgmb tv9 ; khnl tv8 ; KPUA ; Maui news ; namaka@interpac.net ; Rod Thompson ; Audrey McAvoy ; WestHawaii Today ; Honolulu Advertiser ; Pacific Business News
Sent: Wednesday, January 16, 2008 12:58 PM
Subject: RE: Action on DU

Jim,
Too little? This monitoring system provided key data to the Environmental Radiation Ambient Monitoring System for most of the Cold War period! You have no idea of the requisite actions necessary to ensure the public's health and safety. But, I will ignore your comment and continue to pursue my efforts to seek the facts for public health and safety.

The bottom line is that there has been no radioactivity detected above background levels in our ambient surveys of the adjacent proximity of PTA on Saddle Road and the communities in Konawaena, Kealakekua, Holualua, Waikoloa, Waikii Ranch, and the Girl Scout camp! As a matter of fact, the background is quite low. And therefore, there is no scientific reason for me to pursue cessation of activity at PTA.

As I noted in earlier conversations with you, I will give you the facts and will not compromise my integrity for anyone.

Have a good day,
Russ

From: Jim Albertini [mailto:ja@interpac.net]
Sent: Wed 1/16/2008 11:56 AM
To: Takata, Russell S.
Cc: Bob Jacobson; Clifton Tsuji; congresswomanmaziehirono@congressionalemaildispatcher.com; Harry Kim; Josh Green; Cindy Evans; Alan McNarie; PCRC; A P; advertiser; Garden Ise; Garden Island; Hawaii Island Journal; Hilo Trib; Hono Weekly; Honolulu Star-Bulletin; Ian Lind; KBOO; Kevin Dayton; kgmb tv9; khnl tv8; KPUA; Maui news; namaka@interpac.net; Rod Thompson; Audrey McAvoy; WestHawaii Today; Honolulu Advertiser; Pacific Business News
Subject: Re: Action on DU

Aloha Russ,
My initial reaction to your news of an initial air monitoring is that it's something but too little. We citizens, with our own community experts, want in on the decision making process. We want timely access to all the data as well. The key thing at the moment is to STOP all activity at PTA (B-2 bombing and major live-fire planned for Feb.) and other places that could spread the radioactivity before a compolete assessment is completed. You only know that Davy Crockette DU spottings rounds are at PTA. You have no idea if other DU rounds are there and how many. You, and elected officials need to speak out on this to the media if you want to maintain any credibility in the community. Otherwise health and safety of the community is taking a back seat to imperial warmaking. Is there any meaning left to "national security?"
Jim Albertini
Malu `Aina Center For Non-violent Education & Action
P.O. Box AB
`Ola`a (Kurtistown), Hawaii 96760
Phone 808-966-7622
email ja@interpac.net
www.malu-aina.org
----- Original Message -----
From: Takata, Russell S.
To: Jim Albertini
Cc: Bob Jacobson ; Clifton Tsuji ; congresswomanmaziehirono@congressionalemaildispatcher.com ; Harry Kim ; Josh Green ; Cindy Evans
Sent: Wednesday, January 16, 2008 7:56 AM
Subject: RE: Action on DU

Jim,
Happy New Year to you too.
I have made arrangements with EPA to start initial air monitoring using a well validated protocol and monitor for ambient levels. We will shake down the equipment and procedures, identify an initial site, and begin operating within thirty days. More later.
Russ

From: Jim Albertini [mailto:ja@interpac.net]
Sent: Tue 1/15/2008 9:31 PM
To: Takata, Russell S.
Cc: Bob Jacobson; Clifton Tsuji; congresswomanmaziehirono@congressionalemaildispatcher.com; Harry Kim; Josh Green; Cindy Evans
Subject: Action on DU

Aloha Russ,
Happy New Year to you. Below is a copy of a recent email I sent to Col. Killian.

I hereby request you contact U.S. Sen. Dan Inouye and seek funding for first class citizen high tech DU monitors around all confirmed or suspected bases where DU has been used in Hawaii. Afterall, billions are spent on the war and military build up in Hawaii. A few million should be available for monitors. If my math is correct it costs $135,000 in fuel for a B-2 bomber to fly from Guam to Hawaii to drop 2000 lb bombs at PTA risking the spread of DU contamination. Just stopping a few of those bombing flights would help pay for some monitors.

Russ, we want some positive action. Stop the live fire military plans for Feb. at PTA. You and the Army do not even know the full extent of the DU contamination at PTA. To go forward with live-fire is nuts and shows contempt for the health and safety of the troops who will train there and the citizens of this island. You need to speak up and stand up now for public health now.
Mahalo.

Jim Albertini
Malu `Aina Center For Non-violent Education & Action
P.O. Box AB
`Ola`a (Kurtistown), Hawaii 96760
Phone 808-966-7622
email ja@interpac.net
www.malu-aina.org

Aloha Col. Killian:
This is to again put in writing our organization's "Citizen DU Action Demands" that were circulated after the confirmation of DU at Pohakuloa in Aug. 2007 and again presented to you and State DOH employee Russ Takata at the one sided Nov. 18, 2007 meeting on DU. (See below).
I also want to again request a response in writing to the questions I submitted at the Nov. 18, 2007 meeting on DU. To date I have not received any response. You give lip service to concerns for health and safety but your actions and lack of actions speak otherwise.
I look forward to a more positive attitude from you and other military people toward the citizens of Hawaii in 2008.

Jim Albertini
Malu `Aina Center For Non-violent Education & Action
P.O. Box AB
`Ola`a (Kurtistown), Hawaii 96760
Phone 808-966-7622
email ja@interpac.net
www.malu-aina.org

RADIATION MONITORING IN HAWAII!

On Monday, August 20, 2007 the U.S. Army confirmed the presence of depleted uranium (DU) at the Pohakuloa Training Area (PTA) in the center of Hawaii Island.

See <http://www.armytimes.com/news/2007/08/ap_hawaiiuranium_070821/> The DU confirmation came after years of the military denying its presence. Citizen groups kept the pressure on the military and began doing their own radiation monitoring.

Also see http://www.hawaiitribune-herald.com/articles/2007/08/26/local_news/local03.prt
<http://www.hawaiitribune-herald.com/articles/2007/08/26/local_news/local03.prt>
<http://www.hawaiitribune-herald.com/articles/2007/08/26/local_news/local04.prt>

DU is primarily U-238, the isotope of uranium that remains after the fissionable isotope, U-235 has been extracted from natural urarium ore. DU has a half-life of 4.5 billion years. The military has used DU in spotting rounds for the Davy Crockett nuclear weapon system and these spotting rounds have been fired at Schofield Barracks on Oahu and at PTA on Hawaii Island, perhaps other firing ranges in Hawaii and elsewhere too. Other DU spotting rounds may have been fired. Davy Crockett was just one of approximately 60 different kinds of U.S. nuclear weapons in the U.S. arsenal Training with a wide range of weapon systems has taken place at PTA and other live-fire areas throughout Hawaii. The Davy Crockett may just be the tip of a much larger radiation nightmare for Hawaii residents and visitors alike The military says it has no records on the issue. The U.S. used DU armor and bunker piercing weapons in Iraq, Afghanistan and Kosovo. For more on DU weapons and its hazards

See <http://www.informationclearinghouse.info/article18242.htm>

On Tuesday, May 29, 2007 a citizen radiation monitor recorded elevated radiation readings at Mauna Kea State Park adjacent to the military's Pohakuloa Training Area (PTA) in the center of Hawaii Island. The wind on 5/29 blew directly off the live-fire training areas at PTA and dust devils of suspended topsoil were visible in the air. The elevated radiation readings were as high as 75 counts per minute when normal background is 5-20 counts per minute. A number of private citizens are now doing radiation monitoring on Hawaii Island.

It should be noted that Hawaii Island already has a dubious distinction of the nuclear age. According to the U.S. Atomic Energy Commission, of 65 randomly selected worldwide soil samples tested for accumulation of long-lasting plutonium radiation contamination from atmospheric nuclear weapon testing, our Big Island soil ranked NUMBER ONE! Plutonium is one of the most potent carcinogenic substances known. Less than one-millionth of a gram is capable of producing cancer after close exposure. Plutonium has a half-life of 24,000 years, which means it is potentially toxic to humans for at least a half million years. As plutonium is concentrated in the ecological food chain, people can absorb significant quantities. It is preferentially stored in the liver and bone marrow and can cross the placenta into the unborn fetus. (To read the above AEC report see Nature Magazine, Vol. 241, February 16, 1973.)

It should also be noted that the Navy acknowledges discharging millions of gallons of radioactive liquid waste into Pearl Harbor on Oahu and dumping over two thousand 55-gallon steel drums of radioactive solid waste on the ocean floor off Hawaii's shores. What effects such pollution may have on marine life and, in turn, the health and safety of Hawaii's people is simply not clear. But it is commonly accepted that there is no safe level of radiation. (See the book "The Dark Side of Paradise" by Albertini, et. all page 18.)

Military Clean-Up NOT Build-Up!

CITIZEN ACTION DEMANDS

1. Immediate halt to all live-fire and any activity that creates dust at Schofield Barracks, Pohakuloa and other military ranges in Hawaii until there is a complete assessment and clean up of the DU present. Further live-fire and other activities could result in the spread of airborne DU particles which are particularly hazardous if inhaled.

2. Citizen monitors, including Dr. Lorrin Pang MD, former attorney, OHA trustee, and nuclear worker Clarence Ku Ching, and Jim Albertini or some other representative from the peace movement to be involved in the DU assessment and monitoring process to assure transparency and community confidence.

3. The establishment of permanent, continuous, high tech counts per minute (cpm) monitors (at the Army's expense) but independently operated around range impact area where the real-time data is available to the public on line.

4. Testing (at Army expense) for DU exposure of PTA and other military personnel, and members of the civilian community who feel they may have been exposed to DU. (The U.S. is spending $2 billion a day on the military.

There should be funds available to see if citizens are being contaminated by its own radioactive weapons.)

5. Ongoing public balanced informational and Q & A meetings involving the Army, State Dept. of Health, Nuclear Regulatory Commission (NRC), the Center for Disease Control (CDC), Dr. Lorrin Pang and other community resource people.

LINDA LINGLE
GOVERNOR

BRENNON T. MORIOKA
DIRECTOR

Deputy Directors
MICHAEL D. FORMBY
FRANCIS PAUL KEENO
BRIAN H. SEKIGUCHI

STATE OF HAWAII
DEPARTMENT OF TRANSPORTATION
869 PUNCHBOWL STREET
HONOLULU, HAWAII 96813-5097

IN REPLY REFER TO:

HWY-PA
2.7506

April 7, 2008

Mr. Jim Albertini
Malu 'Aina Center for Non-Violent Education & Action
P. O. Box AB
Kurtistown, Hawaii 96760

Dear Mr. Albertini:

Subject: Saddle Road (State Route 200)
Mamalahoa Highway (State Route 190) to Milepost 42
Supplemental EIS Preparation Notice (EISPN)

Thank you for your e-mail/commentary, as addressed to Mr. Ron Terry, our project subconsultant, regarding the existence of depleted uranium (DU) in the Pohakuloa Training Area (PTA), of the U.S. Army.

For your information, the State Department of Transportation also has several questions regarding the DU, and consequently, we have initiated an independent study which would develop a risk assessment regarding the adverse effects of the DU, that may occur as a consequence of the construction and operation of the proposed Saddle Road. All of our studies will be included in the Supplemental Environmental Impact Statement (EIS) for this project.

In addition, your comments have been forwarded to our environmental and risk assessment subconsultants, who will evaluate them during the preparation of their studies for the project's Supplemental EIS. We believe that most of your comments will also be included in the Supplemental EIS.

We appreciate your attendance and the participation of your organization at our meeting with Mr. Terry in January 2008. If you have any questions or comments concerning this project, please contact Nelson Sagum, Project Manager, at (808) 587-1834.

Very truly yours,

BRENNON T. MORIOKA, Ph.D., P.E.
Director of Transportation

bc: HWY-PA
NS:dn

SADDLE ROAD (STATE ROUTE 200)
Mamalahoa Highway (State Route 190) to Milepost 42
County of Hawai‘i, State of Hawai‘i
FHWA Project No. 200(00)

SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT

Submitted Pursuant to Section 42 U.S.C. 4332(2)(c)
and Chapter 343, Hawai‘i Revised Statutes by the

U.S. DEPARTMENT OF TRANSPORTATION
Federal Highway Administration (FHWA)
Central Federal Lands Highway Division
and
STATE OF HAWAI‘I
Department of Transportation (HDOT)
Highways Division

Cooperating Agencies
U.S. Army Garrison, Hawai‘i

Appendix A
Public Involvement and Agency Coordination
A3: 9/6/09 Letter, U.S. Army Garrison to HDOT

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DIR 1497

DEPARTMENT OF THE ARMY
HEADQUARTERS, UNITED STATES ARMY GARRISON, HAWAII
SCHOFIELD BARRACKS, HAWAII 96857-5000

REPLY TO
ATTENTION OF

September 8, 2006

Office of the Garrison Commander

Mr. Rodney Haraga
Director, Department of Transportation
State of Hawaii
869 Punchbowl Street
Honolulu, Hawaii 96813

Dear Mr. Haraga:

The Federal Highway Administration (FHWA), Central Federal Lands Highway Division, in cooperation with the State of Hawaii Department of Transportation (HDOT) has proposed to improve Saddle Road (State Route 200 from Hilo to Mamalahoa Highway) on the Island of Hawaii (FHWA Project No. A-AD-6(1)). The proposed Section I of the realignment goes through the newly acquired "Keamuku Maneuver Area" which is part of the Army's Pohakuloa Training Area (PTA).

The US Army Garrison, Hawaii (USAG-HI) totally supports the Saddle Road Improvement Project in its entirety. The road will greatly benefit the local community by decreasing cross-island travel times and improving traffic safety. However, with the recent acquisition of the Keamuku Maneuver Area, the Army requests that FHWA/HDOT review the selection of route W-3 as preferred Saddle Road realignment alternative as identified in the Final Environmental Impact Statement (EIS), dated August 1999. This recommended realignment bisects the Keamuku Maneuver Area and divides the maneuver area into two sections. Maneuver trails would have to cross route W-3 at several grade separated underpasses that impose administrative restrictions during training exercises and severely impacts training realism.

To minimize the impact on training, the US Army is requesting that FHWA/HDOT consider a new route that runs along the southern boundary of the Keamuku Maneuver Area (see enclosed map). The intent of the proposed new route is not to adversely affect travel times or public safety. As in the earlier planning effort, the Army is willing to serve as a cooperating agency in the Supplemental EIS process.

In order to coordinate the connection of this new route with the HDOT's Saddle Road Extension Project (Queen Kaahumanu Highway to Mamalahoa Highway), please contact Mr. Michael Kumabe, Chief, Planning Division, Directorate of Public Works at 656-1410 ext. 1207. The US Army greatly appreciates your consideration of this request.

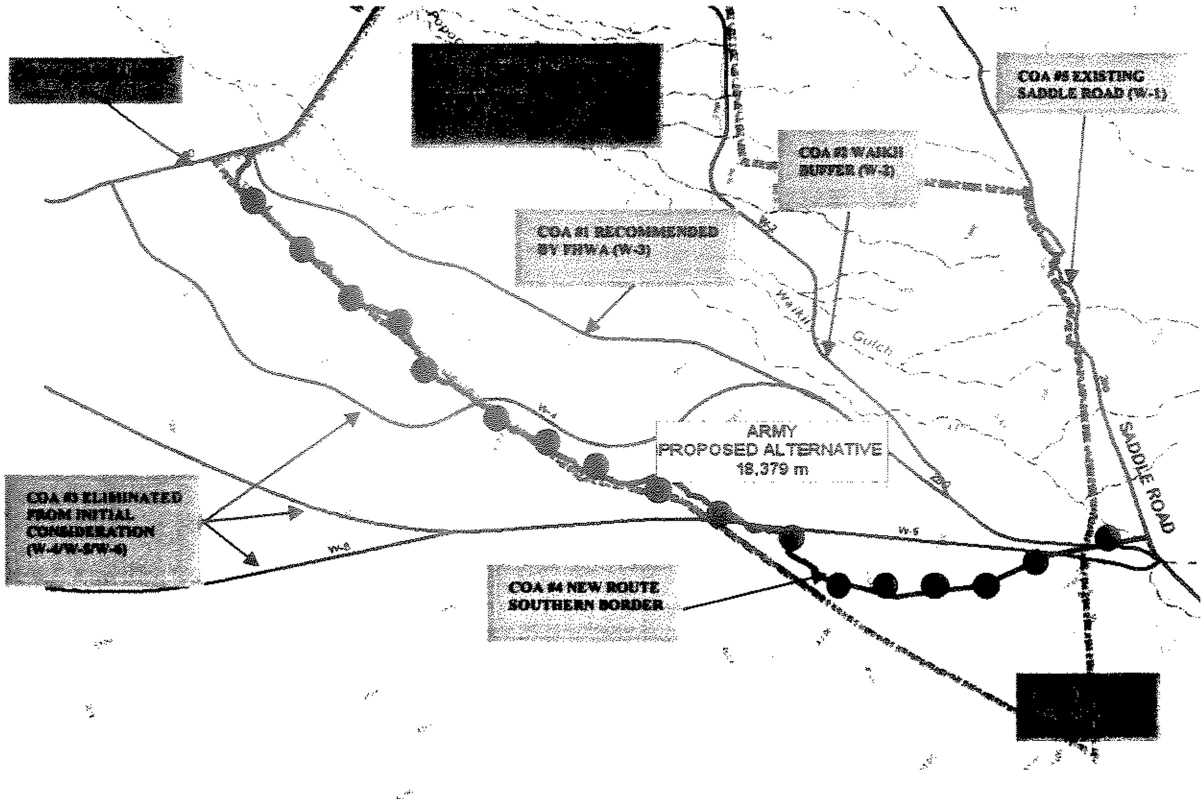
A similar letter is being sent to the co-proponent on this project: Ms. Clara H. Conner, Director, Program Administration, Central Federal Lands Highway Division, Federal Highway Administration, 12300 West Dakota Avenue, Lakewood, Colorado 80228-2683. A copy of both letters is being sent to Mr. Peter Cline, Highways for National Defense - Defense Access Roads Program, Military Surface Deployment and Distribution Command (SDDC), 720 Thimble Shoals Boulevard, Suite 130, Newport News, VA 23606-4537065011.

Sincerely,

Howard J. Killian
Colonel, US Army
Commanding

Enclosure

New Proposed Alignment



US Army's Proposed Alignment

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SADDLE ROAD (STATE ROUTE 200)
Mamalahoa Highway (State Route 190) to Milepost 42
County of Hawai‘i, State of Hawai‘i
FHWA Project No. 200(00)

SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT

Submitted Pursuant to Section 42 U.S.C. 4332(2)(c)
and Chapter 343, Hawai‘i Revised Statutes by the

U.S. DEPARTMENT OF TRANSPORTATION
Federal Highway Administration (FHWA)
Central Federal Lands Highway Division
and
STATE OF HAWAI‘I
Department of Transportation (HDOT)
Highways Division

Cooperating Agencies
U.S. Army Garrison, Hawai‘i

Appendix B
Waters of U.S. Report and Correspondence

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DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS, HONOLULU DISTRICT
FORT SHAFTER, HAWAII 96858-5440

REPLY TO
ATTENTION OF:

September 10, 2009

Regulatory Branch

File No. POH-2008-00021

Mr. Glenn M. Yasui
Administrator, Highways Division
State of Hawaii
Department of Transportation
869 Punchbowl Street
Honolulu, HI 96813-5097

Dear Mr. Yasui:

This is in response to your March 18, 2009 letter requesting a Department of the Army (DA) Jurisdictional Determination (JD) for the Saddle Road realignment and improvement project. Your request is specifically for Section I of the project between Mileposts (MP) 42 to MP 53, the westernmost portion of Saddle Road, ending at the Mamalahoa Highway (SR 190).

Based on our review of the information you furnished, our staff visit to the site, and other resources available to our office, we have determined that your proposed project would not involve the discharge of fill material into waters of the U.S. under our regulatory jurisdiction. Therefore, a DA permit is not required.

Your proposed project was reviewed pursuant to Section 10 of the Rivers and Harbors Act of 1899 (Section 10) and Section 404 of the Clean Water Act (Section 404). Section 10 requires that a DA permit be obtained for certain structures or work in or affecting navigable waters of the United States (U.S.), prior to conducting the work (33 U.S.C. 403). Navigable waters of the U.S. are those waters subject to the ebb and flow of the tide shoreward to the mean high water mark in waters determined to be navigable by the Honolulu District. Your project is not within Section 10 jurisdiction. Section 404 requires that a DA permit be obtained for the placement or discharge of dredged and/or fill material into waters of the U.S., including wetlands, prior to conducting the work (33 U.S.C. 1344). The three crossings proposed between MP 42 and MP 53 do not impact any water of the U.S. (see attached JD). This determination is valid for a period of five (5) years from the date of this letter.

You have the opportunity to submit a formal Administrative Appeal of this Approved JD. Your Request for Appeal (RFA) must be submitted within 60 days of this letter. Should you wish to submit a RFA, please contact this office and we will provide you with the appropriate form detailing the Appeal process.

Thank you for your cooperation with our regulatory program. Please be advised you can provide comments on your experience with the Honolulu District Regulatory Branch by accessing our web-based customer survey form at http://per2.nwp.usace.army.mil/survey.html.

If you have questions, please contact Mr. Robert Deroche of my staff at 808-348-2039 (FAX: 808-438-4060) or by email at robert.d.deroche2@usace.army.mil. Please refer to File No. POH-2008-21 in all future correspondence with this office regarding this project.

Sincerely,

George P. Young, P.E.
Chief, Regulatory Branch

Enclosure

Copy Furnished (w/encl):

Mr. Ron Terry, Ph.D., Geometrician Associates, LLC., P.O. Box 396, Hilo, HI 96721
Mr. Donald K. Okahara, P.E., Okahara & Associates, Inc., 677 Ala Moana Blvd., Suite 703, Honolulu, HI 96813-5419
Mr. Dave Gedeon, U.S. Department of Transportation, 12300 West Dakota Avenue, Suite 280, Lakewood, CO 80228-2583

APPROVED JURISDICTIONAL DETERMINATION FORM
U.S. Army Corps of Engineers

This form should be completed by following the instructions provided in Section IV of the JD Form Instructional Guidebook.

SECTION I: BACKGROUND INFORMATION

A. REPORT COMPLETION DATE FOR APPROVED JURISDICTIONAL DETERMINATION (JD): September 9, 2009

B. DISTRICT OFFICE, FILE NAME, AND NUMBER: CEPOH-EC-R SADDLE ROAD REALIGNMENT 2008-21

C. PROJECT LOCATION AND BACKGROUND INFORMATION: Mile Posts 42 thru 53
State: Hawaii County/parish/borough: Hawaii City:
Center coordinates of site (lat/long in degree decimal format): Lat. 19.8020 ° N, Long. -155.6894 ° W.
Universal Transverse Mercator: 5
Name of nearest waterbody: None
Name of nearest Traditional Navigable Water (TNW) into which the aquatic resource flows: Pacific Ocean
Name of watershed or Hydrologic Unit Code (HUC): 20010000
☒ Check if map/diagram of review area and/or potential jurisdictional areas is/are available upon request.
☐ Check if other sites (e.g., offsite mitigation sites, disposal sites, etc...) are associated with this action and are recorded on a different JD form.

D. REVIEW PERFORMED FOR SITE EVALUATION (CHECK ALL THAT APPLY):
☒ Office (Desk) Determination. Date: September 9, 2009
☒ Field Determination. Date(s): August 10, 2009

SECTION II: SUMMARY OF FINDINGS

A. RHA SECTION 10 DETERMINATION OF JURISDICTION.

There Are no "*navigable waters of the U.S.*" within Rivers and Harbors Act (RHA) jurisdiction (as defined by 33 CFR part 329) in the review area. [*Required*]
☐ Waters subject to the ebb and flow of the tide.
☐ Waters are presently used, or have been used in the past, or may be susceptible for use to transport interstate or foreign commerce. Explain: .

B. CWA SECTION 404 DETERMINATION OF JURISDICTION.

There Are no "*waters of the U.S.*" within Clean Water Act (CWA) jurisdiction (as defined by 33 CFR part 328) in the review area. [*Required*]

1. **Waters of the U.S.**
   a. **Indicate presence of waters of U.S. in review area (check all that apply):** [1]
      ☐ TNWs, including territorial seas
      ☐ Wetlands adjacent to TNWs
      ☐ Relatively permanent waters[2] (RPWs) that flow directly or indirectly into TNWs
      ☐ Non-RPWs that flow directly or indirectly into TNWs
      ☐ Wetlands directly abutting RPWs that flow directly or indirectly into TNWs
      ☐ Wetlands adjacent to but not directly abutting RPWs that flow directly or indirectly into TNWs
      ☐ Wetlands adjacent to non-RPWs that flow directly or indirectly into TNWs
      ☐ Impoundments of jurisdictional waters
      ☐ Isolated (interstate or intrastate) waters, including isolated wetlands

   b. **Identify (estimate) size of waters of the U.S. in the review area:**
      Non-wetland waters: linear feet: width (ft) and/or acres.
      Wetlands: 6.0 acres.

   c. **Limits (boundaries) of jurisdiction** based on: Pick List
      Elevation of established OHWM (if known): .

2. **Non-regulated waters/wetlands (check if applicable):**[3]
   ☐ Potentially jurisdictional waters and/or wetlands were assessed within the review area and determined to be not jurisdictional. Explain: .

---

[1] Boxes checked below shall be supported by completing the appropriate sections in Section III below.
[2] For purposes of this form, an RPW is defined as a tributary that is not a TNW and that typically flows year-round or has continuous flow at least "seasonally" (e.g., typically 3 months).
[3] Supporting documentation is presented in Section III.F.

SECTION III: CWA ANALYSIS

A. TNWs AND WETLANDS ADJACENT TO TNWs

The agencies will assert jurisdiction over TNWs and wetlands adjacent to TNWs. If the aquatic resource is a TNW, complete Section III.A.1 and Section III.D.1. only; if the aquatic resource is a wetland adjacent to a TNW, complete Sections III.A.1 and 2 and Section III.D.1.; otherwise, see Section III.B below.

1. **TNW**
   Identify TNW: .

   Summarize rationale supporting determination: .

2. **Wetland adjacent to TNW**
   Summarize rationale supporting conclusion that wetland is "adjacent": .

B. CHARACTERISTICS OF TRIBUTARY (THAT IS NOT A TNW) AND ITS ADJACENT WETLANDS (IF ANY):

This section summarizes information regarding characteristics of the tributary and its adjacent wetlands, if any, and it helps determine whether or not the standards for jurisdiction established under *Rapanos* have been met.

The agencies will assert jurisdiction over non-navigable tributaries of TNWs where the tributaries are "relatively permanent waters" (RPWs), i.e. tributaries that typically flow year-round or have continuous flow at least seasonally (e.g., typically 3 months). A wetland that directly abuts an RPW is also jurisdictional. If the aquatic resource is not a TNW, but has year-round (perennial) flow, skip to Section III.D.2. If the aquatic resource is a wetland directly abutting a tributary with perennial flow, skip to Section III.D.4.

A wetland that is adjacent to but that does not directly abut an RPW requires a significant nexus evaluation. Corps districts and EPA regions will include in the record any available information that documents the existence of a significant nexus between a relatively permanent tributary that is not perennial (and its adjacent wetlands if any) and a traditional navigable water, even though a significant nexus finding is not required as a matter of law.

If the waterbody[4] is not an RPW, or a wetland directly abutting an RPW, a JD will require additional data to determine if the waterbody has a significant nexus with a TNW. If the tributary has adjacent wetlands, the significant nexus evaluation must consider the tributary in combination with all of its adjacent wetlands. This significant nexus evaluation that combines, for analytical purposes, the tributary and all of its adjacent wetlands is used whether the review area identified in the JD request is the tributary, or its adjacent wetlands, or both. If the JD covers a tributary with adjacent wetlands, complete Section III.B.1 for the tributary, Section III.B.2 for any onsite wetlands, and Section III.B.3 for all wetlands adjacent to that tributary, both onsite and offsite. The determination whether a significant nexus exists is determined in Section III.C below.

1. **Characteristics of non-TNWs that flow directly or indirectly into TNW**

   (i) General Area Conditions:
   Watershed size: Pick List
   Drainage area: Pick List
   Average annual rainfall: inches
   Average annual snowfall: inches

   (ii) Physical Characteristics:
   (a) Relationship with TNW:
   ☐ Tributary flows directly into TNW.
   ☐ Tributary flows through Pick List tributaries before entering TNW.

   Project waters are Pick List river miles from TNW.
   Project waters are Pick List river miles from RPW.
   Project waters are Pick List aerial (straight) miles from TNW.
   Project waters are Pick List aerial (straight) miles from RPW.
   Project waters cross or serve as state boundaries. Explain: .

   Identify flow route to TNW[5]: .
   Tributary stream order, if known: .

---

[4] Note that the Instructional Guidebook contains additional information regarding swales, ditches, washes, and erosional features generally and in the arid West.
[5] Flow route can be described by identifying, e.g., tributary a, which flows through the review area, to flow into tributary b, which then flows into TNW.

(b) General Tributary Characteristics (check all that apply):

Tributary is: ☐ Natural
☐ Artificial (man-made). Explain: .
☐ Manipulated (man-altered). Explain: .

Tributary properties with respect to top of bank (estimate):
Average width: feet
Average depth: feet
Average side slopes: Pick List.

Primary tributary substrate composition (check all that apply):

☐ Silts ☐ Sands ☐ Concrete
☐ Cobbles ☐ Gravel ☐ Muck
☐ Bedrock ☐ Vegetation. Type/% cover:
☐ Other. Explain: .

Tributary condition/stability [e.g., highly eroding, sloughing banks]. Explain: .
Presence of run/riffle/pool complexes. Explain: .
Tributary geometry: Pick List
Tributary gradient (approximate average slope): %

(c) Flow:
Tributary provides for: Pick List
Estimate average number of flow events in review area/year: Pick List
Describe flow regime: .
Other information on duration and volume: .

Surface flow is: Pick List. Characteristics: .

Subsurface flow: Pick List. Explain findings: .
☐ Dye (or other) test performed: .

Tributary has (check all that apply):
☐ Bed and banks
☐ OHWM[6] (check all indicators that apply):

☐ clear, natural line impressed on the bank
☐ changes in the character of soil
☐ shelving
☐ vegetation matted down, bent, or absent
☐ leaf litter disturbed or washed away
☐ sediment deposition
☐ water staining
☐ other (list):
☐ the presence of litter and debris
☐ destruction of terrestrial vegetation
☐ the presence of wrack line
☐ sediment sorting
☐ scour
☐ multiple observed or predicted flow events
☐ abrupt change in plant community

☐ Discontinuous OHWM.[7] Explain: .

If factors other than the OHWM were used to determine lateral extent of CWA jurisdiction (check all that apply):

■ High Tide Line indicated by:
☐ oil or scum line along shore objects
☐ fine shell or debris deposits (foreshore)
☐ physical markings/characteristics
☒ tidal gauges
☐ other (list):

■ Mean High Water Mark indicated by:
☐ survey to available datum;
☐ physical markings;
☐ vegetation lines/changes in vegetation types.

(iii) Chemical Characteristics:
Characterize tributary (e.g., water color is clear, discolored, oily film; water quality; general watershed characteristics, etc.).
Explain: .
Identify specific pollutants, if known: .

[6]A natural or man-made discontinuity in the OHWM does not necessarily sever jurisdiction (e.g., where the stream temporarily flows underground, or where the OHWM has been removed by development or agricultural practices). Where there is a break in the OHWM that is unrelated to the waterbody's flow regime (e.g., flow over a rock outcrop or through a culvert), the agencies will look for indicators of flow above and below the break.
[7]Ibid.

(iv) Biological Characteristics. Channel supports (check all that apply):

☐ Riparian corridor. Characteristics (type, average width): .

☐ Wetland fringe. Characteristics: .

☐ Habitat for:

- ☐ Federally Listed species. Explain findings: .
- ☐ Fish/spawn areas. Explain findings: .
- ☐ Other environmentally-sensitive species. Explain findings: .
- ☐ Aquatic/wildlife diversity. Explain findings: .

2. Characteristics of wetlands adjacent to non-TNW that flow directly or indirectly into TNW

(i) Physical Characteristics:

(a) <u>General Wetland Characteristics:</u>

Properties:

Wetland size: acres

Wetland type. Explain: .

Wetland quality. Explain: .

Project wetlands cross or serve as state boundaries. Explain: .

(b) <u>General Flow Relationship with Non-TNW:</u>

Flow is: Pick List. Explain: .

Surface flow is: Pick List

Characteristics: .

Subsurface flow: Pick List. Explain findings: .

☐ Dye (or other) test performed: .

(c) <u>Wetland Adjacency Determination with Non-TNW:</u>

☐ Directly abutting

☐ Not directly abutting

- ☐ Discrete wetland hydrologic connection. Explain: .
- ☐ Ecological connection. Explain: .
- ☐ Separated by berm/barrier. Explain: .

(d) <u>Proximity (Relationship) to TNW</u>

Project wetlands are Pick List river miles from TNW.

Project waters are Pick List aerial (straight) miles from TNW.

Flow is from: Pick List.

Estimate approximate location of wetland as within the Pick List floodplain.

(ii) Chemical Characteristics:

Characterize wetland system (e.g., water color is clear, brown, oil film on surface; water quality; general watershed characteristics; etc.). Explain: .

Identify specific pollutants, if known: .

(iii) Biological Characteristics. Wetland supports (check all that apply):

☐ Riparian buffer. Characteristics (type, average width): .

☐ Vegetation type/percent cover. Explain: .

☐ Habitat for:

- ☐ Federally Listed species. Explain findings: .
- ☐ Fish/spawn areas. Explain findings: .
- ☐ Other environmentally-sensitive species. Explain findings: .
- ☐ Aquatic/wildlife diversity. Explain findings: .

3. Characteristics of all wetlands adjacent to the tributary (if any)

All wetland(s) being considered in the cumulative analysis: Pick List

Approximately ( ) acres in total are being considered in the cumulative analysis.

For each wetland, specify the following:

Directly abuts? (Y/N)	Size (in acres)	Directly abuts? (Y/N)	Size (in acres)

Summarize overall biological, chemical and physical functions being performed: .

C. SIGNIFICANT NEXUS DETERMINATION

A significant nexus analysis will assess the flow characteristics and functions of the tributary itself and the functions performed by any wetlands adjacent to the tributary to determine if they significantly affect the chemical, physical, and biological integrity of a TNW. For each of the following situations, a significant nexus exists if the tributary, in combination with all of its adjacent wetlands, has more than a speculative or insubstantial effect on the chemical, physical and/or biological integrity of a TNW. Considerations when evaluating significant nexus include, but are not limited to the volume, duration, and frequency of the flow of water in the tributary and its proximity to a TNW, and the functions performed by the tributary and all its adjacent wetlands. It is not appropriate to determine significant nexus based solely on any specific threshold of distance (e.g. between a tributary and its adjacent wetland or between a tributary and the TNW). Similarly, the fact an adjacent wetland lies within or outside of a floodplain is not solely determinative of significant nexus.

Draw connections between the features documented and the effects on the TNW, as identified in the *Rapanos* Guidance and discussed in the Instructional Guidebook. Factors to consider include, for example:

- Does the tributary, in combination with its adjacent wetlands (if any), have the capacity to carry pollutants or flood waters to TNWs, or to reduce the amount of pollutants or flood waters reaching a TNW?
- Does the tributary, in combination with its adjacent wetlands (if any), provide habitat and lifecycle support functions for fish and other species, such as feeding, nesting, spawning, or rearing young for species that are present in the TNW?
- Does the tributary, in combination with its adjacent wetlands (if any), have the capacity to transfer nutrients and organic carbon that support downstream foodwebs?
- Does the tributary, in combination with its adjacent wetlands (if any), have other relationships to the physical, chemical, or biological integrity of the TNW?

Note: the above list of considerations is not inclusive and other functions observed or known to occur should be documented below:

1. **Significant nexus findings for non-RPW that has no adjacent wetlands and flows directly or indirectly into TNWs.** Explain findings of presence or absence of significant nexus below, based on the tributary itself, then go to Section III.D: .

2. **Significant nexus findings for non-RPW and its adjacent wetlands, where the non-RPW flows directly or indirectly into TNWs.** Explain findings of presence or absence of significant nexus below, based on the tributary in combination with all of its adjacent wetlands, then go to Section III.D: .

3. **Significant nexus findings for wetlands adjacent to an RPW but that do not directly abut the RPW.** Explain findings of presence or absence of significant nexus below, based on the tributary in combination with all of its adjacent wetlands, then go to Section III.D: .

D. DETERMINATIONS OF JURISDICTIONAL FINDINGS. THE SUBJECT WATERS/WETLANDS ARE (CHECK ALL THAT APPLY):

1. **TNWs and Adjacent Wetlands.** Check all that apply and provide size estimates in review area:
   - ☐ TNWs: linear feet width (ft), Or, acres.
   - ☐ Wetlands adjacent to TNWs: acres.

2. **RPWs that flow directly or indirectly into TNWs.**
   - ☐ Tributaries of TNWs where tributaries typically flow year-round are jurisdictional. Provide data and rationale indicating that tributary is perennial: .
   - ☐ Tributaries of TNW where tributaries have continuous flow "seasonally" (e.g., typically three months each year) are jurisdictional. Data supporting this conclusion is provided at Section III.B. Provide rationale indicating that tributary flows seasonally: .

Provide estimates for jurisdictional waters in the review area (check all that apply):
- Tributary waters: linear feet width (ft).
- Other non-wetland waters: acres.
  Identify type(s) of waters: .

3. **Non-RPWs[8] that flow directly or indirectly into TNWs.**
   - Waterbody that is not a TNW or an RPW, but flows directly or indirectly into a TNW, and it has a significant nexus with a TNW is jurisdictional. Data supporting this conclusion is provided at Section III.C.

   Provide estimates for jurisdictional waters within the review area (check all that apply):
   - Tributary waters: linear feet width (ft).
   - Other non-wetland waters: acres.
     Identify type(s) of waters: .

4. **Wetlands directly abutting an RPW that flow directly or indirectly into TNWs.**
   - Wetlands directly abut RPW and thus are jurisdictional as adjacent wetlands.
     - Wetlands directly abutting an RPW where tributaries typically flow year-round. Provide data and rationale indicating that tributary is perennial in Section III.D.2, above. Provide rationale indicating that wetland is directly abutting an RPW: .

     - Wetlands directly abutting an RPW where tributaries typically flow "seasonally." Provide data indicating that tributary is seasonal in Section III.B and rationale in Section III.D.2, above. Provide rationale indicating that wetland is directly abutting an RPW: .

   Provide acreage estimates for jurisdictional wetlands in the review area: acres.

5. **Wetlands adjacent to but not directly abutting an RPW that flow directly or indirectly into TNWs.**
   - Wetlands that do not directly abut an RPW, but when considered in combination with the tributary to which they are adjacent and with similarly situated adjacent wetlands, have a significant nexus with a TNW are jurisidictional. Data supporting this conclusion is provided at Section III.C.

   Provide acreage estimates for jurisdictional wetlands in the review area: acres.

6. **Wetlands adjacent to non-RPWs that flow directly or indirectly into TNWs.**
   - Wetlands adjacent to such waters, and have when considered in combination with the tributary to which they are adjacent and with similarly situated adjacent wetlands, have a significant nexus with a TNW are jurisdictional. Data supporting this conclusion is provided at Section III.C.

   Provide estimates for jurisdictional wetlands in the review area: acres.

7. **Impoundments of jurisdictional waters.[9]**
   As a general rule, the impoundment of a jurisdictional tributary remains jurisdictional.
   - Demonstrate that impoundment was created from "waters of the U.S.," or
   - Demonstrate that water meets the criteria for one of the categories presented above (1-6), or
   - Demonstrate that water is isolated with a nexus to commerce (see E below).

E. ISOLATED [INTERSTATE OR INTRA-STATE] WATERS, INCLUDING ISOLATED WETLANDS, THE USE, DEGRADATION OR DESTRUCTION OF WHICH COULD AFFECT INTERSTATE COMMERCE, INCLUDING ANY SUCH WATERS (CHECK ALL THAT APPLY):[10]
- which are or could be used by interstate or foreign travelers for recreational or other purposes.
- from which fish or shellfish are or could be taken and sold in interstate or foreign commerce.
- which are or could be used for industrial purposes by industries in interstate commerce.
- Interstate isolated waters. Explain: .
- Other factors. Explain: .

Identify water body and summarize rationale supporting determination: .

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[8]See Footnote # 3.
[9] To complete the analysis refer to the key in Section III.D.6 of the Instructional Guidebook.
[10] **Prior to asserting or declining CWA jurisdiction based solely on this category, Corps Districts will elevate the action to Corps and EPA HQ for review consistent with the process described in the Corps/EPA *Memorandum Regarding CWA Act Jurisdiction Following Rapanos.***

Provide estimates for jurisdictional waters in the review area (check all that apply):
- ▪ Tributary waters: linear feet width (ft).
- ▪ Other non-wetland waters: acres.
  Identify type(s) of waters: .
- ▪ Wetlands: acres.

F. NON-JURISDICTIONAL WATERS, INCLUDING WETLANDS (CHECK ALL THAT APPLY):
- ▪ If potential wetlands were assessed within the review area, these areas did not meet the criteria in the 1987 Corps of Engineers Wetland Delineation Manual and/or appropriate Regional Supplements.
- ▪ Review area included isolated waters with no substantial nexus to interstate (or foreign) commerce.
  - ☐ Prior to the Jan 2001 Supreme Court decision in "*SWANCC*," the review area would have been regulated based solely on the "Migratory Bird Rule" (MBR).
- ▪ Waters do not meet the "Significant Nexus" standard, where such a finding is required for jurisdiction. Explain: .
- ▪ Other: (explain, if not covered above): .

Provide acreage estimates for non-jurisdictional waters in the review area, where the sole potential basis of jurisdiction is the MBR factors (i.e., presence of migratory birds, presence of endangered species, use of water for irrigated agriculture), using best professional judgment (check all that apply):
- ▪ Non-wetland waters (i.e., rivers, streams): linear feet width (ft).
- ▪ Lakes/ponds: acres.
- ▪ Other non-wetland waters: acres. List type of aquatic resource: .
- ▪ Wetlands: acres.

Provide acreage estimates for non-jurisdictional waters in the review area that do not meet the "Significant Nexus" standard, where such a finding is required for jurisdiction (check all that apply):
- ▪ Non-wetland waters (i.e., rivers, streams): linear feet, width (ft).
- ▪ Lakes/ponds: acres.
- ▪ Other non-wetland waters: acres. List type of aquatic resource: .
- ☒ Wetlands: acres.

SECTION IV: DATA SOURCES.

A. SUPPORTING DATA. Data reviewed for JD (check all that apply - checked items shall be included in case file and, where checked and requested, appropriately reference sources below):
- ☒ Maps, plans, plots or plat submitted by or on behalf of the applicant/consultant: Geometrician Associates LLC.
- ☒ Data sheets prepared/submitted by or on behalf of the applicant/consultant.
  - ☒ Office concurs with data sheets/delineation report.
  - ☐ Office does not concur with data sheets/delineation report.
- ▪ Data sheets prepared by the Corps: .
- ▪ Corps navigable waters' study: .
- ☒ U.S. Geological Survey Hydrologic Atlas: .
  - ☐ USGS NHD data.
  - ☒ USGS 8 and 12 digit HUC maps.
- ☒ U.S. Geological Survey map(s). Cite scale & quad name: .
- ☒ USDA Natural Resources Conservation Service Soil Survey. Citation: NRCS, Web Soil Survey.
- ☒ National wetlands inventory map(s). Cite name: U.S. Fish & Wildlife Service, Wetlands Online Mapper (Scale: 1:36,710).
- ▪ State/Local wetland inventory map(s): .
- ▪ FEMA/FIRM maps: .
- ▪ 100-year Floodplain Elevation is: (National Geodectic Vertical Datum of 1929)
- ☒ Photographs: ☒ Aerial (Name & Date): Google Earth Copy 2007; USACE GIS DOQQ 1977.
  or ☒ Other (Name & Date): Site photographs contained in "Report on Waters of the U.S. Within Proposed Saddle Road Corridor, Section I (MP 42-53) Island of Hawai'i", State of Hawai'i, submitted by Geometrician Associates, Hilo, Hawai'i dated February 2009.
- ▪ Previous determination(s). File no. and date of response letter: .
- ▪ Applicable/supporting case law: .
- ▪ Applicable/supporting scientific literature: .
- ☒ Other information (please specify):

-USACE personnel site visit of 10 August, 2009
-Atlas of Hawaii, 2nd Edition, Department of Geography, University of Hawaii, 1983.

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Report on Waters of the U.S.
Within Proposed Saddle Road Corridor, Section I (MP 42-53)
Island of Hawai‘i, State of Hawai‘i

Geometrician Associates, Hilo, Hawai‘i
February 2009

This report summarizes an evaluation by Geometrician Associates of Waters of the U.S. potentially present on a highway improvement project on the island of Hawai'i. The project title is *Saddle Road (State Route 200), Mamalahoa Highway (State Route 190) to Milepost 6 Project (FHWA Project No. A-AD-6(1)*. The work was conducted under a 2008 contract amendment with DMT Consultant Engineers and on behalf of the Hawai'i Department of Transportation (HDOT).

Project Overview

A Final Environmental Impact Statement for the proposed Saddle Road Improvements project (as it is commonly known) was released in September 1999, followed by the issuance of a Record of Decision (ROD) for the Saddle Road improvements on October 30, 1999. The EIS process included consideration of twelve action alternatives incorporating use of the existing alignment and potential new alignments between Mamalahoa Highway (SR 190) to Milepost (MP) 6. The project was divided into four different sections (Sections I, II, III and IV, from west to east) to consider and select various alternative routes and to assist in project scheduling. These sections and the Selected Alternative are illustrated in **Figure 1**. Construction of the entire 48 miles is being done in phases. After receiving appropriate permits and approvals, including a jurisdictional determination finding no Waters of the U.S. in the portions between Milepost 14 and 53 as part of the EIS process in 1999, construction began in 2004 on a 6.5-mile part of Section II from Milepost 28 to 35. This segment was opened to public traffic in May 2007. The remainder of Section II between MP 35 and 42 is expected to be finished by fall 2009. A subsequent project that opened to public traffic in October 2008 is the section in Section III from Milepost 19 to 28. The western portion of the project, Section I, from the “Seven Steps” near MP 42 to Mamalahoa Highway, has not yet been scheduled for final design or construction.

HDOT is working with the Federal Highway Administration, Central Federal Lands Highway Division (FHWA-CFLHD) to prepare a Supplemental Environmental Impact Statement (SEIS) for Section I, the western section of the Saddle Road Improvements Project. The SEIS is necessary because the U.S. Department of the Army Garrison Hawai‘i purchased property from Parker Ranch known as the Keamuku parcel (State of Hawai‘i TMK (3rd.) 6-7-001:041) through which the Section I Saddle Road Improvements is proposed to pass (**Figure 2**). The U.S. Army has incorporated this property into the Pohakuloa Training Area and use it for military training.

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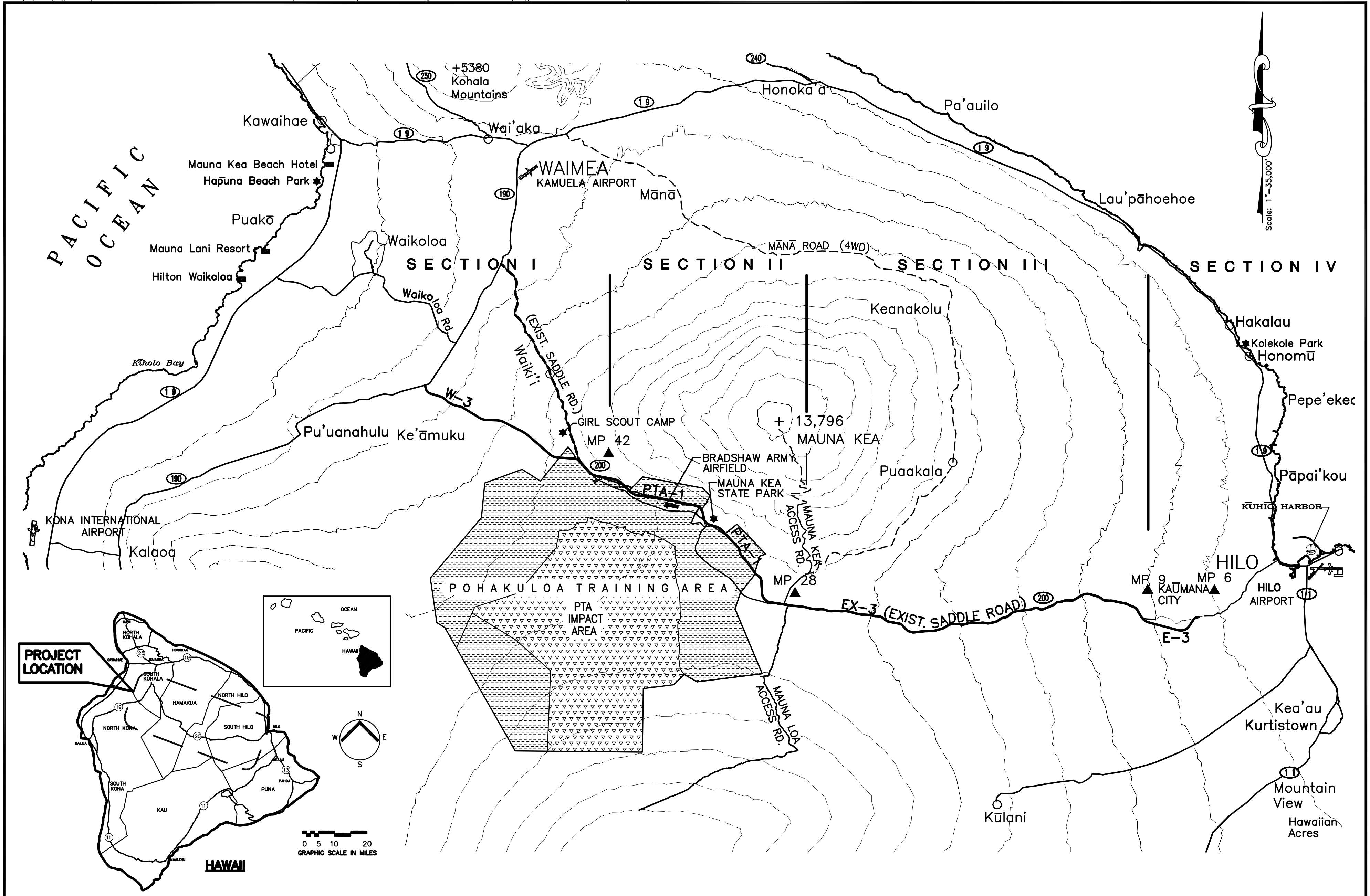

Report of Waters of the U.S.
Saddle Road, MP 42-53
Island of Hawai'i, State of Hawai'i

Figure 1:
Selected Saddle Road Alternative
12/10/08

This property included the area in which the western section of the Saddle Road was planned to pass, along the alignment termed W-3, which was selected in the Record of Decision. In 2006, the U.S. Army requested that HDOT and FHWA-CFLHD relocate the road as close as practical to the southern boundary of the Keamuku property. In response to that request, HDOT has developed a new alternative called W-7, the location of which is approximate until further design is completed (see **Figure 2**). Both alternatives, the 9.7-mile long W-3 and the 10.3-mile W-7, are under consideration in the SEIS for Section I. Note that the common connection point of both W-3 and W-7 to existing the Saddle Road near MP 42 is outside the Keamuku property; both alignments include approximately 0.6 mile within the Keʻekeʻe area.

This report is intended for use as background for a letter requesting jurisdictional determination (JD) for potential Waters of the U.S. from the U.S. Army Corps of Engineers (USACE), Honolulu District, for Section I of the Saddle Road.
It is understood that as more than five years have passed since the original jurisdictional determinations were made as part of the 1999 EIS, a new JD will be required for this section of the Saddle Road between milepost 42 and SR 190. The JD is requested to cover both of the SEIS alternatives under consideration, W-3 and W-7.

Regulatory Background

Waters of the United States (U.S.) is a regulatory term referring to surface waters that are under the jurisdiction of the USACE. Surface waters may include streams, streambeds, rivers, lakes, reservoirs, arroyos, washes, other ephemeral watercourses and wetlands. Any actions that result in effects on Waters of the U.S. require compliance with the Section 404 of the Clean Water Act

The U.S. Army Corps of Engineers (USACE) made jurisdictional determinations for the original study routes in Section I (W-2 and W-3, the latter of which was selected in the Record of Decision for the proposed Saddle Road project in the 1990s. No Waters of the U.S. were identified within this section of the study corridor (USACE letter dated August 22, 1997, reproduced in FEIS - Part II, 1.4.4, and EPA letter dated August 12, 1998, FEIS - Part II, 1.4.5) (**Exhibit A**). The EIS reported that although the proposed road corridor crossed several major intermittent drainages, many of which were formed by glacial meltwater at the end of the Pleistocene Era 10,000 years ago, it contained no Waters of the U.S.

Since 1999, when the original Saddle Road EIS was being developed, the USACE has substantially revised its practical definition of Waters of the U.S. and also its methods for assessing them. The latest guidance is contained in *JD Form Instructional Guidebook* and the *Approved Jurisdictional Determination Form*; these digital files are available on the Honolulu District website (http://www.poh.usace.army.mil/EC-R/EC-R.htm). This report utilizes the methodology and forms referenced above.

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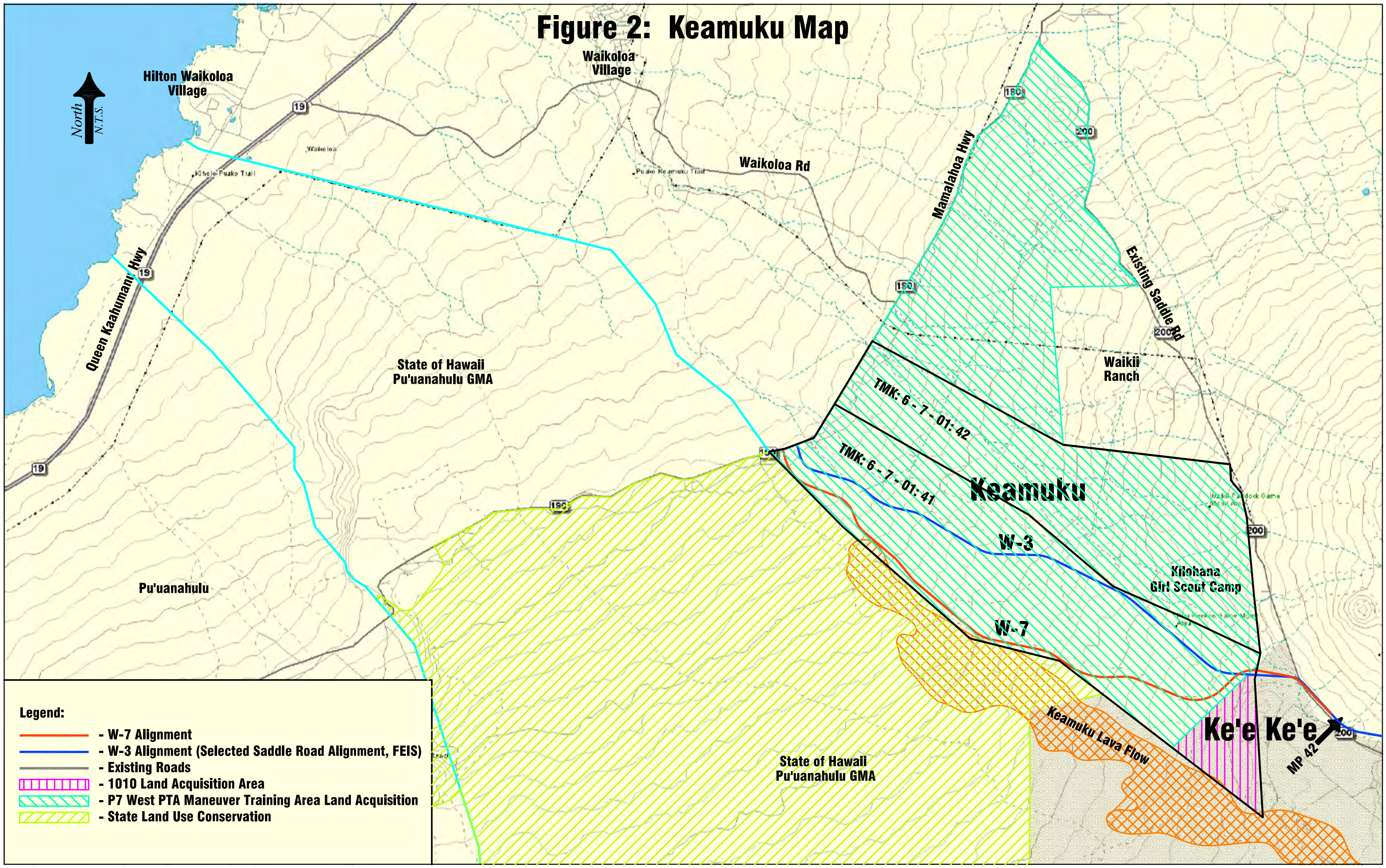

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Figure 2:
Keamuku Map
12/10/08

In particular, the methodology utilized in this analysis has been consistent with the latest guidance, the *U.S. Army Corps of Engineers Jurisdictional Determination Form Instructional Guidebook* (Rev. 5/23/07). In this guidance, which is available on USACE websites, the USACE has reaffirmed that all traditional navigable waters (TNW) are jurisdictional, and that any stream that generally flowed three continuous months of the year or more – called a relatively permanent water (RPW) – is also jurisdictional. It is understood that any wetlands adjacent to RPW, as well as non-RPW streams and wetlands adjacent to them, need to be evaluated to see if they have a significant nexus to a TNW. The USACE, interpreting a ruling by the U.S. Supreme Court, defines this as follows:

> "A significant nexus exists if the tributary, in combination with all of its adjacent wetlands, has more than a speculative or an insubstantial effect on the chemical, physical, and/or biological, integrity of a TNW. Principal considerations when evaluating significant nexus include the volume, duration, and frequency of the flow of water in the tributary and the proximity of the tributary to a TNW, plus the hydrologic, ecologic, and other functions performed by the tributary and all of its adjacent wetlands."

Therefore, the first task of our work in Section I of the Saddle Road has been to identify within the affected W-3 and W-7 corridors all TNWs, tributary RPWs, and tributary non-RPW streams, along with any wetlands or other special aquatic sites. After these are identified and mapped, certain waters will be by definition jurisdictional, and for others, the issue of a significant nexus must then be examined, and then a jurisdictional determination should be made.

Geological Setting

As shown on the attached USGS maps (**Figure 3**), no blue-line streams are crossed by either the W-3 or W-7 corridors within the Keamuku property or the Ke‘eke‘e section There is a distinct geomorphological difference between the central and northern parts of the Keamuku parcel that contain deep, blue-line gulches and the southern part that lacks them. This roughly corresponds to a geological difference between older and younger Mauna Kea flows, as shown in the attached geologic map (**Figure 4**). The very youngest flows – where there are no blue-line streams whatsoever – are found on the southern margin of the Keamuku property, where W-7 and a portion of W-3 pass. The Ke‘eke‘e section consists of rough lava flows as well as cinder cone and Holocene surficial deposits.

The topography of the area strongly reflects the geology. The Saddle Road area near Pu‘u Ke‘eke‘e at the base of Mauna Kea is fairly flat, reflecting alluvial Pleistocene and later deposits over old lava flow and ash deposits from cones such as Puu Ke‘eke‘e, which exhibits typical cinder cone topography. The far southern portion of the Keamuku property, which contains most of W-7 and the western (makai) segment of W-3, has a surface in which the lobes of the lava flows that flowed downslope are clearly visible, with little erosion or sediment build-up. Soil is not strongly developed and few erosional or alluvial features are evident.

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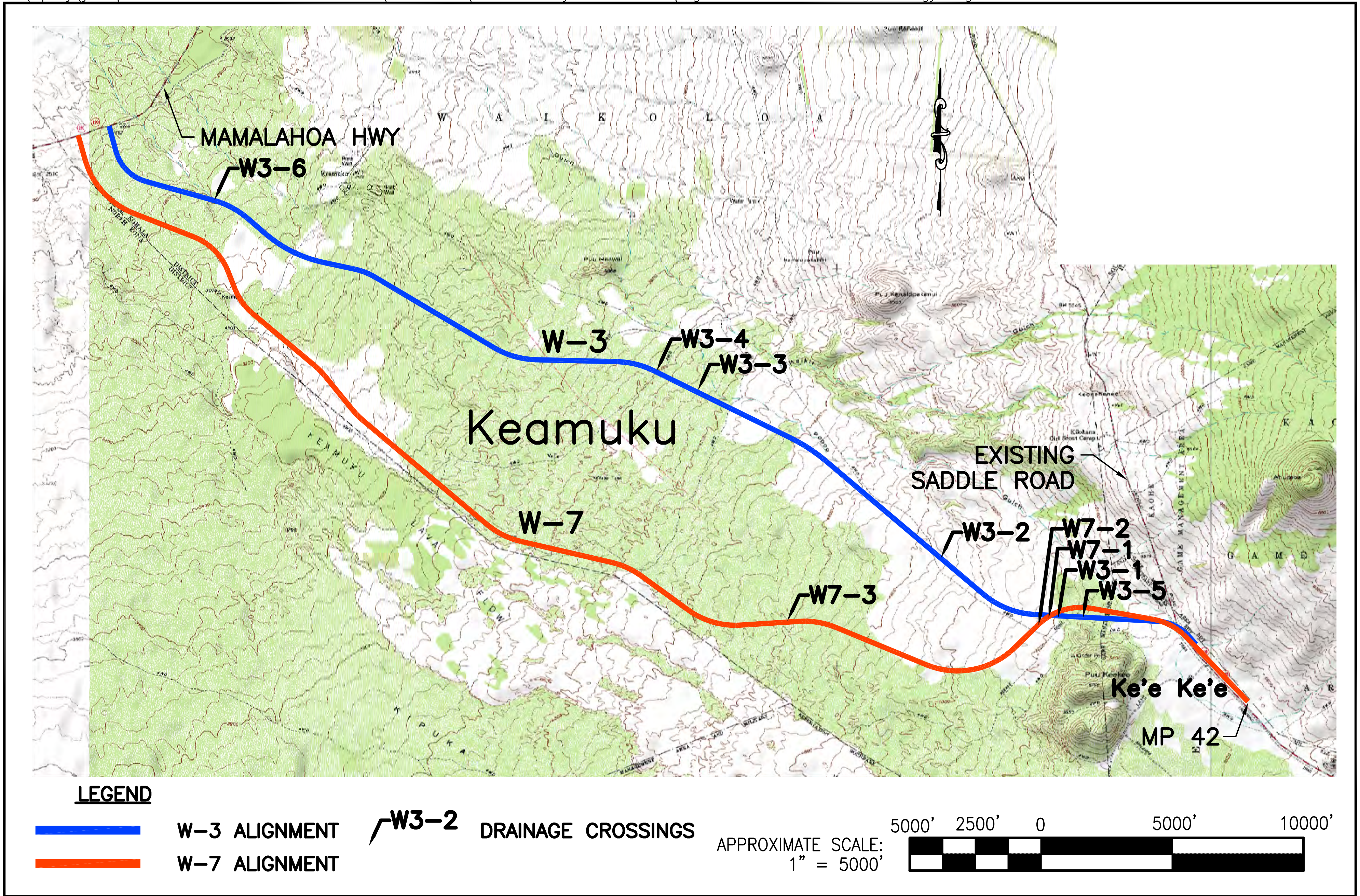

Report of Waters of the U.S.
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Island of Hawai'i, State of Hawai'i

Figure 3:
USGS Map
12/10/08

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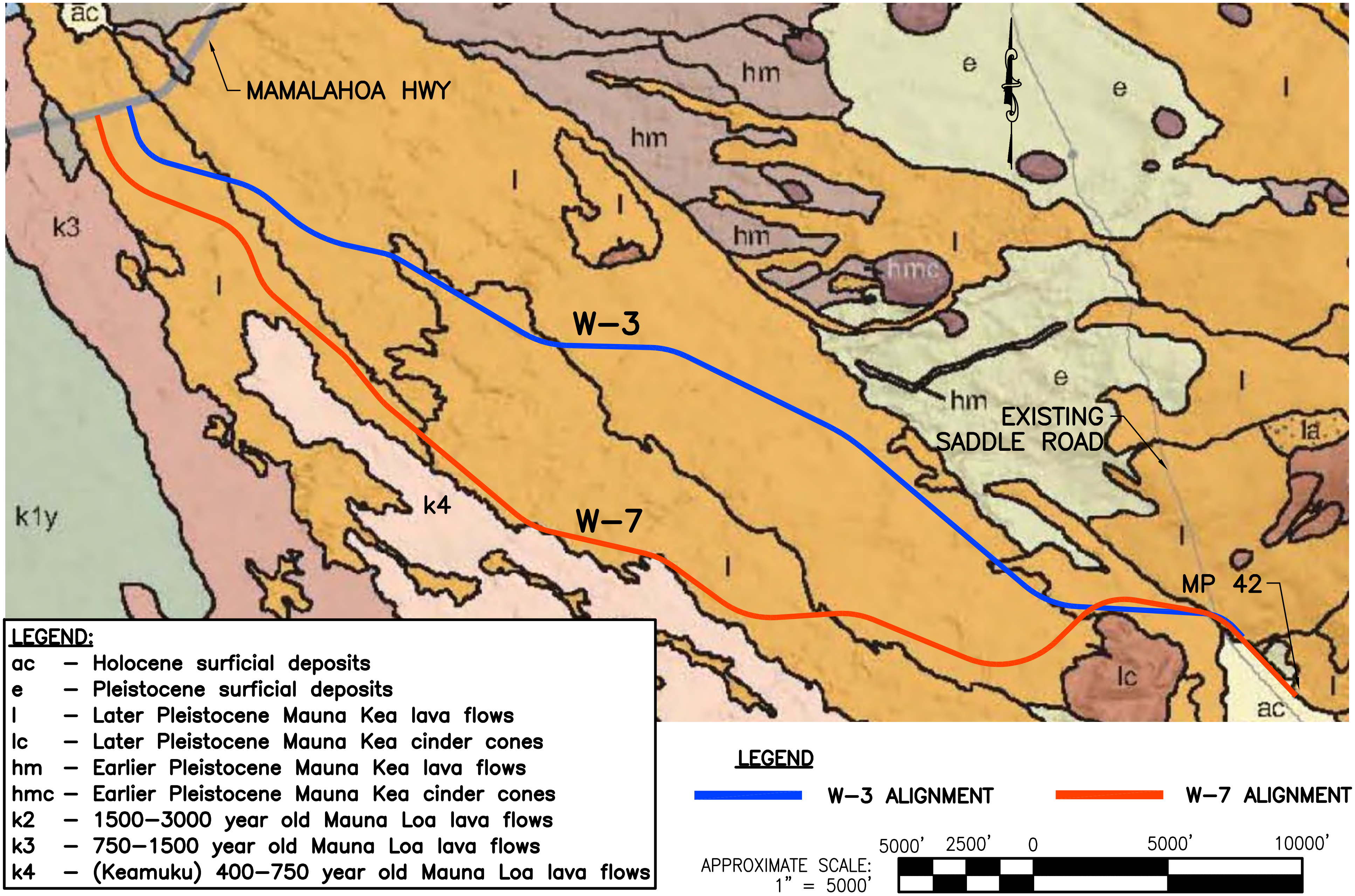

Report of Waters of the U.S.
Saddle Road, MP 42-53
Island of Hawai'i, State of Hawai'i

Figure 4:
Geology Map
12/10/08

In the middle southern part of Keamuku, which contains the eastern (mauka) portion of W-7 and most of W-3, the topography generally has a smoother appearance, reflecting a cover of ash, cinders and sand of variable thickness on top of the bedrock lava flows.

A satellite-based aerial image of the eastern portion of the study area draped over a digital terrain model and rotated to provide an oblique view reveals these differences in the topography (**Figure 5**). Note the complete lack of apparent drainages in the southern portion (where the main portion of W-7 lies), the hummocky terrain with small, discontinuous drainages between some of the hummocks in the southern part of the central area, and the true intermittent gulch in the northernmost part (neither the W-3 nor W-7 alignment crosses such a gulch).

Soil patterns are highly complex, but some generalizations can be made. Soil in the southern parts of Keamuku varies from non-existent, on rough lava land, to minimal, on rough stony land, to thin organic soils over ‘a‘a (Kaimu Series), to stony soils about 20-30 inches deep formed in ash (Pu‘u Pa Series). Some inclusions of deeper soils formed in ash are also present (Waikaloa Series). Minimal erosion and deposition is evident on most of the areas covered by these soils. Soils on the middle and northern parts of Keamuku include both the Kaimu and Pu‘u Pa Series, but are dominated by soils of the Waikaloa and Waimea Series, the latter of which is the thickest (and possibly oldest) of all these soils and is heavily dissected by intermittent or ephemeral streams in places. In the Ke‘eke‘e area near Saddle Road there are a number of soil types, but in general the soil is thin and highly stony. Where W-7 and W-3 diverge as they proceed east, W-7 lies well south of W-3 and lies atop the rockiest soils with little erosion or deposition evident. Where W-3 is farthest from W-7, in the middle section of Keamuku, the thickest and least stony soils occur.

FIELD METHODOLOGY

On five separate days during August and September of 2008, a team of two to four scientists and technicians led by Ron Terry, Ph.D., systematically walked and closely examined both the W-3 and W-7 corridors from their common terminus with the Saddle Road near MP 42 to the Mamalahoa Highway, a distance of about 11 miles. The width of the W-3 corridor was 200 feet (the study corridor for the 1999 EIS), and the width of the W-7 corridor was 500 feet, which is the refined corridor width for all environmental studies being conducted for the current SEIS.

For all sites within the right-of-way of a drainage that appeared to have any potential to be considered as a Water of the U.S., the site was first located using a handheld global positioning system (GPS) device, then photographed and evaluated using the criteria in the USACE data sheets referenced above.

FINDINGS

We encountered nine crossings of drainage features during the field surveys described in the previous section that merited measurement and study, six on W-3 and three on W-7. They are detailed in **Table 1**, mapped on **Figure 6**, illustrated by representative photos in **Figures 7a-f**, and discussed below. The full records for each site are contained in the data sheets and photographs attached as **Exhibit B** to this report.

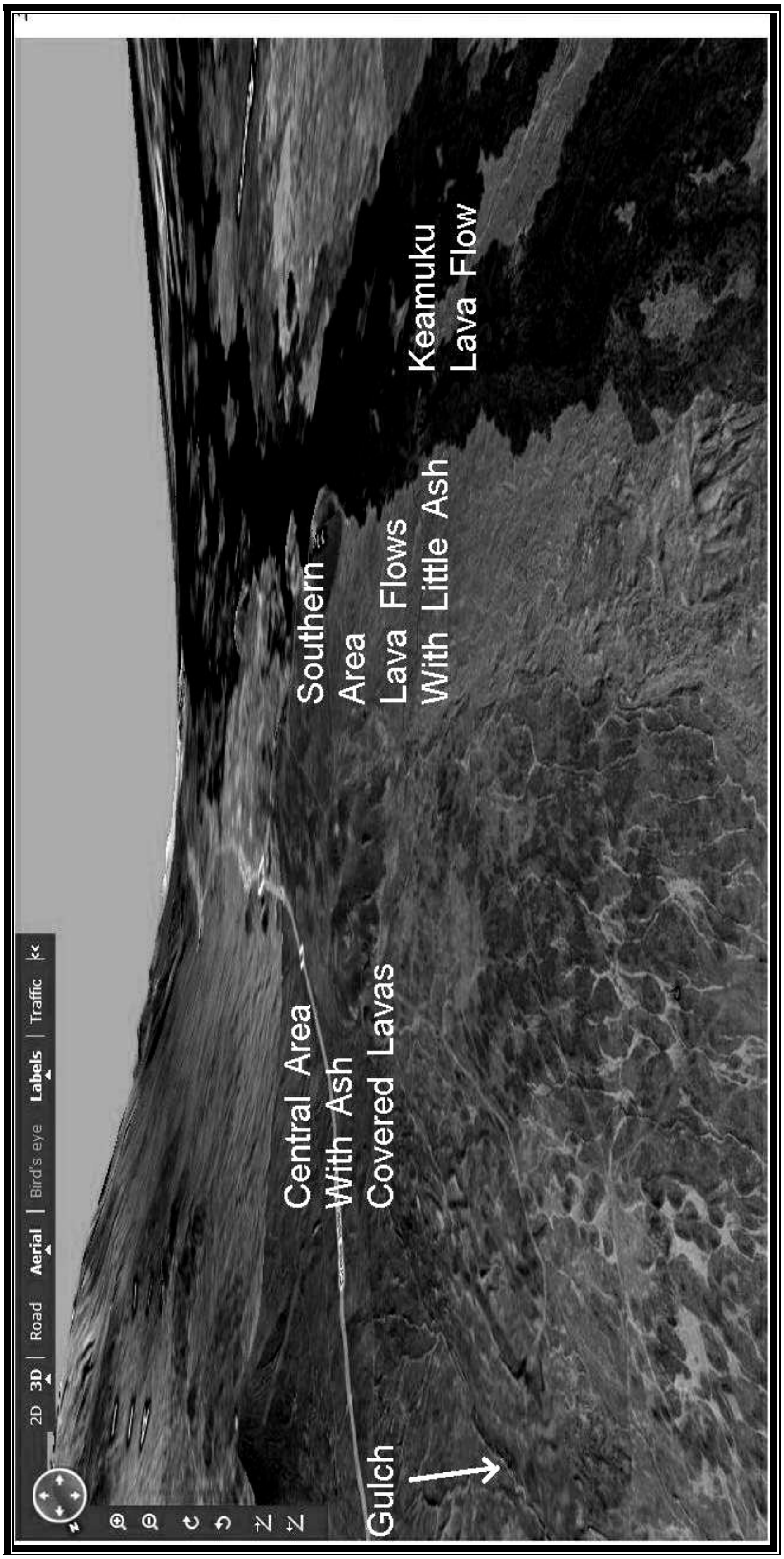

Figure 5 *Aerial Imagery of Eastern Part of Study Area from Microsoft Virtual Earth ©*

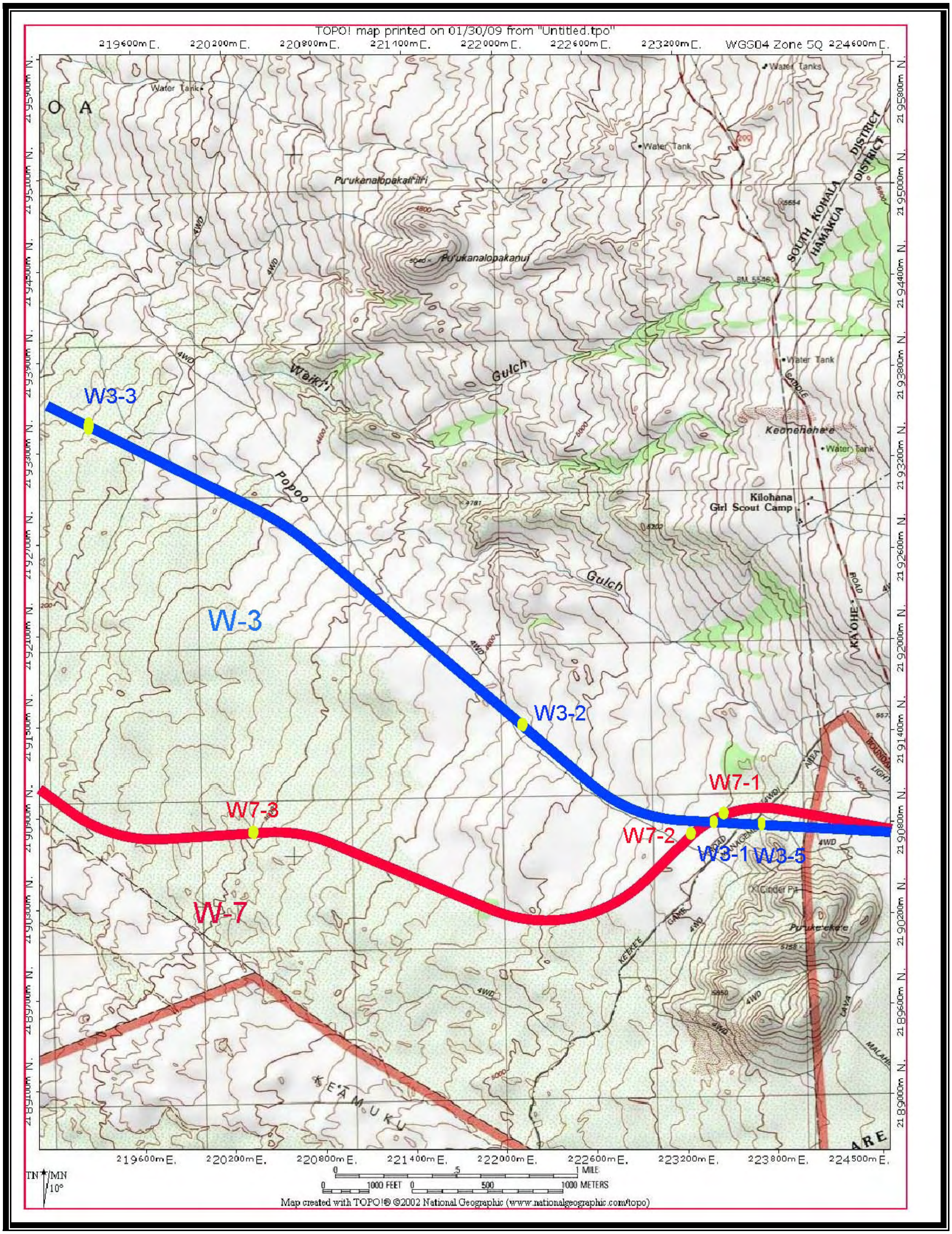

Figure 6a *Drainage Crossings on W-3 and W-7, Mauka Section*

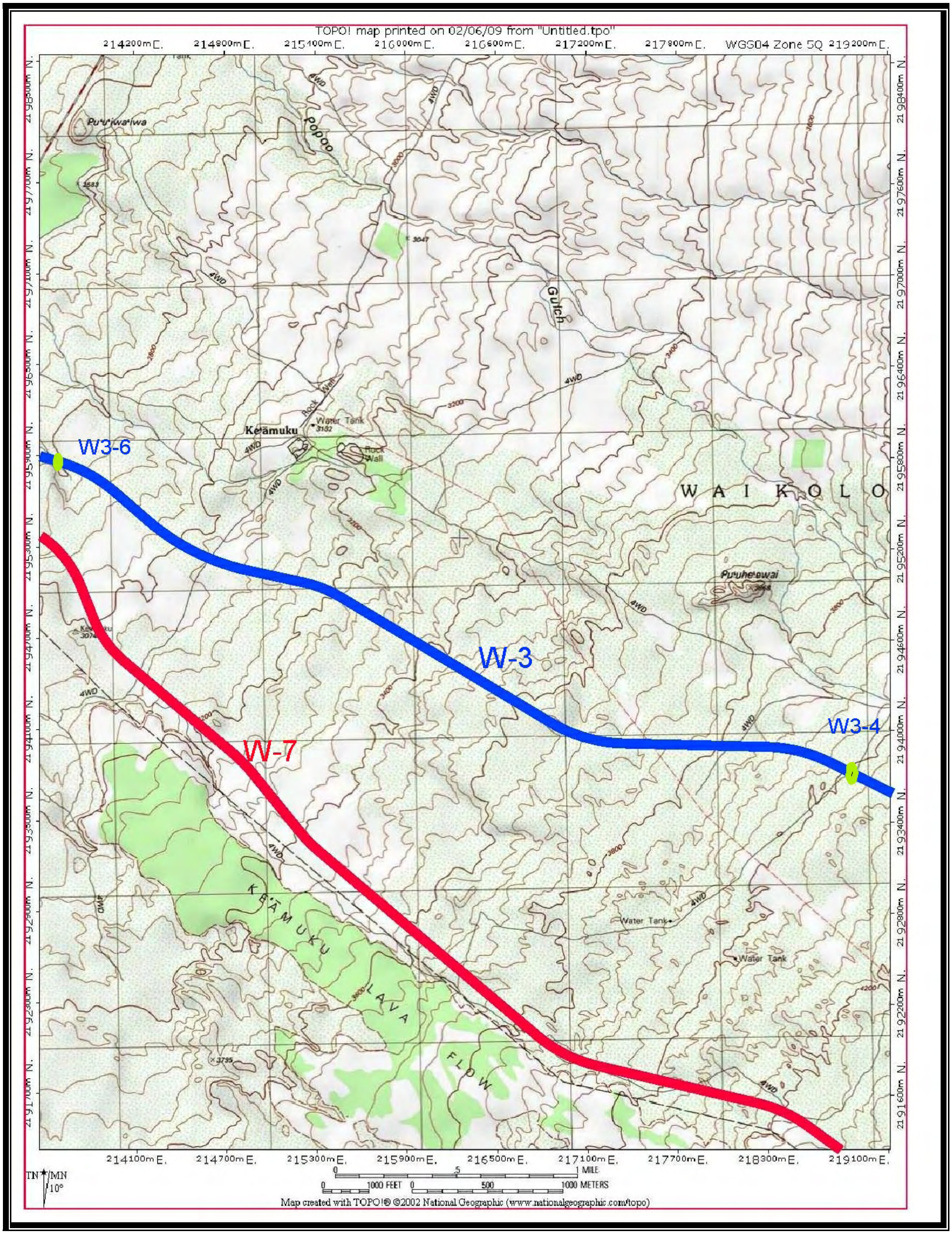

Figure 6b *Drainage Crossings on W-3 and W-7, Makai Section*

Table 1
Drainage Crossing Details

Name of crossing	Lat/Long (Decimal Degrees)*	Average width/depth (feet)	Substrate/Geometry
W3-1	19.7941 155.6393	15/3	Grass, shrubs and bedrock, meandering
W3-2	19.7996 155.6522	30/3	Grass, meandering
W3-3	19.8172 155.6798	27/6	Grass and bedrock, straight
W3-4	19.8195 155.6843	11/2	Grass, meandering
W3-5	19.7938 155.6366	20/3	Grass, meandering
W3-6	19.8372 155.7335	10/2	Grass, meandering
W7-1	19.7940 155.6401	28/6	Veg, meandering
W7-2	19.7935 155.6413	20/3	Grass, meandering
W7-3	19.7935 155.6691	20/4	Grass and bedrock, meandering

*Derived by handheld GPS. No high water indicators present at any sites, and all drainages were highly ephemeral. Channel slopes were the same as regional slopes.

Individual drainage crossings are described below:

- Crossing W3-1 is typical of most of the other drainages, in that it has a bed that is a combination of bedrock and kikuyu grass (*Pennisetum clandestinum*) exhibiting no obvious signs of systematic erosion or deposition or high-water marks, although water clearly flows through on rare occasions. The sideslopes have kikuyu grass, fountain grass (*Pennisetum setaceum*), the common native shrub aʻaliʻi (*Dodonea viscosa*), and the herb fireweed (*Senecio madagascarensis*). Although only one of these plants is listed in the *National List of Plant Species That Occur in Wetlands (Region H),* (kikuyu grass, listed as FACU – a plant species that are likely to occur in uplands, but may occasionally be found in wetlands), none of the plants are associated with wetlands. All but aʻaliʻi are alien introductions. The drainage outlets in a flat area dominated by kikuyu grass and disappears.
- Crossings W3-2, W3-3, and W3-4 are very similar to Crossing W3-1.
- Crossing W3-5 is similar to Crossing W3-1 in most respects but is on the footslope of the steep cinder cone Puʻu Keʻekeʻe and has slightly higher sideslopes. This drainage outlets into the same channel crossed at W3-1 and W7-1.
- Crossing W3-6 is in the drier, lower, western half of Keamuku and has only kikuyu grass and fountain grass. In other respects it is similar to the other crossings. This small swale drains into a small flat depression that outlets into an ephemeral gulch that has a number of tributaries and is mapped as a blue-line (but unnamed) stream on USGS maps. This gulch eventually disappears about two miles downhill, approximately eight miles from the Pacific Ocean and any other TNW or RPW. W3-6 is the only crossing over a swale that is tributary to another drainage.
- Crossing W7-1 is almost identical to W3-1 and in fact is in a different location on this same short channel.
- Crossing W7-2 is similar to W7-1 but in an adjacent crease between lava flow hummocks.

Figure 7a *"Channel" in V-shaped contact between linear lava flow hummocks at Crossing W3-03*.

Figure 7b *Typical "bed' of drainage shows no evidence of flow at Crossing W3-03.*

Figure 7c *As hummock contrast varies, "channels" may disappear and any ephemeral flows widen out and percolate, as here at W3-02.*

Figure 7d *Downslope view of basin at Crossing W3-02, below drainage shown in Figure 7c. No channel is present in this basin, which contains alluvial, colluvial and aeolian deposits.*

Figure 7e *Typical meandering swale in minor hummock contact zone.*

Figure 7f *Relatively deep incising has occurred in spots on a V-shaped contact zone between a prominent younger' a'a flow type on the south and the ash-covered surface of the central area, at Crossing W7-03. Cattle and goats erode banks with trails and utilize caves seeking shade. Despite apparent prominence, this "drainage" disappears shortly downhill.*

- Crossing W7-3 crosses the one drainage that had a length of more than about 600 feet (see Figure 7f). This drainage runs approximately a mile along the clear contact between a young, rocky lava flow (the most northern lobe of the younger flows on the southern end of Keamuku) that runs parallel to and about ten to twenty feet higher than an adjacent older lava flow mantled with ash. As the slope tilts slightly sideways towards the younger lava flow, runoff from occasional storms is channeled down and along this contact zone, where it has eroded some areas as deep as 15 feet. When the cross-slope topography no longer favors sheet flow in extreme rainfall events in the direction of the contact zone, the drainage disappears.

None of the nine crossings appear to meet the definition of a Water of the U.S. All are extremely ephemeral, and the channels of all but one (W3-6) essentially disappear into basins between hills after running for distances of dozens to hundreds of feet. Thus, eight of the drainages are not tributary in any way to any relatively permanent waters (RPWs), such as an intermittent stream, and thereby to potential traditional navigable waters (TNWs). The only exception, the swale crossed in W3-6, drains into a small flat depression that outlets into an ephemeral gulch that has a number of tributaries and is mapped as a blue-line (but unnamed) stream on USGS maps, but which eventually disappears approximately eight miles from the Pacific Ocean and any other TNW or RPW.

Rather than intermittent streams, these drainage features are essentially the V-shaped contacts between hummocky lava flows. Figures 7a-f illustrate essential elements of these drainage features. Almost all rainwater immediately sinks in youthful lava flows, but where ash has mantled the lava flows, a soil forms that is a little less permeable and some runoff occurs in heavy rains. This naturally gets funneled into these Vs, slightly eroding out the soil and ash and in places exposing the bedrock that lies one to four feet beneath the surface. Where the Vs are naturally steep, the erosion is more intense, and where the Vs are gentle, deposition occurs rather than erosion, and the V tends to fill in. At some point along the contact the V will flatten out and disappear, and finally no channel at all is evident, as this runoff simply spreads and percolates. Typically, in between the sets of hummocky lava flows are plains or basins with minor quantities of alluvium, colluvium, and aeolian deposits. The basins generally have no real outlet channel.

Even if these drainages were tributary to RPWS, which all but one is not, it would be doubtful that they would have a significant nexus to a TNW. The amount and frequency of flows in such features is minor, and it is doubtful that sediment or water generated in these areas makes its way overland for any significant distance. The ground surface is highly permeable, and where overland runoff is generated, it percolates in natural basins. No habitat for native reptiles or amphibians (none of which exist in Hawai‘i), aquatic birds, fish, or invertebrates is present. No wetlands or riparian plants or vegetation are present. In sum, there would appear to be insubstantial effect on the chemical, physical, and/or biological, integrity of the Pacific Ocean, the nearest TNW, which lies a minimum of ten miles from this area. The reasoning for this lack of a significant nexus is also true for W3-6, the one drainage that is tributary to any other drainage, as it does not connect directly or indirectly to a TNW.

It is important to note that there are drainages to the north of the area traversed by W-3 and W-7 that vary between highly ephemeral, with flows occurring during a few hours a year, to intermittent, flowing for several days a year. Even there, however, no RPW is present, as no drainage with a flow more than three months per year (or in fact, more than a few days per year) exists in that area. The largest such drainage is Auwaikeakua Gulch, which may have short-duration but impressive flows during heavy rains and has caused floods downstream in Waikoloa Village. None of the tiny drainages intersected by W-3 or W-7 flow into Auwaikeakua Stream or similar gulches.

No springs, wetlands or special aquatic sites were observed within the entire study area covered during these field investigations, and none are known to exist in the general area.

SUMMARY

In summary, no jurisdictional Waters of the U.S. appear to be present, as no wetlands or special aquatic sites are present, and none of the highly ephemeral and poorly developed drainage features meets the criteria of a Water of the U.S. for streams. Specifically, there are no traditional navigable waters (TNWs), relatively permanent waters (RPWs), or non-RPW streams that are tributary to RPWs and/or have a significant nexus to a TNW.

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SADDLE ROAD (STATE ROUTE 200)
Mamalahoa Highway (State Route 190) to Milepost 42
County of Hawai‘i, State of Hawai‘i
FHWA Project No. 200(00)

SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT

Submitted Pursuant to Section 42 U.S.C. 4332(2)(c)
and Chapter 343, Hawai‘i Revised Statutes by the

U.S. DEPARTMENT OF TRANSPORTATION
Federal Highway Administration (FHWA)
Central Federal Lands Highway Division
and
STATE OF HAWAI‘I
Department of Transportation (HDOT)
Highways Division

<u>Cooperating Agencies</u>
U.S. Army Garrison, Hawai‘i

Appendix C
Botanical Report

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Botanical Study for Proposed Alignment W-7 for the Realignment of Saddle Road (State Route 200)

May 28, 2009

Prepared for:

Hawai‘i Department of Transportation
Highways Division

and

U.S. Department of Transportation
Federal Highway Administration
Central Federal Lands Highway Division

Prepared by:

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and

DMT Associates
Honolulu, HI

Botanical Study for Proposed Alignment W-7 for the Realignment of Saddle Road (State Route 200)

Executive Summary

This botanical study covers a proposed alternative alignment, identified as Alignment W7, of the portion of the Saddle Road 7 that extends from Mamalahoa Highway eastward to a point on the existing Saddle Road, within the Pohakuloa Training Area (PTA).

The project area is on the leeward (dry) slope of Mauna Kea on open land between about 2600 and 5800 feet above sea level. The annual rainfall is around 20 inches. Approximately 8.9 miles is within Keʻamuku and 1.4 miles is within PTA. After years of military training activities, many of the plant communities of PTA are still dominated by native plants and numerous endangered plants are known from various parts of PTA. In contrast, decades of cattle-grazing in Keʻamuku have profoundly changed the composition and appearance of the vegetation.

Three endangered plant species (*Haplostachys haplostachya, Stenogyne angustifolia,* and *Vigna o-wahuensis*) were discovered in near the southern border of the Keʻamuku property. The proposed W-7 alignment was carefully positioned to avoid all of the known locations of these endangered species. No endangered plants were found within the proposed project area during the current botanical survey. No other plants or plant communities with significant value for conservation were found within the study area.

The vegetation within the Keʻamuku parcel has been extensively altered by years of cattle-grazing and is now largely pasture land The general appearance is of rolling grasslands on the rugged slope of Mauna Kea with some extensive stands of the indigenous shrub *ʻaʻaliʻi* . The dominant pasture grasses are two widely-spread introduced species, fountaingrass and kikuyugrass. A small number of mostly common, native shrubs and trees are scattered within these grasslands. The vegetation within PTA is only somewhat more intact. Human activity has altered the vegetation, introducing numerous weedy introduced plants but leaving a couple of native species as still dominant plants.

Three Endangered Plants Habitats protecting endangered species are near the proposed W-7 Alignment. It is recommended that, if selected, the roadway should be built and managed to reduce the risk of fire spreading from the roadway to these protected areas.

Botanical Study for Proposed Alignment W-7 for the Realignment of Saddle Road (State Route 200)

Introduction

This botanical study has been conducted in conjunction with a Supplemental Environmental Impact Statement for the proposed realignment of a portion of Saddle Road (State Route 200). Specifically, this botanical study covers a proposed alternative, identified as Alignment W-7, that extends from Mamalahoa Highway (State Route 190) eastward to a point between mileposts 41 and 42 of the existing Saddle Road (State Route 200), within the Pohakuloa Training Area (PTA). Approximately 8.9 miles of this 10.3 mile-long route traverses TMK parcel 6-7-001:041, within the 23,977 acre land known as Keʻamuku, within the ahupuaʻa of Waikoloa, South Kohala, Hawaii County. The remaining 1.4 miles is within the Pohakuloa Training Area.

The purposes of this botanical study are to provide a baseline description of the plants and vegetation of the study area and to locate and identify endangered plant species (if any), other rare species, and other valuable botanical resources within the study area.

Numerous endangered and rare plants are known from PTA (USACH 1977; Shaw 1997, and many others). After many years of military training activities, many of the plant communities of PTA are still dominated by native plants and largely native in character. The Keʻamuku parcel has a significantly different land-use history than PTA. Within Keʻamuku, decades of cattle-grazing have profoundly changed the composition and appearance of the vegetation.

A recent survey of the Keʻamuku parcel (Arnett 2002) found three endangered species near the southern border of the Keʻamuku property. These are *Haplostachys haplostachya*, (common name: *honohono*) a perennial mint with showy white flowers; *Stenogyne angustifolia* (no common name) a twining mint, and *Vigna o-wahuensis* (no common name) a very rare legume vine. Prior to 2002, *Haplostachys* and *Stenogyne* were only known to exist within PTA and nowhere else. Arnett (2002) recorded and mapped the location of over 8,000 *Haplostachys*, 11 *Stenogyne*, and 74 *Vigna* within Keʻamuku. The proposed W-7 alignment was carefully positioned to avoid all of the known locations of these endangered species.

Methods

General Description of the Project Area

The project area is on the west-facing slope of Mauna Kea. This is the leeward and, therefore, dry slope. This proposed road project traverses open land between about 2600 feet and 5800 feet above sea level. The annual rainfall is around 20 inches, perhaps somewhat dryer at the upper elevation and wetter at the lower. The great majority of the site is on lava flows erupted from Mauna Kea more than 10,000 years ago. A few slivers are on the Keʻamuku flow which came from Mauna Loa 200 to 750 years ago (Wolfe and Morris 1996).

The indigenous vegetation would probably have been classified as montane dry shrublands, montane dry grasslands and subalpine dry shrublands. However, the vegetation within the Keʻamuku parcel has been extensively altered by years of cattle-grazing and is now largely a pasture of introduced grasses with scattered shrubs and a very few trees. The indigenous vegetation within PTA is only somewhat more intact.

Study Corridor

The study corridor follows the proposed W-7 Alignment a distance of 54,400 feet from its origin at Mamalahoa Highway to a terminus on the existing Saddle Road within PTA. The study corridor traverses 46,800 linear feet through Keʻamuku and another 7500 linear feet through PTA. The centerline of the proposed right-of-way and the outer limits of the 500 foot-wide study corridor were surveyed and staked by land surveyors before the commencement of this botanical survey. Numbered stakes were placed every 300 feet along the centerline and limits.

Field Survey

All vascular plant species observed within the study corridor were identified and recorded. Taxonomy of flowering plants follows Wagner et al. (1990), for the most part, and ferns are named according to Palmer (2003). Estimates of the abundance of each species and vegetation descriptions were also recorded allowing the study corridor to be subdivided into a number of vegetation zones. The abundance estimates integrated observations within each zone. Abundance was recorded as “common,” meaning dominant in all or most of the zone; “frequent,” meaning occurring in most parts of the zone but usually with relatively little biomass; “infrequent,” meaning individuals were seen in only a few parts of the zone or were sparsely scattered within the zone; and “rare,” meaning only one or a few individual plants were seen in only one location.

An “index of importance” was calculated by arbitrarily assigning the value of 5 to each common species, 3 to frequent species, 1 to infrequent species, and 0 to rare species. These values were totaled and partitioned between native and introduced species in order to give an index of the relative importance, based on abundance. These values are used as a general indicator of the importance of native species in each zone, but cannot be used as quantitative measures of abundance or biomass.

Level of Effort

The initial botanical survey of the entire alignment was conducted on the 5th, 6th, 10th, and 12th of September, 2008. The field team was led by botanist, Grant Gerrish, who accompanied the technicians on the alignment at all times during the survey. The technicians for the September, 2008, survey were J. Johansen, J. Schulten, and E. Hansen, all graduates or students of the Biology Department, University of Hawaii at Hilo. All have had previous field experience with Hawaiian vegetation. Prior to beginning the survey, all the technicians examined living specimen of the rare plants in the greenhouse at PTA.

The botanical survey consisted of a 100% visual, walking survey. This means that the botanists walked along the entire alignment in an orderly manner that ensured visual observation of all parts of the study corridor. Surveys were conducted with three or four team members evenly spaced within one-half the width of the study corridor. That is, the team members were spaced between the staked centerline and the staked outer limit, walking roughly in parallel along the alignment. The team then covered the rest of the corridor by reversing direction and spacing themselves between the centerline and the other outer limit. With a team of three, spacing was approximately 83 feet between workers, requiring each to survey a swath 42 feet wide on either side of him/herself. With a four-member team, spacing was 62 feet between workers and each responsible for 31 foot-wide swaths on either side. The four member team was used on September 6 when surveying vegetation similar to nearby habitat known to support the endangered plants, *Haplostachys* and *Stenogyne*.

The leader and technicians spent a total of 88 hours in the study corridor. Total area of the study area is calculated as 54,400 linear feet multiplied by 500 foot width or 624.4 acres. This area was surveyed at the rate of 56.8 acres per person day (624.4 acres/88 person hours X 8 person hours per person day = 56.8 acres/person day.)

This level of effort and intensity of coverage provided a good probability that a shrub or tree extending above the prevailing grasses would be seen and identified. The probability that a small, solitary plant would be seen if it were lower in height than the prevailing grasses is lower.

An additional survey was conducted on May 9, 2009. This survey was timed to follow the seasonal winter and spring rains to increase the probability that any rare plants that might be in the study corridor would be actively growing and more readily found. This survey was conducted along the proposed alignment within the “Native Shrubs Amidst Fountaingrass” vegetation zone (Table 1). Two endangered plants, *Haplostachys* and *Stenogyne*, occur within this vegetation type not far from the study corridor. For this survey, the team consisted of Grant Gerrish and four technicians who are employed with the Natural Resources Division at Pohakuloa Training Area. All four technicians have field experience searching for and working with *Haplostachys* and other endangered plants at PTA. This survey covered approximately 6,000 feet of the study corridor with team members spaced 50 feet apart.

Results

Rare and Endangered Plants

No plants listed as endangered or threatened by the State of Hawaii or the U.S. Fish and Wildlife Service were found within the study area.

A small population that appears to be *Chamaesyce olowaluana* was found in the study corridor at 3600 feet above sea level (24,900 feet from the origin). This is a species that the U.S. Fish and Wildlife Service has unofficially named as a "species of concern," meaning that it may be declining. The population consisted of four small individuals that have been grazed and one large, near-dead specimen. The large individual was 6 feet high and approximately 5 inches in diameter at the base, with only a few living leaves present. These plants are tentatively identified as *C. olowaluana* based on leaf form and the large size of the near-dead, mature specimen. However, the poor condition of all the plants precludes positive identification; the plants could possibly be *C. multiformis*, a native species that is somewhat more common and not a species of concern.

Plant Species of the Proposed W-7 Alignment Study Area

A total of 91 species of vascular plants were recorded within the study corridor during the field survey (Appendix). Of these, 15 are endemic to the Hawaiian Islands and 15 are indigenous, meaning they are native to Hawaii and they occur naturally in other places, too. Sixty-one species are introduced, meaning they were brought to Hawaii by people, including one of Polynesian introduction, *ʻihiʻai* (*Oxalis corniculata*).

Only two of the endemic species, *ʻaweoweo* (*Chenopodium* oahuense) and hard-stemmed lovegrass (*Eragrostis atropiodes*), are common or dominant anywhere in the study area. These two are dominant only where the study corridor leaves Keʻamuku and enters PTA as it approaches the existing Saddle Road. Seven of the fifteen endemic species were recorded as rare within the study area, meaning only one or very few individuals were observed. These findings show that endemic plants have been nearly extirpated from Keʻamuku during years of cattle-grazing.

Vegetation of the Proposed W-7 Alignment Study Area

Overview of the Vegetation

Nearly all of the Keʻamuku parcel has been used for cattle production for many years. Thus, the vegetation of most of the area is pasture, made up of introduced grasses with varying numbers of scattered native shrubs, many introduced forbs (weeds) and a few introduced shrubs and trees. The general appearance is of rolling grasslands on the rugged slope of Mauna Kea with some extensive stands of the indigenous shrub *ʻaʻaliʻi* (*Dodonaea viscosa*). From Mamalahoa Highway up to about 4600 feet above sea level, fountaingrass (*Pennisetum* *setaceum*) is the single dominant pasture grass. Above this elevation, kikuyugrass (*P. clandestinum*) becomes the dominant pasture species.

Seven different vegetation zones were recognized (Table 1, Figure1). These are similar to the vegetation zones reported by Arnett (2002). The zones generally correspond primarily to differences in human land-use patterns and secondarily to differences in the substrate. Four of the five zones within Keʻamuku (Fountaingrass with *ʻAʻaliʻi,* Native Shrubs Amidst Fountaingrass, Rangeland and *ʻAʻaliʻi,* and Moderate to Dense *ʻAʻaliʻi*) differ mainly in the balance between the two introduced pasture grasses (fountaingrass and kikuyugrass) and the abundance of native shrubs. In general, native shrubs are more numerous and diverse where grazing has been less intense. Often, these areas are those with very rocky surface and rugged terrain that may impede access by cattle. The fifth vegetation zone within Keʻamuku is the Keʻamuku Lava Flow, a young, near-barren *ʻaʻa* flow.

ʻAʻaliʻi, an indigenous shrub, is common in much of the study area and is a dominant species in several vegetation zones in Keʻamuku. It is probable that this abundance is in response to disturbance of the natural vegetation by human actions and does not represent the foundation of a healthy native plant community. *ʻAʻaliʻi* is tolerant of the wildfires that are frequent in this environment and it is relatively unpalatable to cattle. Overgrazing may increase the abundance of this native shrub. In contrast, nearly all other native plants in this region decline in response to wildfire and cattle grazing.

The two vegetation zones outside of the Keʻamuku parcel near Saddle Road (*Eragrostis* Grassland and *ʻAheahea* Shrubland) are somewhat different having a native grass and native shrubs among the dominant plants. Even here, however, introduced plan species outnumber the natives.

<u>Description of the Vegetation Along the Proposed W7 Alignment</u>

2600-4200 Ft. Elevation: Fountaingrass with *ʻAʻaliʻi* and Sparse Native Shrubs

This vegetation type prevails over the lower half of the proposed alignment, extending from the origin at Mamalahoa Highway for 27,400 feet. The overall appearance is of a vast grassland with a small and inconspicuous component of shrubs and small trees. This area is now used for cattle pasture and has been for many decades. The vegetation is introduced grasses and forbs, with widely scattered native shrubs and a few introduced shrubs and trees. This vegetation type is underlain by very stony land partially covered by shallow, fine textured soil. In the lower elevation portion, this covering soil is a fine sandy, mineral soil (Puu Pa soil series) but at higher elevation it is derived mostly from organic matter (Kaimu soil series) (Sato et al. 1973).

Table 1. Plant Communities recognized along the W7 Alignment; their location and extent beginning at Mamalahoa Highway; elevation, percentage of total community species that are endemic or indigenous (native), and an index weighted by plant abundance of the importance of native species within the community.

Community	**Location**	**Extent (linear feet)**	**Elevation (feet above sea level)**	**% Native Species**	**% Native Importance Index**
Fountaingrass with *Aàli‘i*	Ke‘amuku	0-27,400 (27,400)	2,600-4,200	34	22
Ke‘amuku Flow	Ke‘amuku	27,400-28,700 (1,300)	4,200-4,300	70	62
Native Shrubs Amidst Fountaingrass	Ke‘amuku	28,700– 34,600 (5,900)	4,300-4,600	28	25
Rangeland and *‘a‘ali‘i*	Ke‘amuku	34,600– 44,700 (10,100)	4,600-5,100	39	26
Moderate to Dense *‘a‘ali‘i*	Ke‘amuku	44,700– 46,800 (2,100)	5,100-5,200	37	30
Eragrostis Grassland	PTA	46,800 – 51,000 (4,200)	5,200-5,600	37	38
‘Aheahea Shrubland	PTA	51,000– 54,400 (3,300)	5,600-5,800	21	27

Throughout this zone, fountaingrass is the ever-present dominant plant, usually covering 90% or more of the surface. In swales where the surface has been covered by silt, other grasses dominate. At lower elevations, these swales are marked by buffelgrass (*Cenchrus ciliaris*) and guinea grass (*Panicum maximum*), at higher elevations within this zone, kikuyugrass dominates these small areas. Natal redtop (*Rhynchelytrum repens*) and barbwire grass (*Cymbopogon refractus*) are two other introduced grasses that are relatively wide spread. The most common of the introduced forbs are the ubiquitous and toxic yellow-flowered fire weed (*Senecio madagascarensis*), Tinaroo glycine (*Neonotonia wightii*), and black medick (*Medicago lupulina*) the latter two of which were probably intentionally seeded to improve the quality of the pasture.

The most common shrubs are the indigenous *‘a‘ali‘i* and, somewhat less common, *‘ilima*. *‘A‘ali‘i* is variable in cover, ranging from widely scattered to approaching 50% cover in a few places at higher elevation in this zone. Other native shrubs or trees include *pukiawe* (*Leptecophylla tameiameiae*), *naio* (*Myoporum sandwicense*),*‘ulei* (*Osteomeles anthyllidifolia*) , and *na‘ena‘e* (*Dubautia cilliolata*), all of which are very widely scattered. One individual, or one small population, was found of *'akia* (*Wikstroemia pulcherrima*) and *‘akoko* (*Chamaesyce olowaluana*), both endemic large shrubs.

The introduced European olive (*Olea europaea*) is frequently seen in the middle reaches of this zone. It is conspicuous amidst the sea of fountaingrass because its foliage is dense and dark in

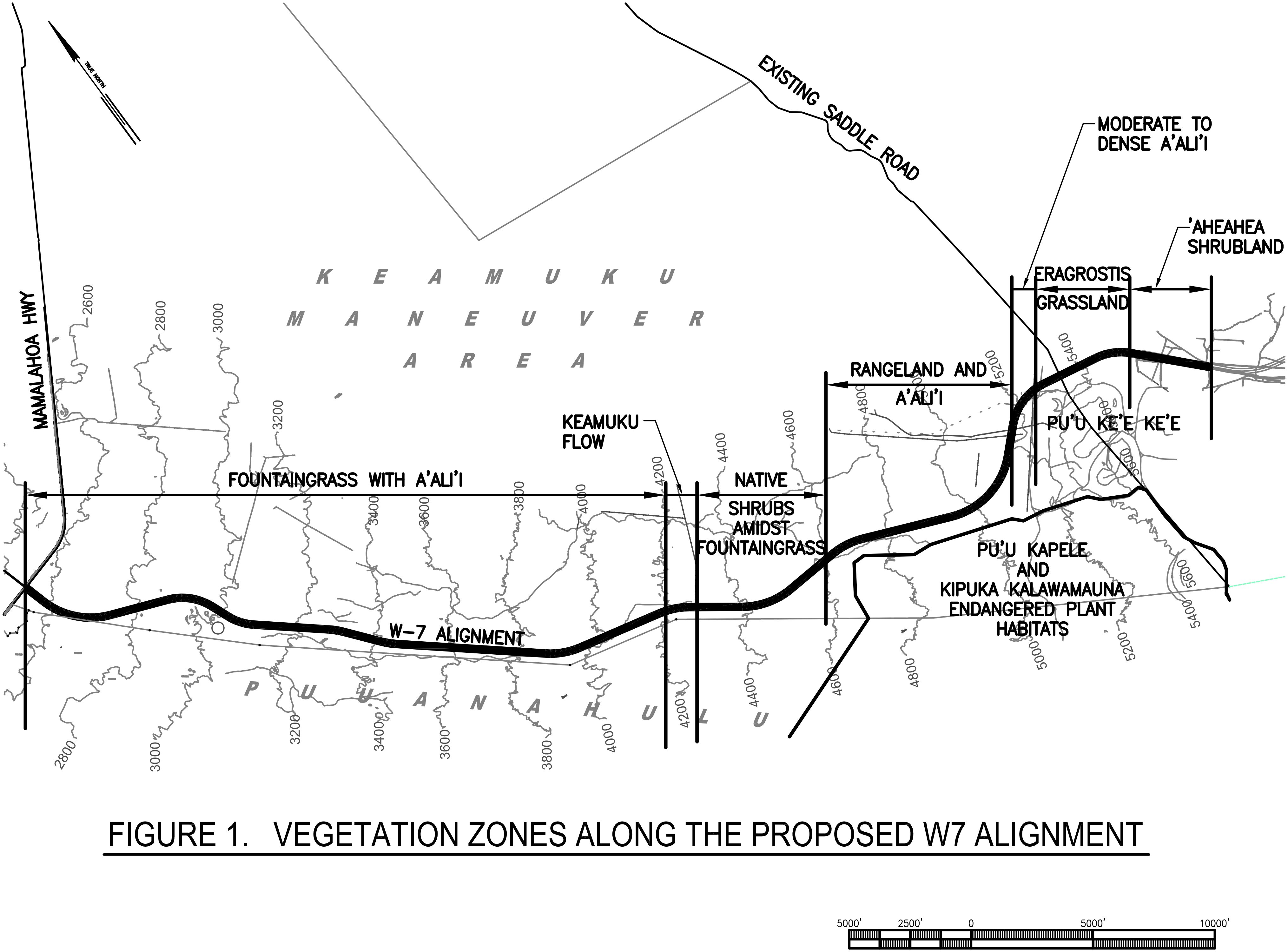

FIGURE 1. VEGETATION ZONES ALONG THE PROPOSED W7 ALIGNMENT

color. Introduced *haole koa* (*Leucaena leucocephala*), although less visible, is frequent at least in some areas, as is indigo (*Indigofera suffruticosa*) a much smaller shrub.

Nineteen of the fifty-six plant species (34%) recorded in this zone are native species; the rest are introduced, including one of Polynesian introduction. However, the "index of importance," calculated using the estimated frequency values, is only 22% for native species (Table 1). This indicates that the nineteen native species have disproportionately low cover and play a minor roll in the ecology of the vegetation of this zone.

4200-4300 Ft. Elevation: Keʻamuku Lava Flow

A 1300-foot section of the centerline of the study area traverses the sparsely vegetated Keʻamuku Lava Flow. Somewhat more of the southern edge of the study area is also on this flow. This is the only part of the study corridor that is situated on lava from Mauna Loa. The Keʻamuku Flow is very rugged *ʻa*ʻa lava dated to between 200 and 750 years before the present time (Wolfe and Morris 1996). The Keʻamuku Flow is very visible because the nearly-barren, brown lava contrasts with the surrounding pastures and grasslands.

The most conspicuous plant species on the Keʻamuku Flow is *ʻohiʻa lehua* (*Metrosideros polymorpha*), however only one individual of this native tree actually falls within the study corridor. Other native trees and shrubs include, *naio* (*Myoporum sandwicense*) and *pukiawe* (*Leptecophylla tameiameiae)*, both of which are common. Many of the introduced plants that are dominant in the surroundings, especially fountaingrass, fireweed and barbwire grass, are also found on the Keʻamuku Flow, however, in much lower densities.

Seven of the ten plant species (70%) within the study corridor on the Keʻamuku Flow are native species. This is the highest percent native species of all the vegetation zones along the proposed alignment. Similarly, the index of importance for native species is the highest here, at 62% (Table 1). These high values for native plants point out that this young lava flow is not easily invaded by introduced plants and the native plants may be more tolerant of the harsh conditions of the barren lava.

4300-4600 Ft. Elevation: Native Shrubs Amidst Fountaingrass

The vegetation of this zone differs from the fountaingrass pastures below the Keʻamuku Flow in that the native shrubs and trees are more dominant and conspicuous here. In places, the *ʻaʻaliʻi* forms about 50% cover and is up to 5 feet high. The other native shrubs, especially *ʻilima*, *pukiawe*, and *naʻenaʻe*, are much more common than at the lower elevation. In certain locations, especially silt-laden swales, the ground cover of fountaingrass is replaced by kikuyugrass, fireweed, black medick, and scarlet sage (*Salvia coccinea*), all introduced plants.

The surface in this zone is much more rocky and rugged than in the fountaingrass grasslands at lower elevation and is mapped in the soil survey as Very Stony Land (Sato et al. 1973). This ruggedness probably accounts for the presence of more species of native plants here. This is the habitat type that supports two endangered native species, *Haplostachys haplostachya* and

Stenogyne angustifolia, a short distance south of the proposed alignment. About 5900 feet of the proposed alignment is within this vegetation type.

Although native shrubs are an important component of the vegetation in this zone, there is a large number of introduced plants, including fountaingrass, kikuyugrass and fireweed that rank among the dominants. Thirteen of the 46 (28%) plant species in this zone are native. The index of importance of native species is even lower at 25%.

Thirteen of the twenty-nine (45%) plant species found in this vegetation zone are native. The index of importance of native species is somewhat lower at 33% (Table 1). The difference between these two indices reflects the findings that even though there are a substantial number of native species, more introduced plants are among the dominants. These

4600-5100 Ft. Elevation: Rangeland and *'Aa'ali'i*

An extent of 10,100 feet of the study corridor passes through this heavily degraded rangeland. This zone has the potential for good pasture because the soil here, mapped as Kilohana Loamy Fine Sand (Sato et al. 1973) is much less stony than at lower elevations along the study corridor. This zone includes two subtypes with very different appearances: heavily grazed kikuyugrass pasture and dense stands of *'a'ali'i*, that is four to five feet high and difficult to pass through. These two subtypes are included together because it appears that they both are the product of heavy cattle grazing over a period of time. *'A'ali'i* is one of the few native plant species that is relatively tolerant of both cattle grazing and fire. In this zone, the grass is currently cropped very short and appears overgrazed. Even in the grassy areas, shrubs of *'a'ali'i* are present, indicating that it is at least as tolerant as the introduced grasses of heavy grazing and the fires that occur in this zone. In fact, it appears that the dense stands of *'a'ali'i* are the product of years of overgrazing and probably frequent fire. These extensive areas are no longer of any value for grazing. If intensive grazing continues in the grassy areas, they may be converted to dense *'a'ali'i* stands. In these areas, the indigenous *'a'ali'i* behaves as a successional species and this vegetation type should not be considered a remnant of the original vegetation.

Seven of the eighteen (39%) plant species found in this zone are native. However, only one of these, *'a'ali'i* has a high importance value. The trend noted above of native plant species having disproportionately low cover, and therefore importance values, is strongest in this vegetation zone, resulting in an index of importance for native plants of just 26% (Table 1).

5100-5200 Ft. Elevation: Moderate to Dense *'A'ali'i*

At this elevation, the vegetation is somewhat less degraded in that a few other species of native trees and shrubs are sparsely represented. These appear to be remnants of the original vegetation rather that reinvasion following degradation, as in the previous vegetation type. These native plants include *mamane* (*Sophora chrysophylla*), *ilima* (*Sida fallax*), *naio* and a single specimen of *pilo* (*Coprosma montana*) seen during the survey.

‘A‘ali‘i is the dominant species in much of this zone; however, it also includes extensive areas of heavily gazed kikuyugrass with many introduced weeds, including fireweed, black mustard (*Brassica nigra*) , stinkweed (*Tagetes minuta*) and crown-beard (*Verbesina encelioides*). Thirty-seven percent of the plant species recorded are native species; the index of importance for native species is somewhat lower at thirty percent (Table 1). An extent of 2100 linear feet of the study corridor passes through this vegetation type. The underlying soil is mapped as Kilohana Loamy Fine Sand (Sato et al. 1973).

5200-5600 Ft. Elevation: *Eragrostis* Grassland

At 46,800 linear feet from the origin on Mamalahoa Highway, the study corridor crosses *Ke‘eke‘e* Road and leaves the Ke‘amuku parcel. This zone east of *Ke‘eke‘e* Road has not been grazed, at least in recent years. Here, the dominant grass is the endemic hard-stemmed lovegrass (*Eragrostis atropioides*) which forms a near-complete cover in most areas. The terrain is very rugged in the lower half of this zone and native shrubs are common, as are some introduced weedy species. *‘A‘ali‘i* is common and *mamane*, *naio*, and *‘ilima* are frequent. Kikuyugrass is the most common of the introduced plants, but orchardgrass (*Dactylis glomerata)*, stinkweed and fireweed are also abundant. The upper part of the zone, nearing the existing Saddle Road, is a leveler and smoother surface and also more disturbed and degraded by human activities. Here, the native shrubs are less frequent and the weedy introduced species become more prevalent.

In this zone, thirty-seven percent of the 38 species recorded are native, and the index of importance for native species is 38% (Table 1). The soil in this zone is mapped as Keekee Loamy Sand, derived from cinder material erupted from nearby Puu Ke‘eke‘e and other nearby cinder cones (Sato et al. 1973).

5600-5800 Ft. Elevation: *‘Aheahea* Shrublands

At this elevation, the study corridor rejoins the existing Saddle Road and is superimposed over it for an extent of 3300 linear feet before terminating. This zone has an unusual substrate and a unique set of forces of disturbance that support a unique combination of native and introduced plant species. The surface is mapped as a deposit of alluvial and colluvial sand and gravel deposited by gravity and running water (Wolfe and Morris 1996).

The dominant plant is the endemic shrub *‘aweoweo* forming a stand about five feet high. The native hard-stemmed lovegrass is also common. Research shows that both of these endemic species are tolerant of disturbance and resprout after fire (Lamb 1981, Sherry et al. 1999). It is probable that this community does not represent the original indigenous plant community but is itself a product of disturbance. Other than those two hardy native species, the vegetation contains a large collection of introduced grasses and weeds, probably associated with continuing human disturbance near Saddle Road. One of the more conspicuous is Russian thistle (or tumbleweed) (*Salsola kali*). Between the shrubs and other plants, much of the surface is barren and dusty and there is much evidence of human activity. Twenty-one percent of the twenty-four species present are native and the index of importance for native species is only slightly higher at twenty-seven percent (Table 1).

Discussion of Potential Adverse Impacts of Proposed Action and Recommendations

No endangered plant species or unique, sensitive native plant communities were found within the study corridor.

Endangered Plant Habitats have been established within PTA at Kipuka Kalawamauna and Puu Ka Pele. These are the primary sites where h*onohono* (*Haplostachys*) survives within the Hawaiian Islands (and on Earth) today. Puu Kapele is about 6770 feet southeast and Kipuka Kalawamauna is about 4700 feet south of the proposed W-7 alignment. A third Endangered Plants Habitat has been designated within Keʻamuku to protect and manage *Haplostachys* and *Stenogyne angustifolia*. This site is approximately 500 feet west of the proposed W-7 alignment. These sites are managed by the U.S. Army to protect and recover endangered plant species. All three sites have been fenced to exclude feral ungulates.

<u>Recommendation</u>

These three Endangered Plants Habitats should be protected from any increased risk of wildfire that may originate from the proposed road. Protection should include constructing features in the roadway that minimize the probability that fire will spread from the road, management of roadside vegetation to reduce available fuel, if needed, and a well-designed and well-supported fire suppression plan specifically for the Endangered Plants Habitats. Specific fire protection plans are discussed in the Supplemental EIS.

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APPENDIX

Vascular plant species found within the Proposed W7 Alignment, Saddle Road. Estimated abundance given for each Vegetation Zone traversed by the study corridor.

ORGN = Origin (E = endemic, I = indigenous, P= Polynesian introduction, A = introduced); LF = Life Form (T = tree, S = shrub, H = herb, G = grass or grass-like, F = fern, L = liana or vine).

VEGETATION ZONES
1 - Fountaingrass with *Aàli‘i*
2 - Ke‘amuku Flow
3 - Native Shrubs Amidst Fountaingrass
4 - Rangeland and *A‘ali‘i*
5 - Moderate to Dense *A‘ali‘i*
6 - *Eragrostis* Grassland
7 - *‘Aheahea* Shrubland

ABUNDANCE WITHIN ZONES
C - Common
F - Frequent
I - Infrequent
R - Rare

ORGN	LF	BOTANICAL NAME COMMON NAME	1	2	3	4	5	6	7
A	F	*Adiantum hispidulum* Sw. rough maidenhair fern	I		I				
A	S	*Ageratina riparia* (Regel) R. King & H. Robinson *Hamakua pamakani*	R						
A	H	*Anagalis arvensis* L. pimpernel	I		I				
I	F	*Asplenium adiantum-nigrum* L. *‘iwa‘iwa*	I	F	I			I	
E	F	*Asplenium trichomanes* L. subsp. *densum* maidenhair spleenwort	R		R			I	
E	H	*Argemone glauca* Pope *pua-kala*			R	R		I	
A	G	*Avena fatua* L. wild oat						I	F

Vascular plant species found within the Proposed W7 Alignment. (Continued)

ORGN	LF	BOTANICAL NAME COMMON NAME	1	2	3	4	5	6	7
A	H	*Bidens alba* (L.) DC beggar's tick			I				
E	S	*Bidens menziesii* (Gray) Sherff subsp. *filiformis* *ko'oko'olau*				R			
A	H	*Bidens pilosa* L. *ki nehe*, Spanish needle	R				I	I	I
A	H	*Brassica nigra* (L.) W.Koch black mustard			I	I	F	F	F
A	G	*Bromus rigidus* Roth ripgut grass			I				I
A	G	*Bromus willdenowii* Kunth rescue grass					I	I	I
E	G	*Carex wahuensis* C. A. Mey. no common name	R		R			R	
A	G	*Cenchrus ciliaris* L. buffelgrass	C						
A	H	*Centaurea melitensis* L. yellow star thistle			I				
A	H	*Centaureum erythraea* Rafn. bitter herb	I		F	I	I	I	
A	H	*Chamaecrista nicitans* (L.) Moench partridge pea	F						
E	T	*Chamaesyce olowaluana* (Sherff) Croizat & Degener *'akoko*	R						
A	H	*Chenopodium ambrosioides* L. Mexican tea						I	I
E	S	*Chenopodium oahuense* (Meyen) Aellen *'aheahea*					I	F	C

Vascular plant species found within the Proposed W7 Alignment. (Continued)

ORGN	LF	BOTANICAL NAME COMMON NAME	VEGETATION ZONES 1	2	3	4	5	6	7
A	H	*Cirsium vulgare* (Savi) Ten. bull thistle	I						
I	L	*Coculus trilobus* (Thunb.) DC *huehu*	I						
A	H	*Conyza bonariensis* (L.) Cronq. hairy horseweed	I				I	I	F
A	H	*Conyza canadensis* (L.) Cronq. horseweed	I				I	I	F
E	T	*Coprosma montana* Hbd. *pilo*						R	
A	H	*Crotolaria pallida* Aiton smooth rattlepod	R						
A	G	*Cymbopogon refractus* (R. Br.) A. Camus barbwire grass	F	F	I				
A	G	*Dactylis glomerata* L. orchardgrass	I			F	F	I	F
A	H	*Desmodium sandwicense* E. Mey. Spanish clover	R						
I	S	*Dodonaea viscosa* Jacq. *‘a‘ali‘i*	C	C	C	C	C	C	I
E	S	*Dubautia cilliolata* (DC) Keck *na'ena'e*	R		F	R			
E	G	*Eragrostis atropioides* Hillebr. hard-stemmed lovegrass				I	I	C	C
A	T	*Eucalyptus* cf. *citridora* Hook. lemon-scented gum				R			
A	H	*Galium divaricatum* Pourr. ex Lam. bedstraw			I	I			
A	H	*Geranium homeanum* Turcz. cranesbill	I		I				

Vascular plant species found within the Proposed W7 Alignment. (Continued)

ORGN	LF	BOTANICAL NAME COMMON NAME	1	2	3	4	5	6	7
A	H	*Helichrysum foetidum* (L.) Cass. stinking everlasting						I	I
A	H	*Heterotheca grandiflora* Nutt. telegraph plant			I			F	F
A	G	*Holcus lanatus* L. velvetgrass						I	I
A	S	*Indigofera suffruticosa* Mill. indigo	F						
I	V	*Ipomoea indica* (J. Burm.) Merr. morning glory	I						
A	H	*Lepidium virginicum* L. pepperwort	I		I	C	C	F	I
I	S	*Leptecophylla tameiameiae* (Cham. & Schltdl.) C.M. Weiller *pukiawe*	I	C	I				
A	S	*Leucaena leucocephala* (Lam.) de Wit *koa haole*	F						
I	H	*Lythrum maritimum* Kunth *pukamole*	R		I				
A	H	*Marrubium vulgare* L. common horehound			I				
A	H	*Medicago lupulina* L. black medick	I		F	I			I
A	H	*Medicago polymorpha* bur clover			F	F			
A	H	*Melilotus alba* Medik. white sweet clover	R						
A	G	*Melinis minutiflora* Beauv. molassesgrass	I		I				

Vascular plant species found within the Proposed W7 Alignment. (Continued)

ORGN	LF	BOTANICAL NAME / COMMON NAME	1	2	3	4	5	6	7
E	T	*Metrosideros polymorpha* Gaud. var. *incana* / *'ohi'a-lehua*		I					
I	T	*Myoporum sandwicense* A. Gray / *naio*	I	F	R		I	I	
A	H	*Neonotonia wightii* (Am.) Lackey / Tinaroo glycine	C						
A	T	*Olea europaea* L. / *'oliw*, olive	I		R				
I	S	*Osteomeles anthyllidifolia (Sm.)* Lindl. / ‘ulei	I		I		I		
A	T	*Oppuntia ficus-indica*(L.) Mill. / *panini*	I		R			I	
P	H	*Oxalis corniculata* L. / *'ihi'ai*, yellow wood sorrel	I		I	I			
A	G	*Panicum maximum* Jacq. / Guinea grass	C						
A	L	*Passiflora suberosa* L. / *huehue haole*	R						
I	F	*Pellaea ternifolia* (Cav.) Link / cliffbrake	R	F	I		I		
A	G	*Pennisetum clandestinum* Hochst. ex Chiov. / kikuyugrass	F		C	C	C	C	I
A	G	*Pennisetum setaceum* (Forsk.) Chiov. / fountaingrass	C	C	C	F	F	I	I
I	H	*Peperomia leptostachya* Hook & Arnott / *‘ala‘ala wai nui*	R						
A	H	*Petrorhagia velutina* (Gaus.) Ball&Heyw. / childing pink					I	I	

Vascular plant species found within the Proposed W7 Alignment. (Continued)

ORGN	LF	BOTANICAL NAME / COMMON NAME	1	2	3	4	5	6	7
A	H	*Picris hieracioides* L. hawkweed			I				
I	F	*Psilotum nudum* (L.) Griseb. *moa*	R						
A	H	*Plantago lanceolata* L. narrow-leaved plantain	I		I	I		I	
I	F	*Pleopeltis thunbergiana* Kaulf. *pakahakaha*	F				I	F	I
E	F	*Pteridium aquilinum* (L.) Kuhn var. *decompositum* (Gaud.) Tryon bracken	I				I		
A	G	*Rhynchelytrum repens* (Willd.) Hubb. Natal redtop	F		F		F	F	I
A	H	*Rumex acetosella* L. sheep sorrel						I	
E	S	*Rumex giganteus* W. T. Aiton *pawale*						I	
A	H	*Salsola kali* L. Russian thistle					I	I	C
A	H	*Salvia coccinea* B.Juss *ex* Murray scarlet sage			F				
E	T	*Santalum paniculatum* Hook. & Arnott *'iliahi*	R						
A	H	*Senecio madagascariensis* Poiret Madagascar ragwort, fireweed	F	C	C	C	C	F	F
I	S	*Sida fallax* Walp. *'ilima*	I	I	C	I	I	F	I
A	H	*Silene gallica* L. small-flowered catchfly			I				

Vascular plant species found within the Proposed W7 Alignment. (Continued)

ORGN	LF	BOTANICAL NAME COMMON NAME	VEGETATION ZONES 1	2	3	4	5	6	7
I	H	*Solanum americanum* Mill. *popolo*, nightshade			R		I	I	
A	H	*Sonchus oleraceus* L. *pualele*			I				
E	T	*Sophora chrysophylla* (Salisb.) Seem *mamane*				I	I	I	
A	G	*Sporobolus indicus* (L.) R. Br. West Indian dropseed	I						
A	H	*Tagetes minuta* L. stinkweed			I	I	F	F	F
A	H	*Verbascum thapsus* L. common mullein						I	I
A	H	*Verbena litoralis* Kunth vervain	I		F			I	
A	H	*Verbesina encelioides* (Cav.) Benth.&Hook crown-beard	I				F	F	F
A	H	*Vicia villosa* Roth hairy vetch	I		F		F	I	
A	G	*Vulpia bromoides* (L.) S.F. Gray brome fescue			I				
A	H	*Wahlenbergia gracillis* no common name			I				
I	S	*Waltheria indica* L. *uhaloa*	I						
E	S	*Wikstroemia pulcherrima* Skottsb. *'akia*	R						

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SADDLE ROAD (STATE ROUTE 200)
Mamalahoa Highway (State Route 190) to Milepost 42
County of Hawai‘i, State of Hawai‘i
FHWA Project No. 200(00)

SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT

Submitted Pursuant to Section 42 U.S.C. 4332(2)(c)
and Chapter 343, Hawai‘i Revised Statutes by the

U.S. DEPARTMENT OF TRANSPORTATION
Federal Highway Administration (FHWA)
Central Federal Lands Highway Division
and
STATE OF HAWAI‘I
Department of Transportation (HDOT)
Highways Division

Cooperating Agencies
U.S. Army Garrison, Hawai‘i

Appendix D
Vertebrate Fauna Report

Avian and Terrestrial Mammalian Species Surveys Conducted on the W-7 Alignment of the Hawai‘i State Route 200 - Māmalahoa Highway to Milepost 6 Saddle Road Realignment Project North Kona District, Island Of Hawai‘i.

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U.S. Department of Transportation
Federal Highway Administration
Central Federal Lands Highway Division
Project No. A-AD-6 (1)

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September 22, 2009

Table of Contents

Figures & Tables

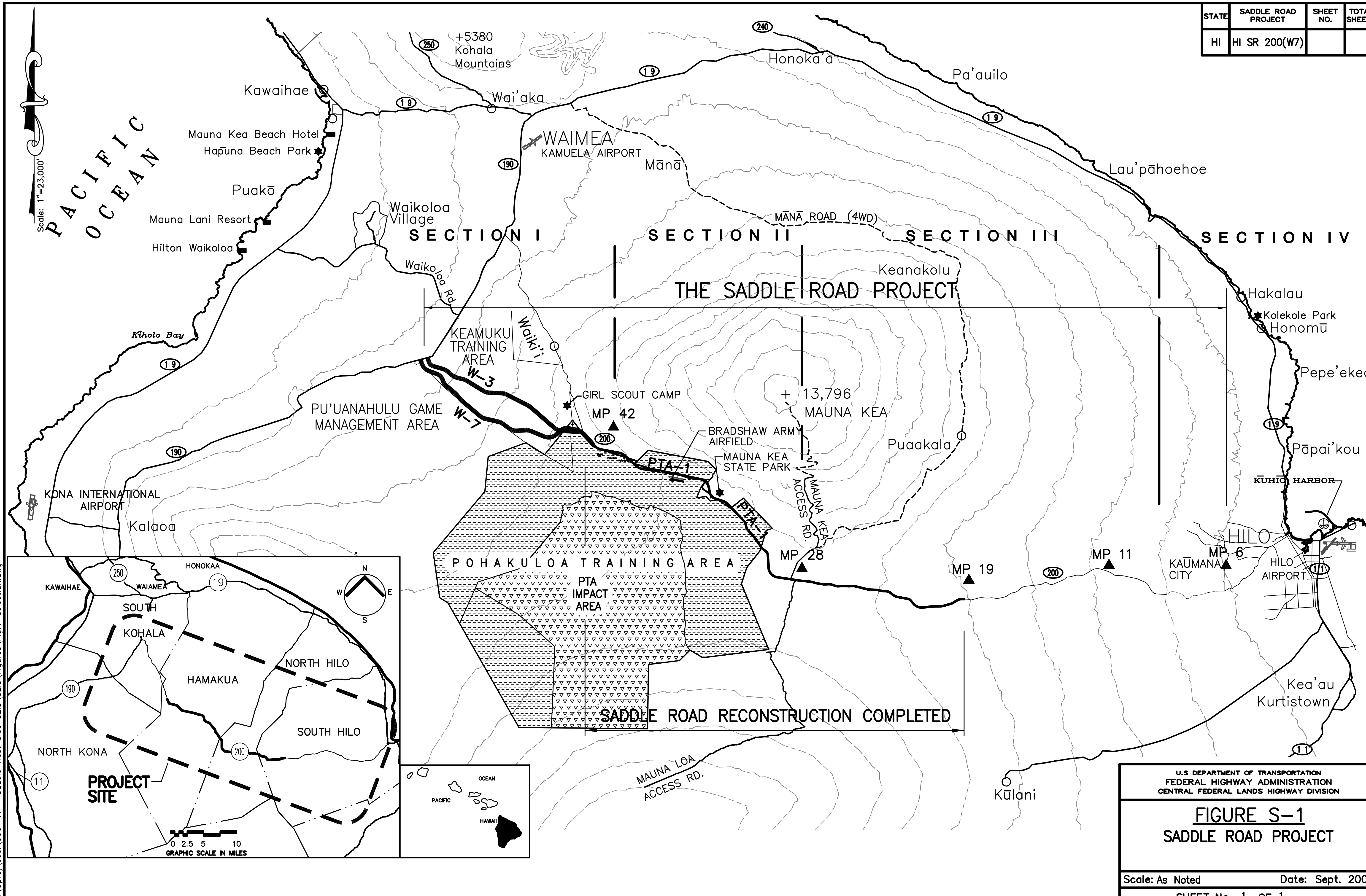
Introduction

The State of Hawaii, Department of Transportation, Highways Division (HDOT), in consultation with the Federal Highways Administration (FHWA), Central Federal Lands Highway Division is proposing to realign and improve the Saddle Road (State Route 200), from Māmalahoa Highway (State Route 190) to Milepost 6 on the Hilo side of the island, (hereinafter Saddle Road Improvement Project) (Figure S-1). A Final Environmental Impact Statement (EIS) and Record of Decision for the Saddle Road improvements were completed in 1999 (FHWA, *et al.* 1999). As part of the EIS process, twelve action alternatives incorporating use of the existing alignment and potential new alignments were considered. The project was divided into four different sections (Sections I, II, III, and IV) for purposes of alternative development and selection, as well as project scheduling (Figure 1). In the intervening years since the release of the EIS, the Department of the Army has purchased a large section of land in the Ke'āmuku area from Parker Ranch. This development has rendered the selected alignment, W-3, in Section I to no longer fulfill one of the key purposes and needs of the proposed improvement project, namely the separation of military training activity from the general driving public using the Saddle Road. Another alignment, W-7, has been proposed and studied to fulfill the need to separate civilian traffic from military training activities. This report documents the avian and mammalian studies that were conducted as part of the revised project and will be included in the supplemental EIS that is currently being prepared.

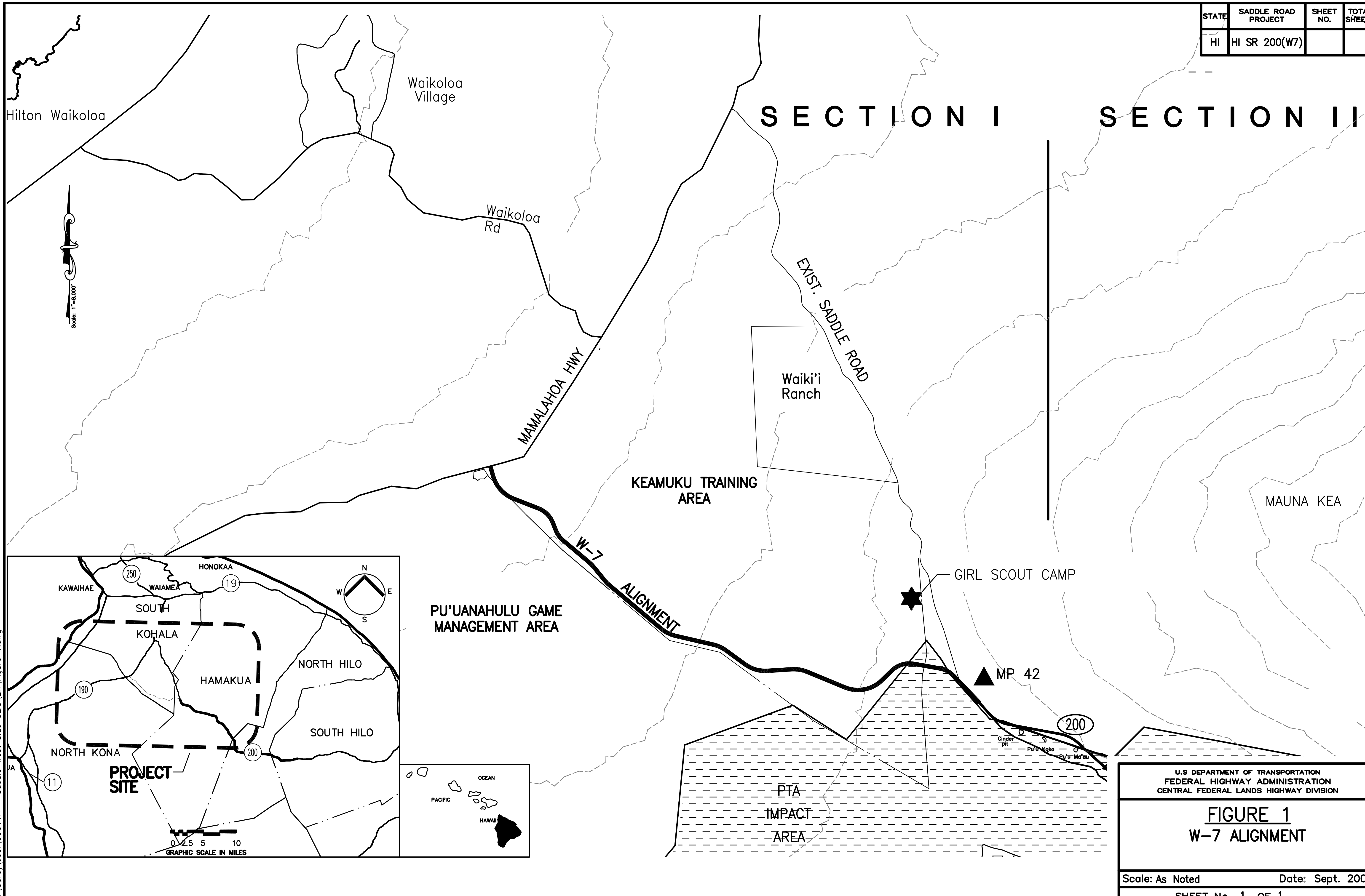
The primary purpose of the survey that I report on in this document was to determine if there were any avian or mammalian species currently listed as endangered, threatened, or proposed for listing under either the federal or the State of Hawai'i's endangered species programs on, or within the immediate vicinity of the proposed W-7 alignment. Federal and State of Hawai'i listed species status follows species identified in the following referenced documents (Division of Land and Natural Resources (DLNR) 1998, Federal Register 2005, U. S. Fish & Wildlife Service (USFWS) 2005, 2009). Fieldwork was conducted in June 2009.

Avian phylogenetic order and nomenclature follows *The American Ornithologists' Union Check-list of North American Birds 7th Edition* (American Ornithologists' Union 1998), and the 42nd through the 49th supplements to *Check-list of North American Birds* (American Ornithologists' Union 2000; Banks et al. 2002, 2003, 2004, 2005, 2006, 2007, 2008). Mammal scientific names follow *Mammals in Hawaii* (Tomich 1986). Place names follow *Place Names of Hawaii* (Pukui et al. 1974).

Hawaiian and scientific names are italicized in the text. A glossary of technical terms and acronyms used in the document, which may be unfamiliar to the reader, are included at the end of the narrative text on Page 16.



STATE | SADDLE ROAD PROJECT | SHEET NO. | TOTAL SHEETS
HI | HI SR 200(W7)
Scale: 1"=23,000'
PACIFIC OCEAN
+5380 Kohala Mountains
Kawaihae
Wai'aka
Honoka'a
Pa'auilo
Mauna Kea Beach Hotel
Hapuna Beach Park
WAIMEA
KAMUELA AIRPORT
Mānā
Lau'pāhoehoe
Puakō
Mauna Lani Resort
Hilton Waikoloa
Waikoloa Village
MĀNĀ ROAD (4WD)
SECTION I
SECTION II
SECTION III
SECTION IV
Waikoloa Rd
Keanakolu
THE SADDLE ROAD PROJECT
Hakalau
Kolekole Park
Honomū
Kiholo Bay
KEAMUKU TRAINING AREA
Waiki'i
W-3
W-7
Pepe'ekeo
GIRL SCOUT CAMP
+ 13,796
MAUNA KEA
MP 42
PU'UANAHULU GAME MANAGEMENT AREA
BRADSHAW ARMY AIRFIELD
MAUNA KEA STATE PARK
Puaakala
Pāpai'kou
PTA-1
MAUNA KEA ACCESS RD.
KŪHIŌ HARBOR
KONA INTERNATIONAL AIRPORT
Kalaoa
HILO
MP 28
MP 19
MP 11
MP 6
KAŪMANA CITY
HILO AIRPORT
POHAKULOA TRAINING AREA
PTA IMPACT AREA
KAWAIHAE
HONOKAA
WAIMEA
SOUTH KOHALA
HAMAKUA
NORTH HILO
SOUTH HILO
NORTH KONA
PROJECT SITE
0 2.5 5 10
GRAPHIC SCALE IN MILES
N E S W
OCEAN
PACIFIC
HAWAII
Kea'au
Kurtistown
SADDLE ROAD RECONSTRUCTION COMPLETED
MAUNA LOA ACCESS RD.
Kūlani
U.S DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
CENTRAL FEDERAL LANDS HIGHWAY DIVISION
FIGURE S-1
SADDLE ROAD PROJECT
Scale: As Noted
Date: Sept. 2009
SHEET No. 1 OF 1
O:\Oproj\Joel\99011A – Saddle West Side SEIS\SEIS\Figures\Fig.1-select.alt.dwg



O:\Oproj\Joel\99011A – Saddle West Side SEIS\BA\Figure 1.dwg

General Site and Project Description

The W-7 alignment gently slopes from east to west, from an elevation of ~ 1765 meters (5800-feet), above mean sea level (ASL), along the existing Saddle Road, down slope to where it will intersect the existing Māmalahoa Highway at ~ 760 meters (2493-feet) ASL. The alignment is roughly 10.3 miles long, with approximately 8.9 miles within TMK: 6-7-001:041: the remaining 1.4 miles of the alignment goes through a portion of the main Pōhakuloa Training Area (PTA) (Figure 1).

The project area is on the west-facing slope of Mauna Kea, on the leeward side of the island. Annual rainfall is in the neighborhood of 50 centimeters (20-inches) a year, with the upper reaches somewhat drier. The terrain present along the alignment is composed of a mix of *ʻaʻā* and *pāhoehoe* lava flows disgorged from Mauna Kea more than 14,000 and 65,000 years ago during the Pleistocene Age. Additionally there are surficial alluvial deposits in many areas, which were washed down from Mauna Kea at the end of the last ice age. Along the southern boundary of the area several small fingers of *ʻaʻā* from the Keʻāmuku flow, deposited by Mauna Loa between 200 and 750 years ago overlay portions of the older Mauna Kea flows (Wolfe and Morris 1996).

The vast majority of the site has been extensively altered by decades of cattle grazing and is now largely a pasture of introduced grasses with scattered shrubs and very few trees. The vegetation between the eastern terminus of the project and approximately the 4200 foot level is dominated by fountain grass (*Pennisetum setaceum*), with sparse amounts of *ʻaʻalilʻi* (*Dodenea viscose*), and numerous other alien grasses and Madagascar ragwort (*Senecio madagascariensis*) (Figure 2). At the lower elevations in this section there are also pockets buffelgrasss (*Cenchrus ciliaris*), Guinea grass (*Panicum maximum*), and Kikuyu grass (*Pennisetum clandestinum*). Between the 4300 foot and 4600 foot elevation the makeup of the vegetation is similar to that found in the lower section, except that in this zone the native species are dominate, with large dense stands of *ʻaʻaliʻi* making up to 50% of the ground cover (Figure 3). Between the 4300-foot elevation and the boundary of the Keʻāmuku parcel and PTA proper the habitat is similar to the previously described ones, but with varying densities of the component species, as is to be expected in pastureland that is grazed on a rotational basis (Figure 4). Between approximately 5200-feet ASL and the eastern terminus of the project the substrate is markedly different than that found lower on the alignment, in this area is made up of alluvial and colluvial sand and gravel deposited by the erosion of Mauna Kea by the melting of the last ice cap. On this substrate the dominate plant is the endemic shrub *ʻaheahea* (*Chenopodium oahuense*).

Mammalian Survey Methods

With the exception of the endangered Hawaiian hoary bat (*Lasiurus cinereus semotus*), or *ʻōpeʻapeʻa* as it is known locally, all terrestrial mammals currently found on the Island of Hawaiʻi are alien species. Most are ubiquitous. The survey of mammals was limited to visual and auditory detection, coupled with visual observation of scat, tracks, and other animal sign. A running tally was kept of all vertebrate species observed and heard within the project area.

Figure – 3 Fountain grass dominated western end of W-7

Figure – 4 *‘A‘ali‘i* and grass shrubland W-7

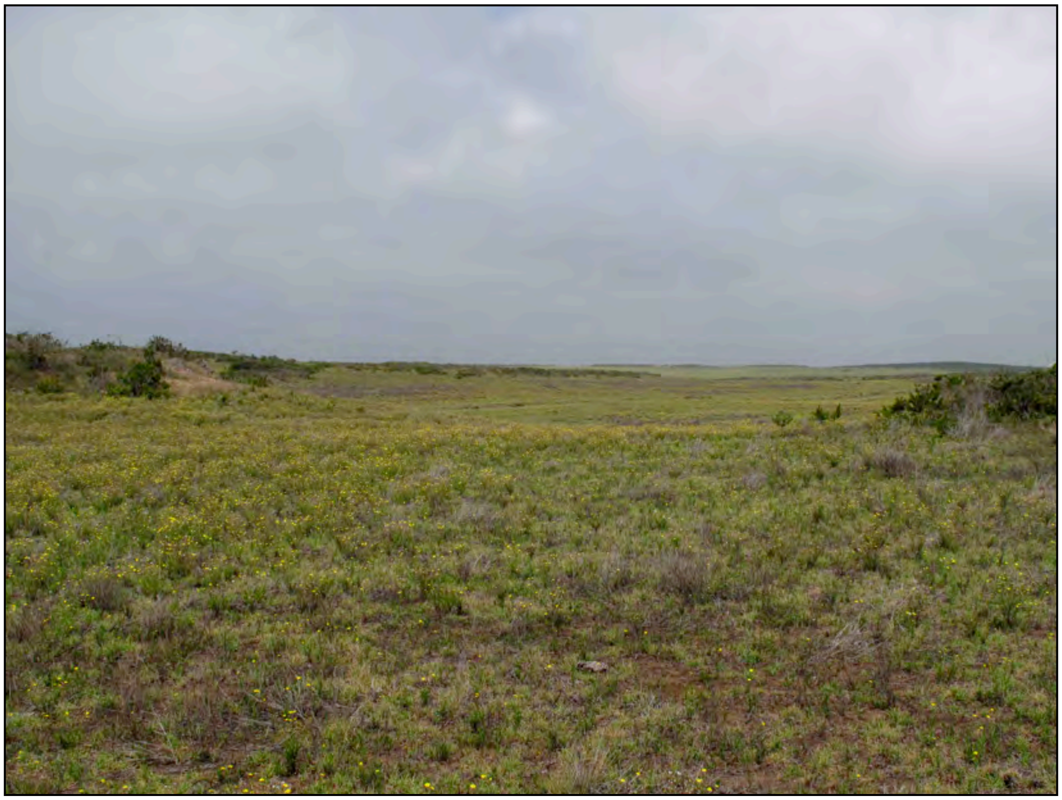


Figure - 5 Heavily grazed grass land with Madagascar ragwort upper third of W-7

Mammalian Survey Results

A total of nine mammalian species were detected during the course of this survey (Table 1). Several European house mice (*Mus musculus domesticus*) were seen at various locations within the site. Small Indian mongooses (*Herpestes a. auropunctatus*) were seen at several locations, predominantly on the western third of the alignment. Several horses (*Equus c. caballus*) were seen within the Ke‘āmuku parcel. Pigs (*Sus s. scrofa*), domestic cattle (*Bos taurus*), and feral goats (*Capra h. hirca*), and feral sheep (*Ovis aries*) were seen in numbers along the whole length of the Ke‘āmuku parcel. Additionally, tracks, scat and sign of dog (*Canis f. familiaris*), small Indian mongoose, cat (*Felis c. catus*), horse, pig, cattle, goat and sheep were encountered throughout the Ke‘āmuku parcel. Of particular note were the numerous very large flocks of goats seen in the mid-to-upper elevation areas of the alignment; over 400 animals were seen a day (Figure 6).

All nine of the mammals recorded are considered to be alien to the Hawaiian Islands. Hawai‘i‘s sole endemic terrestrial mammalian species, the endangered Hawaiian hoary bat, was not detected during the course of this survey.

Table 1 - Mammalian Species Detected Saddle Road W-7 Alignment

Common name	***Scientific name***	***Det/Type***
	RODENTIA - Gnawers	
	Muridae - Old World Rats & Mice	
European house mouse	*Mus musculus domesticus*	V
	CARNIVORA- Flesh Eaters	
	Canidae - Wolves, Jackals & Allies	
Domestic dog	*Canis f. familiaris*	Si
	Viverridae - Civets & Allies	
Small Indian mongoose	*Herpestes a. auropunctatus*	V, Si, Skel
	Felidae- Cats	
House cat	*Felis catus*	Si
	PERISSODACTYLA - Odd-Toed Ungulates	
	Equidae - Horses, Asses & Zebras	
Domestic horse	*Equus c. caballus*	V, Si
	ATRIODACTYLA - Even-Toed Ungulates	
	Suicidae - Old World Swine	
Pig	*Sus s. scrofa*	V, Si
	Bovidae- Hollow-horned Ruminants	
Domestic cattle	*Bos taurus*	V, Si, Skel
Goat	*Capra h. hircus*	V, Si, Skel
Domestic sheep	*Ovis aries*	V, Si,

Key To Table 1

Det/Type	Detection type
V	Visual – animals that were seen
Skel	Skeleton – animals that were detected through observation of skeletal remains
A	Audio – animals that were detected by sound
Si	Sign – animals that were detected by seeing tracks, scat and other sign

Figure – 6 Goats (*Capra h. hirca*) Mid level W-7

Avian Survey Methods

Forty-five avian count stations were sited along the W-7 alignment. Count stations were placed at approximately 350-meter intervals equally spaced along the proposed right-of-way. Six-minute point counts were made at each of the 45-count stations. Each station was counted once. Field observations were made with the aid of Leitz 10 X 42 binoculars and by listening for vocalizations. Counts were concentrated between 06:30 a.m. and 10:00 a.m., the peak of daily bird activity.

Avian Survey Results

A total of 749 individual birds of 27 different species, representing 18 separate families, were recorded during station counts (Table 2). Three of the species recorded, Pacific Golden-Plover (*Pluvialis fulva*), Ruddy Turnstone (*Arenaria interpres*), and Short-eared Owl (*Asio flammeus sandwichensis*) are native species. The Pacific Golden-Plover, and Ruddy Turnstone are indigenous migratory shorebird species that nests in the high Arctic during the late spring and summer months, returning to Hawai‘i and the Tropical Pacific to spend the fall and winter months each year. They usually leave Hawai‘i for their trip back to the Arctic in late April or the very early part of May each year, though as evidenced by this surveys results small numbers of both of these species over-summer in Hawai‘i. The Hawaiian endemic sub-species of the Short-eared Owl, or *Pueo* is a diurnal bird of prey, regularly seen within the grassland areas in North and

South Kohala. The remaining 24 avian species detected are all considered to be alien to the Hawaiian Islands.

Avian diversity and densities were low, though in keeping with the habitat present within the project area. I recorded no birds at one of the 45-count station. Two species, Sky Lark (*Alauda arvensis*), and House Finch (*Carpodacus mexicanus*), accounted for slightly less than 54% of the total number of birds recorded during station counts. The most common avian species recorded was Sky Lark, which accounted for slightly less than 40% of the total number of individual birds recorded. An average of 17 individual birds were recorded per station count.

Table 2 - Avian Species Detected Saddle Road W-7 Alignment

Common Name	Scientific Name	ST	RA
	GALLIFORMES		
	PHASIANIDAE - Pheasants & Partridges		
	Phasianinae - Pheasants & Allies		
Gray Francolin	*Francolinus pondicerianus*	A	0.31
Black Francolin	*Francolinus francolinus*	A	0.51
Erckel's Francolin	*Francolinus erckelii*	A	1.20
Japanese Quail	*Coturnix japonica*	A	0.11
Ring-necked Pheasant	*Phasianus colchicus*	A	0.20
	Meleagridinae - Turkeys		
Wild Turkey	*Meleagris gallopavo*	A	0.42
	ODONTOPHORIDAE - New World Quail		
California Quail	*Callipepla californica*	A	0.22
	CHARADRIIFORMES		
	CHARADRIIDAE - Lapwings & Plovers		
	Charadriinae - Plovers		
Pacific Golden-Plover	*Pluvialis fulva*	IM	0.11
	SCOLOPACIDAE - Sandpipers, Phalaropes & Allies		
	Scolopacinae - Sandpipers & Allies		
Ruddy Turnstone	*Arenaria interpres*	IM	0.24
	PTEROCLIDIDAE - Sandgrouse		
Chestnut-bellied Sandgrouse	*Pterocles exustus*	A	0.31
	COLUMBIFORMES		
	COLUMBIDAE - Pigeons & Doves		
Rock Pigeon	*Columba livia*	A	0.71
Spotted Dove	*Streptopelia chinensis*	A	0.11
Zebra Dove	*Geopelia striata*	A	0.38
	STRIGIFORMES		
	TYTONIDAE - Barn Owls		
Barn Owl	*Tyto alba*	A	0.04

Table 2 continued

Common Name	Scientific Name	ST	RA
	STRIGIDAE - Typical Owls		
Short-eared Owl	*Asio flammeus sandwichensis*	ES	0.09
	PASSERIFORMES		
	ALAUDIDAE - Larks		
Sky Lark	*Alauda arvensis*	A	6.58
	ZOSTEROPIDAE - White-Eyes		
Japanese White-eye	*Zosterops japonicus*	A	0.16
	MIMIDAE -Mockingbirds & Thrushes		
Northern Mockingbird	*Mimus polyglottos*	A	0.18
	STURNIDAE - Starlings		
Common Myna	*Acridotheres tristis*	A	0.29
	EMBERIZIDAE - Emberizids		
Saffron Finch	*Sicalis flaveola*	A	0.27
	CARDINALIDAE - Cardinals Saltators & Allies		
Northern Cardinal	*Cardinalis cardinalis*	A	0.20
	FRINGILLIDAE - Fringilline And Cardueline Finches & Allies		
	Carduelinae - Carduline Finches		
House Finch	*Carpodacus mexicanus*	A	2.36
Yellow-fronted Canary	*Serinus mozambicus*	A	0.27
	PASSERIDAE - Old World Sparrows		
House Sparrow	*Passer domesticus*	A	0.04
	ESTRILDIDAE - Estrildid Finches		
	Estrildinae - Estrildine Finches		
Red Avadavat	*Amandava amandava*	A	0.16
African Silverbill	*Lonchura cantans*	A	0.87
Nutmeg Mannikin	*Lonchura punctulata*	A	0.31

KEY TO TABLE 1

ST Status
A Alien Species
IM Indigenous Migratory Species
ES Endemic Sub-species
RA Relative Abundance – number of individual birds detected divided by the number of stations (45)

Discussion

Mammalian Resources

The findings of the mammalian survey are consistent with at least one other faunal survey conducted on portions of the W-7 alignment (David 1996a), as well as with several other surveys conducted within similar habitat in the South Kohala District, or on lands that are adjacent to portions of the project alignments within the recent past (David 1999b, 2002, 2004, David and Guinther 2006).

Although not detected during the course of this survey, it is likely that Hawaiian hoary bats over-fly portions of the proposed right-of-way on a seasonal basis, as bats have been documented within *mauka* portions of the PTA facility, and south of the western terminus in Waikoloa Village on a seasonal basis (Jacobs 1994, Cooper *et al.*, 1992, David 2009). There is no suitable Hawaiian hoary bat roosting habitat present within, or close to the W-7 alignment.

Several European house mice were detected at several locations along the corridors surveyed. Additionally, it is likely that roof rats (*Rattus r. rattus*), Norway rats (*Rattus norvegicus*), and possibly Polynesian rats (*Rattus exulans hawaiiensis*) utilize resources within the general project site on a seasonal basis within the project area.

All of the other mammalian species recorded during the course of this survey are commonly occurring species present on farmland, pasturage and the grasslands present in the general project area. All of these mammals are considered alien to the Hawaiian Islands, and none are protected under either state or the federal endangered species statutes.

Avian Resources

The findings of this survey are consistent with at least one other avian surveys conducted on portions of the W-7 alignment (David 1996a), as well as with several other surveys conducted within similar habitat in the South Kohala District, or on lands that are adjacent to portions of the project alignments within the recent past (David 1999b, 2002, 2004, David and Guinther 2006). During the course of this survey I recorded a slightly higher number of avian species and numbers than I did during the 1996 survey of the same general area. These findings are not surprising as the habitat present on the site during 1996 was even more depauperate than encountered during this survey; many areas within the Keʻāmuku parcel were bare ground in 1996, due to a multi-year drought. The vegetation present on the site during the course of this survey was verdant when compared to that found in 1996. The Keʻāmuku parcel is as green as I have seen it in the 35 years that I have lived on the island.

A total of 27-different avian species were recorded during the time spend within the project area (Table 2). Three of the species recorded, Pacific Golden-Plover, Ruddy Turnstone, and the Hawaiian endemic sub-species of the Short-eared Owl are considered to be native to the Hawaiian Islands. As previously stated Pacific Golden-Plover and Rudy Turnstone are regularly seen throughout Hawaiʻi between the months of July and early May, though as evidenced by this surveys results small numbers of both of these species over-summer in Hawaiʻi. Short-eared Owls are an uncommon, irruptive diurnal owl species that are still found in goodly numbers on the Big Island, where it is most frequently encountered in open grassland areas, though usually in somewhat less xeric conditions that present within most of this project area. The remaining 24 avian species detected are all considered to be alien to the Hawaiian Islands. No species currently listed, or proposed for listing under either the US Federal or the State of Hawaiʻi endangered species programs was detected during the course of this survey.

Although not detected during the course of this survey the endangered Nēnē (*Branta sandwichensis*) has been recorded in low numbers within the Keʻāmuku parcel. During the 1996 survey of two alignments (W-3 and W-4) that were located parallel to the W-7 alignment, one to the north and the other to the south, I saw one Nēnē in an area close to the current alignment. Since the Army purchased the Ke'āmoku parcel their biologists have reported seeing ≤ 2 Nēnē on several occasions close to the western terminus of this alignment, including one apparent nesting attempt north of the W-7 alignment in 2008. The repeated sightings of Nēnē within the general area have apparently involved three separate individual birds (Lena Schnell 2009, personnel communication).

Although not detected during this survey, it is possible that small numbers of the endangered endemic Hawaiian Petrel (*Pterodroma sandwichensis*), and the threatened Newell's Shearwater (*Puffinus auricularis newelli*), over-fly the project area between the months of May and November (Banko 1980a, 1980b, Harrison 1990, Cooper et al., 1992, Day *et al.*, 2003a).

Hawaiian Petrels were formerly common on the Island of Hawaiʻi (Wilson and Evans 1890–1899). This pelagic seabird reportedly nested in large numbers on the slopes of Mauna Loa and in the saddle area between Mauna Loa and Mauna Kea (Henshaw 1902), as well as at the mid-to-high elevations of Mount Hualālai. It has, within recent historic times, been reduced to relict breeding colonies located at high elevations on Mauna Loa and, possibly, Mount Hualālai (Banko 1980a, Banko et al. 2001, Cooper and David 1995, Cooper et al. 1995, Day et al. 2003a, Harrison 1990, Simons and Hodges 1998). Hawaiian Petrels were first listed as an endangered species by the USFWS) in 1967 and by the State of Hawaiʻi in 1973 (Federal Register 1967, DLNR 1998)

Newell's Shearwaters were formerly common on the Island of Hawaiʻi (Wilson and Evans 1890–1899). This species breeds on Kauaʻi, Hawaiʻi, and Molokaʻi. Newell's Shearwater populations have dropped precipitously since the 1880s (Banko 1980b, Day et al., 2003b). This pelagic species nests high in the mountains in burrows excavated under thick vegetation, especially *uluhe* (*Dicranopteris linearis*) fern. Newell's Shearwater was listed as a threatened species by the USFWS in 1975 and by the State of Hawaiʻi in 1973 (Federal Register 1975, DLNR 1998).

The primary cause of mortality in both Hawaiian Petrels and Newell's Shearwaters is thought to be predation by alien mammalian species at the nesting colonies (U.S. Fish & Wildlife Service 1983, Simons and Hodges 1998, Ainley et al. 2001, Hue et al., 2001). Collision with man-made structures is considered to be the second most significant cause of mortality of these seabird species in Hawaiʻi. Nocturnally flying seabirds, especially fledglings on their way to sea in the summer and fall, can become disoriented by exterior lighting. When disoriented, seabirds often collide with manmade structures, and if they are not killed outright, the dazed or injured birds are easy targets of opportunity for feral mammals (Hadley 1961, Telfer 1979, Sincock 1981, Reed et al. 1985, Telfer et al. 1987, Cooper and Day 1998, Podolsky et al. 1998, Ainley et al. 2001). There is no suitable nesting habitat within or close to the proposed project site for either of these pelagic seabird species.

Potential Impacts to Protected Vertebrate Species

Hawaiian Hoary Bat

As previously discussed, it is likely that Hawaiian hoary bats overfly portions of the alignment on a seasonal basis. They may also forage for volant insects over portions of the project area on a seasonal basis, though the xeric nature of the habitat present and the lack of dense vegetation within the site likely means that there is little in the way of food resources that might attract a bat to the area.

Currently there is no suitable bat roosting habitat along the entire length of the project corridor, so it is unlikely that the clearing, grubbing construction and operation of a roadway through the area will result in deleterious impacts to this listed species.

Nēnē

The principal potential risk that the operation of the proposed roadway poses to Nēnē is that birds may be attracted to the roadway following build out in search of water, heat and gravel along the roadbed. Motorists on several of the Big Islands roadways have hit Nēnē over the past few years.

Hawaiian Petrel and Newell's Shearwater

The principal potential impact that construction and operation of the proposed alignment poses to Hawaiian Petrels and Newell's Shearwaters is the increased threat that birds will be downed after becoming disoriented by lights associated with the project.

The two main project specific actions that pose a potential threat to these nocturnally flying seabirds are: 1) during construction if it is deemed expedient, or necessary to conduct nighttime construction activities, 2) if streetlights are required for traffic safety reasons following build-out of the roadway.

Recommendations

If nighttime construction activity, be it actual construction activity or equipment maintenance is proposed during the construction phase of the project, all associated lights should be shielded, and when large flood/work lights are used they should be placed on poles that are high enough to allow the lights to be pointed directly at the ground.

If streetlights are installed in conjunction with the new road, it is recommended that lights be shielded to reduce the potential for interactions of nocturnally flying Hawaiian Petrels and Newell's Shearwaters with external lights and man-made structures (Reed et al. 1985, Telfer et al. 1987). This minimization measure would serve the dual purpose of minimizing the threat of disorientation and downing of Hawaiian Petrels and Newell's Shearwaters, while at the same time complying with the Hawaii County Code § 14 – 50 *et seq.* which requires the shielding of exterior lights so as to lower the ambient glare caused by unshielded lighting to the astronomical observatories located on Mauna Kea.

Since there are potential issues associated with Nene, Hawaiian Petrel and Newell's Shearwaters it is recommend that the project consult with the USFWS under Section 7 of the endangered species act, to ensure compliance with that statute.

Glossary:

‘A‘ā – Clinker lava formed by slow moving lava flows
Alien – Introduced to Hawai‘i by humans
Commensal - Animals that share humans’ food and shelter, such as rats and mice
Crepuscular – Twilight hours
Diurnal – Daytime
Endangered – Listed and protected under the Endangered Species Act of 1973, as amended as an endangered species.
Endemic – Native and unique to the Hawaiian Islands
Indigenous – Native to the Hawaiian Islands, but also found elsewhere naturally
Mauka – Upslope, towards the mountains
*Maka*i – Down-slope, towards the ocean
Nocturnal – Night-time, after dark
Pāhoehoe – Sheet lava formed by relatively fast moving lava flows
‘Ōpe‘ape‘a – Hawaiian hoary bat
Pelagic – An animal that spends its life at sea – in this case seabirds that only return to land to nest and rear their young
Phylogenetic – The evolutionary order that organisms are arranged by
Pueo – Hawaiian endemic sub-species of the Short-eared Owl
Sign – Biological term referring tracks, scat, rubbing, odor, marks, nests, and other signs created by animals by which their presence may be detected
Threatened – Listed and protected under the ESA as a threatened species
Volant – Flying, capable of flight, as in flying insect
Xeric - Extremely dry conditions or habitat

ASL – Above mean sea level
DLNR – Hawaii State Department of Land & Natural Resources
TMK – Tax Map Key
USFWS – United State Fish & Wildlife Service

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SADDLE ROAD (STATE ROUTE 200)
Mamalahoa Highway (State Route 190) to Milepost 42
County of Hawai‘i, State of Hawai‘i
FHWA Project No. 200(00)

SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT

Submitted Pursuant to Section 42 U.S.C. 4332(2)(c)
and Chapter 343, Hawai‘i Revised Statutes by the

U.S. DEPARTMENT OF TRANSPORTATION
Federal Highway Administration (FHWA)
Central Federal Lands Highway Division
and
STATE OF HAWAI‘I
Department of Transportation (HDOT)
Highways Division

Cooperating Agencies
U.S. Army Garrison, Hawai‘i

Appendix E
Depleted Uranium Report

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Final
Saddle Road
Uranium Soils Investigation and
Baseline Human Health Risk Assessment

Ke'amuku Parcel, South Kohala District
Hawai'i Island, State of Hawai'i
TMK (3rd) 6-7-001:003

Prepared for:

Hawai'i Department of Transportation – Highways Division
and
U.S. Department of Transportation – Federal Highway Administration
Central Federal Lands Highway Division

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October 2009

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GLOSSARY OF ACRONYMS, TECHNICAL TERMS AND MEASUREMENTS

$\mu g/m^3$ - Micrograms of compound per cubic meter of air.

^{234}Th - Thorium-234

^{234}U - Uranium-234

^{235}U - Uranium-235

^{238}U - Uranium-238

ADD - Average Daily Dose. A compound- and facility-specific value generated by an equation designed to estimate a receptor's potential daily intake from exposure to compound with potential noncarcinogenic effects.

ANL - Argonne National Laboratory

ATSDR - Agency for Toxic Substances and Disease Registry

BHHRA - Baseline Human Health Risk Assessment

C - Carbon

CERCLA - Comprehensive Environmental Response, Compensation, and Liability Act

COPC - Compounds of Potential Concern - Those site-related compounds examined in detail in the quantitative risk assessment.

cm - centimeter

CSF - Cancer Slope Factor - A numerical estimate of the carcinogenic potency of a compound. CSFs are developed by the United States Environmental Protection Agency's Human Health Assessment Group for both oral and inhalation routes of exposure.

CSM - Conceptual Site Model

d - day

Dose - Concentration of a compound to which a receptor may be exposed. Dose is usually expressed in units of milligrams of compound per kilogram of body weight per day.

Dose-Response Evaluation - The process of quantitatively evaluating toxicity information and characterizing the relationship between the dose of the compound and the likelihood and magnitude of adverse health effects in the exposed population. From the quantitative dose-response relationship, toxicity values are identified and used in the risk characterization step to estimate the potential for adverse effects occurring in the receptors evaluated in the risk assessment.

DU - Depleted Uranium

EPC - Exposure Point Concentration

EU - Enriched Uranium

F - Temperature in Degrees Fahrenheit

HEAST - Health Effects Assessment Summary Tables

HI - Hazard Index - The sum of the compound-specific hazard quotients for a particular exposure pathway.

HQ - Hazard Quotient - The ratio of the calculated Chronic Average Daily Dose to the Reference Dose for a particular compound. A Hazard Quotient of less than one indicates that the Reference Dose for that compound has not been exceeded. Therefore, it can be assumed with a high degree of certainty that no adverse noncarcinogenic health effects are expected to occur as a result of exposure to that particular compound via that particular route. Because the reference dose is derived using multiple safety factors, a Hazard Quotient greater than one does not indicate that health effects are expected but rather that further analysis is warranted.

IRIS - Integrated Risk Information System - A computerized database of toxicological information maintained by the United States Environmental Protection Agency.

K - Potassium

LADD - Lifetime Average Daily Dose - A compound- and facility-specific value generated by an equation designed to estimate a receptor's potential daily intake from exposure to potentially carcinogenic compounds.

LOAEL - Lowest Observed Adverse Effect Level - The lowest experimental dose above the NOAEL at which a statistically significant difference in response between the control and exposed group is discernable.

mg/kg - Milligrams of compound per kilogram of medium.

mg/kg-day - Milligrams of compound per kilogram of body weight per day.

mg/l - Milligrams of compound per liter of water.

NCP - National Contingency Plan

NOAEL - No Observed Adverse Effect Level - An experimental dose greater than zero at which no statistically significant difference in response can be detected between the control and exposed groups.

Noncarcinogenic Effects - Category of adverse health effects that does not include cancers (e.g., liver effects, changes in blood enzyme levels, variances in body weight).

NRC - Nuclear Regulatory Commission

NTP - National Toxicology Program

pCi/g - picocuries per gram

ppm - part per million

PELCR - Potential Excess Lifetime Cancer Risk - An estimate of the increased probability of developing cancer given exposure to particular doses of particular compounds via specific exposure scenarios. The likelihood, over and above the background cancer rate, that a receptor will develop cancer in his or her lifetime as a result of facility-related exposures to compounds in various environmental media.

PRG - Preliminary Remediation Goal

PTA - Pohakūloa Training Area

Quantitative Risk Assessment - The mathematical and scientific procedure by which compounds present in environmental media are evaluated for their potential to adversely impact the health of individuals who may contact them.

Ra - Radium

Rn - Radon

RCRA - Resource Conservation and Recovery Act

RESRAD - *Res*idual *Rad*ioactivity

Response - Carcinogenic or noncarcinogenic health effect associated with exposure to a compound

RfC - Reference Concentration - An experimentally derived level of a compound in air modified by multiple safety factors of ten. It is the air concentration at which no statistical difference in response is expected to occur for an exposed population. The RfC is a toxicity value for compounds with noncarcinogenic effects via the inhalation route of exposure, and is usually expressed in units of milligrams of compound per cubic meter of air.

RfD - Reference Dose - An experimentally derived level of exposure, modified by multiple safety factors. The RfD is the dose predicted to produce no statistical difference in response for an exposed population. The RfD is a toxicity value for compounds with noncarcinogenic effects via the oral and inhalation routes of exposure, and is expressed in units of milligrams of compound per kilogram of body weight per day.

RME - Reasonable Maximum Exposure

SEIS - Supplemental Environmental Impact Statement

Th - Thorium

Threshold - The level of exposure below which no adverse noncarcinogenic health effects are known or expected to occur.

Total Excess Lifetime Cancer Risk - The sum of all pathway-specific Excess Lifetime Cancer Risks for a given receptor.

Total Hazard Index - The sum of all pathway-specific Hazard Indices for a given receptor.

Uncertainty Factor - An empirically-derived factor that is applied to a NOAEL or LOAEL in order to derive an RfD. Uncertainty factors account for some of the uncertainties associated with extrapolating information in a dose-response study to the general population.

U - Uranium

UCL - Upper Confidence Limit

USEPA - United States Environmental Protection Agency

EXECUTIVE SUMMARY

This report presents the results of a surface soil sampling event, a source determination and background evaluation and Baseline Human Health Risk Assessment (BHHRA) for uranium (U) isotopes along the proposed Saddle Road alignment (State Route 200) bordering Pohakūloa Training Area (PTA). The assessment addresses the public's concern that depleted uranium originating from military operations at PTA may impact the health of those that may be involved in the construction of the proposed alignment as well as those that may use the road in the future. The risk assessment considers both chemical and radiological toxicity from uranium. This document has been prepared in accordance with the provisions of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP).

Site Description

Saddle Road is a narrow, winding, two-lane road with steep grades, sharp curves, poor pavement, and substandard drainage. Parts of the easternmost portion have been widened and repaved by the County of Hawai'i, but until the current effort dating from 1996, no attempt had been made to correct deficiencies in vertical or horizontal curves, which reflected the original path built during World War II. Saddle Road has become increasingly important for access to the U.S. Department of the Army's PTA, Mauna Kea, Mauna Loa, Mauna Kea State Park, outdoor recreation areas used for hunting and gathering, ranch lands, and the communities of Waiki'i Ranch and Kaumana. Its role is increasing as a cross-island transportation route linking East and West Hawai'i for business travel, the transport of goods and services, tourism/recreation, shopping, and to some extent for commuting. Currently, about six miles of the improved Saddle Road have been completed, and another nine-mile section is nearly complete. A roughly five-mile section has been graded and is expected to be complete by the end of 2009, at which time another eight-mile section that is currently being designed and undergoing permit review is expected to begin construction. All of these segments are east of the roughly 12-mile section mauka of Mamalahoa Highway that is the subject of the Supplemental EIS to which this analysis pertains.

Project Background

In August 2007, US Army contractors discovered one intact M101 spotting round during a screening survey of the remote Impact Area at PTA. The recovered fragment consisting of depleted uranium (DU) was nearly completely unoxidized and found lying on a bare rock lava surface. Subsequent surveys uncovered aluminum firing tubes for the spotting round, but no additional spotting rounds themselves. Recently, ten soil samples were collected by the US Army from sites where sediment had collected from past runoff/erosion events around the perimeter of PTA. Radiometric analysis of those samples found only natural U abundances and $^{234}U/^{238}U$ isotopic composition (Rubin 2008). Irrespective, a portion of the proposed Saddle Road alignment is proposed to transverse the Ke'āmuku Parcel, a former Parker Ranch property recently deeded to the U.S. Army, which is downwind during times when the prevailing regional tradewinds are in effect, particularly at night or in the early morning before daytime heating causes a convectional sea breeze that blows from the west across Keamuku towards the saddle. The Hawai'i State Department of Transportation, in consultation with the Saddle Road Task Force (a citizen group appointed by U.S. Senator Daniel K. Inouye to guide development of the project), determined that it would be prudent to examine the presence and risk of depleted uranium to human receptors who may construct or traverse Saddle Road, as part of the Supplemental Environmental Impact Statement (SEIS) being prepared to address a modified route across this property.

Analytical Methods and Results

In June 2008, concentrations of ^{234}U, ^{235}U and ^{238}U isotopes in surface soil along the proposed Saddle Road alignment were collected by AMEC and analyzed via two analytical methods. The first method to evaluate uranium isotope concentrations, Inductively Coupled Plasma Mass Spectrometry (ICP-MS), was utilized to provide precision and low detection limits for the ^{235}U and ^{238}U isotopes. Results for the ICP-MS method verify the presence of ^{238}U, but resulted in non-detects for the ^{234}U and ^{235}U isotopes indicating that they were either not present or below their respective minimum detection limits. The ICP-MS data was considered but not used in the background analysis and risk assessment as the assessments require data input by activity and/or mass concentration. The second analytical method utilized in this study was Alpha Spectrometry. The alpha spectrometry results were expected to provide the greatest precision and lowest detection limit for the ^{234}U isotope. Results of the alpha spectrometry analysis indicate the presence of all three isotopes in site soils. ^{235}U was detected in only one of the five (5) locations sampled. Given that data for all three isotopes were available for the alpha spectrometry method, data obtained from this method comprised the data set utilized for both the background analyses and human health risk assessment.

Background Analysis

Uranium occurs naturally in trace amounts in Hawaiian rocks, soils and waters at or below concentrations of 1 to 3 parts per million (ppm) by weight (Rubin 2008). Uranium may also occur in soils due to anthropogenic action, such as from military use or as a byproduct of nuclear energy generation. Determining the source of any uranium isotopes detected along the proposed Saddle Road alignment was one objective of this study. Two methods were employed to evaluate uranium isotope source. The first method compared site-specific total U mass concentrations to naturally occurring U mass concentrations in Hawai‘i. Total U was determined by summing the isotopic concentrations of ^{234}U, ^{235}U and ^{238}U detected at each of the 5 independent sites along the proposed Saddle Road alignment. Results of this analysis indicate that total uranium along the proposed Saddle Road alignment are at or below levels occurring naturally in native Hawaiian soils. Total U based on alpha spectrometry analyses ranged from 0.4 parts per million (ppm) at location DU003 to 1.3 ppm at DU001. The average at all five locations was 0.8 ppm.

The second method used to determine whether detected U originates from natural or DU sources was the evaluation of isotope abundance. Except in extremely rare circumstances (not found in Hawai‘i), natural U dispersed in rocks and soils have a comparatively greater $^{234}U/^{238}U$ and $^{235}U/^{238}U$ ratio than those originating from DU. Although use of the $^{235}U/^{238}U$ is considered a more precise measurement than the $^{234}U/^{238}U$ ratio in isotopic fingerprinting of U contamination, the utility of the $^{234}U/^{238}U$ ratio is significant when ^{235}U data are not available or when concentrations of the ^{235}U isotope are too low to detect. This is the case here and as such, the $^{234}U/^{238}U$ ratio was used as the second method to fingerprint the U source. The naturally occurring $^{234}U/^{238}U$ ratio in soil has been determined to be in the range of 0.5 to 1.2 (Sansone et al. 2001). $^{234}U/^{238}U$ ratios at the Saddle Road alignment ranged from 0.74 to 1.79, with an average ratio across all five (5) locations of 1.16. Assuming the average ratio across the 5 sites is representative of the proposed alignment; these results indicate that the $^{234}U/^{238}U$ isotopic ratio is within the background range.

Baseline Human Health Risk Assessment

A baseline human health risk assessment (BHHRA) was performed to evaluate the potential risk posed by uranium isotopes detected at the proposed Saddle Road alignment. The alignment was evaluated as a single decision unit represented by five (5) distinct sampling locations. Receptors were assumed to be exposed to the lesser of the maximum concentration of each isotope detected or the 95% UCL of the mean. Risks were evaluated for the following receptors:

- A construction worker scenario assumed to be on site for 8 hours a day for 250 days in 1 year and assumed to contact surface and subsurface soil.

- A recreational user of the road assumed to frequent the Site 350 days a year for 2 hours a day, as child for 6 years and as an adult for 24 years, totaling a 30 year recreational tenure. Recreational receptors were assumed to contact just the surface soil

Potential estimated lifetime cancer risks were calculated using the RESidual RADioactivity (RESRAD) computer code, Version 6.4, developed by Argonne National Laboratory (ANL 2007). Carcinogenic risks were compared to the USEPA regulatory level of concern of 10^{-6} and 10^{-4}. Estimated noncarcinogenic risks posed from the chemical toxicity of Uranium are presented as total site Hazard Indices and were calculated by summing the pathway specific Hazard Quotients. A total Hazard Index of 1 was considered to be the regulatory level of concern.

The results for each receptor are presented below. Of the receptors analyzed, none were found to exceed the most conservative USEPA lifetime cancer risk regulatory level of concern of 10^{-6} or the noncarcinogenic Hazard Index regulatory level of concern of 1.

Construction worker

The Construction Worker scenario is assumed to be on site for 8 hours a day for 250 days in 1 year and contact surface and subsurface soil. The construction worker was found to have a carcinogenic risk of 1E-06, and a noncarcinogenic risk of 4E-03.

Recreational/Commuter

This receptor is a user of the road on a daily basis. The recreational receptor is assumed to frequent the Site 350 days a year for 2 hours a day, as child for 6 years and as an adult for 24 years, totaling a 30 year recreational tenure. Recreational receptors were assumed to contact just the surface soil. The carcinogenic risk associated with this receptor were found to be 3E-07 for the Child Receptor and 9E-07 for the Adult Receptor. These carcinogenic risks can be summed for a total carcinogenic risk of a 1E-06 for the full 30 year tenure. The noncarcinogenic risk was calculated to be 3E-03 for the Child Receptor and 1E-03 for the Adult Receptor.

Lead Analysis

In addition to the Uranium investigation and risk assessment, surface soils at all five (5) sample locations were analyzed for lead. Laboratory results can be found in Appendix A. Results were compared to the USEPA Region 9 residential Preliminary Remediation Goals (PRGs) for lead in soil of 400 mg/kg. The maximum lead concentration detected at any site was 3.3 mg/kg at sampling location DU004. All lead values were well below the screening level criteria and was excluded from further analysis.

Conclusions

Based on the available surface soil data collected in June 2008 at five (5) locations along the proposed alignment, it has been determined that uranium detected at the site originates from natural sources. Potential noncancer health risks from the ingestion, inhalation and dermal contact of soil along the proposed alignment are below USEPA's acceptable risk level of concern. Potential cancer risks from radiological activity of the detected U isotopes are below the most conservative regulatory criteria.

SECTION 1
INTRODUCTION

This report presents the results of a surface soil sampling event, a source determination and background evaluation, and a Baseline Human Health Risk Assessment for uranium (U) isotopes along the proposed Saddle Road alignment (State Route 200) bordering Pohakūloa Training Area (PTA). The assessment addresses the public's concern that depleted uranium originating from military operations at PTA may impact the health of those that may be involved in the construction of the proposed alignment as well as those that may use the road in the future. The risk assessment considers both chemical and radiological toxicity from uranium. This evaluation was prepared for the State of Hawai‘i Department of Transportation, Highways Division and the U.S. Department of Transportation, Federal Highway Administration Central Federal Lands Highway Division.

1.1 General Site Setting

The Site is contained within or directly adjacent to the Ke‘āmuku parcel, a 23,977-acre property (tax map key [TMK]: 3rd Div., 6-7-001:003) purchased in 2006 from Parker Ranch by the U.S. Army as an addition to its Pohakūloa Training Area (PTA) (Figure 1 taken from Geometrician 2007). Although planned for military use, the Army currently allows grazing on the parcel as a fire mitigation measure. The parcel is bordered by the existing Saddle Road, the Waiki‘i Ranch subdivision and nearby homes and farms on the north, by the remainder of PTA on the east, by the Pu‘uanahulu Game Management Area on the south, and by private, undeveloped lands across Māmalahoa Highway on the west (Geometrician 2007).

1.2 Description of Problem

A surface soils assessment, source analysis and baseline human health risk assessment was requested to support a Supplemental Environmental Impact Statement (SEIS) that is being prepared for the Saddle Road extension and realignment, which will eventually bisect a portion of the PTA northwest of MP42 (proposed W-3 route) or possibly south of the W-3 route (proposed W-7 route. Note: W-7 is in the conceptual stage). These two areas (W-3 and W-7) are in proximity to Ke’āmuku on the western side of PTA.

In August, 2007, U.S. Army contractors discovered depleted uranium (DU) fragments at PTA. Although the Army acknowledges that DU material is considered a chemical hazard, the Army maintains that DU does not pose a risk to public health and that insufficient quantities have been detected to pose a risk to human health. Sampling and analytical data for DU are not available in areas where the proposed Saddle Road extension is to be constructed. In the absence of analytical data, the source of U as well as the potential risks to human receptors (construction workers that will be involved in the construction of the Saddle Road extension or occupants of vehicles that may use the road in the future) cannot be determined.

The objective of this study was therefore to gather analytical data of sufficient quality and quantity necessary to support a background source evaluation and human health risk assessment. The background evaluation is designed to determine whether the source of uranium at the site was naturally occurring or if anthropogenic depleted uranium sources also contribute to uranium presence. The human health risk assessment determines the degree of risk, if any, that uranium and poses for construction workers and users/commuters who may use Saddle Road in the future.

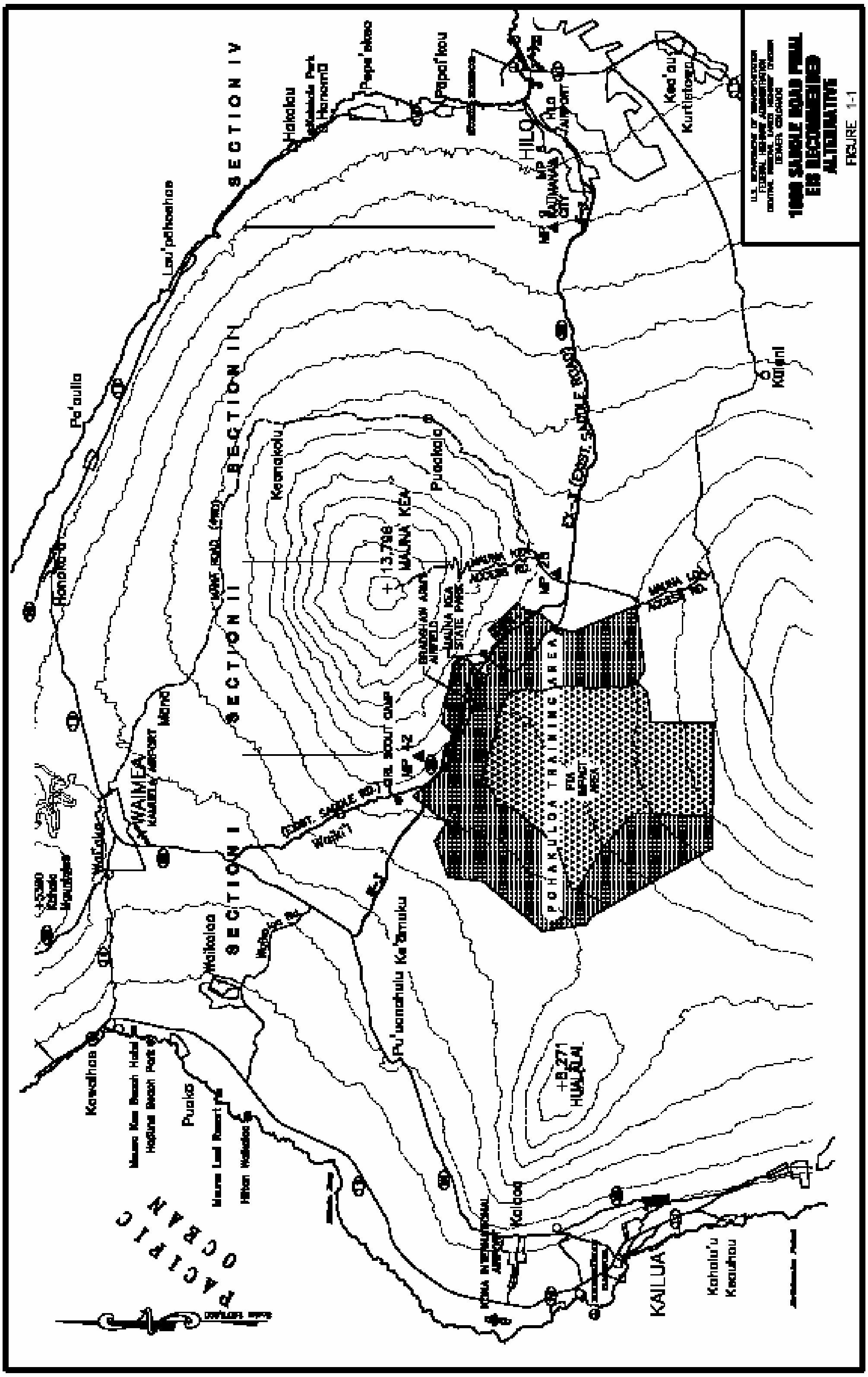

Figure 1: Site Location Map

SECTION 2
SITE DESCRIPTION

This section presents background information relevant to the project including site history, descriptions of geology and soils, hydrogeology, hydrology, and climate.

2.1 Site History

A portion of the proposed Saddle Road alignment is proposed to transverse the Ke'āmuku Parcel, a former Parker Ranch property recently deeded to the U.S. Army, which is downwind from PTA. The Site is currently zoned for agricultural use and it is assumed to have been used for agricultural use throughout most of its recent history. The US Army conducted training at PTA during the mid-1960s using the M101 spotting round of the Davy Crockett Weapon System. The M101 spotting round was a small (20mm) low speed (velocity) projectile that weighed approximately 1 pound. Each round contained approximately one half pound D38 U Alloy (92% DU and 8% molybdenum) (Rubin 2008). This spotting round was designed to mirror the flight characteristics of larger caliber rounds and was fired to identify the correct range and bearing for those larger caliber rounds. These rounds typically broke into large fragments after use.

In August 2007, U.S. Army contractors discovered one intact M101 spotting round during a screening survey of the remote Impact Area at PTA. The recovered fragment consisting of depleted uranium (DU) was nearly completely unoxidized and found lying on a bare rock lava surface. Subsequent surveys uncovered aluminum firing tubes for the spotting round, but no additional spotting rounds themselves. Recently, ten soil samples were collected from sites where sediment had collected from past runoff/erosion events around the perimeter of PTA. Radiometric analysis of those samples found only natural U abundances and $^{234}U/^{238}U$ isotopic composition (Rubin 2008). No sampling has been performed along the proposed alignment.

2.2 Geology and Soils

The Site is situated on late Pleistocene and Holocene lava flows from Mauna Kea covered with volcanic ash deposits (MacDonald 1983; Wolfe 1996). The topography reflects the hummocky character of lava flows. The only major relief features are found in a few gulches and at several 100-foot plus high cinder cones, both of which are concentrated in the northern part of Ke'āmuku. The surface has weathered through time to produce deep, well-drained soils (Geometrician 2007). Soil types anticipated to be encountered during this sampling effort include: Kilohana loamy fine sand, Pu'u Pa extremely stony very fine sandy loam, very stony land, and Kaimū extremely stony peat. In general, these soils exhibit fairly rapid permeability, slow runoff, and slight erosion potential (USDA 1973).

2.3 Hydrogeology

According to Mink and Lau (1990), the area of concern overlies two different aquifers, the Anaehoʻomalu aquifer system (Northwest Mauna Loa aquifer sector) and the Waimea aquifer system (West Mauna Kea aquifer sector). The aquifers are both classified as unconfined, high level aquifers in dike compartments and/or flank lava deposits. They are considered irreplaceable, fresh water aquifers (< 250 milligrams per liter [mg/L] chloride content) with high vulnerability to contamination due to its proximity to the surface. Groundwater from portions of these aquifers is currently used as a drinking water source.

2.4 Hydrology

According to maps in the Atlas of Hawaiʻi, 3rd ed. (Juvik 1998), annual rainfall averages approximately 25 inches in Keʻāmuku overall, being slightly greater at higher elevations and less at lower elevations. Although no perennial streams, lakes, springs, or wetlands are present, the Keʻāmuku property includes a number of ephemeral drainages mapped on U.S. Geological Survey (USGS) maps. These originate on the steep slopes of Mauna Kea and cross the existing Saddle Road at various bridges, culverts and dips in the road. There is a distinct shift in the amount of dissection in the Keʻāmuku property from north to south, as the terrain changes from highly-dissected, older Mauna Kea lava flows with many ephemeral streams in the north to younger, lightly-dissected flows with few ephemeral streams in the south. The very youngest Mauna Kea flows are found on the southern margin of the Keʻāmuku property, where the W-7 alignment is located. South of this are Mauna Loa lava flows, which also lack any stream dissection (Geometrician 2007).

Since there are no perennial stream channels within the Keʻāmuku area, no baseline data on surface water quality are available. All of the drainages within the study corridor ultimately discharge to the ocean or to littoral springs through subsurface flow (Geometrician 2007).

The only baseline water quality data available for Keʻāmuku are from required water sampling of a 2,500-foot deep well that supplies water for the Waikiʻi Ranch subdivision. The well is located within 200 feet of the existing Saddle Road and has been consistently found to meet all of the federal standards for safe drinking water. There is no recorded contamination associated with this well (Geometrician 2007). A second well which goes to a depth of 4,300 feet is also located in Waikiʻi. No further information is provided for this well.

2.5 Climate

The average maximum daily temperature in the Keʻāmuku area varies from about 70 to 80 degrees Fahrenheit, with an average minimum of 60 to 70 degrees. Keʻāmuku on average receives about 25 inches of rainfall annually, with greater totals at higher elevations and less at lower ones, according to maps in the Atlas of Hawaiʻi, 3rd ed. (Juvik 1998). Winds vary between northeast trades funneled through the saddle between Mauna Loa and Mauna Kea and upslope winds generated by heating of the land surface. Light and variable "kona" winds occasionally replace this pattern, most often in winter. According to site data, Morning winds are easterly at 15 to 25 knots (17-1/4 to 28-3/4 mph) and afternoon winds are westerly at 15 to 20 knots (17-1/4 to 23 mph). The entire Keʻāmuku parcel is subject to fog, which above 4,000 feet in elevation is frequent (Geometrician 2007).

SECTION 3
SOIL SAMPLING PROGRAM AND RESULTS

The surface soil sampling program is described in its entirety in Final Sampling and Analysis Plan (SAP), Depleted Uranium Risk Assessment (AMEC 2008). The Final SAP describes sample locations, sampling methods, data quality objectives, data quality indicators, desired levels of detection and analytical laboratory Standard Operating Procedures.

Briefly, in June 2008, five (5) surface soil samples were collected, during a single environmental site investigation along the proposed Saddle Road alignment per the AMEC 2008 protocol (Figure 2). The soil samples were analyzed for Uranium by Alpha Spectrometry by USEPA Method EML A-01-R MOD, by ICP-MS by USEPA method SW846 6020, and for Percent Moisture by USEPA method MCAWW 160.3 MOD. Soil samples were also analyzed for Lead by USEPA method SW846 6020.

Results

Analytical laboratory data sheets are provided in Appendix A. Lead and Uranium were analyzed for and detected in surface soil at the Site. Summary analytical results are provided in Table 1.

The first method to evaluate uranium isotope concentrations, Inductively Coupled Plasma Mass Spectrometry (ICP-MS) was utilized to provide precision and low detection limits for the ^{235}U and ^{238}U isotopes. Results for the ICP-MS method verify the presence of ^{238}U, but resulted in non-detects for the ^{234}U and ^{235}U isotopes indicating that they were either not present or below their respective minimum detection limits. These data were considered but not used in the background analysis and risk assessment because the assessments require data input by activity and/or mass concentration. The second analytical method utilized in this study was Alpha Spectrometry. The alpha spectrometry results were expected to provide the greatest precision and lowest detection limit for the ^{234}U isotope. Results of the alpha spectrometry analysis indicate the presence of all three isotopes in site soils. ^{235}U was detected in only one of the 5 locations sampled. Given that data for all three isotopes were available for the alpha spectrometry method, data obtained from this method comprised the data set utilized for both the background analyses and human health risk assessment.

Table 1: Summary of Analytical Results

		ICP-MS	Radiochemistry				Lead
Sample ID	**Isotope**	**Concentration (ppb)**	**Isotope**	**Result (pCi/g)**	**Mass Concentration (ppb)**	**$^{234}U/^{238}U$ Activity Ratio****	**Concentration (mg/kg)**
DU0001	234	ND	234	**0.436**	**0.0701**	1.184783	3.0
	235	ND	235/236	ND	NA		
	238	**160**	238	**0.368**	**1094.66**		
DU0002	234	ND	234	**0.157**	**0.0252**	1.180451	2.8
	235	ND	235/236	ND	NA		
	238	**130**	238	**0.133**	**395.62**		
DU0003	234	ND	234	**0.118**	**0.019**	1.787879	1.8
	235	ND	235/236	ND	NA		
	238	**64**	238	**0.066 (J)**	**196.32**		
DU0004	234	ND	234	**0.144**	**0.0231**	1.107692	3.3
	235	ND	235/236	ND	NA		
	238	**100**	238	**0.13**	**386.7**		
DU0005	234	ND	234	**0.199**	**0.032**	0.739777	3.0
	235	ND	235/236	ND	NA		
	238	**140**	238	**0.269**	**800.17**		
DU0006*	234	ND	234	**0.123**	**0.0198**	1.008197	2.0
	235	ND	235/236	**0.018 (J)**	**8.29**		
	238	**100**	238	**0.122**	**362.9**		
DU0007*	234	ND	234	**0.127**	**0.0204**	0.824675	2.4
	235	ND	235/236	ND	NA		
	238	**110**	238	**0.154**	**458.09**		

*Samples DU0006 and DU0007 are replicate samples of DU0002.

**Natural 234/238 Uranium Activity Ratio Ranges from 0.5 to 1.2

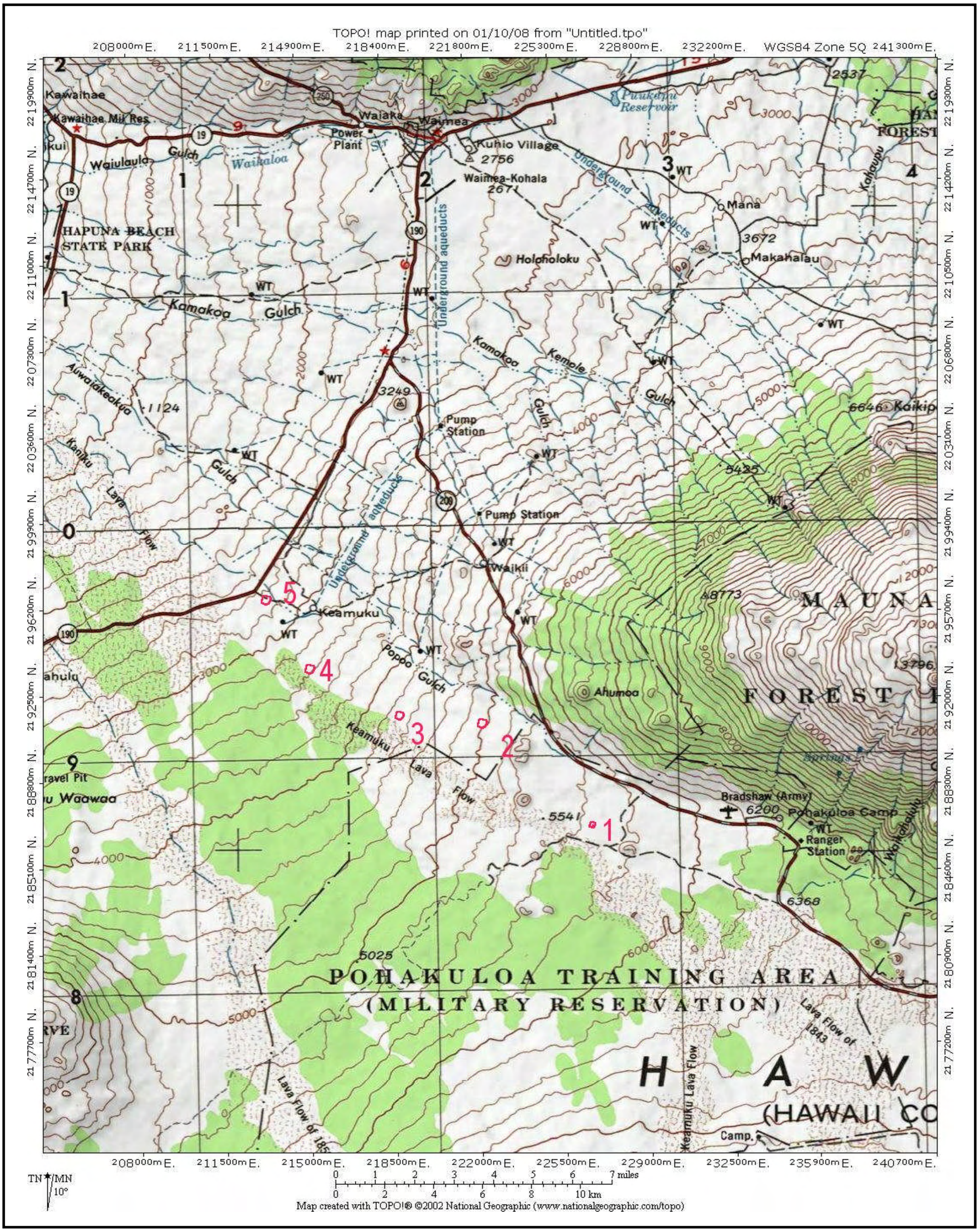

Figure 2: Sample Location Map

SECTION 4
BACKGROUND EVALUATION

Two methods can be utilized to determine whether detected U originates from natural or DU or enriched U (EU) sources. The first method involves a simple comparison of site U concentrations to U concentrations found in typical unimpacted environmental media. The second method compares isotopic abundance (isotope ratios) from site-specific media to the isotope abundance in typical unimpacted environmental media. This study utilized both methods of evaluation. The following sections provide detailed information regarding sources of radiation in the environment, a description of depleted and enriched uranium (DU and EU), and a site-specific source analysis of U at the proposed Saddle Road alignment. Sections 4.1, 4.2, and 4.3 have been taken from Rubin (2008) and are consistent with Sansone et al. (2001), Stegnar and Benedik (2001), and ATSDR (1999).

4.1 Sources of Radiation in the Environment

U is a naturally occurring heavy metal. Rocks, soil, coral, water, air, plants and animals all contain varying amounts of U. Natural U is a mixture of three types (or isotopes) of U, written as ^{234}U, ^{235}U, and ^{238}U. Although these isotopes are different radioactive materials with differing radioactive properties, they are the same chemically. Because U normally occurs at very low concentration in natural materials at Earth's surface, (less than 5 parts per million by weight, ppm), geochemists refer to it as a "trace element". U ores and U rich minerals do not occur in Hawai'i, but U is dispersed at low abundance in normal rock forming minerals.

There are many sources of radioactivity in the environment besides U – some are natural and some are manmade. An environmental assessment typically considers both natural and contaminant sources of radioactivity. There are multiple natural radiation sources that humans come in contact with every day. Those most relevant to this assessment include the chemical elements thorium, radium, radon, potassium and carbon, which have the chemical symbols Th, Ra, Rn, K and C. Th is a heavy metal like U that occurs in rocks and soils at similar concentration to U. Th has one major isotope (^{232}Th) and several minor ones, all of which are radioactive. Ra is a natural radioactive byproduct from the decay of U (and to a much lesser extent, Th). It is in the same chemical family as the element calcium (Ca), and occurs at low levels in many materials at Earth's surface.

Radon is a radioactive gas formed from Ra that continually seeps out of rocks, soils and waters. All of the atoms of U, Th, Ra, and Rn on Earth are radioactive. K and C are slightly different:

these two elements are very common in materials found at Earth's surface, including the human body, yet they are only mildly radioactive because just a small fraction of the K and C atoms are radioactive (these radioactive isotopes are written as ^{40}K and ^{14}C). Both elements are mostly made up of stable (non-radioactive) isotopes; some forms of carbon (such as coal and petroleum) have no ^{14}C in them.

The atomic age brought many new sources of radioactivity into our world. For instance, atmospheric atomic bomb tests in the 20th century produced radioactive isotopes of plutonium, strontium, cesium, and iodine (to name just a few) that were previously extremely rare or not found on Earth. Many of these bomb-test isotopes have since decayed away, although the longest-lived isotopes can still be found at shallow depths in soils, lake sediments, and glaciers around the world. Other modern activities also occasionally release artificial radio-isotopes into the environment, including everything from the nuclear power industry to nuclear medicine to the manufacture and disposal of household smoke detectors. A person exposed to high levels of radioactivity close to the source can suffer numerous possible toxic effects that depend on the type of radioactive material. This is why users of radioactive materials follow strict protocols (based on time, distance, and shielding) to minimize negative impacts on themselves or the general public, and why, for instance, highly radioactive patients undergoing nuclear medicine therapy are kept away from the general public.

4.2 Natural, Depleted, and Enriched Uranium

New forms of U with isotopic compositions that differ greatly from natural U are another development of the atomic age. An industrial process called enrichment is used to concentrate ^{234}U and ^{235}U producing enriched uranium (EU) used for nuclear fuel. The material leftover from the enrichment process is called DU because it has lower concentrations of these two isotopes than natural uranium. DU is thus a modified form of U from which these lighter and more radioactive isotopes have been partially removed, creating a substance that has more ^{238}U than natural U. The resultant change in the isotopic composition makes it possible to distinguish naturally occurring U from enriched and depleted forms.

EU is more radioactive than natural U, with more highly enriched forms being more radioactive than less enriched forms. Depending on the percent enrichment, EU can be used as nuclear fuel for power plants (less enriched, sometimes called "low EU") or atomic weapons (more enriched, sometimes called "high EU"). DU has numerous civilian and military uses that on occasion cause it to be introduced into the environment. Civilian uses include radiation shielding, gyroscopes, and stabilizers in aircraft. Past and present military uses include spotting rounds, munitions and as shielding in armored vehicles.

4.3 U Mass Concentration

Uranium occurs naturally in trace amounts in Hawaiian rocks, soils and waters at or below concentrations of 1 to 3 parts per million (ppm) by weight (Rubin 2008). The sum of the 3 most prevalent isotopes (^{234}U, ^{235}U and ^{238}U) can be used as to estimate total U concentrations. If site-specific U concentrations are significantly greater than representative background U concentrations, one can surmise that additional sources of U exist.

4.4 Isotopic Fingerprinting

The proportions of U isotopes in a substance can be used to determine the source of the U it contains. If environmental U contamination is suspected, isotopic tests can determine if the U came from natural U ore or from non-natural DU or EU. Except in extremely rare cases (not found in Hawai‘i), natural U dispersed in rocks, soils and waters at earth’s surface today have the same $^{235}U/^{238}U$ radioactivity ratio, even if the U concentration (by weight) is different between them. This fact provides a fingerprint of natural U isotopic composition. DU has comparatively less ^{235}U and EU has more, giving this material non-natural $^{235}U/^{238}U$ ratio. There have been slight variations in the ^{235}U depletion level in DU manufactured in different places and times, but normally ^{235}U has been reduced by at least 70% from its natural value. ^{234}U is affected even more by depletion and enrichment than ^{235}U. However, unlike ^{235}U, the amount of ^{234}U in a natural material can vary relative to the amount of ^{238}U due to natural processes, making the $^{234}U/^{238}U$ ratio less precise but still useful for isotopic fingerprinting of U contamination. The reason $^{234}U/^{238}U$ varies in nature and $^{235}U/^{238}U$ does not is that most ^{234}U in a rock has been produced there from decay of ^{238}U and its immediate daughters, causing slight radiation damage to the place in a mineral where it resides. ^{235}U and ^{238}U are not decay products of other isotopes on Earth so there is no radiation damage to their mineral residence sites.

The radiation damage from ^{234}U production increases with the age of the rock, causing that ^{234}U atom to be more easily leached from the rock during rock weathering. The water that does the leaching usually ends up with elevated $^{234}U/^{238}U$ and the rock and soil residues usually have lower ratios, although secondary mineral formation can affect rock and water ratios as well. Recoil of ^{234}U atoms as they are produced can also push “extra” ^{234}U into soil water. The changes in $^{234}U/^{238}U$ from natural processes are usually smaller than the changes caused by the manufacture of DU and EU, so $^{234}U/^{238}U$ is still useful for fingerprinting of U contamination in nature.

Contamination generally results in elevated U concentrations, although if U is leaching from the environment almost as fast as the contaminant is added, the isotopic composition is affected but the overall U concentration may not change as dramatically. If the contamination is from natural U (e.g., some phosphorous fertilizers or U ores) the U concentration will change but the isotopic composition will not. The isotopic composition will change if contamination is from DU or EU. If DU or EU contamination is present, U in environmental samples will be mixtures of natural and contaminant U, with intermediate isotopic composition, except in extremely contaminated cases. Mixing follows predictable trajectories. Laboratory measurements of U concentration and isotopic composition are used to determine the type and amount of contamination.

4.5 Site Specific U Source Identification

Section 4.5.1 describes the site specific analysis of U mass concentration while sections 4.5.2 describes the use of isotopic fingerprinting to determine whether U at the site is from natural or anthropogenic sources.

4.5.1 U Mass Concentration

Uranium occurs naturally in trace amounts in Hawaiian rocks, soils and waters at or below concentrations of 1 to 3 parts per million (ppm) by weight (Rubin 2008). Total U at the site was determined by summing the isotopic concentrations of ^{234}U, ^{235}U and ^{238}U detected at each of the 5 independent sites along the proposed Saddle Road alignment. Results of this analysis indicate that total uranium along the proposed Saddle Road alignment are at or below levels occurring naturally in native Hawaiian soils. Total U based on alpha spectometry analyses ranged from 0.4 parts per million (ppm) at location DU003 to 1.3 ppm at DU001. The average at all five (5) locations was 0.8 ppm.

4.5.2 Isotopic Fingerprinting

The second method used to determine whether detected U originates from natural or DU sources was the evaluation of isotope abundance. Except in extremely rare circumstances (not found in Hawai‘i), natural U dispersed in rocks and soils have a comparatively greater ^{234}U/^{238}U and ^{235}U/^{238}U ratio than those originating from DU. Although use of the ^{235}U/^{238}U is considered a more precise measurement than the ^{234}U/^{238}U ratio in isotopic fingerprinting of U contamination, the utility of the ^{234}U/^{238}U ratio is significant when ^{235}U data are not available or when concentrations of the ^{235}U isotope are too low to detect. This is the case here and as such, the ^{234}U/^{238}U ratio was used as the second method to fingerprint U source. Naturally occurring ^{234}U/^{238}U ratio in soil has been determined to be in the range of 0.5 to 1.2 (Sansone et al. 2001).

$^{234}U/^{238}U$ ratios at the Saddle Road alignment ranged from 0.74 to 1.79, with an average ratio across all five (5) locations of 1.16. Assuming the average ratio across the five (5) sites is representative of the proposed alignment, these results indicate that the $^{234}U/^{238}U$ isotopic ratio is within the background range.

SECTION 5
Baseline Human Health Risk Assessment

This section describes the HHRA processes and methodologies used to identify the hazards associated with potential uranium exposures for identified receptors. Information available regarding depleted uranium use was evaluated, a site characterization plan was formulated and implemented, constituents of potential concern (COPCs) were selected for quantitative risk assessment, receptors identified, and risk quantified. Additionally, a screening level lead assessment was performed to determine potential human health risk from lead detected at the site.

5.1 Hazard Identification

In the Hazard Identification step, analytical data are evaluated and constituents of potential concern (COPC) are selected for quantitative risk assessment. Data have been collected during a single phase of investigation. Samples assessed include on-Site surface soil data only. In this risk assessment, subsurface soil concentrations were assumed to be equal to surface soil concentrations. This assumption was considered conservative (protective of human health) because the mobility of U in soils is considered low and it likely that subsurface soil concentrations would be reduced in comparison to surface soils at the same location (Rubin 2008).

5.1.1 Summary of Available Site Data

Data were collected during a single post-remedial phase of investigation in June 2008. Environmental surface soil samples were collected from 10,000 square foot areas at five (5) distinct locations along the proposed alignment. Sampling locations can be found on Figure 2.

The soil samples were analyzed for Uranium by Alpha Spectrometry by USEPA Method EML A-01-R MOD, by ICP-MS by USEPA method SW846 6020, and for Percent Moisture by USEPA method MCAWW 160.3 MOD. Soil samples were also analyzed for Lead by USEPA method SW846 6020.

5.1.2 Selection of COPCs

Based on the nature of the site, problem and need to address public concerns two chemicals were analyzed and considered for evaluation. They included lead and three U isotopes (^{234}U, ^{235}U and ^{238}U). Other chemicals may be present at the Site but were not included in this assessment.

5.1.3 Analysis of Lead

All five (5) soil sample locations were analyzed for lead. Results of the Analysis can be found in Appendix A. Results were compared to the USEPA Region 9 Preliminary Remediation Goals (PRGs) for lead in soil of 400 mg/kg. Of the five (5) soil sample locations, the maximum detected was 3.3 mg/kg at sampling location DU004 falling well below the PRG. Due to these low levels, lead was excluded from any further additional analysis.

5.1.4 Analysis of Uranium

Five (5) soil samples were analyzed for uranium by both Alpha Spectrometry and Inductively Coupled Plasma Mass Spectrometry (ICP-MS). ICP-MS analysis is generally considered to have the greatest precision and lowest detection limits for detecting the ^{235}U and ^{238}U isotopes. The ICP-MS results provided Non Detects for all the samples for the ^{234}U and ^{235}U isotopes. The highest reading for the ^{238}U isotope was 0.16 mg/kg at sampling location DU001.

Soil samples were also analyzed by Alpha Spectrometry to determine radiological activity. Alpha Spectrometry is considered to have greater precision and lower detection limits for the ^{234}U. The highest detected ^{234}U isotope was 0.436 pCi/g at sampling location DU001. The Alpha Spectrometry also has readings as high as 0.018 for ^{235}U at sampling location DU002, and 0.368 pCi/g for ^{235}U at sampling location DU001. It should be noted though that all ^{235}U results were still below the reporting limit.

Activity determined in the alpha spectrometry analysis was converted to a mass concentration by via the following formula:

$$U_{Total} = \left(\frac{^{234}U}{6{,}250\, pCi/\mu g} \right) + \left(\frac{^{235}U}{2.16\, pCi/\mu g} \right) + \left(\frac{^{238}U}{3.36\, pCi/\mu g} \right)$$

where:

U_{Total} = Total mass concentration of uranium (mg/kg)

^{234}U, ^{235}U, and ^{238}U = Isotopic radioactivity concentration (pCi/g)

Based on conversion above, the highest mass concentration detected using Alpha Spectrometry analysis was 1.095 ppm at sampling location DU001. Because the results from the Alpha Spectrometry analysis provide evaluation of the progeny Uranium, and overall recorded higher activity and resulting mass concentrations, in order to be conservative, these results were used in lieu of ICP-MS results in the BHHRA.

5.2 Dose-Response Assessment

The purpose of the Dose-Response Assessment is to identify both the types of adverse health effects a COPC may potentially cause, as well as the relationship between the amount of COPCs to which receptors may be exposed (dose) and the likelihood of an adverse health effect (response). The USEPA characterizes adverse health effects as either carcinogenic or noncarcinogenic and dose-response relationships are defined for oral and inhalation routes of exposure. The results of the toxicity assessment, when combined with the results of the exposure assessment (Section 5.3), provide an estimate of potential risk.

This section provides dose-response information for COPCs evaluated in the risk assessment for the Site. Section 5.2.1 describes the USEPA approach for developing noncarcinogenic dose-response values. The carcinogenic dose-response relationships developed by USEPA are discussed in Section 5.2.2. Noncarcinogenic and carcinogenic dose-response values used in this risk assessment are presented in Table 2. Dose-response information used in this risk assessment was obtained from the following sources:

- USEPA's Integrated Risk Information System (IRIS) (USEPA 2008);
- Agency for Toxic Substances & Disease Registry's Minimal Risk Levels (MRLs) for Hazardous Substances (ATSDR 2007);
- USEPA Region IX's Preliminary Remediation Goals (USEPA 2004).

5.2.1 Noncarcinogenic Dose-Response

Constituents with known or potential noncarcinogenic effects are assumed to have a dose below which no adverse effect occurs or, conversely, above which an effect may be seen. This dose is called the "threshold dose". In laboratory experiments, this dose is known as the "no observed adverse effects level" (NOAEL). The lowest dose at which an adverse effect is seen is called the lowest observed adverse effects level (LOAEL). By applying uncertainty factors to the NOAEL or the LOAEL, the USEPA (and other regulatory agencies from which toxicity values used in this assessment were acquired) have developed reference doses (RfDs) for chronic exposures to constituents with potential noncarcinogenic effects.

Table 2: Noncarcinogenic and Carcinogenic Dose Response

	Constituent	
	Uranium	
Oral CSF *(mg/kg-d)^-1*	NA	a
Inhalation CSF *(mg/kg-d)^-1*	NA	a
Inhalation URF *(ug/m^3)^-1*	NA	a
Oral TDI/RfD *(mg/kg-d)*	3.00E-03	a
Inhalation TC/RfC *(ug/m^3)*	3.00E-01	b
Inhalation RFDi *(mg/kg/day)*	8.60E-05	c

NA - Not Applicable
(a) U.S. EPA (2008). IRIS.
(b) ATSDR MRLs (2008)
(c) Derived from Inhalation RfC.

Uncertainty factors account for unknowns associated with the dose-response value, such as the effect of using an animal study to derive a human dose-response value, extrapolating from the high doses used in the laboratory experiment to the low doses typically encountered in environmental settings, and evaluating sensitive subpopulations. For constituents with potential noncarcinogenic effects, the RfD provides reasonable certainty that if the specified exposure dose is below the RfD, then no noncarcinogenic health effects are expected to occur even if daily exposure were to occur for a lifetime. RfDs are expressed in terms of milligrams of constituent per kilogram of body weight per day (mg/kg-day). The oral RfD for Uranium is 3E-03 mg/kg-day (IRIS 2008) and is used for oral and dermal routes of exposure. The inhalation RfD used was 8.6E-05 mg/kg-day and was derived from the ATSDR MRL inhalation reference concentration.

5.2.2 Carcinogenic Dose-Response

The underlying assumption of regulatory risk assessment for constituents with known or assumed potential carcinogenic effects is that no threshold dose exists. In other words, it is assumed that a finite level of risk is associated with any dose above zero. For carcinogenic effects, the USEPA uses a two-step evaluation in which the constituent is assigned a weight-of-evidence classification, and then a cancer slope factor (CSF) is calculated.

The weight-of-evidence classification summarizes the evidence about the likelihood of the constituent being a human carcinogen. Group A constituents are classified as human carcinogens, Group B constituents are probable human carcinogens, Group C constituents are possible human carcinogens, Group D constituents are not classifiable as to human carcinogenicity, and, for Group E constituents, there is evidence of noncarcinogenicity for humans.

In the second part of the evaluation, CSFs are calculated for constituents that are known or probable human carcinogens. The USEPA has developed computerized models that extrapolate observed responses at high doses used in animal studies to predicted responses in humans at the low doses encountered in environmental situations. The models developed by the USEPA assume no threshold and use animal or human data to develop an estimate of the carcinogenic potency of a constituent. The USEPA refers to this numerical estimate as the CSF. The computerized models used by USEPA assume that carcinogenic dose-response is linear at low doses.

Uranium itself is not considered to be carcinogenic when inhaled ingested or contacted dermally. However, its radiological activity is assumed to have carcinogenic effects. Potential carcinogenic risks are therefore addressed using Argonne National Laboratory (ANL 2007) RESidual RADioactivity (RESRAD) computer code, Version 6.4. This software was developed in coordination with the Department of Energy (DOE), USEPA, and Nuclear Regulatory Commission (NRC), as a tool for predicting human health risks due to residual radioactivity in soils. The code uses radionuclide CSFs presented in Federal Guidance Report (FGR) No. 13 (USEPA 2002), which incorporate HEAST 2001 risk coefficient values.

RESRAD's computer code was developed to provide site-specific residual radioactive material guidelines as well as radiation dose and excess lifetime cancer risk to a chronic exposure. RESRAD uses a pathway analysis method in which the relation between radionuclide concentrations in soil and the does to a member of a critical population group is expressed as a pathway sum, which is the sum of products of "pathway factors." Pathway factors correspond to pathway segments connecting compartments in the environment between which radionuclides can be transported or radiation emitted. Radiation doses, health risks, soil guidelines and media concentrations are calculated over user-specified time intervals. The source is adjusted over time to account for radioactive decay and ingrowth, leaching, erosion, and mixing. With few exceptions, all RESRAD default parameters were used without site-specific modification. Site-specific exposure factors used in the RESRAD assessment are described in Section 5.5.

5.3 Exposure Assessment

The risk assessment process requires the creation of exposure scenarios to assess the potential for adverse health effects from constituents at or near the Site. While these scenarios represent hypothetical people and activities, they reflect the physical description of the Site and the surrounding residential, industrial and commercial areas, as well as the activities that may typically occur in these areas. Both current and reasonably foreseeable future potential exposures are evaluated.

In this assessment, past and current uses of the subject site were analyzed in order to determine the potential exposure scenarios relevant for the site. The exposure assessment is divided into seven subsections. Section 5.3.1 describes the potential receptors and exposure scenarios selected for evaluation in the risk assessment. Section 5.3.3 presents the potential exposure pathways evaluated for the Site. Section 5.3.4 describes the conceptual site model. Section 5.4 describes the statistical methods used to estimate exposure-point concentrations. Section 5.5 describes exposure factors used in the risk assessment. Absorption adjustment factors are discussed in Section 5.6 and dermal permeability constants are discussed in Section 5.7. Section 5.8 describes the methods used to estimate potential exposure doses.

5.3.1 Potential Exposure Scenarios

In creating potential exposure scenarios for evaluation in the risk assessment, the likelihood of potential exposure to Site-related constituents via many pathways was considered. Some pathways were excluded from further analysis because the route of exposure was physically impossible or highly unlikely given the conditions of the Site. Based on information about land use, topography, and current Site conditions, current and future exposure scenarios were developed for the Site.

5.3.2 Current and Future Exposure Scenarios

As described in Section 1.1 the Site is located in and around the PTA (Figure 1). A general description of the property and an account of its history are provided. Likely current and future exposure scenarios evaluated include adult construction workers, working on the road, and a commuter, who uses the road on a daily basis. Construction workers were assumed to work on the site and excavate a large area for construction for 8 hours a day, 250 days a year for 1 year. Construction workers are expected to be exposed to both surface and subsurface soils, inhalation of soil derived dust, and any external gamma radiation. Recreational users are commuters assumed to contact surficial soils, breath soil derived dust, and are exposed to external radiation for 2 hours a day for 350 days per year for 30 years, 6 as a child and 24 as an adult.

5.3.3 Identification of Potential Exposure Pathways

As described in Risk Assessment Guidance for Superfund: Volume I - Human Health Evaluation Manual (USEPA 1989), four elements must be present in order for a potential human exposure pathway to be complete:

1. a source and mechanism of constituent release to the environment;
2. an environmental transport medium (e.g., soil, water or soil vapor);
3. an exposure point, or point of potential contact with the potentially affected medium; and
4. a receptor (e.g., human) with a route of exposure at the point of contact.

Potential exposure pathways are the mechanisms by which potential receptors may be exposed to constituents. The potential exposure pathways included in this assessment were selected based on the most likely mechanisms of exposure and observations at the Site. The most likely potential exposure pathways at the Site are ingestion of and dermal contact with soil, exposure via inhalation of soil-derived dust, and exposure to external gamma radiation. A Conceptual Site Model summarizing exposure pathways is provided in Figure 3

5.3.4 Conceptual Site Model

The CSM presents potential sources, release mechanisms, transport media, routes of migration through the environment, exposure media, and potential human receptors. The Conceptual Site Model also presents the possible human receptors evaluated in this assessment, and the potential exposure pathways available to these receptors.

5.4 Exposure Point Concentrations

Exposure point concentrations for constituents detected in media at the Site were estimated using all relevant analytical data collected (as representative of current site conditions) from the single site investigation described in Section 3.   As described, samples were collected from the surface soil only.

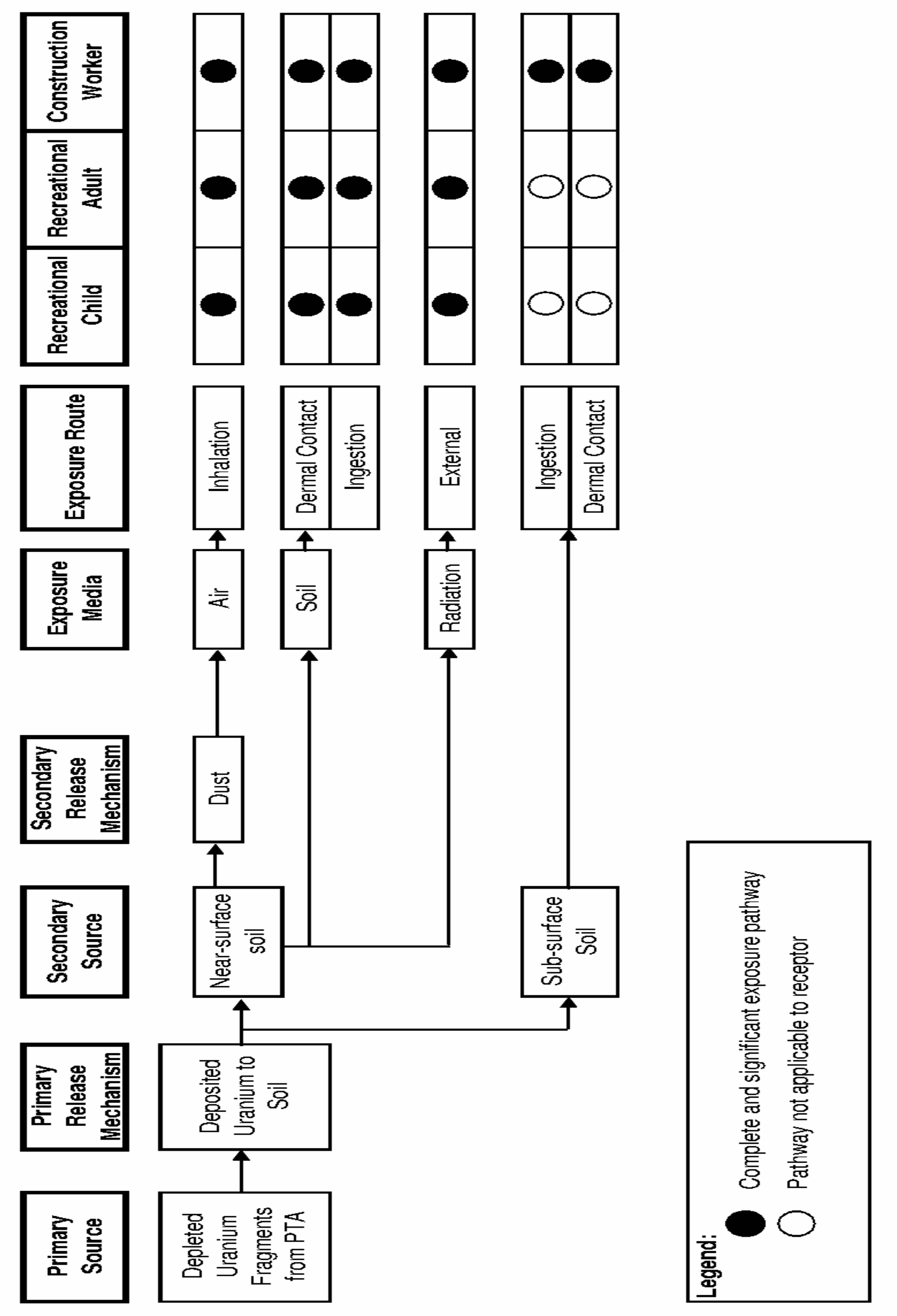

Figure 3: Conceptual Site Model

Surface soil samples were used to estimate exposure point concentrations for direct contact exposure, inhalation of soil derived dust, and external radiation for these scenarios. For direct contact to construction workers, surface soil samples were conservatively used to estimate subsurface soil concentrations assuming the highest concentration of contaminants would be found at the surface as potential contamination was a result of deposition.

In calculating exposure point concentrations, all replicate samples were averaged. Summary statistics (minimum, maximum, mean, standard deviation, frequency of detection, and 95% upper confidence limit on the arithmetic mean concentration [95% UCL]) were calculated for each U isotope detected in soil from the Site. The 95% UCL was calculated using USEPA's ProUCL software Version 4.0 (USEPA 2007). The USEPA has determined that the average concentration of a COPC represents a reasonable estimate of the concentration in an environmental medium that a receptor may potentially contact when that contact occurs at random over an extended period of time. For estimating exposures to COPCs in environmental media, USEPA has proposed various ways of estimating the exposure point concentration to account for the uncertainty due to incomplete sampling and/or analytical data variability. These range from using the maximum concentration when few samples have been collected from a potential exposure area to various methods of estimating a 95% UCL on the mean concentration.

For data with a normal distribution, the 95% UCL of the mean is calculated using the t-distribution (Student's t-statistic) in the following algorithm:

$$95\% \quad UCL\ (ppm) = x + \frac{s\ t}{\sqrt{n}}$$

where:

x = arithmetic mean concentration (mg/Kg)

s = standard deviation (mg/Kg)

t = Student's *t* distribution statistic

n = number of data points

For data that are log-normally distributed, USEPA recommends the use of the Land method based on the *H*-statistic for determining the 95% UCL of the mean. The algorithm supplied by USEPA for determining the 95% UCL when data are log-normally distributed is:

$$UCL = e^{\left(x + 0.5s^2 + \frac{sH}{\sqrt{n-1}}\right)}$$

where:

x = arithmetic mean concentration (mg/Kg)

s = standard deviation of log transformed data (mg/Kg)

H = Land distribution statistic

n = number of data points

The H-statistic frequently estimates a 95% UCL of the mean that is greater than the maximum concentration observed at a site when the input data are highly variable (i.e., when the relative standard deviation (RSD) exceeds 100%) and, in some cases, estimates concentrations in excess of one part per part. In these cases, the biased estimates of the "average" concentration are likely reflecting datasets that include many samples collected from areas of higher concentrations and fewer samples collected from areas of lower concentrations. This is the case at most sites where sampling efforts have intentionally been focused in areas of expected contamination and their immediate vicinity, but often not in other portions of a site where concentrations are likely to be lower but where potential exposure may occur at equal or even higher frequency. In this case, the data distribution is controlled by the sampling strategy rather than any distribution in nature. That is, areas of high concentration are more frequently represented than areas of lower concentration, even though both may be equally likely to represent a contact point by a hypothetical receptor. Therefore, the estimated exposure point concentration is biased high and does not represent the actual concentration that the receptor "encounters." The "distribution" observed in the biased dataset similarly does not represent the actual distribution of concentrations across the entire site or exposure area. Furthermore, a large part of the error in applying the H statistic lies in the inability of the algorithm to properly calculate the arithmetic mean when the data are not lognormally distributed.

If the data were non-parametric in distribution (i.e., not normal or lognormal in distribution), the data were further evaluated to determine if the sample results represent highly skewed distributions. For datasets that are neither normal nor lognormal or are highly skewed in distribution, the 95% UCL on the mean was based on the higher of the values from the percentile or standard bootstrapping techniques. In cases where sufficient data to calculate a 95% UCL of the mean were not available, the exposure point concentration was based on the maximum detected concentration.

Appendix A presents the analytical results and summary statistics for each constituent detected in soil samples collected from the site. The 95% UCL was calculated for each isotope from the Alpha Spectrometry analysis. For ^{235}U and ^{238}U the calculated UCL exceeded the maximum value detected so the maximum detected activity was used as the EPC. For ^{234}U, the data was found to be normally distributed and the EPC was based on the calculated t-statistic. Table 3 provides a summary of estimated exposure point concentrations used in the quantitative risk assessment for each sampling location.

Table 3: Exposure Point Concentrations

	EPC for Soil (mg/kg)	EPCs for Soil (pCi/g)			EPC Mass Conversion (mg/kg)		
Chemical	**Total**	**234 U**	**235 U**	**238 U**	**234 U**	**235 U**	**238 U**
Uranium	0.925	0.436	0.006	0.310	0.0001	0.0028	0.9226
		Mass Percentage				Activity Ratio	
		234 U	**235 U**	**238 U**		**234/238**	**235/238**
		7.54E-05	3.00E-03	9.97E-01		1.41E+00	1.94E-02

5.5 Exposure Factors

The exposure factors used in the quantitative risk assessment are summarized in Table 4.

Individual exposure factors are discussed below.

5.5.1 Body Weight

Body weights were derived from USEPA Exposure Factors Handbook (USEPA 1997) by averaging the male and female data for mean body weight. The average adult body weight used in this risk assessment was 71.8 kg. The average child body weight used in this risk assessment was 16 kg.

5.5.2 Duration of Exposure

Exposure durations were taken from USEPA Exposure Factors Handbook (USEPA 1997). It is important to note that USEPA (1997) states that the average occupation job tenure is 6.6 years, which contrasts significantly from the standard default worker duration of 25 years. This value is the upper bound occupation job tenure, which is consistent with a Reasonable Maximum Exposure (RME) scenario.

Table 4: Exposure Factors

	Parameter (units)	Soil/ Deposited Dust	Rationale
Child – Recreational	Exposure Time - vapor (hr/d)	2	Activity Specific Value
	Exposure Time - dust (hr/d)	2	Activity Specific Value
	Exposure Time - dermal-water (hr/d)	NA	Activity Specific Value
	Exposure Frequency - dermal (event/d)	1	AMEC Assumption
	Exposure Frequency (d/y)	52	Activity Specific Value
	Exposure Duration (y)	6	Activity Specific Value
	Body Weight (kg)	16	USEPA - Exposure Factors (1997)
	Averaging Period - Cancer (d)	25550	USEPA - 70 years
	Averaging Period - Noncancer (d)	2190	Based on Exposure Duration
	Ingestion Rate (mg/d) or (L/d)	200	USEPA - Exposure Factors (1997)
	Inhalation Rate (m^3/hr)	0.417	USEPA - Exposure Factors (1997)
	Fraction from Site (unitless)	1	Activity Specific Value
	Surface Area Exposed (cm^2/d)	2800	USEPA - Region IX PRG
	Soil-to-Skin Adherence Factor (mg/cm^2)	0.29	USEPA - Exposure Factors (1997)
Adult – Recreational	Exposure Time - vapor (hr/d)	2	Activity Specific Value
	Exposure Time - dust (hr/d)	2	Activity Specific Value
	Exposure Time - dermal-water (hr/d)	NA	Activity Specific Value
	Exposure Frequency - dermal (event/d)	1	AMEC Assumption
	Exposure Frequency (d/y)	52	Activity Specific Value
	Exposure Duration (y)	24	Activity Specific Value
	Body Weight (kg)	71.8	USEPA - Exposure Factors (1997)
	Averaging Period - Cancer (d)	25550	USEPA - 70 years
	Averaging Period - Noncancer (d)	8760	Based on Exposure Duration
	Ingestion Rate (mg/d) or (L/d)	100	USEPA - Exposure Factors (1997)
	Inhalation Rate (m^3/hr)	0.833	USEPA - Exposure Factors (1997)
	Fraction from Site (unitless)	1	Activity Specific Value
	Surface Area Exposed (cm^2/d)	5700	USEPA - Region IX PRG
	Soil-to-Skin Adherence Factor (mg/cm^2)	0.29	USEPA - Exposure Factors (1997)
Construction Worker	Exposure Time - vapor (hr/d)	8	Activity Specific Value
	Exposure Time - dust (hr/d)	8	Activity Specific Value
	Exposure Time - dermal-water (hr/d)	NA	Activity Specific Value
	Exposure Frequency - dermal (event/d)	1	AMEC Assumption
	Exposure Frequency (d/y)	250	Activity Specific Value
	Exposure Duration (y)	1	Activity Specific Value
	Body Weight (kg)	71.8	USEPA - Exposure Factors (1997)
	Averaging Period - Cancer (d)	25550	USEPA - 70 years
	Averaging Period - Noncancer (d)	365	Based on Exposure Duration
	Ingestion Rate (mg/d) or (L/d)	330	USEPA - Exposure Factors (1997)
	Inhalation Rate (m^3/hr)	0.833	USEPA - Exposure Factors (1997)
	Fraction from Site (unitless)	1	Activity Specific Value
	Surface Area Exposed (cm^2/d)	3300	USEPA - Region IX PRG
	Soil-to-Skin Adherence Factor (mg/cm^2)	0.29	USEPA - Exposure Factors (1997)

The construction worker scenario assumes an exposure duration for a single year. For the recreational user scenario, it is assumed that a visitor would be exposed to the environmental media for multiple years. The recreational scenario is split, assuming 6 years as a child and 24 years as an adult totaling a 30-year tenure.

5.5.3 Exposure Frequency

The exposure frequency for the on-site worker is a standard Human Health Evaluation Manual: Supplemental Guidance: *Standard Default Exposure Factors* (USEPA 1991a) and Exposure Factors Handbook (USEPA 1997). The Construction worker it is assumed a 250 day exposure frequency for the year they are on site. For the recreational scenario, an exposure frequency of 350 days per year is assumed.

5.5.4 Amount of Soil and Sediment Ingested

In the interest of health protectiveness, AMEC has assumed that the typical adult soil ingestion rate for all workers to be 330 mg/day, recreational adults to be 100 mg/day, and 200 mg/day for recreational children.

5.5.5 Body Surface Area Exposed to Soil/Groundwater

USEPA Region 9 PRG Guidance for Dermal Exposure Pathway (2004) recommends that the skin surface area for recreational adults be set as 5,700 cm^2. This guidance also recommends a surface area for contact for recreational children of 2,900 cm^2 and a surface area for construction workers of 3,300 cm^2.

5.5.6 Lifetime

For carcinogenic risk assessment, the lifetime average daily dose must be calculated. Based on recent studies, the Exposure Factors Handbook (USEPA 1997) recommends that risk assessors use the default value of 70 years.

5.5.7 Soil Adherence Rate

The mean adherence value from USEPA (1997) (0.29 mg/cm^2) is assumed in this risk assessment.

5.6 Relative Absorption Factors

To estimate the potential risk to human health that may be posed by the presence of COPC in soil, it is necessary first to estimate the potential exposure dose of each COPC. The potential exposure dose is similar to the administered dose or applied dose in a laboratory experiment. The animal-derived cancer slope factors (CSFs) and reference doses (RfDs) used in quantitative risk assessment are based on applied doses in most cases. However, the efficiency of COPC absorption via a particular route and from a particular matrix (e.g., soil, water) at the Site may differ from the absorption efficiency for the exposure route and matrix used in the experimental study that serves as the basis for the CSF or RfD. As recommended by USEPA (1989), Relative Absorption Factors (RAFs) for Site-related COPCs have been derived and used in the calculation of potential exposure doses presented above.

RAFs allow risk assessors to make appropriate adjustments if the efficiency of absorption is known to or expected to differ because of physiological effects and/or matrix or vehicle effects. RAFs can be less than one or greater than one, depending on the COPC and potential routes of exposure at a site.

When RfDs and CSFs are based on administered doses, the RAF is calculated as the ratio of the estimated absorption for the site-specific medium and route of potential exposure, to the known or estimated absorption for the laboratory study from which the RfD or CSF was derived. When absorption from the site-specific exposure is assumed to be the same as absorption in the laboratory study, then the RAF is 1.0. This assessment conservatively assumes absorption from all pathways (oral, inhalation and dermal) are equal to the oral absorption from the toxicity study in which the RFD was derived. All RAFs in this assessment were therefore conservatively set at 1.0 including the RAF for the dermal pathway. This almost certainly overestimates absorption and risk. It should also be noted that the Health Effects Assessment Summary Tables (HEAST) - Radionuclides Table (2001) provides a Gastrointestinal (GI) absorption fraction for Uranium of .02. This GI absorption factor represents the fraction of the radionuclide that may be absorbed from the gastrointestinal (GI) tract into blood following an oral intake.

5.7 Method to Estimate Average Daily Dose

Reasonable maximum exposure (RME) scenarios are evaluated in this risk assessment. Conservative exposure assumptions are used to construct a reasonable maximum exposure scenario. Most individuals will not be subject to all the conditions that comprise the RME scenario. Individuals who do not meet all conditions in the RME scenario have lower potential exposures to constituents, and therefore, lower potential risks associated with those exposures.

The Chronic Average Daily Dose (CADD) is an estimate of a receptor's potential daily intake from exposure to constituents with potential noncarcinogenic effects. Note that Average Daily Dose is a term used in risk assessment and does not represent a true average because the assumptions used to derive it do not represent "averages". According to USEPA (1989), the exposure dose should be calculated by averaging over the period of time for which the receptor is assumed to be exposed. The CADD for each constituent via each route of exposure is compared to the RfD for that constituent to estimate the potential hazard index due to exposure to that constituent via that route of exposure. Hazard indices are presented and discussed in Section 5.1

For constituents with potential carcinogenic effects, the Lifetime Average Daily Dose (LADD) is an estimate of potential daily intake over the course of a lifetime. The LADD was not calculated in this assessment as it was assumed that there presently exists no carcinogenic effects from the chemical exposure to Uranium. Carcinogenic risks in this assessment were based on the radiological effects associated with the COPC.

The equations for estimating a receptor's potential chronic average daily dose and the exposure parameters used are discussed in the following paragraphs. The calculations for all receptors evaluated in this risk assessment are presented in Appendix B (Risk Characterization Spreadsheets).

Ingestion & Dermal Contact with Soil & Sediment

$$\text{ADD (mg/kg - day)} = \frac{C \times [(IR \times FI \times RAF_o) + (SA \times AF \times FA \times RAF_d \times EFD)] \times EF \times ED \times CF}{BW \times AT}$$

where:

ADD = Average Daily Dose (mg/kg-day)

C = Chemical Concentration (mg/kg)

IR = Ingestion Rate (mg/day)

FI = Fraction Ingested from Site (unitless)

RAF_o = Relative Absorption Factor (Oral-Soil) (unitless)

SA = Skin Surface Area (cm2)

AF = Adherence Factor (mg/cm2/event)

FA = Fraction Absorbed from Site (unitless)

RAF_d = Relative Absorption Factor (Dermal-Soil) (unitless)

EFD = Exposure Frequency - Dermal (event/day)

EF = Exposure Frequency (days/year)

ED = Exposure Duration (years)

CF = Conversion factor (kg/mg)

BW = Body Weight (kg)

AT = Averaging Time (days) (ED x 365 days/yr, noncancer) (75 yr. x 365 days/yr, cancer)

Inhalation of Soil Derived Dust

$$ADD\,(mg/kg\text{ - }day) = \frac{C_{dust} \times IR \times RAF_i \times ET \times EF \times ED}{AT \times BW}$$

where :

ADD = Average Daily Dose (mg/kg-day)

C_{dust} = Chemical Concentration (mg/kg)

IR = Ingestion Rate (mg/day)

RAF_i = Relative Absorption Factor (Inhalation) (unitless)

ET = Exposure Time - dust (hr/d)

EF = Exposure Frequency (days/year)

ED = Exposure Duration (years)

BW = Body Weight (kg)

AT = Averaging Time (days) (ED x 365 days/yr, noncancer) (75 yr. x 365 days/yr, cancer)

SECTION 6
RISK CHARACTERIZATION

Risk characterization is the step in the risk assessment process that combines the results of the exposure assessment and the toxicity assessment for each COPC to estimate the potential for carcinogenic and noncarcinogenic human health effects from chronic exposure to that constituent. This section summarizes the results of the risk characterization.

6.1 Noncarcinogenic Risk Assessment

The noncarcinogenic risk assessment for Uranium is generally characterized by combining exposure assumptions and toxicity data to derive Hazard Quotients (HQs) or Hazard Indices (HI). Noncarcinogenic health effects are estimated by comparing the Chronic Average Daily Dose (CADD) for each constituent with the Reference Dose for that constituent. The resulting ratio, which is unitless, is known as the Hazard Quotient (HQ) for that constituent. The HQ is calculated using the following formula:

Hazard Quotient

$A = B \div C$

where:

A = Hazard Quotient (unitless);

B = Chronic Average Daily Dose (mg/kg-day); and

C = Reference Dose (mg/kg-day).

When the Hazard Quotient for a given constituent and pathway does not exceed 1, the Reference Dose has not been exceeded, and no adverse noncarcinogenic health effects are expected to occur as a result of exposure to that constituent via that pathway. The HQs for each constituent are summed to yield the HI for that pathway. A Total HI is then calculated for each exposure medium by summing the pathway-specific HIs. A Total HI that does not exceed 1 indicates that no adverse noncarcinogenic health effects are expected to occur as a result of that receptor's potential exposure to the environmental medium evaluated.

Hazard Indices associated with each receptor are presented below. Summary data is provided in Table 5.

Table 5
Summary of Potential Hazard Indices

	Hazard Index		
Compound	*Child Recreational*	*Adult Recreational*	*Construction Worker*
Uranium	**3.E-03**	**1.E-03**	**4.E-03**

Construction Worker

The Construction Worker scenario assumed that the worker is on site for 8 hours a day for 250 days in 1 year and assumed to contact surface and subsurface soil. The construction worker was found to have a noncarcinogenic HI of 4E-03, well below the USEPA accepted criteria of 1.

Recreational/Commuter

This receptor is a user of the road on a daily basis. The recreational receptor is assumed to frequent the Site 350 days a year for 2 hours a day, as child for 6 years and as an adult for 24 years, totaling a 30 year recreational tenure. Recreational receptors were assumed to contact just the surface soil. The noncarcinogenic risk for this receptor was calculated to be 3E-03 for the Child Receptor and 1E-03 for the Adult Receptor. The higher of the two noncarcinogenic calculated risk is used to estimate the risk for the recreational/commuter receptor. Therefore the noncarcinogenic risk for the full 30 year tenure would be as a child at 3E-03, well below the USEPA accepted criteria of 1.

6.2 Carcinogenic Risk

U is not considered to be carcinogenic. However, the radiological activity of its isotopes and daughter products is considered potentially cancer causing. The RESidual RADioactivity (RESRAD) computer code, Version 6.4 (ANL 2007), was used to estimate the radiological dose and total PELCR for both potential receptors. RESRAD was developed by ANL, in conjunction with the Department of Energy (DOE), USEPA and the Nuclear Regulatory Commission (NRC) as a tool for predicting human health risks due to radioactivity in soils. The code uses radionuclide CSFs presented in Federal Guidance Report (FGR) No. 13 (USEPA 2002), which incorporates HEAST 2001 risk coefficient values.

To determine the dose and total excess cancer risk per unit concentration of U, the EPC in pCi/g was used as the source term for each uranium isotope. Where available, site specific data was incorporated into the model. Site specific parameters include the following:

Pathways	– External Gamma, Inhalation, and Soil Ingestion
Cover/Hydrology	– Windspeed was adjusted to a site specific value of 9.163 m/s (20.5 mph)
	– Precipitation was adjusted to a site specific value of 0.635 m/year
Occupancy	– Inhalation rate adjusted to be receptor dependent, 0.833 m^3 per hour for adults and construction workers, and 0.417 m^3 for children.
	– Period of exposure adjusted to be site and receptor specific, 350 days per year for children/adults, and 250 days per year for the worker
	– Exposure duration adjusted to 6 years for children, 24 for adults, and 25 for the worker
	– Outdoor time fraction adjusted to 1, assuming that all exposure would be outdoors

Where site-specific parameters were not available, the RESRAD default parameters were used as model input values. Results from the RESRAD analysis can be found in Appendix C.

In evaluating dose and risk due to the external gamma pathway, it was assumed that all receptors received their exposure while outdoors. For each receptor, the maximum dose-to-source ratios and risk-to-source ratios over a period of 1,000 years were obtained from the corresponding RESRAD dose and health risk output report. Risks from each isotope and their progeny were summed to obtain the total risk for each receptor.

Construction Worker

The Construction Worker scenario was assumed to be on site for 8 hours a day for 250 days in 1 year and assumed to contact surface and subsurface soil. Carcinogenic risk for the construction worker was 1E-06.

Recreational/Commuter

This receptor is a user of the road on a daily basis. The recreational receptor is assumed to use the proposed alignment 350 days a year for 2 hours a day, as child for 6 years and as an adult for 24 years, totaling a 30 year recreational tenure. Recreational receptors were assumed to contact surface soil only. The carcinogenic risk associated with this receptor was found to be 3E-07 for the Child Receptor and 9E-07 for the Adult Receptor. These carcinogenic risks can be summed for a total carcinogenic risk of a 1E-06 for the full 30-year tenure.

A summary of results from the RESRAD analysis can be found on Table 6. A final summary of both the chemical and radiological risk assessment can be found on Table 7.

Table 6: Summary of RESRAD Analysis

		Ac-227	Pa-231	Pb-210	Ra-226	Th-230	U-234	U-235	U-238	Total
Construction Worker	*Ground*	1.14E-11	5.01E-12	2.91E-15	3.44E-11	9.44E-13	2.57E-09	7.53E-08	8.06E-07	9.E-07
	Inhalation	1.01E-14	1.69E-14	1.29E-16	7.06E-16	2.37E-13	1.71E-09	2.11E-11	1.03E-09	3.E-09
	Soil	4.41E-13	7.11E-13	2.05E-13	1.83E-13	1.18E-11	8.34E-08	1.17E-09	7.49E-08	2.E-07
	Total Excess Lifetime Cancer Risk	1.18E-11	5.74E-12	2.08E-13	3.46E-11	1.30E-11	8.77E-08	7.65E-08	8.82E-07	**1.E-06**
Child Recreational	*Ground*	1.90E-13	2.98E-13	1.10E-17	4.85E-13	5.52E-14	6.31E-10	1.85E-08	1.98E-07	2.E-07
	Inhalation	3.55E-16	2.10E-15	1.02E-18	2.10E-17	2.91E-14	8.80E-10	1.09E-11	5.32E-10	1.E-09
	Soil	6.25E-15	3.58E-14	6.59E-16	2.19E-15	5.86E-13	1.74E-08	2.44E-10	1.56E-08	3.E-08
	Total Excess Lifetime Cancer Risk	1.97E-13	3.35E-13	6.71E-16	4.88E-13	6.70E-13	1.89E-08	1.87E-08	2.14E-07	**3.E-07**
Adult Recreational	*Ground*	1.02E-11	4.63E-12	2.49E-15	3.05E-11	8.71E-13	2.47E-09	7.23E-08	7.75E-07	8.E-07
	Inhalation	3.80E-14	6.54E-14	4.62E-16	2.63E-15	9.19E-13	6.89E-09	8.53E-11	4.17E-09	1.E-08
	Soil	1.67E-13	2.79E-13	7.43E-14	6.87E-14	4.62E-12	3.40E-08	4.79E-10	3.05E-08	7.E-08
	Total Excess Lifetime Cancer Risk	1.04E-11	4.97E-12	7.73E-14	3.05E-11	6.41E-12	4.34E-08	7.29E-08	8.10E-07	**9.E-07**

Table 7: Final Summary

Excess Lifetime Cancer Risk				*Hazard Index*		
Construction Worker	*Recreational Child*	*Recreational Adult*	*Total Recreational Scenario*	*Construction Worker*	*Recreational Child*	*Recreational Adult*
1.E-06	**3.E-07**	**9.E-07**	**1.E-06**	**4.E-03**	**3.E-03**	**1.E-03**

SECTION 7
UNCERTAINTY ANALYSIS

Within any of the four steps of the risk assessment process, assumptions must be made due to a lack of absolute scientific knowledge. Some of the assumptions are supported by considerable scientific evidence, while others have less support. Every assumption introduces some degree of uncertainty into the risk assessment process. Conservative assumptions are made throughout the risk assessment to ensure that public health is protected. Therefore, when all of the assumptions are combined, it is much more likely that actual risks, if any, are overestimated rather than underestimated.

The assumptions that introduce the greatest amount of uncertainty in this risk assessment are discussed in this section. They are discussed in general terms, because, for most of the assumptions, there is not enough information to assign a numerical value that can be factored into the calculation of risk.

7.1 Hazard Identification

During the Hazard Identification step, media and constituents of concern are selected for inclusion in the quantitative risk assessment. In this assessment only lead and U were selected as COPCs. Uncertainty may be introduced due to this decision as additional chemicals may be present, but were not evaluated. Additionally, the analytical methods used to determine the concentration of lead or U may introduce significant uncertainty into the risk assessment process. To reduce laboratory method uncertainty, samples were analyzed by two independent methods. They included ICP-MS and Alpha Spectrometry. ICP-MS was theoretically more precise and provided lower detection limits for ^{235}U and ^{238}U isotopes. Alpha Spectrometry was theoretically more precise and provided lower detection limits for ^{234}U. The results indicate that ICP-MS was not the more sensitive method for any isotope, and the differences observed between methods provides some uncertainty as to the validity of our results. To address this uncertainty, this assessment utilized the alpha spectrometry results which overall provided more detailed results as well as higher activity and resulting mass concentrations. Using the higher results may potentially overestimate the actual risk.

7.2 Dose-Response Assessment

Dose-response values are usually based on limited toxicological data. For this reason, a margin of safety is built into estimates of both carcinogenic and noncarcinogenic risk, and actual risks are lower than those estimated. The two major areas of uncertainty introduced in the dose-response assessment are: (1) animal to human extrapolation; and (2) high to low dose extrapolation. These are discussed below.

Human dose-response values are often extrapolated, or estimated, using the results of animal studies. Extrapolation from animals to humans introduces a great deal of uncertainty in the risk assessment because in most instances, it is not known how differently a human may react to the constituent compared to the animal species used to test the constituent. The procedures used to extrapolate from animals to humans involve conservative assumptions and incorporate several uncertainty factors that overestimate the adverse effects associated with a specific dose. As a result, overestimation of the potential for adverse effects to humans is more likely than underestimation.

Predicting potential health effects from the exposure to media on-Site requires the use of models to extrapolate the observed health effects from the high doses used in laboratory studies to the anticipated human health effects from low doses experienced in the environment. The models contain conservative assumptions to account for the large degree of uncertainty associated with this extrapolation (especially for potential carcinogens in the radiological risk assessment) and therefore, tend to be more likely to overestimate than underestimate the risks.

This risk assessment also utilized a conservative set of assumptions when evaluating the bioavailable fraction of COPCs available for absorption by the human body. Relative absorption factors (RAFs) estimate the amount a chemical that is absorbed by the body through different routes of exposure. As very little literature was available on the bioaccessible fraction from Uranium, AMEC used default ingestion, dermal and inhalation absorption fractions of 1, meaning the absorption in the animal study used to derive the toxicity value is identical to that in humans. More realistic bioavailable fractions for these pathways could be derived and would most likely reduce the estimate risk derived in this assessment.

7.3 Exposure Assessment

During the exposure assessment, average daily doses of COPCs to which receptors are potentially exposed are estimated, which involves assumptions about how often exposure occurs. Such assumptions include location, accessibility, and use of an area. With this in mind, the receptor, or person who may potentially be exposed, and the location of exposure, were both defined for this risk assessment. The locations where certain activities were assumed to take place have been purposely selected to be consistent with the use of the Site.

The potential intake rates and exposure frequencies and durations assumed in the risk assessment were considered to be conservative. For example, a potential recreational scenario was assumed to be present at the Site in which a person may be present for 2 hours per day, 350 days per year for 6 years as a child and another 24 as an adult. Such assumptions almost certainly overestimate actual exposures. If more realistic and reasonable potential exposure assumptions had been employed in the risk assessment, the estimated risks would have been lower, perhaps substantially lower. The construction worker scenario assumed an 8-hour workday, 250 days per year, for 1 year.

Exposure point concentrations are estimated values of what is a Reasonable Maximum Exposure across the entire site. Given that these are estimates, a significant amount of uncertainty can be introduced into the assessment. For the soil pathways, the surface soil was assumed to be equivalent to the subsurface soil. This assumes that all Uranium is evenly distributed to depth in the contaminated zone. This could potentially overestimate any exposure to subsurface soils assuming the highest concentrations would be at the surface due to deposition.

Exposure Point Concentrations were also taken from either the calculated using a 95% UCL or the maximum detected activity between the five samples. With very few samples, the variability was high, and in most cases resulted in the EPC being taken from at or near the maximum activity detected. This more than likely overestimated actual site concentrations but, as the site was evaluated as a single decision unit, using statistical analysis to generalize the actual concentrations across the site could possibly overestimate or underestimate the calculated risk.

Additional uncertainty is also introduced by assuming non-detect laboratory results as present as zero. This assumption was based on the very limited and low concentrations detected across the site. Extensive analysis was performed on the sample results before making this assumption. Using half detection limits as a surrogate detection to calculate Exposure Point Concentrations resulted in unrealistic data results especially in the ICP-MS analysis. As there is no effective way to determine actual concentrations of contaminants below the reporting limit of the laboratory, this may potentially underestimate the concentration of contaminants.

Other exposure factors including inhalation rate, ingestion rate, soil adherence factor and body weight were all based on recommendation from the EPA Exposure Factors Handbook (1997), which as closely represent actual site values as reasonably available.

7.4 Risk Characterization

The risk of adverse human health effects depends on estimated levels of exposure and on dose-response relationships. Once exposure to, and risk from, each of the selected constituents is calculated, the total risk posed by exposure to Site-related COPCs is determined by combining the health risk contributed by each constituent. Where COPCs do not interact, do not affect the same target organ or do not have the same mechanism of action, summing the risks for multiple COPCs results in an overestimate of risk posed by the Site. Because U and lead were assessed separately, little uncertainty is added in this phase of the assessment.

SECTION 8
CONCLUSIONS

This study has assessed the potential human health risks associated with Uranium and Lead exposures from surface soils at the proposed Saddle road alignment. Lead concentrations in all samples were well below the USEPA Region IX residential PRG of 400 parts per million, with the maximum lead concentration detected at any location of 3.3 mg/kg at sampling location DU004.

Included in this study was a uranium background level assessment to assess whether onsite uranium was from natural or anthropogenic sources. Two methods were employed to evaluate uranium isotope source. The first method compared site-specific total U mass concentrations to naturally occurring U mass concentrations in Hawai‘i. Total U was determined by summing the isotopic concentrations of ^{234}U, ^{235}U and ^{238}U detected at 5 independent sites along the proposed Saddle Road alignment. Results of this analysis indicated that total uranium along the proposed Saddle Road alignment are at or below levels occurring naturally in native Hawaiian soils. Total U based on alpha spectroscopy analyses ranged from 0.4 parts per million (ppm) at location DU003 to 1.3 ppm at DU001. The average at all five (5) locations was 0.8 ppm. The second method used to determine whether detected U originates from natural or DU sources was the evaluation of isotope abundance. Except in extremely rare circumstances (not found in Hawai‘i), natural U dispersed in rocks and soils have a comparatively greater $^{234}U/^{238}U$ and $^{235}U/^{238}U$ ratio than those originating from DU. Although use of the $^{235}U/^{238}U$ is considered a more precise measurement than the $^{234}U/^{238}U$ ratio in isotopic fingerprinting of U contamination, its utility is significant when ^{235}U data are not available or when concentrations of the ^{235}U isotope are too low to detect. This is the case here and as such, the $^{234}U/^{238}U$ ratio was used as the second method to fingerprint U source. The naturally occurring $^{234}U/^{238}U$ ratio in soil has been determined to be in the range of 0.5 to 1.2 (Sansone et al. 2001). $^{234}U/^{238}U$ ratios at the Saddle Road alignment ranged from 0.74 to 1.79, with an average ratio across all five (5) locations of 1.16. These results indicate that the $^{234}U/^{238}U$ isotopic ratio across the proposed alignment is within the background range.

A baseline human health risk assessment (BHHRA) was performed to evaluate the potential risk posed by uranium isotopes detected at the proposed Saddle Road alignment. The alignment was evaluated as a single decision unit represented by five distinct sampling locations. Receptors were assumed to be exposed to either the maximum concentration of each isotope detected or the 95% UCL of the mean. Risks were evaluated for the following receptors:

- A construction worker scenario assumed to be on site for 8 hours a day for 250 days in 1 year and assumed to contact surface and subsurface soil.
- A recreational user of the road assumed to frequent the Site 350 days a year for 2 hours a day, as child for 6 years and as an adult for 24 years, totaling a 30 year recreational tenure. Recreational receptors were assumed to contact just the surface soil

The Construction Worker scenario assumed to be on site for 8 hours a day for 250 days in 1 year and assumed to contact surface and subsurface soil. The construction worker was found to have a carcinogenic risk of 1E-06, and a noncarcinogenic risk of 4E-03.

The recreational receptor was assumed to frequent the Site 350 days a year for 2 hours a day, as child for 6 years and as an adult for 24 years, totaling a 30 year recreational tenure. Recreational receptors were assumed to contact only surficial soils. The carcinogenic risk associated with this receptor was found to be 3E-07 for the Child Receptor and 9E-07 for the Adult Receptor. These carcinogenic risks can be summed for a total carcinogenic risk of a 1E-06 for the full 30 year tenure. The noncarcinogenic risk was calculated to be 3E-03 for the Child Receptor and 1E-03 for the Adult Receptor. The higher of the two noncarcinogenic calculated risk is used to estimate the risk for the recreational/commuter receptor. Therefore the noncarcinogenic risk for the full 30 year tenure would be as a child at 3E-03.

Based on the available surface soil data collected in June 2008 at five (5) locations along the proposed alignment, it has been determined that uranium detected at the site originates from natural sources. Potential noncancer health risks from the ingestion, inhalation and dermal contact of soil along the proposed alignment are below USEPA's acceptable risk level of concern. Potential cancer risks from radiological activity of the detected U isotopes are below the most conservative regulatory criteria.

SECTION 9
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Appendix **A**

ANALYTICAL SAMPLING RESULTS

TestAmerica

THE LEADER IN ENVIRONMENTAL TESTING

ANALYTICAL REPORT

PROJECT NO. PTA DU SAMPLING

Soil Sampling

Lot #: F8F190108

Jamie Anderson

AMEC Earth & Environmental
Airport Industrial Center
3375 Koapaka St., Ste F251
Honolulu, HI 96819

TESTAMERICA LABORATORIES, INC.

Sheryl A. Adams for Kay Clay
Project Manager

July 3, 2008

Case Narrative
LOT NUMBER: **F8F190108**

This report contains the analytical results for the seven samples received under chain of custody by TestAmerica St. Louis on June 18, 2008. These samples are associated with your Soil Sampling project.

The analytical results included in this report meet all applicable quality control procedure requirements except as noted on the following page.

The test results in this report meet all NELAP requirements for parameters in which accreditations are held by TestAmerica St. Louis. Any exceptions to NELAP requirements are noted in the case narrative. The case narrative is an integral part of this report.

All chemical analysis results are based upon sample as received, wet weight, unless noted otherwise. All radiochemistry results are based upon sample as dried and ground with the exception of tritium, unless requested wet weight by the client.

Observations/Nonconformances
Reference the chain of custody and condition upon receipt report for any variations on receipt conditions and temperature of samples on receipt.

ICP-MS (6020)
Batch: 8176078
1) The samples were analyzed at a dilution due to high concentrations of target analytes. The reporting limit has been adjusted only for those targets reported from the dilution run.

2) The ICB was above the reporting limit for uranium 238. However, the bracketing CCB's are all within limits. The CCB's are sampled from the same cup as the ICB, indicating the ICB failure is an anomaly. The sample results will be reported with this narrative.

3) The MS (MSD) recovery for uranium 235 and 238 is outside the established QC limits. The RPD is within method acceptance criteria indicating a possible matrix interference. Method performance is demonstrated by acceptable LCS recovery.

Affected Samples:
F8F190108 (1): DU 001
F8F190108 (2): DU 002
F8F190108 (3): DU 003
F8F190108 (4): DU 004
F8F190108 (5): DU 005
F8F190108 (6): DU 006
F8F190108 (7): DU 007

METHODS SUMMARY

F8F190108

PARAMETER	ANALYTICAL METHOD	PREPARATION METHOD
Isotopic Uranium by Alpha Spectroscopy	EML A-01-R MOD	
ICP-MS (6020)	SW846 6020	
Percent Moisture	MCAWW 160.3 MOD	MCAWW 160.3 MOD

References:

EML	"ENVIRONMENTAL MEASUREMENTS LABORATORY PROCEDURES MANUAL" HASL-300 28TH EDITION, VOLUME I and II DEPARTMENT OF ENERGY
MCAWW	"Methods for Chemical Analysis of Water and Wastes", EPA-600/4-79-020, March 1983 and subsequent revisions.
SW846	"Test Methods for Evaluating Solid Waste, Physical/Chemical Methods", Third Edition, November 1986 and its updates.

SAMPLE SUMMARY

F8F190108

WO #	SAMPLE#	CLIENT SAMPLE ID	SAMPLED DATE	SAMP TIME
KP7GK	001	DU 001	06/11/08	12:00
KP7HT	002	DU 002	06/11/08	15:15
KP7HX	003	DU 003	06/11/08	14:30
KP7H0	004	DU 004	06/11/08	13:32
KP7H1	005	DU 005	06/11/08	12:45
KP7H2	006	DU 006	06/11/08	15:15
KP7H4	007	DU 007	06/11/08	15:15

NOTE(S):

- The analytical results of the samples listed above are presented on the following pages.
- All calculations are performed before rounding to avoid round-off errors in calculated results.
- Results noted as "ND" were not detected at or above the stated limit.
- This report must not be reproduced, except in full, without the written approval of the laboratory.
- Results for the following parameters are never reported on a dry weight basis: color, corrosivity, density, flashpoint, ignitability, layers, odor, paint filter test, pH, porosity pressure, reactivity, redox potential, specific gravity, spot tests, solids, solubility, temperature, viscosity, and weight.

AMEC Earth & Environmental

Client Sample ID: DU 001

TOTAL Metals

Lot-Sample #...: F8F190108-001 **Matrix.......:** SOLID
Date Sampled...: 06/11/08 12:00 **Date Received..:** 06/18/08
% Moisture.....: 1.0

PARAMETER	RESULT	REPORTING LIMIT	UNITS	METHOD	PREPARATION-ANALYSIS DATE	WORK ORDER #
Prep Batch #...: 8176078						
Lead	**3.0**	**0.76**	**mg/kg**	**SW846 6020**	**06/24-07/01/08**	**KP7GK1AD**
		Dilution Factor: 2.5		Analysis Time..: 00:36		
Uranium 234	ND	0.0051	mg/kg	SW846 6020	06/24-07/01/08	KP7GK1AF
		Dilution Factor: 1		Analysis Time..: 16:09		
Uranium 235	ND	0.0051	mg/kg	SW846 6020	06/24-07/01/08	KP7GK1AG
		Dilution Factor: 1		Analysis Time..: 16:09		
Uranium 238	**0.16**	**0.0051**	**mg/kg**	**SW846 6020**	**06/24-07/01/08**	**KP7GK1AH**
		Dilution Factor: 1		Analysis Time..: 16:09		

NOTE(S):

Results and reporting limits have been adjusted for dry weight.

AMEC Earth & Environmental

Client Sample ID: DU 001

General Chemistry

Lot-Sample #...: F8F190108-001 **Work Order #...:** KP7GK **Matrix.........:** SOLID
Date Sampled...: 06/11/08 12:00 **Date Received..:** 06/18/08
% Moisture.....: 1.0

PARAMETER	RESULT	RL	UNITS	METHOD	PREPARATION-ANALYSIS DATE	PREP BATCH #
Percent Moisture	**1.0**	**0.10**	**%**	**MCAWW 160.3 MOD**	**06/20-06/23/08**	**8172171**
		Dilution Factor: 1		Analysis Time..: 00:00		

AMEC Earth & Environmental

Client Sample ID: DU 002

TOTAL Metals

Lot-Sample #...: F8F190108-002 **Matrix.......:** SOLID
Date Sampled...: 06/11/08 15:15 **Date Received..:** 06/18/08
% Moisture.....: 5.2

PARAMETER	RESULT	REPORTING LIMIT	UNITS	METHOD	PREPARATION-ANALYSIS DATE	WORK ORDER #
Prep Batch #...: 8176078						
Lead	**2.8**	**0.79**	**mg/kg**	**SW846 6020**	**06/24-07/01/08**	**KP7HT1AD**
		Dilution Factor: 2.5		Analysis Time..: 01:00		
Uranium 234	ND	0.0053	mg/kg	SW846 6020	06/24-07/01/08	KP7HT1AF
		Dilution Factor: 1		Analysis Time..: 16:32		
Uranium 235	ND	0.0053	mg/kg	SW846 6020	06/24-07/01/08	KP7HT1AG
		Dilution Factor: 1		Analysis Time..: 16:32		
Uranium 238	**0.13**	**0.0053**	**mg/kg**	**SW846 6020**	**06/24-07/01/08**	**KP7HT1AH**
		Dilution Factor: 1		Analysis Time..: 16:32		

NOTE(S):

Results and reporting limits have been adjusted for dry weight.

AMEC Earth & Environmental

Client Sample ID: DU 002

General Chemistry

Lot-Sample #...: F8F190108-002 **Work Order #...:** KP7HT **Matrix.........:** SOLID
Date Sampled...: 06/11/08 15:15 **Date Received..:** 06/18/08
% Moisture.....: 5.2

PARAMETER	RESULT	RL	UNITS	METHOD	PREPARATION-ANALYSIS DATE	PREP BATCH #
Percent Moisture	**5.2**	**0.10**	**%**	**MCAWW 160.3 MOD**	**06/20-06/23/08**	**8172171**
		Dilution Factor: 1		Analysis Time..: 00:00		

AMEC Earth & Environmental

Client Sample ID: DU 003

TOTAL Metals

Lot-Sample #...: F8F190108-003 **Matrix.......:** SOLID
Date Sampled...: 06/11/08 14:30 **Date Received..:** 06/18/08
% Moisture.....: 10

PARAMETER	RESULT	REPORTING LIMIT	UNITS	METHOD	PREPARATION-ANALYSIS DATE	WORK ORDER #
Prep Batch #...: 8176078						
Lead	**1.8**	**0.84**	**mg/kg**	**SW846 6020**	**06/24-07/01/08**	**KP7HX1AD**
		Dilution Factor: 2.5		Analysis Time..: 01:04		
Uranium 234	ND	0.0056	mg/kg	SW846 6020	06/24-07/01/08	KP7HX1AF
		Dilution Factor: 1		Analysis Time..: 16:37		
Uranium 235	ND	0.0056	mg/kg	SW846 6020	06/24-07/01/08	KP7HX1AG
		Dilution Factor: 1		Analysis Time..: 16:37		
Uranium 238	**0.064**	**0.0056**	**mg/kg**	**SW846 6020**	**06/24-07/01/08**	**KP7HX1AH**
		Dilution Factor: 1		Analysis Time..: 16:37		

NOTE(S):

Results and reporting limits have been adjusted for dry weight.

AMEC Earth & Environmental

Client Sample ID: DU 003

General Chemistry

Lot-Sample #...: F8F190108-003 **Work Order #...:** KP7HX **Matrix.........:** SOLID
Date Sampled...: 06/11/08 14:30 **Date Received..:** 06/18/08
% Moisture.....: 10

PARAMETER	RESULT	RL	UNITS	METHOD	PREPARATION-ANALYSIS DATE	PREP BATCH #
Percent Moisture	**10.2**	**0.10**	**%**	**MCAWW 160.3 MOD**	**06/20-06/23/08**	**8172171**
		Dilution Factor: 1		Analysis Time..: 00:00		

AMEC Earth & Environmental

Client Sample ID: DU 004

TOTAL Metals

Lot-Sample #...: F8F190108-004 **Matrix.......:** SOLID
Date Sampled...: 06/11/08 13:32 **Date Received..:** 06/18/08
% Moisture.....: 23

PARAMETER	RESULT	REPORTING LIMIT	UNITS	METHOD	PREPARATION-ANALYSIS DATE	WORK ORDER #
Prep Batch #...: 8176078						
Lead	**3.3**	**0.98**	**mg/kg**	**SW846 6020**	**06/24-07/01/08**	**KP7H01AD**
		Dilution Factor: 2.5		Analysis Time..: 01:08		
Uranium 234	ND	0.0065	mg/kg	SW846 6020	06/24-07/01/08	KP7H01AF
		Dilution Factor: 1		Analysis Time..: 16:43		
Uranium 235	ND	0.0065	mg/kg	SW846 6020	06/24-07/01/08	KP7H01AG
		Dilution Factor: 1		Analysis Time..: 16:43		
Uranium 238	**0.10**	**0.0065**	**mg/kg**	**SW846 6020**	**06/24-07/01/08**	**KP7H01AH**
		Dilution Factor: 1		Analysis Time..: 16:43		

NOTE(S):

Results and reporting limits have been adjusted for dry weight.

AMEC Earth & Environmental

Client Sample ID: DU 004

General Chemistry

Lot-Sample #...: F8F190108-004 **Work Order #...:** KP7H0 **Matrix.........:** SOLID
Date Sampled...: 06/11/08 13:32 **Date Received..:** 06/18/08
% Moisture.....: 23

PARAMETER	RESULT	RL	UNITS	METHOD	PREPARATION-ANALYSIS DATE	PREP BATCH #
Percent Moisture	**23.3**	**0.10**	**%**	**MCAWW 160.3 MOD**	**06/20-06/23/08**	**8172171**
		Dilution Factor: 1		Analysis Time..: 00:00		

AMEC Earth & Environmental

Client Sample ID: DU 005

TOTAL Metals

Lot-Sample #...: F8F190108-005 **Matrix.......:** SOLID
Date Sampled...: 06/11/08 12:45 **Date Received..:** 06/18/08
% Moisture.....: 16

PARAMETER	RESULT	REPORTING LIMIT	UNITS	METHOD	PREPARATION-ANALYSIS DATE	WORK ORDER #
Prep Batch #...: 8176078						
Lead	**3.0**	**0.89**	**mg/kg**	**SW846 6020**	**06/24-07/01/08**	**KP7H11AD**
		Dilution Factor: 2.5		Analysis Time..: 01:12		
Uranium 234	ND	0.006	mg/kg	SW846 6020	06/24-07/01/08	KP7H11AF
		Dilution Factor: 1		Analysis Time..: 16:48		
Uranium 235	ND	0.006	mg/kg	SW846 6020	06/24-07/01/08	KP7H11AG
		Dilution Factor: 1		Analysis Time..: 16:48		
Uranium 238	**0.14**	**0.006**	**mg/kg**	**SW846 6020**	**06/24-07/01/08**	**KP7H11AH**
		Dilution Factor: 1		Analysis Time..: 16:48		

NOTE(S):

Results and reporting limits have been adjusted for dry weight.

AMEC Earth & Environmental

Client Sample ID: DU 005

General Chemistry

Lot-Sample #...: F8F190108-005 **Work Order #...:** KP7H1 **Matrix.........:** SOLID
Date Sampled...: 06/11/08 12:45 **Date Received..:** 06/18/08
% Moisture.....: 16

PARAMETER	RESULT	RL	UNITS	METHOD	PREPARATION-ANALYSIS DATE	PREP BATCH #
Percent Moisture	**16.1**	**0.10**	**%**	**MCAWW 160.3 MOD**	**06/20-06/23/08**	**8172171**
		Dilution Factor: 1		Analysis Time..: 00:00		

AMEC Earth & Environmental

Client Sample ID: DU 006

TOTAL Metals

Lot-Sample #...: F8F190108-006 **Matrix.......:** SOLID
Date Sampled...: 06/11/08 15:15 **Date Received..:** 06/18/08
% Moisture.....: 5.8

PARAMETER	RESULT	REPORTING LIMIT	UNITS	METHOD	PREPARATION-ANALYSIS DATE	WORK ORDER #
Prep Batch #...: 8176078						
Lead	**2.0**	**0.80**	**mg/kg**	**SW846 6020**	**06/24-07/01/08**	**KP7H21AD**
		Dilution Factor: 2.5		Analysis Time..: 01:15		
Uranium 234	ND	0.0053	mg/kg	SW846 6020	06/24-07/01/08	KP7H21AF
		Dilution Factor: 1		Analysis Time..: 17:13		
Uranium 235	ND	0.0053	mg/kg	SW846 6020	06/24-07/01/08	KP7H21AG
		Dilution Factor: 1		Analysis Time..: 17:13		
Uranium 238	**0.10**	**0.0053**	**mg/kg**	**SW846 6020**	**06/24-07/01/08**	**KP7H21AH**
		Dilution Factor: 1		Analysis Time..: 17:13		

NOTE(S):

Results and reporting limits have been adjusted for dry weight.

AMEC Earth & Environmental

Client Sample ID: DU 006

General Chemistry

Lot-Sample #...: F8F190108-006 **Work Order #...:** KP7H2 **Matrix.........:** SOLID
Date Sampled...: 06/11/08 15:15 **Date Received..:** 06/18/08
% Moisture.....: 5.8

PARAMETER	RESULT	RL	UNITS	METHOD	PREPARATION-ANALYSIS DATE	PREP BATCH #
Percent Moisture	**5.8**	**0.10**	**%**	**MCAWW 160.3 MOD**	**06/20-06/23/08**	**8172171**
		Dilution Factor: 1		Analysis Time..: 00:00		

AMEC Earth & Environmental

Client Sample ID: DU 007

TOTAL Metals

Lot-Sample #...: F8F190108-007 **Matrix.......:** SOLID
Date Sampled...: 06/11/08 15:15 **Date Received..:** 06/18/08
% Moisture.....: 6.3

PARAMETER	RESULT	REPORTING LIMIT	UNITS	METHOD	PREPARATION-ANALYSIS DATE	WORK ORDER #
Prep Batch #...: 8176078						
Lead	**2.4**	**0.80**	**mg/kg**	**SW846 6020**	**06/24-07/01/08**	**KP7H41AD**
		Dilution Factor: 2.5		Analysis Time..: 01:19		
Uranium 234	ND	0.0053	mg/kg	SW846 6020	06/24-07/01/08	KP7H41AF
		Dilution Factor: 1		Analysis Time..: 17:18		
Uranium 235	ND	0.0053	mg/kg	SW846 6020	06/24-07/01/08	KP7H41AG
		Dilution Factor: 1		Analysis Time..: 17:18		
Uranium 238	**0.11**	**0.0053**	**mg/kg**	**SW846 6020**	**06/24-07/01/08**	**KP7H41AH**
		Dilution Factor: 1		Analysis Time..: 17:18		

NOTE(S):

Results and reporting limits have been adjusted for dry weight.

AMEC Earth & Environmental

Client Sample ID: DU 007

General Chemistry

Lot-Sample #...: F8F190108-007 **Work Order #...:** KP7H4 **Matrix.........:** SOLID
Date Sampled...: 06/11/08 15:15 **Date Received..:** 06/18/08
% Moisture.....: 6.3

PARAMETER	RESULT	RL	UNITS	METHOD	PREPARATION-ANALYSIS DATE	PREP BATCH #
Percent Moisture	**6.3**	**0.10**	**%**	**MCAWW 160.3 MOD**	**06/20-06/23/08**	**8172171**
		Dilution Factor: 1		Analysis Time..: 00:00		

METHOD BLANK REPORT

TOTAL Metals

Client Lot #...: F8F190108 **Matrix.........:** SOLID

PARAMETER	RESULT	REPORTING LIMIT	UNITS	METHOD	PREPARATION-ANALYSIS DATE	WORK ORDER #
MB Lot-Sample #: F8F240000-078 **Prep Batch #...:** 8176078						
Lead	ND	0.30	mg/kg	SW846 6020	06/24-07/01/08	KQF4L1AA
		Dilution Factor: 1				
		Analysis Time..: 00:28				
Uranium 234	ND	0.005	mg/kg	SW846 6020	06/24-07/01/08	KQF4L1AC
		Dilution Factor: 1				
		Analysis Time..: 15:58				
Uranium 235	ND	0.005	mg/kg	SW846 6020	06/24-07/01/08	KQF4L1AD
		Dilution Factor: 1				
		Analysis Time..: 15:58				
Uranium 238	ND	0.005	mg/kg	SW846 6020	06/24-07/01/08	KQF4L1AE
		Dilution Factor: 1				
		Analysis Time..: 15:58				

NOTE(S):

Calculations are performed before rounding to avoid round-off errors in calculated results.

LABORATORY CONTROL SAMPLE EVALUATION REPORT

TOTAL Metals

Client Lot #...: F8F190108 **Matrix..........:** SOLID

PARAMETER	PERCENT RECOVERY	RECOVERY LIMITS	METHOD	PREPARATION-ANALYSIS DATE	WORK ORDER #
LCS Lot-Sample#: F8F240000-078 **Prep Batch #...:** 8176078					
Lead	105	(82 - 118)	SW846 6020	06/24-07/01/08	KQF4L1AF
		Dilution Factor: 12.5		Analysis Time..: 00:32	
Uranium 235	104	(80 - 120)	SW846 6020	06/24-07/01/08	KQF4L1AH
		Dilution Factor: 1		Analysis Time..: 16:03	
Uranium 238	103	(80 - 120)	SW846 6020	06/24-07/01/08	KQF4L1AJ
		Dilution Factor: 1		Analysis Time..: 16:03	

NOTE(S):

Calculations are performed before rounding to avoid round-off errors in calculated results.

MATRIX SPIKE SAMPLE EVALUATION REPORT

TOTAL Metals

Client Lot #...: F8F190108 **Matrix.........:** SOLID
Date Sampled...: 06/11/08 12:00 **Date Received..:** 06/18/08

PARAMETER	PERCENT RECOVERY	RECOVERY LIMITS	RPD	RPD LIMITS	METHOD	PREPARATION-ANALYSIS DATE	WORK ORDER #
MS Lot-Sample #: F8F190108-001 **Prep Batch #...:** 8176078							
						% Moisture.....: 1.0	
Lead	100	(75 - 125)			SW846 6020	06/24-07/01/08	KP7GK1AL
	91	(75 - 125)	8.6	(0-30)	SW846 6020	06/24-07/01/08	KP7GK1AM
		Dilution Factor: 2.5					
		Analysis Time..: 00:44					
Uranium 235	44	(75 - 125)			SW846 6020	06/24-07/01/08	KP7GK1AN
	42	(75 - 125)		(0-30)	SW846 6020	06/24-07/01/08	KP7GK1AP
		Dilution Factor: 1					
		Analysis Time..: 16:20					
Uranium 238	37	(75 - 125)			SW846 6020	06/24-07/01/08	KP7GK1AQ
	35	(75 - 125)		(0-30)	SW846 6020	06/24-07/01/08	KP7GK1AR
		Dilution Factor: 1					
		Analysis Time..: 16:20					

NOTE(S):

Calculations are performed before rounding to avoid round-off errors in calculated results.

Results and reporting limits have been adjusted for dry weight.

SAMPLE DUPLICATE EVALUATION REPORT

General Chemistry

Client Lot #...: F8F190108 **Work Order #...:** KP7H4-SMP KP7H4-DUP **Matrix.......:** SOLID

Date Sampled...: 06/11/08 15:15 **Date Received..:** 06/18/08

% Moisture.....: 6.3

PARAM RESULT	DUPLICATE RESULT	UNITS	RPD	RPD LIMIT	METHOD	PREPARATION-ANALYSIS DATE	PREP BATCH #
Percent Moisture					SD Lot-Sample #: F8F190108-007		
6.3	7.5	%	17	(0-30)	MCAWW 160.3 MOD	06/20-06/23/08	8172171
		Dilution Factor: 1			Analysis Time..: 00:00		

AMEC Earth & Environmental

Client Sample ID: DU 001

Radiochemistry

Lab Sample ID:	F8F190108-001	Date Collected:	06/11/08 1200
Work Order:	KP7GK	Date Received:	06/18/08 0915
Matrix:	SOLID		

Parameter	Result	Qual	Total Uncert. (2 σ+/-)	RL	MDC	Prep Date	Analysis Date
Iso URANIUM (LONG CT) DOE A-01-R MOD				**pCi/g**	**Batch # 8175252**		**Yld % 80**
Uranium 234	**0.436**		**0.096**	0.100	**0.024**	**06/23/08**	**06/26/08**
Uranium 235/236	0.014	U	0.020	0.100	0.031	06/23/08	06/26/08
Uranium 238	**0.368**		**0.087**	0.100	**0.024**	**06/23/08**	**06/26/08**

NOTE(S)

Data are incomplete without the case narrative.

MDC is determined by instrument performance only.
Bold results are greater than the MDC

U Result is less than the sample detection limit.

AMEC Earth & Environmental

Client Sample ID: DU 001 DUP

Radiochemistry

Lab Sample ID:	F8F190108-001X	Date Collected:	06/11/08 1200
Work Order:	KP7GK	Date Received:	06/18/08 0915
Matrix:	SOLID		

Parameter	Result	Qual	Total Uncert. (2 σ+/-)	RL	MDC	Prep Date	Analysis Date
Iso URANIUM (LONG CT) DOE A-01-R MOD				pCi/g	Batch # 8175252		Yld % 82
Uranium 234	**0.300**		**0.076**	0.100	**0.025**	**06/23/08**	**06/26/08**
Uranium 235/236	0.003	U	0.011	0.100	0.028	06/23/08	06/26/08
Uranium 238	**0.298**		**0.076**	0.100	**0.027**	**06/23/08**	**06/26/08**

NOTE(S)

Data are incomplete without the case narrative.

MDC is determined by instrument performance only.
Bold results are greater than the MDC

U Result is less than the sample detection limit.

AMEC Earth & Environmental

Client Sample ID: DU 002

Radiochemistry

Lab Sample ID: F8F190108-002
Work Order: KP7HT
Matrix: SOLID

Date Collected: 06/11/08 1515
Date Received: 06/18/08 0915

Parameter	Result	Qual	Total Uncert. (2 σ+/-)	RL	MDC	Prep Date	Analysis Date
Iso URANIUM (LONG CT) DOE A-01-R MOD				**pCi/g**	**Batch # 8175252**		**Yld % 92**
Uranium 234	**0.157**		**0.051**	0.100	**0.024**	**06/23/08**	**06/26/08**
Uranium 235/236	0.008	U	0.013	0.100	0.021	06/23/08	06/26/08
Uranium 238	**0.133**		**0.047**	0.100	**0.025**	**06/23/08**	**06/26/08**

NOTE(S)

Data are incomplete without the case narrative.

MDC is determined by instrument performance only.
Bold results are greater than the MDC

U Result is less than the sample detection limit.

AMEC Earth & Environmental

Client Sample ID: DU 003

Radiochemistry

Lab Sample ID:	F8F190108-003	Date Collected:	06/11/08 1430
Work Order:	KP7HX	Date Received:	06/18/08 0915
Matrix:	SOLID		

Parameter	Result	Qual	Total Uncert. (2 σ+/-)	RL	MDC	Prep Date	Analysis Date
Iso URANIUM (LONG CT) DOE A-01-R MOD				pCi/g		Batch # 8175252	Yld % 83
Uranium 234	**0.118**		**0.047**	0.100	**0.029**	**06/23/08**	**06/26/08**
Uranium 235/236	0.017	U	0.022	0.100	0.031	06/23/08	06/26/08
Uranium 238	**0.066**	**J**	**0.035**	0.100	**0.023**	**06/23/08**	**06/26/08**

NOTE(S)

Data are incomplete without the case narrative.

MDC is determined by instrument performance only.
Bold results are greater than the MDC

J Result is greater than sample detection limit but less than stated reporting limit.
U Result is less than the sample detection limit.

AMEC Earth & Environmental

Client Sample ID: DU 004

Radiochemistry

Lab Sample ID:	F8F190108-004	Date Collected:	06/11/08 1332
Work Order:	KP7H0	Date Received:	06/18/08 0915
Matrix:	SOLID		

Parameter	Result	Qual	Total Uncert. (2 σ+/-)	RL	MDC	Prep Date	Analysis Date
Iso URANIUM (LONG CT) DOE A-01-R MOD			**pCi/g**		**Batch # 8175252**		**Yld % 87**
Uranium 234	**0.144**		**0.050**	0.100	**0.025**	**06/23/08**	**06/26/08**
Uranium 235/236	0.0050	U	0.0099	0.100	0.013	06/23/08	06/26/08
Uranium 238	**0.130**		**0.047**	0.100	**0.018**	**06/23/08**	**06/26/08**

NOTE(S)

Data are incomplete without the case narrative.

MDC is determined by instrument performance only.
Bold results are greater than the MDC

U Result is less than the sample detection limit.

AMEC Earth & Environmental

Client Sample ID: DU 005

Radiochemistry

Lab Sample ID: F8F190108-005
Work Order: KP7H1
Matrix: SOLID

Date Collected: 06/11/08 1245
Date Received: 06/18/08 0915

Parameter	Result	Qual	Total Uncert. (2 σ+/-)	RL	MDC	Prep Date	Analysis Date
Iso URANIUM (LONG CT) DOE A-01-R MOD				**pCi/g**		**Batch # 8175252**	**Yld % 76**
Uranium 234	**0.199**		**0.062**	0.100	**0.026**	**06/23/08**	**06/26/08**
Uranium 235/236	0.01	U	0.016	0.100	0.025	06/23/08	06/26/08
Uranium 238	**0.269**		**0.073**	0.100	**0.026**	**06/23/08**	**06/26/08**

NOTE(S)

Data are incomplete without the case narrative.

MDC is determined by instrument performance only.
Bold results are greater than the MDC

U Result is less than the sample detection limit.

AMEC Earth & Environmental

Client Sample ID: DU 006

Radiochemistry

Lab Sample ID: F8F190108-006
Work Order: KP7H2
Matrix: SOLID

Date Collected: 06/11/08 1515
Date Received: 06/18/08 0915

Parameter	Result	Qual	Total Uncert. (2 σ+/-)	RL	MDC	Prep Date	Analysis Date
Iso URANIUM (LONG CT) DOE A-01-R MOD				pCi/g		Batch # 8175252	Yld % 72
Uranium 234	**0.123**		0.049	0.100	0.013	06/23/08	06/26/08
Uranium 235/236	**0.018**	J	0.020	0.100	0.016	06/23/08	06/26/08
Uranium 238	**0.122**		0.049	0.100	0.021	06/23/08	06/26/08

NOTE(S)

Data are incomplete without the case narrative.

MDC is determined by instrument performance only.
Bold results are greater than the MDC

J Result is greater than sample detection limit but less than stated reporting limit.

AMEC Earth & Environmental

Client Sample ID: DU 007

Radiochemistry

Lab Sample ID:	F8F190108-007	Date Collected:	06/11/08 1515
Work Order:	KP7H4	Date Received:	06/18/08 0915
Matrix:	SOLID		

Parameter	Result	Qual	Total Uncert. (2 σ+/-)	RL	MDC	Prep Date	Analysis Date
Iso URANIUM (LONG CT) DOE A-01-R MOD				**pCi/g**	**Batch # 8175252**		**Yld % 79**
Uranium 234	**0.127**		**0.048**	0.100	**0.012**	**06/23/08**	**06/26/08**
Uranium 235/236	0.0	U	0.0055	0.100	0.015	06/23/08	06/26/08
Uranium 238	**0.154**		**0.054**	0.100	**0.026**	**06/23/08**	**06/26/08**

NOTE(S)

Data are incomplete without the case narrative.

MDC is determined by instrument performance only.
Bold results are greater than the MDC

U Result is less than the sample detection limit.

METHOD BLANK REPORT

Radiochemistry

Client Lot ID: F8F190108
Matrix: SOLID

Parameter	Result	Qual	Total Uncert. (2 σ+/-)	RL	MDC	Prep Date	Lab Sample ID Analysis Date
Iso URANIUM (LONG CT) DOE A-01-R MOD			**pCi/g**	**Batch # 8175252**		**Yld % 87**	**F8F230000-252B**
Uranium 234	0.007	U	0.015	0.100	0.027	06/23/08	06/26/08
Uranium 235/236	-0.0012	U	0.0025	0.100	0.023	06/23/08	06/26/08
Uranium 238	0.003	U	0.015	0.100	0.033	06/23/08	06/26/08

NOTE(S)

Data are incomplete without the case narrative.

MDC is determined using instrument performance only
Bold results are greater than the MDC

U Result is less than the sample detection limit.

Laboratory Control Sample Report

Radiochemistry

Client Lot ID: F8F190108
Matrix: SOLID

Parameter	Spike Amount	Result	Total Uncert. (2 σ+/-)	MDC	% Yld	% Rec	Lab Sample ID QC Control Limits
Iso URANIUM (LONG CT) DOE A-01-R MOD			**pCi/g**	**A-01-R MOD**			**F8F230000-252C**
Uranium 234	19.6	20.1	2.8	0.3	86	103	(70 - 122)
Uranium 238	19.6	17.4	2.5	0.3	86	89	(69 - 119)
	Batch #:	8175252		**Analysis Date:**	06/26/08		

NOTE(S)

MDC is determined by instrument performance only

Calculations are performed before rounding to avoid round-off error in calculated results

DUPLICATE EVALUATION REPORT

Radiochemistry

Client Lot ID:	F8F190108	Date Sampled:	06/11/08
Matrix:	SOLID	Date Received:	06/18/08

Parameter	SAMPLE Result		Total Uncert. (2σ +/-)	% Yld	DUPLICATE Result		Total Uncert. (2 σ +/-)	% Yld	QC Sample ID Precision	
Iso URANIUM (LONG CT) DOE A-01-R MOD				**pCi/g**	**A-01-R MOD**				**F8F190108-001**	
Uranium 234	**0.436**		**0.096**	80	**0.300**		**0.076**	82	37	%RPD
Uranium 235/236	0.014	U	0.020	80	0.003	U	0.011	82	139	%RPD
Uranium 238	**0.368**		**0.087**	80	**0.298**		**0.076**	82	21	%RPD
	Batch #:		8175252 (Sample)		8175252 (Duplicate)					

NOTE(S)

Data are incomplete without the case narrative.
Calculations are performed before rounding to avoid round-off error in calculated results

U Result is less than the sample detection limit.

is
er Trail North
, MO 63045
.298.8566 fax 314.298.8757

cut 3270

Chain of Custody Record

TestAmerica — THE LEADER IN ENVIRONMENTAL TESTING

TestAmerica Laboratories, Inc.

Client Contact	Project Manager: Russell Okoji	Site Contact:	Date: 6/11/08	COC No: 001
rth & Environmental	Tel/Fax: 808-391-9906	Lab Contact:	Carrier: FedEx	1 of 1 COCs
paka Street, Suite F251	Analysis Turnaround Time			Job No.
HI 96819	Calendar (C) or Work Days (W) Standard			
-2462 Phone	TAT if different from Below			SDG No.
-5379 FAX	☐ 2 weeks			
ame: PTA DU Sampling	☐ 1 week			
	☐ 2 days			
	☐ 1 day			

Sample Identification	Sample Date	Sample Time	Sample Type	Matrix	# of Cont.	Filtered Sample	Lead by ICP-MS (6020A)	Isotopic Uranium by ICP-MS (6020A)	Isotopic Uranium by Alpha Spec.	Long Count (U234, U235, U238)	Prep - Dry and Grind	Prep - Total Dissolution Prep	Sample Specific Notes:
DU 001	6/11/2008	12:00	Composite	Soil	1		X	X	X	X	X	X	
DU 002	6/11/2008	3:15	Composite	Soil	1		X	X	X	X	X	X	
DU 003	6/11/2008	2:30	Composite	Soil	1		X	X	X	X	X	X	
DU 004	6/11/2008	1:32	Composite	Soil	1		X	X	X	X	X	X	
DU 005	6/11/2008	12:45	Composite	Soil	1		X	X	X	X	X	X	MS/MSD
DU 006	6/11/2008	3:15	Composite	Soil	1		X	X	X	X	X	X	
DU 007	6/11/2008	3:15	Composite	Soil	1		X	X	X	X	X	X	

Bag — SW 06.18.08

tion Used: Ice

Hazard Identification

1-Hazard ☐ Flammable ☐ Skin Irritant Poison B ☐ Unknown ☐

Sample Disposal (A fee may be assessed if samples are retained longer than 1 month)
☐ Return To Client ☒ Disposal By Lab ☐ Archive For ________ Months

structions/QC Requirements & Comments: Conduct MS/MSD on DU 005. Dry and grind all soil before subsampling.

	Company	Date/Time	Received by	Company	Date/Time
hed by: Jamie L Anderson [signature]	Company: AMEC	6/16/08 @ 13:00	Received by: [signature]	TA-STL	06.18.08 0915
hed by:	Company:	Date/Time:	Received by:	Company:	Date/Time:
hed by:	Company:	Date/Time:	Received by:	Company:	Date/Time:

TestAmerica
THE LEADER IN ENVIRONMENTAL TESTING

- 3270 -

Lot #(s): F8F190108

Condition Upon Receipt Form

Client: AMEC
Quote No: 79901
COC/RFA No: 001
Initiated By: SV
Date: 06.18.08
Time: 0915

Shipping Information

Shipper Name: FedX
Shipping # (s):*

Multiple Packages Y (N)
Sample Temperature (s):**

1.	7920 7241 6650	6.		1.	4	6.	
2.		7.		2.		7.	
3.		8.		3.		8.	
4.		9.		4.		9.	
5.		10.		5.		10.	

*Numbered shipping lines correspond to Numbered Sample Temp lines

**Sample must be received at 4°C ± 2°C- If not, note contents below. Temperature variance does NOT affect the following: Metals-Liquid or Rad tests- Liquid or Solids

Condition (Circle "Y" for yes, "N" for no and "N/A" for not applicable):

1.	(Y) N	Are there custody seals present on the cooler?	8.	Y (N)	Are there custody seals present on bottles?
2.	Y (N) N/A	Do custody seals on cooler appear to be tampered with?	9.	Y N (N/A)	Do custody seals on bottles appear to be tampered with?
3.	(Y) N	Were contents of cooler frisked after opening, but before unpacking?	10.	Y N (N/A)	Was sample received with proper pH[1]? (If not, make note below)
4.	(Y) N	Sample received with Chain of Custody?	11.	Y N	If N/A- Was pH taken by original TestAmerica lab?
5.	(Y) N N/A	Does the Chain of Custody match sample ID's on the container(s)?	12.	(Y) N	Sample received in proper containers?
6.	Y (N)	Was sample received broken?	13.	Y N (N/A)	Headspace in VOA or TOX liquid samples? (If Yes, note sample ID's below)
7.	(Y) N	Is sample volume sufficient for analysis?	14.	Y N (NA)	Was Internal COC/Workshare received?

[1] For DOE-AL (Pantex, LANL, Sandia) sites, pH of ALL containers received must be verified, EXCEPT VOA, TOX and soils.

Notes:

Corrective Action:
- ☐ Client Contact Name: Informed by:
- ☐ Sample(s) processed "as is"
- ☐ Sample(s) on hold until: If released, notify:

Appendix **B**

CHEMICAL ASSESSMENT RISK CHARACTERIZATION SPREADSHEETS

APPENDIX C
SUMMARY OF POTENTIAL CANCER RISKS AND HAZARD INDICES
CONSTRUCTION WORKER

SADDLE ROAD

	Excess Lifetime Cancer Risk					Hazard Index				
Compound	Soil	Sediment	Groundwater	Surface Water	Total	Soil	Sediment	Groundwater	Surface Water	Total
Uranium	NA	NA	NA	NA	NA	3.82E-03	NA	NA	NA	3.82E-03

CONSTRUCTION WORKER SOIL EXPOSURES
RISK CHARACTERIZATION
SADDLE ROAD

Scenario:	Subactivity name
Receptor:	Construction Worker
Medium:	Soil
Exposure Pathway:	Ingestion and Dermal Contact

ADD (mg/kg-day) = $\frac{CS \times [(IR \times FI \times RAF) + (SA \times AF \times FA \times RAF \times EFD)] \times EF \times ED \times CF}{BW \times AT}$

Hazard Quotient (HQ) = ADD (mg/kg-day) / RfD (mg/kg-day)
Cancer Risk (ELCR) = ADD (mg/kg-day) * CSF [1/(mg/kg-day)]

Parameter (units)	Value
ADD: Average Daily Dose (mg/kg-day)	See Below
CS: Chemical Concentration in Soil (mg/kg)	Chemical-Specific
IR: Ingestion Rate (mg/day)	330
RAF: Relative Absorption Factor (Oral-Soil) (unitless)	Chemical-Specific
FI: Fraction Ingested from Site (unitless)	1
SA: Skin Surface Area (cm2)	3300
AF: Adherence Factor (mg/cm2/event)	0.29
RAF: Relative Absorption Factor (Dermal-Soil) (unitless)	Chemical-Specific
FA: Fraction Absorbed from Site (unitless)	1
EFD: Exposure Frequency - Dermal (event/day)	1
EF: Exposure Frequency (days/year)	250
ED: Exposure Duration (years)	1
BW: Body Weight (kg)	71.8
AT: Averaging Time (days) (ED x 365 days/yr, noncancer)	365
AT: Averaging Time (days) (75 yr. x 365 days/yr, cancer)	25550
CF: Conversion factor (kg/mg)	1.00E-06
RfD: Reference Dose (mg/kg-day)	Chemical-Specific
CSF: Cancer Slope Factor [1/(mg/kg-day)]	Chemical-Specific

		Noncancer Hazard Quotient					Excess Lifetime Cancer Risk				
Compound	Soil Concentration (mg/kg)	Oral-Soil RAF (noncancer)	Dermal-Soil RAF (noncancer)	ADD (noncancer) (mg/kg-day)	Chronic TDI/RfD (mg/kg-day)	Soil HQ	Oral-Soil RAF (cancer)	Dermal-Soil RAF (cancer)	ADD (cancer) (mg/kg-day)	CSF [1/(mg/kg-day)]	Soil Risk
Uranium	9.25E-01	1	1	1.14E-05	3.00E-03	3.79E-03	1	1	NA	NA	NA
						3.79E-03					0.00E+00

CONSTRUCTION WORKER - SOIL EXPOSURES
RISK CHARACTERIZATION
SADDLE ROAD

Scenario:	Subactivity name
Receptor:	Construction Worker
Medium:	Dust from soil
Exposure Pathway:	Inhalation

$$\text{ADD (mg/kg/day)} = \frac{\text{Cdust x IR x RAF x ET x EF x ED}}{\text{AT x BW}}$$

Hazard Quotient (HQ) = ADD (mg/kg/day) / RfDi (mg/kg/day)
Cancer Risk (ELCR) = ADD (mg/kg/day) * CSFi [1/(mg/kg/day)]

Parameter (units)	Value
ADD: Average Daily Dose (mg/kg/day)	See Below
CS: Chemical Concentration in Soil (mg/kg)	Chemical-Specific
Cdust: Concentration of dust-bound chemical in air (mg/m3)	Calculated
RAF: Relative Absorption Factor (Inhalation) (unitless)	Chemical-Specific
ET: Exposure Time - dust (hr/d)	8
EF: Exposure Frequency (days/year)	250
ED: Exposure Duration (years)	1
IR: Inhalation Rate (m3/hr)	0.833
AT: Averaging Time (days) (ED x 365 days/yr, noncancer)	365
AT: Averaging Time (days) (75 yr. x 365 days/yr, cancer)	25550
BW: Body Weight (kg)	71.8
RfDi: Reference Dose Inhalation (mg/kg/day)	Chemical-Specific
CSFi: Cancer Slope Factor Inhalation [1/(mg/kg/day)]	Chemical-Specific

			Noncancer Hazard Quotient				Excess Lifetime Cancer Risk			
Compound	Soil Concentration (mg/kg)	Chemical Concentration in Air (mg/m3)	Inhalation RAF (noncancer)	ADD (noncancer) (mg/kg/day)	RFDi (non-cancer) (mg/kg/day)	Soil-Dust HQ	Inhalation RAF (cancer)	ADD (cancer) (mg/kg/day)	CSFi [1/(mg/kg/day)]	Soil- Dust Risk
Uranium	9.25E-01	4.63E-08	1	2.94E-09	8.60E-05	3.42E-05	1	NA	NA	NA
						3.42E-05				0.00E+00

APPENDIX C
SUMMARY OF POTENTIAL CANCER RISKS AND HAZARD INDICES
CHILD-SUBACTIVITY
SADDLE ROAD

	Excess Lifetime Cancer Risk					Hazard Index				
Compound	Soil	Sediment	Groundwater	Surface Water	Total	Soil	Sediment	Groundwater	Surface Water	Total
Uranium	NA	NA	NA	NA	NA	2.78E-03	NA	NA	NA	2.78E-03

CHILD - SUBACTIVITY - SOIL EXPOSURES
RISK CHARACTERIZATION
SADDLE ROAD

Scenario:	Subactivity name
Receptor:	Child
Medium:	Soil
Exposure Pathway:	Ingestion and Dermal Contact

$$ADD\ (mg/kg\text{-}day) = \frac{CS \times [(IR \times FI \times RAF) + (SA \times AF \times FA \times RAF \times EFD)] \times EF \times ED \times CF}{BW \times AT}$$

Hazard Quotient (HQ) = ADD (mg/kg-day) / RfD (mg/kg-day)
Cancer Risk (ELCR) = ADD (mg/kg-day) * CSF [1/(mg/kg-day)]

Parameter (units)	Value
ADD: Average Daily Dose (mg/kg-day)	See Below
CS: Chemical Concentration in Soil (mg/kg)	Chemical-Specific
IR: Ingestion Rate (mg/day)	200
RAF: Relative Absorption Factor (Oral-Soil) (unitless)	Chemical-Specific
FI: Fraction Ingested from Site (unitless)	1
SA: Skin Surface Area (cm2)	2800
AF: Adherence Factor (mg/cm2/event)	0.29
RAF: Relative Absorption Factor (Dermal-Soil) (unitless)	Chemical-Specific
FA: Fraction Absorbed from Site (unitless)	1
EFD: Exposure Frequency - Dermal (event/day)	1
EF: Exposure Frequency (days/year)	52
ED: Exposure Duration (years)	6
BW: Body Weight (kg)	16
AT: Averaging Time (days) (ED x 365 days/yr, noncancer)	2190
AT: Averaging Time (days) (75 yr. x 365 days/yr, cancer)	25550
CF: Conversion factor (kg/mg)	1.00E-06
RfD: Reference Dose (mg/kg-day)	Chemical-Specific
CSF: Cancer Slope Factor [1/(mg/kg-day)]	Chemical-Specific

		Noncancer Hazard Quotient					Excess Lifetime Cancer Risk				
Compound	Soil Concentration (mg/kg)	Oral-Soil RAF (noncancer)	Dermal-Soil RAF (noncancer)	ADD (noncancer) (mg/kg-day)	Chronic TDI/RfD (mg/kg-day)	Soil HQ	Oral-Soil RAF (cancer)	Dermal-Soil RAF (cancer)	ADD (cancer) (mg/kg-day)	CSF [1/(mg/kg-day)]	Soil Risk
Uranium	9.25E-01	1	1	8.34E-06	3.00E-03	2.78E-03	1	1	NA	NA	NA
						2.78E-03					0.00E+00

CHILD - SUBACTIVITY - SOIL EXPOSURES
RISK CHARACTERIZATION
SADDLE ROAD

Scenario:	Subactivity name
Receptor:	Child
Medium:	Dust from soil
Exposure Pathway:	Inhalation

ADD (mg/kg/day) = $\frac{\text{Cdust x IR x RAF x ET x EF x ED}}{\text{AT x BW}}$

Hazard Quotient (HQ) = ADD (mg/kg/day) / RfDi (mg/kg/day)
Cancer Risk (ELCR) = ADD (mg/kg/day) * CSFi [1/(mg/kg/day)]

Parameter (units)	Value
ADD: Average Daily Dose (mg/kg/day)	See Below
CS: Chemical Concentration in Soil (mg/kg)	Chemical-Specific
Cdust: Concentration of dust-bound chemical in air (mg/m3)	Calculated
RAF: Relative Absorption Factor (Inhalation) (unitless)	Chemical-Specific
ET: Exposure Time - dust (hr/d)	2
EF: Exposure Frequency (days/year)	52
ED: Exposure Duration (years)	6
IR: Inhalation Rate (m3/hr)	0.417
AT: Averaging Time (days) (ED x 365 days/yr, noncancer)	2190
AT: Averaging Time (days) (75 yr. x 365 days/yr, cancer)	25550
BW: Body Weight (kg)	16
RfDi: Reference Dose Inhalation (mg/kg/day)	Chemical-Specific
CSFi: Cancer Slope Factor Inhalation [1/(mg/kg/day)]	Chemical-Specific

			Noncancer Hazard Quotient				Excess Lifetime Cancer Risk			
Compound	Soil Concentration (mg/kg)	Chemical Concentration in Air (mg/m3)	Inhalation RAF (noncancer)	ADD (noncancer) (mg/kg/day)	RFDi (non-cancer) (mg/kg/day)	Soil-Dust HQ	Inhalation RAF (cancer)	ADD (cancer) (mg/kg/day)	CSFi [1/(mg/kg/day)]	Soil- Dust Risk
Uranium	9.25E-01	4.63E-08	1	3.43E-10	8.60E-05	3.99247E-06	1	NA	NA	NA
						3.99E-06				0.00E+00

APPENDIX C
SUMMARY OF POTENTIAL CANCER RISKS AND HAZARD INDICES
ADULT -SUBACTIVITY
SADDLE ROAD

	Excess Lifetime Cancer Risk					Hazard Index				
Compound	Soil	Sediment	Groundwater	Surface Water	Total	Soil	Sediment	Groundwater	Surface Water	Total
Uranium	NA	NA	NA	NA	NA	1.07E-03	NA	NA	NA	1.07E-03

ADULT - SUBACTIVITY - SOIL EXPOSURES
RISK CHARACTERIZATION
SADDLE ROAD

Scenario:	Subactivity name
Receptor:	Adult Resident
Medium:	Soil
Exposure Pathway:	Ingestion and Dermal Contact

$$ADD\ (mg/kg\text{-}day) = \frac{CS \times [(IR \times FI \times RAF) + (SA \times AF \times FA \times RAF \times EFD)] \times EF \times ED \times CF}{BW \times AT}$$

Hazard Quotient (HQ) = ADD (mg/kg-day) / RfD (mg/kg-day)
Cancer Risk (ELCR) = ADD (mg/kg-day) * CSF [1/(mg/kg-day)]

Parameter (units)	Value
ADD: Average Daily Dose (mg/kg-day)	See Below
CS: Chemical Concentration in Soil (mg/kg)	Chemical-Specific
IR: Ingestion Rate (mg/day)	100
RAF: Relative Absorption Factor (Oral-Soil) (unitless)	Chemical-Specific
FI: Fraction Ingested from Site (unitless)	1
SA: Skin Surface Area (cm2)	5700
AF: Adherence Factor (mg/cm2/event)	0.29
RAF: Relative Absorption Factor (Dermal-Soil) (unitless)	Chemical-Specific
FA: Fraction Absorbed from Site (unitless)	1
EFD: Exposure Frequency - Dermal (event/day)	1
EF: Exposure Frequency (days/year)	52
ED: Exposure Duration (years)	24
BW: Body Weight (kg)	71.8
AT: Averaging Time (days) (ED x 365 days/yr, noncancer)	8760
AT: Averaging Time (days) (75 yr. x 365 days/yr, cancer)	25550
CF: Conversion factor (kg/mg)	1.00E-06
RfD: Reference Dose (mg/kg-day)	Chemical-Specific
CSF: Cancer Slope Factor [1/(mg/kg-day)]	Chemical-Specific

Compound	Soil Concentration (mg/kg)	Noncancer Hazard Quotient					Excess Lifetime Cancer Risk				
		Oral-Soil RAF (noncancer)	Dermal-Soil RAF (noncancer)	ADD (noncancer) (mg/kg-day)	Chronic TDI/RfD (mg/kg-day)	Soil HQ	Oral-Soil RAF (cancer)	Dermal-Soil RAF (cancer)	ADD (cancer) (mg/kg-day)	CSF [1/(mg/kg-day)]	Soil Risk
Uranium	9.25E-01	1	1	3.22E-06	3.00E-03	1.07E-03	1	1	NA	NA	NA
						1.07E-03					0.00E+00

ADULT - SUBACTIVITY - SOIL EXPOSURES
RISK CHARACTERIZATION
SADDLE ROAD

Scenario:	Subactivity name
Receptor:	Adult Resident
Medium:	Dust from soil
Exposure Pathway:	Inhalation

ADD (mg/kg/day) = $\frac{\text{Cdust x IR x RAF x ET x EF x ED}}{\text{AT x BW}}$

Hazard Quotient (HQ) = ADD (mg/kg/day) / RfDi (mg/kg/day)
Cancer Risk (ELCR) = ADD (mg/kg/day) * CSFi [1/(mg/kg/day)]

Parameter (units)	Value
ADD: Average Daily Dose (mg/kg/day)	See Below
CS: Chemical Concentration in Soil (mg/kg)	Chemical-Specific
Cdust: Concentration of dust-bound chemical in air (mg/m3)	Calculated
RAF: Relative Absorption Factor (Inhalation) (unitless)	Chemical-Specific
ET: Exposure Time - dust (hr/d)	2
EF: Exposure Frequency (days/year)	52
ED: Exposure Duration (years)	24
IR: Inhalation Rate (m3/hr)	0.833
AT: Averaging Time (days) (ED x 365 days/yr, noncancer)	8760
AT: Averaging Time (days) (75 yr. x 365 days/yr, cancer)	25550
BW: Body Weight (kg)	71.8
RfDi: Reference Dose Inhalation (mg/kg/day)	Chemical-Specific
CSFi: Cancer Slope Factor Inhalation [1/(mg/kg/day)]	Chemical-Specific

			Noncancer Hazard Quotient				Excess Lifetime Cancer Risk			
Compound	Soil Concentration (mg/kg)	Chemical Concentration in Air (mg/m3)	Inhalation RAF (noncancer)	ADD (noncancer) (mg/kg/day)	RFDi (non-cancer) (mg/kg/day)	Soil-Dust HQ	Inhalation RAF (cancer)	ADD (cancer) (mg/kg/day)	CSFi [1/(mg/kg/day)]	Soil- Dust Risk
Uranium	9.25E-01	4.63E-08	1	1.53E-10	8.60E-05	1.78E-06	1	NA	NA	NA
						1.78E-06				0.00E+00

Appendix C

RADIOLOGICAL ASSESSMENT
RISK CHARACTERIZATION REPORTS

RESRAD
CONSTRUCTION WORKER

Uranium Soils Investigation
Baseline Human Health Risk Assessment
Saddle Road
October 2009

Intrisk : Construction Worker Receptor

File   : C:\RESRAD_FAMILY\RESRAD\USERFILES\SITE1.RAD

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Part III: Intake Quantities and Health Risk Factors

Cancer Risk Slope Factors Summary Table
Risk Library: FGR 13 Morbidity

Menu	Parameter	Current Value	Base Case*	Parameter Name
Sf-1	Ground external radiation slope factors, 1/yr per (pCi/g):			
Sf-1	Ac-227+D	1.47E-06	3.48E-10	SLPF(1,1)
Sf-1	Pa-231	1.39E-07	1.39E-07	SLPF(2,1)
Sf-1	Pb-210+D	4.21E-09	1.41E-09	SLPF(3,1)
Sf-1	Ra-226+D	8.49E-06	2.29E-08	SLPF(4,1)
Sf-1	Th-230	8.19E-10	8.19E-10	SLPF(5,1)
Sf-1	U-234	2.52E-10	2.52E-10	SLPF(6,1)
Sf-1	U-235+D	5.43E-07	5.18E-07	SLPF(7,1)
Sf-1	U-238	4.99E-11	4.99E-11	SLPF(8,1)
Sf-1	U-238+D	1.14E-07	4.99E-11	SLPF(9,1)
Sf-2	Inhalation, slope factors, 1/(pCi):			
Sf-2	Ac-227+D	2.13E-07	1.49E-07	SLPF(1,2)
Sf-2	Pa-231	7.62E-08	7.62E-08	SLPF(2,2)
Sf-2	Pb-210+D	3.08E-08	1.58E-08	SLPF(3,2)
Sf-2	Ra-226+D	2.83E-08	2.82E-08	SLPF(4,2)
Sf-2	Th-230	3.40E-08	3.40E-08	SLPF(5,2)
Sf-2	U-234	2.78E-08	2.78E-08	SLPF(6,2)
Sf-2	U-235+D	2.50E-08	2.50E-08	SLPF(7,2)
Sf-2	U-238	2.36E-08	2.36E-08	SLPF(8,2)
Sf-2	U-238+D	2.36E-08	2.36E-08	SLPF(9,2)
Sf-3	Food ingestion, slope factors, 1/(pCi):			
Sf-3	Ac-227+D	6.53E-10	2.45E-10	SLPF(1,3)
Sf-3	Pa-231	2.26E-10	2.26E-10	SLPF(2,3)
Sf-3	Pb-210+D	3.44E-09	1.18E-09	SLPF(3,3)
Sf-3	Ra-226+D	5.15E-10	5.14E-10	SLPF(4,3)
Sf-3	Th-230	1.19E-10	1.19E-10	SLPF(5,3)
Sf-3	U-234	9.55E-11	9.55E-11	SLPF(6,3)
Sf-3	U-235+D	9.76E-11	9.44E-11	SLPF(7,3)
Sf-3	U-238	8.66E-11	8.66E-11	SLPF(8,3)
Sf-3	U-238+D	1.21E-10	8.66E-11	SLPF(9,3)
Sf-3	Water ingestion, slope factors, 1/(pCi):			
Sf-3	Ac-227+D	4.86E-10	2.01E-10	SLPF(1,4)
Sf-3	Pa-231	1.73E-10	1.73E-10	SLPF(2,4)
Sf-3	Pb-210+D	2.66E-09	8.81E-10	SLPF(3,4)
Sf-3	Ra-226+D	3.86E-10	3.85E-10	SLPF(4,4)
Sf-3	Th-230	9.10E-11	9.10E-11	SLPF(5,4)
Sf-3	U-234	7.07E-11	7.07E-11	SLPF(6,4)
Sf-3	U-235+D	7.18E-11	6.96E-11	SLPF(7,4)
Sf-3	U-238	6.40E-11	6.40E-11	SLPF(8,4)
Sf-3	U-238+D	8.71E-11	6.40E-11	SLPF(9,4)
Sf-3	Soil ingestion, slope factors, 1/(pCi):			
Sf-3	Ac-227+D	6.53E-10	2.45E-10	SLPF(1,5)
Sf-3	Pa-231	2.26E-10	2.26E-10	SLPF(2,5)
Sf-3	Pb-210+D	3.44E-09	1.18E-09	SLPF(3,5)
Sf-3	Ra-226+D	5.15E-10	5.14E-10	SLPF(4,5)
Sf-3	Th-230	1.19E-10	1.19E-10	SLPF(5,5)

Cancer Risk Slope Factors Summary Table (continued)

Risk Library: FGR 13 Morbidity

Menu	Parameter	Current Value	Base Case*	Parameter Name
Sf-3	U-234	9.55E-11	9.55E-11	SLPF(6,5)
Sf-3	U-235+D	9.76E-11	9.44E-11	SLPF(7,5)
Sf-3	U-238	8.66E-11	8.66E-11	SLPF(8,5)
Sf-3	U-238+D	1.21E-10	8.66E-11	SLPF(9,5)
Sf-Rn	Radon Inhalation slope factors, 1/(pCi):			
Sf-Rn	Rn-222	1.80E-12	1.80E-12	SLPFRN(1,1)
Sf-Rn	Po-218	3.70E-12	3.70E-12	SLPFRN(1,2)
Sf-Rn	Pb-214	6.20E-12	6.20E-12	SLPFRN(1,3)
Sf-Rn	Bi-214	1.50E-11	1.50E-11	SLPFRN(1,4)
Sf-Rn	Radon K factors, (mrem/WLM):			
Sf-Rn	Rn-222 Indoor	7.60E+02	7.60E+02	KFACTR(1,1)
Sf-Rn	Rn-222 Outdoor	5.70E+02	5.70E+02	KFACTR(1,2)

*Base Case means Default.Lib w/o Associate Nuclide contributions.

Risk Slope and Environmental Transport Factors for the Ground Pathway

Nuclide	Slope(i)*	ETFG(i,t) At Time in Years (dimensionless)							
(i)		t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
Ac-227	3.480E-10	9.567E-01	9.567E-01	9.567E-01	9.567E-01	9.567E-01	9.567E-01	9.567E-01	9.567E-01
At-218	3.570E-09	9.702E-01	9.702E-01	9.702E-01	9.702E-01	9.702E-01	9.702E-01	9.702E-01	9.702E-01
Bi-210	2.760E-09	9.450E-01	9.450E-01	9.450E-01	9.450E-01	9.450E-01	9.450E-01	9.450E-01	9.450E-01
Bi-211	1.880E-07	9.453E-01	9.453E-01	9.453E-01	9.453E-01	9.453E-01	9.453E-01	9.453E-01	9.453E-01
Bi-214	7.480E-06	9.401E-01	9.401E-01	9.401E-01	9.401E-01	9.401E-01	9.401E-01	9.401E-01	9.400E-01
Fr-223	1.400E-07	9.502E-01	9.502E-01	9.502E-01	9.502E-01	9.502E-01	9.502E-01	9.502E-01	9.502E-01
Pa-231	1.390E-07	9.456E-01	9.456E-01	9.456E-01	9.456E-01	9.456E-01	9.456E-01	9.456E-01	9.456E-01
Pa-234	8.710E-06	9.400E-01	9.400E-01	9.400E-01	9.400E-01	9.400E-01	9.400E-01	9.400E-01	9.400E-01
Pa-234m	6.870E-08	9.393E-01	9.393E-01	9.393E-01	9.393E-01	9.393E-01	9.393E-01	9.393E-01	9.393E-01
Pb-210	1.410E-09	9.813E-01	9.813E-01	9.813E-01	9.813E-01	9.813E-01	9.813E-01	9.813E-01	9.813E-01
Pb-211	2.290E-07	9.399E-01	9.399E-01	9.399E-01	9.399E-01	9.399E-01	9.399E-01	9.399E-01	9.399E-01
Pb-214	9.820E-07	9.456E-01	9.456E-01	9.456E-01	9.456E-01	9.456E-01	9.456E-01	9.456E-01	9.456E-01
Po-210	3.950E-11	9.390E-01	9.390E-01	9.390E-01	9.390E-01	9.390E-01	9.390E-01	9.390E-01	9.390E-01
Po-211	3.580E-08	9.360E-01	9.360E-01	9.360E-01	9.360E-01	9.360E-01	9.360E-01	9.360E-01	9.360E-01
Po-214	3.860E-10	9.360E-01	9.360E-01	9.360E-01	9.360E-01	9.360E-01	9.360E-01	9.360E-01	9.360E-01
Po-215	7.480E-10	9.410E-01	9.410E-01	9.410E-01	9.410E-01	9.410E-01	9.410E-01	9.410E-01	9.410E-01
Po-218	4.260E-11	9.390E-01	9.390E-01	9.390E-01	9.390E-01	9.390E-01	9.390E-01	9.390E-01	9.390E-01
Ra-223	4.340E-07	9.496E-01	9.496E-01	9.496E-01	9.496E-01	9.496E-01	9.496E-01	9.496E-01	9.496E-01
Ra-226	2.290E-08	9.524E-01	9.524E-01	9.524E-01	9.524E-01	9.524E-01	9.524E-01	9.524E-01	9.524E-01
Rn-219	2.250E-07	9.461E-01	9.461E-01	9.461E-01	9.461E-01	9.461E-01	9.461E-01	9.461E-01	9.461E-01
Rn-222	1.740E-09	9.370E-01	9.370E-01	9.370E-01	9.370E-01	9.370E-01	9.370E-01	9.370E-01	9.370E-01
Th-227	3.780E-07	9.508E-01	9.508E-01	9.508E-01	9.508E-01	9.508E-01	9.508E-01	9.508E-01	9.508E-01
Th-230	8.190E-10	9.588E-01	9.588E-01	9.588E-01	9.588E-01	9.588E-01	9.588E-01	9.588E-01	9.588E-01
Th-231	2.450E-08	9.599E-01	9.599E-01	9.599E-01	9.599E-01	9.599E-01	9.599E-01	9.599E-01	9.599E-01
Th-234	1.630E-08	9.610E-01	9.610E-01	9.610E-01	9.610E-01	9.610E-01	9.610E-01	9.610E-01	9.610E-01
Tl-207	1.520E-08	9.403E-01	9.403E-01	9.403E-01	9.403E-01	9.403E-01	9.403E-01	9.403E-01	9.403E-01
Tl-210	0.000E+00	1.000E+00	1.000E+00	1.000E+00	1.000E+00	1.000E+00	1.000E+00	1.000E+00	1.000E+00
U-234	2.520E-10	9.643E-01	9.643E-01	9.643E-01	9.643E-01	9.643E-01	9.643E-01	9.643E-01	9.643E-01
U-235	5.180E-07	9.520E-01	9.520E-01	9.520E-01	9.520E-01	9.520E-01	9.520E-01	9.520E-01	9.520E-01
U-238	4.990E-11	9.912E-01	9.912E-01	9.912E-01	9.912E-01	9.912E-01	9.912E-01	9.912E-01	9.912E-01

* - Units are 1/yr per (pCi/g) at infinite depth and area. Multiplication by ETFG(i,t) converts to site conditions.

Amount of Intake Quantities QINT(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As pCi/yr at t= 0.000E+00 years

Radio-	Water Independent Pathways (Inhalation w/o radon)					Water Dependent Pathways					Total
Nuclide	Inhalation	Plant	Meat	Milk	Soil	Water	Fish	Plant	Meat	Milk	Ingestion*
Ac-227	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Pa-231	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Pb-210	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Ra-226	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Th-230	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
U-234	2.529E-03	0.000E+00	0.000E+00	0.000E+00	3.597E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.597E+01
U-235	3.480E-05	0.000E+00	0.000E+00	0.000E+00	4.950E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	4.950E-01
U-238	1.798E-03	0.000E+00	0.000E+00	0.000E+00	2.558E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.558E+01

* Sum of all ingestion pathways, i.e. water independent plant, meat, milk, soil
and water-dependent water, fish, plant, meat, milk pathways

Amount of Intake Quantities QINT9(irn,i,t) and QINT9W(irn,i,t) for Inhalation of
Radon and its Decay Products as pCi/yr at t= 0.000E+00 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent   Water-dep. == Water-dependent

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 0.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Ac-227	1.139E-11	0.0000	1.012E-14	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.414E-13	0.0000
Pa-231	5.014E-12	0.0000	1.686E-14	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.112E-13	0.0000
Pb-210	2.907E-15	0.0000	1.287E-16	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.049E-13	0.0000
Ra-226	3.438E-11	0.0000	7.062E-16	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.829E-13	0.0000
Th-230	9.444E-13	0.0000	2.372E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.181E-11	0.0000
U-234	2.572E-09	0.0025	1.707E-09	0.0016	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.340E-08	0.0797
U-235	7.526E-08	0.0719	2.113E-11	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.173E-09	0.0011
U-238	8.061E-07	0.7705	1.032E-09	0.0010	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.489E-08	0.0716
Total	8.840E-07	0.8449	2.760E-09	0.0026	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.595E-07	0.1524

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 0.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Plant		Meat		Milk		All Pathways**	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Ac-227	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.184E-11	0.0000
Pa-231	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.742E-12	0.0000
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.080E-13	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.456E-11	0.0000
Th-230	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.299E-11	0.0000
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.768E-08	0.0838
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.646E-08	0.0731
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.821E-07	0.8431
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.046E-06	1.0000

** Sum of water independent ground, inhalation, plant, meat, milk, soil
and water dependent water, fish, plant, meat, milk pathways

Excess Cancer Risks CNRS9(irn,i,t) and CNRS9W(irn,i,t) for Inhalation of
Radon and its Decay Products at t= 0.000E+00 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	2.483E-14	4.982E-16	6.246E-19	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	2.483E-14	4.982E-16	6.246E-19	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 0.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
U-234	2.608E-09	0.0025	1.707E-09	0.0016	2.533E-14	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.341E-08	0.0797
U-235	7.528E-08	0.0719	2.115E-11	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.175E-09	0.0011
U-238	8.061E-07	0.7705	1.032E-09	0.0010	3.171E-19	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.490E-08	0.0716
Total	8.840E-07	0.8449	2.760E-09	0.0026	2.533E-14	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.595E-07	0.1524

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 0.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All pathways	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.773E-08	0.0838
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.648E-08	0.0731
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.821E-07	0.8431
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.046E-06	1.0000

***CNRSI(i,p,t) includes contribution from decay daughter radionuclides

Amount of Intake Quantities QINT(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As pCi/yr at t= 1.000E+00 years

Radio-	Water Independent Pathways (Inhalation w/o radon)					Water Dependent Pathways					Total
Nuclide	Inhalation	Plant	Meat	Milk	Soil	Water	Fish	Plant	Meat	Milk	Ingestion*
Ac-227	1.156E-11	0.000E+00	0.000E+00	0.000E+00	1.644E-07	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.644E-07
Pa-231	7.347E-10	0.000E+00	0.000E+00	0.000E+00	1.045E-05	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.045E-05
Pb-210	5.063E-14	0.000E+00	0.000E+00	0.000E+00	7.201E-10	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	7.201E-10
Ra-226	4.924E-12	0.000E+00	0.000E+00	0.000E+00	7.003E-08	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	7.003E-08
Th-230	2.274E-08	0.000E+00	0.000E+00	0.000E+00	3.234E-04	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.234E-04
U-234	2.523E-03	0.000E+00	0.000E+00	0.000E+00	3.589E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.589E+01
U-235	3.472E-05	0.000E+00	0.000E+00	0.000E+00	4.938E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	4.938E-01
U-238	1.794E-03	0.000E+00	0.000E+00	0.000E+00	2.551E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.551E+01

* Sum of all ingestion pathways, i.e. water independent plant, meat, milk, soil
and water-dependent water, fish, plant, meat, milk pathways

Amount of Intake Quantities QINT9(irn,i,t) and QINT9W(irn,i,t) for Inhalation of
Radon and its Decay Products as pCi/yr at t= 1.000E+00 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	2.723E-06	2.658E-08	1.988E-11	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	2.723E-06	2.658E-08	1.988E-11	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent   Water-dep. == Water-dependent

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Ac-227	1.269E-11	0.0000	1.127E-14	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.918E-13	0.0000
Pa-231	5.406E-12	0.0000	1.818E-14	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.669E-13	0.0000
Pb-210	3.378E-15	0.0000	1.496E-16	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.381E-13	0.0000
Ra-226	3.863E-11	0.0000	7.934E-16	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.055E-13	0.0000
Th-230	1.019E-12	0.0000	2.560E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.274E-11	0.0000
U-234	2.566E-09	0.0025	1.703E-09	0.0016	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.321E-08	0.0797
U-235	7.509E-08	0.0719	2.108E-11	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.171E-09	0.0011
U-238	8.043E-07	0.7705	1.029E-09	0.0010	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.472E-08	0.0716
Total	8.820E-07	0.8449	2.754E-09	0.0026	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.591E-07	0.1524

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Plant		Meat		Milk		All Pathways**	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Ac-227	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.319E-11	0.0000
Pa-231	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.191E-12	0.0000
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.416E-13	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.883E-11	0.0000
Th-230	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.402E-11	0.0000
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.748E-08	0.0838
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.628E-08	0.0731
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.800E-07	0.8431
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.044E-06	1.0000

** Sum of water independent ground, inhalation, plant, meat, milk, soil
and water dependent water, fish, plant, meat, milk pathways

Excess Cancer Risks CNRS9(irn,i,t) and CNRS9W(irn,i,t) for Inhalation of
Radon and its Decay Products at t= 1.000E+00 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	2.790E-14	5.597E-16	7.017E-19	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	2.790E-14	5.597E-16	7.017E-19	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
U-234	2.606E-09	0.0025	1.703E-09	0.0016	2.846E-14	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.322E-08	0.0797
U-235	7.510E-08	0.0720	2.111E-11	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.172E-09	0.0011
U-238	8.043E-07	0.7705	1.029E-09	0.0010	3.705E-19	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.472E-08	0.0716
Total	8.820E-07	0.8449	2.754E-09	0.0026	2.846E-14	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.591E-07	0.1524

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All pathways	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.753E-08	0.0839
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.630E-08	0.0731
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.800E-07	0.8431
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.044E-06	1.0000

***CNRSI(i,p,t) includes contribution from decay daughter radionuclides

Amount of Intake Quantities QINT(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As pCi/yr at t= 3.000E+00 years

Radio-	Water Independent Pathways (Inhalation w/o radon)					Water Dependent Pathways					Total
Nuclide	Inhalation	Plant	Meat	Milk	Soil	Water	Fish	Plant	Meat	Milk	Ingestion*
Ac-227	1.011E-10	0.000E+00	0.000E+00	0.000E+00	1.439E-06	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.439E-06
Pa-231	2.194E-09	0.000E+00	0.000E+00	0.000E+00	3.120E-05	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.120E-05
Pb-210	1.342E-12	0.000E+00	0.000E+00	0.000E+00	1.909E-08	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.909E-08
Ra-226	4.419E-11	0.000E+00	0.000E+00	0.000E+00	6.284E-07	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	6.284E-07
Th-230	6.806E-08	0.000E+00	0.000E+00	0.000E+00	9.680E-04	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	9.680E-04
U-234	2.511E-03	0.000E+00	0.000E+00	0.000E+00	3.572E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.572E+01
U-235	3.456E-05	0.000E+00	0.000E+00	0.000E+00	4.915E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	4.915E-01
U-238	1.786E-03	0.000E+00	0.000E+00	0.000E+00	2.540E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.540E+01

* Sum of all ingestion pathways, i.e. water independent plant, meat, milk, soil
and water-dependent water, fish, plant, meat, milk pathways

Amount of Intake Quantities QINT9(irn,i,t) and QINT9W(irn,i,t) for Inhalation of
Radon and its Decay Products as pCi/yr at t= 3.000E+00 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	2.443E-05	2.384E-07	1.784E-10	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	2.443E-05	2.384E-07	1.784E-10	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Ac-227	1.553E-11	0.0000	1.380E-14	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.019E-13	0.0000
Pa-231	6.185E-12	0.0000	2.080E-14	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.774E-13	0.0000
Pb-210	4.482E-15	0.0000	1.985E-16	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.160E-13	0.0000
Ra-226	4.808E-11	0.0000	9.875E-16	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.557E-13	0.0000
Th-230	1.168E-12	0.0000	2.934E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.460E-11	0.0000
U-234	2.554E-09	0.0025	1.695E-09	0.0016	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.282E-08	0.0797
U-235	7.473E-08	0.0719	2.098E-11	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.165E-09	0.0011
U-238	8.005E-07	0.7705	1.024E-09	0.0010	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.437E-08	0.0716
Total	8.778E-07	0.8449	2.741E-09	0.0026	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.584E-07	0.1524

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Plant		Meat		Milk		All Pathways**	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Ac-227	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.614E-11	0.0000
Pa-231	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.083E-12	0.0000
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.207E-13	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.833E-11	0.0000
Th-230	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.607E-11	0.0000
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.707E-08	0.0838
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.592E-08	0.0731
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.759E-07	0.8430
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.039E-06	1.0000

** Sum of water independent ground, inhalation, plant, meat, milk, soil
and water dependent water, fish, plant, meat, milk pathways

Excess Cancer Risks CNRS9(irn,i,t) and CNRS9W(irn,i,t) for Inhalation of
Radon and its Decay Products at t= 3.000E+00 years

Radon Pathway	Radionuclides Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	3.472E-14	6.966E-16	8.733E-19	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	3.472E-14	6.966E-16	8.733E-19	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent   Water-dep. == Water-dependent

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
U-234	2.603E-09	0.0025	1.695E-09	0.0016	3.542E-14	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.283E-08	0.0797
U-235	7.476E-08	0.0720	2.101E-11	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.167E-09	0.0011
U-238	8.005E-07	0.7705	1.025E-09	0.0010	4.968E-19	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.437E-08	0.0716
Total	8.778E-07	0.8449	2.741E-09	0.0026	3.542E-14	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.584E-07	0.1524

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All pathways	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.713E-08	0.0839
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.594E-08	0.0731
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.759E-07	0.8430
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.039E-06	1.0000

***CNRSI(i,p,t) includes contribution from decay daughter radionuclides

Amount of Intake Quantities QINT(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As pCi/yr at t= 1.000E+01 years

Radio-	Water Independent Pathways (Inhalation w/o radon)					Water Dependent Pathways					Total
Nuclide	Inhalation	Plant	Meat	Milk	Soil	Water	Fish	Plant	Meat	Milk	Ingestion*
Ac-227	1.021E-09	0.000E+00	0.000E+00	0.000E+00	1.452E-05	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.452E-05
Pa-231	7.192E-09	0.000E+00	0.000E+00	0.000E+00	1.023E-04	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.023E-04
Pb-210	4.669E-11	0.000E+00	0.000E+00	0.000E+00	6.641E-07	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	6.641E-07
Ra-226	4.859E-10	0.000E+00	0.000E+00	0.000E+00	6.910E-06	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	6.910E-06
Th-230	2.250E-07	0.000E+00	0.000E+00	0.000E+00	3.200E-03	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.200E-03
U-234	2.470E-03	0.000E+00	0.000E+00	0.000E+00	3.513E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.513E+01
U-235	3.400E-05	0.000E+00	0.000E+00	0.000E+00	4.835E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	4.835E-01
U-238	1.756E-03	0.000E+00	0.000E+00	0.000E+00	2.498E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.498E+01

* Sum of all ingestion pathways, i.e. water independent plant, meat, milk, soil
and water-dependent water, fish, plant, meat, milk pathways

Amount of Intake Quantities QINT9(irn,i,t) and QINT9W(irn,i,t) for Inhalation of
Radon and its Decay Products as pCi/yr at t= 1.000E+01 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	2.685E-04	2.621E-06	1.961E-09	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	2.685E-04	2.621E-06	1.961E-09	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+01 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Ac-227	2.764E-11	0.0000	2.456E-14	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.071E-12	0.0000
Pa-231	8.853E-12	0.0000	2.977E-14	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.256E-12	0.0000
Pb-210	1.037E-14	0.0000	4.590E-16	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.309E-13	0.0000
Ra-226	9.106E-11	0.0001	1.870E-15	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.843E-13	0.0000
Th-230	1.684E-12	0.0000	4.229E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.105E-11	0.0000
U-234	2.513E-09	0.0025	1.667E-09	0.0016	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.147E-08	0.0797
U-235	7.351E-08	0.0719	2.064E-11	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.146E-09	0.0011
U-238	7.874E-07	0.7704	1.008E-09	0.0010	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.315E-08	0.0716
Total	8.636E-07	0.8449	2.696E-09	0.0026	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.558E-07	0.1524

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+01 years

Water Dependent Pathways

Radio-Nuclide	Water risk	Water fract.	Fish risk	Fish fract.	Plant risk	Plant fract.	Meat risk	Meat fract.	Milk risk	Milk fract.	All Pathways** risk	All Pathways** fract.
Ac-227	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.873E-11	0.0000
Pa-231	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.014E-11	0.0000
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.417E-13	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.154E-11	0.0001
Th-230	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.316E-11	0.0000
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.565E-08	0.0838
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.468E-08	0.0731
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.616E-07	0.8430
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.022E-06	1.0000

** Sum of water independent ground, inhalation, plant, meat, milk, soil
and water dependent water, fish, plant, meat, milk pathways

Excess Cancer Risks CNRS9(irn,i,t) and CNRS9W(irn,i,t) for Inhalation of
Radon and its Decay Products at t= 1.000E+01 years

Radon Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	6.574E-14	1.319E-15	1.653E-18	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	6.574E-14	1.319E-15	1.653E-18	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent   Water-dep. == Water-dependent

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+01 years

Water Independent Pathways (Inhalation excludes radon)

Radio-Nuclide	Ground risk	Ground fract.	Inhalation risk	Inhalation fract.	Radon risk	Radon fract.	Plant risk	Plant fract.	Meat risk	Meat fract.	Milk risk	Milk fract.	Soil risk	Soil fract.
U-234	2.605E-09	0.0025	1.668E-09	0.0016	6.706E-14	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.148E-08	0.0797
U-235	7.355E-08	0.0720	2.069E-11	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.149E-09	0.0011
U-238	7.874E-07	0.7704	1.008E-09	0.0010	1.193E-18	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.316E-08	0.0716
Total	8.636E-07	0.8449	2.696E-09	0.0026	6.706E-14	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.558E-07	0.1524

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+01 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All pathways	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.576E-08	0.0839
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.472E-08	0.0731
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.616E-07	0.8430
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.022E-06	1.0000

***CNRSI(i,p,t) includes contribution from decay daughter radionuclides

Amount of Intake Quantities QINT(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As pCi/yr at t= 3.000E+01 years

Radio-	Water Independent Pathways (Inhalation w/o radon)					Water Dependent Pathways					Total
Nuclide	Inhalation	Plant	Meat	Milk	Soil	Water	Fish	Plant	Meat	Milk	Ingestion*
Ac-227	7.112E-09	0.000E+00	0.000E+00	0.000E+00	1.011E-04	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.011E-04
Pa-231	2.058E-08	0.000E+00	0.000E+00	0.000E+00	2.927E-04	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.927E-04
Pb-210	1.063E-09	0.000E+00	0.000E+00	0.000E+00	1.512E-05	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.512E-05
Ra-226	4.245E-09	0.000E+00	0.000E+00	0.000E+00	6.037E-05	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	6.037E-05
Th-230	6.594E-07	0.000E+00	0.000E+00	0.000E+00	9.378E-03	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	9.378E-03
U-234	2.357E-03	0.000E+00	0.000E+00	0.000E+00	3.352E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.352E+01
U-235	3.243E-05	0.000E+00	0.000E+00	0.000E+00	4.613E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	4.613E-01
U-238	1.676E-03	0.000E+00	0.000E+00	0.000E+00	2.383E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.383E+01

* Sum of all ingestion pathways, i.e. water independent plant, meat, milk, soil and water-dependent water, fish, plant, meat, milk pathways

Amount of Intake Quantities QINT9(irn,i,t) and QINT9W(irn,i,t) for Inhalation of
Radon and its Decay Products as pCi/yr at t= 3.000E+01 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	2.343E-03	2.286E-05	1.711E-08	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	2.343E-03	2.286E-05	1.711E-08	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+01 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Ac-227	7.412E-11	0.0001	6.586E-14	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.873E-12	0.0000
Pa-231	1.599E-11	0.0000	5.378E-14	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.269E-12	0.0000
Pb-210	5.034E-14	0.0000	2.229E-15	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.549E-12	0.0000
Ra-226	2.950E-10	0.0003	6.060E-15	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.569E-12	0.0000
Th-230	3.111E-12	0.0000	7.814E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.890E-11	0.0000
U-234	2.397E-09	0.0025	1.591E-09	0.0016	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.772E-08	0.0797
U-235	7.014E-08	0.0719	1.969E-11	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.094E-09	0.0011
U-238	7.513E-07	0.7702	9.615E-10	0.0010	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.979E-08	0.0716
Total	8.242E-07	0.8450	2.573E-09	0.0026	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.487E-07	0.1524

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+01 years

Water Dependent Pathways

Radio-	Water		Fish		Plant		Meat		Milk		All Pathways**	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Ac-227	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.706E-11	0.0001
Pa-231	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.831E-11	0.0000
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.602E-12	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.966E-10	0.0003
Th-230	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.279E-11	0.0000
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.171E-08	0.0838
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.125E-08	0.0730
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.220E-07	0.8427
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.754E-07	1.0000

** Sum of water independent ground, inhalation, plant, meat, milk, soil
and water dependent water, fish, plant, meat, milk pathways

Excess Cancer Risks CNRS9(irn,i,t) and CNRS9W(irn,i,t) for Inhalation of
Radon and its Decay Products at t= 3.000E+01 years

Radon Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	2.123E-13	4.258E-15	5.338E-18	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	2.123E-13	4.258E-15	5.338E-18	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+01 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
U-234	2.695E-09	0.0028	1.591E-09	0.0016	2.165E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.776E-08	0.0797
U-235	7.023E-08	0.0720	1.981E-11	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.099E-09	0.0011
U-238	7.513E-07	0.7702	9.616E-10	0.0010	6.452E-18	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.980E-08	0.0716
Total	8.242E-07	0.8450	2.573E-09	0.0026	2.165E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.487E-07	0.1524

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+01 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All pathways	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.205E-08	0.0841
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.135E-08	0.0731
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.220E-07	0.8427
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.754E-07	1.0000

***CNRSI(i,p,t) includes contribution from decay daughter radionuclides

Amount of Intake Quantities QINT(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As pCi/yr at t= 1.000E+02 years

Radio-	Water Independent Pathways (Inhalation w/o radon)					Water Dependent Pathways					Total
Nuclide	Inhalation	Plant	Meat	Milk	Soil	Water	Fish	Plant	Meat	Milk	Ingestion*
Ac-227	3.802E-08	0.000E+00	0.000E+00	0.000E+00	5.407E-04	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	5.407E-04
Pa-231	5.815E-08	0.000E+00	0.000E+00	0.000E+00	8.271E-04	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	8.271E-04
Pb-210	2.369E-08	0.000E+00	0.000E+00	0.000E+00	3.369E-04	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.369E-04
Ra-226	4.254E-08	0.000E+00	0.000E+00	0.000E+00	6.050E-04	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	6.050E-04
Th-230	2.028E-06	0.000E+00	0.000E+00	0.000E+00	2.884E-02	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.884E-02
U-234	1.999E-03	0.000E+00	0.000E+00	0.000E+00	2.843E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.843E+01
U-235	2.751E-05	0.000E+00	0.000E+00	0.000E+00	3.913E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.913E-01
U-238	1.422E-03	0.000E+00	0.000E+00	0.000E+00	2.022E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.022E+01

* Sum of all ingestion pathways, i.e. water independent plant, meat, milk, soil
and water-dependent water, fish, plant, meat, milk pathways

Amount of Intake Quantities QINT9(irn,i,t) and QINT9W(irn,i,t) for Inhalation of
Radon and its Decay Products as pCi/yr at t= 1.000E+02 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	2.327E-02	2.271E-04	1.699E-07	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	2.327E-02	2.271E-04	1.699E-07	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent   Water-dep. == Water-dependent

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+02 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Ac-227	2.580E-10	0.0003	2.292E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.000E-11	0.0000
Pa-231	3.595E-11	0.0000	1.209E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.100E-12	0.0000
Pb-210	5.440E-13	0.0000	2.409E-14	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.835E-11	0.0000
Ra-226	1.824E-09	0.0022	3.747E-14	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.703E-12	0.0000
Th-230	7.608E-12	0.0000	1.911E-12	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.512E-11	0.0001
U-234	2.033E-09	0.0025	1.349E-09	0.0016	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.593E-08	0.0795
U-235	5.950E-08	0.0717	1.670E-11	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.277E-10	0.0011
U-238	6.373E-07	0.7684	8.156E-10	0.0010	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.921E-08	0.0714
Total	7.010E-07	0.8452	2.184E-09	0.0026	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.262E-07	0.1522

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+02 years

Water Dependent Pathways

Radio-	Water		Fish		Plant		Meat		Milk		All Pathways**	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Ac-227	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.682E-10	0.0003
Pa-231	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.117E-11	0.0000
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.892E-11	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.834E-09	0.0022
Th-230	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.046E-10	0.0001
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.931E-08	0.0836
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.044E-08	0.0729
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.973E-07	0.8408
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.294E-07	1.0000

** Sum of water independent ground, inhalation, plant, meat, milk, soil
and water dependent water, fish, plant, meat, milk pathways

Excess Cancer Risks CNRS9(irn,i,t) and CNRS9W(irn,i,t) for Inhalation of
Radon and its Decay Products at t= 1.000E+02 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	1.303E-12	2.615E-14	3.278E-17	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	1.303E-12	2.615E-14	3.278E-17	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+02 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
U-234	3.865E-09	0.0047	1.351E-09	0.0016	1.330E-12	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.606E-08	0.0796
U-235	5.979E-08	0.0721	1.705E-11	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.428E-10	0.0011
U-238	6.373E-07	0.7684	8.159E-10	0.0010	9.875E-17	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.922E-08	0.0714
Total	7.010E-07	0.8452	2.184E-09	0.0026	1.330E-12	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.262E-07	0.1522

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+02 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All pathways	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.128E-08	0.0859
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.075E-08	0.0733
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.973E-07	0.8408
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.294E-07	1.0000

***CNRSI(i,p,t) includes contribution from decay daughter radionuclides

Amount of Intake Quantities QINT(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As pCi/yr at t= 3.000E+02 years

Radio-	Water Independent Pathways (Inhalation w/o radon)					Water Dependent Pathways					Total
Nuclide	Inhalation	Plant	Meat	Milk	Soil	Water	Fish	Plant	Meat	Milk	Ingestion*
Ac-227	8.883E-08	0.000E+00	0.000E+00	0.000E+00	1.263E-03	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.263E-03
Pa-231	1.088E-07	0.000E+00	0.000E+00	0.000E+00	1.547E-03	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.547E-03
Pb-210	2.337E-07	0.000E+00	0.000E+00	0.000E+00	3.324E-03	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.324E-03
Ra-226	2.873E-07	0.000E+00	0.000E+00	0.000E+00	4.087E-03	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	4.087E-03
Th-230	4.891E-06	0.000E+00	0.000E+00	0.000E+00	6.957E-02	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	6.957E-02
U-234	1.249E-03	0.000E+00	0.000E+00	0.000E+00	1.777E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.777E+01
U-235	1.720E-05	0.000E+00	0.000E+00	0.000E+00	2.446E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.446E-01
U-238	8.885E-04	0.000E+00	0.000E+00	0.000E+00	1.264E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.264E+01

* Sum of all ingestion pathways, i.e. water independent plant, meat, milk, soil
and water-dependent water, fish, plant, meat, milk pathways

Amount of Intake Quantities QINT9(irn,i,t) and QINT9W(irn,i,t) for Inhalation of
Radon and its Decay Products as pCi/yr at t= 3.000E+02 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	1.541E-01	1.504E-03	1.125E-06	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	1.541E-01	1.504E-03	1.125E-06	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent   Water-dep. == Water-dependent

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+02 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Ac-227	5.402E-10	0.0010	4.799E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.094E-11	0.0000
Pa-231	6.232E-11	0.0001	2.096E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.841E-12	0.0000
Pb-210	4.364E-12	0.0000	1.932E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.077E-10	0.0006
Ra-226	1.054E-08	0.0199	2.165E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.608E-11	0.0001
Th-230	1.702E-11	0.0000	4.274E-12	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.128E-10	0.0004
U-234	1.271E-09	0.0024	8.432E-10	0.0016	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.120E-08	0.0779
U-235	3.719E-08	0.0703	1.044E-11	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.798E-10	0.0011
U-238	3.983E-07	0.7534	5.098E-10	0.0010	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.700E-08	0.0700
Total	4.479E-07	0.8472	1.369E-09	0.0026	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.939E-08	0.1502

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+02 years

Water Dependent Pathways

Radio-	Water		Fish		Plant		Meat		Milk		All Pathways**	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Ac-227	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.616E-10	0.0011
Pa-231	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.137E-11	0.0001
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.122E-10	0.0006
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.060E-08	0.0200
Th-230	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.341E-10	0.0004
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.331E-08	0.0819
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.778E-08	0.0715
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.358E-07	0.8243
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.287E-07	1.0000

** Sum of water independent ground, inhalation, plant, meat, milk, soil
and water dependent water, fish, plant, meat, milk pathways

Excess Cancer Risks CNRS9(irn,i,t) and CNRS9W(irn,i,t) for Inhalation of
Radon and its Decay Products at t= 3.000E+02 years

Radon Pathway	Radionuclides: Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	7.382E-12	1.481E-13	1.857E-16	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	7.382E-12	1.481E-13	1.857E-16	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+02 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
U-234	1.183E-08	0.0224	8.474E-10	0.0016	7.529E-12	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.175E-08	0.0790
U-235	3.779E-08	0.0715	1.113E-11	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.096E-10	0.0012
U-238	3.983E-07	0.7534	5.103E-10	0.0010	1.473E-15	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.703E-08	0.0700
Total	4.479E-07	0.8472	1.369E-09	0.0026	7.530E-12	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.939E-08	0.1502

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+02 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All pathways	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.443E-08	0.1030
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.841E-08	0.0727
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.358E-07	0.8244
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.287E-07	1.0000

***CNRSI(i,p,t) includes contribution from decay daughter radionuclides

Amount of Intake Quantities QINT(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As pCi/yr at t= 1.000E+03 years

Radio-	Water Independent Pathways (Inhalation w/o radon)					Water Dependent Pathways					Total
Nuclide	Inhalation	Plant	Meat	Milk	Soil	Water	Fish	Plant	Meat	Milk	Ingestion*
Ac-227	6.086E-08	0.000E+00	0.000E+00	0.000E+00	8.656E-04	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	8.656E-04
Pa-231	6.948E-08	0.000E+00	0.000E+00	0.000E+00	9.882E-04	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	9.882E-04
Pb-210	1.208E-06	0.000E+00	0.000E+00	0.000E+00	1.718E-02	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.718E-02
Ra-226	1.287E-06	0.000E+00	0.000E+00	0.000E+00	1.831E-02	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.831E-02
Th-230	8.696E-06	0.000E+00	0.000E+00	0.000E+00	1.237E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.237E-01
U-234	2.410E-04	0.000E+00	0.000E+00	0.000E+00	3.427E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.427E+00
U-235	3.319E-06	0.000E+00	0.000E+00	0.000E+00	4.720E-02	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	4.720E-02
U-238	1.715E-04	0.000E+00	0.000E+00	0.000E+00	2.439E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.439E+00

* Sum of all ingestion pathways, i.e. water independent plant, meat, milk, soil
and water-dependent water, fish, plant, meat, milk pathways

Amount of Intake Quantities QINT9(irn,i,t) and QINT9W(irn,i,t) for Inhalation of
Radon and its Decay Products as pCi/yr at t= 1.000E+03 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	5.678E-01	5.542E-03	4.146E-06	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	5.678E-01	5.542E-03	4.146E-06	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent   Water-dep. == Water-dependent

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+03 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Ac-227	3.585E-10	0.0024	3.185E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.390E-11	0.0001
Pa-231	3.869E-11	0.0003	1.301E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.489E-12	0.0000
Pb-210	2.120E-11	0.0001	9.386E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.494E-09	0.0102
Ra-226	4.474E-08	0.3042	9.189E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.380E-10	0.0016
Th-230	2.952E-11	0.0002	7.413E-12	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.690E-10	0.0025
U-234	2.451E-10	0.0017	1.626E-10	0.0011	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.946E-09	0.0540
U-235	7.176E-09	0.0488	2.014E-12	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.119E-10	0.0008
U-238	7.687E-08	0.5227	9.838E-11	0.0007	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.141E-09	0.0486
Total	1.295E-07	0.8804	2.727E-10	0.0019	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.732E-08	0.1178

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+03 years

Water Dependent Pathways

Radio-	Water		Fish		Plant		Meat		Milk		All Pathways**	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Ac-227	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.727E-10	0.0025
Pa-231	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.431E-11	0.0003
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.517E-09	0.0103
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.497E-08	0.3058
Th-230	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.060E-10	0.0028
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.354E-09	0.0568
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.290E-09	0.0496
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.411E-08	0.5719
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.471E-07	1.0000

** Sum of water independent ground, inhalation, plant, meat, milk, soil
and water dependent water, fish, plant, meat, milk pathways

Excess Cancer Risks CNRS9(irn,i,t) and CNRS9W(irn,i,t) for Inhalation of
Radon and its Decay Products at t= 1.000E+03 years

Radon Pathway	Radionuclides Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	2.563E-11	5.142E-13	6.447E-16	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	2.563E-11	5.142E-13	6.447E-16	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent   Water-dep. == Water-dependent

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+03 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
U-234	4.501E-08	0.3060	1.716E-10	0.0012	2.613E-11	0.0002	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.003E-08	0.0682
U-235	7.574E-09	0.0515	2.463E-12	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.313E-10	0.0009
U-238	7.689E-08	0.5227	9.871E-11	0.0007	1.373E-14	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.158E-09	0.0487
Total	1.295E-07	0.8802	2.727E-10	0.0019	2.615E-11	0.0002	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.732E-08	0.1177

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+03 years

Water Dependent Pathways

Radio-Nuclide	Water risk	Water fract.	Fish risk	Fish fract.	Radon risk	Radon fract.	Plant risk	Plant fract.	Meat risk	Meat fract.	Milk risk	Milk fract.	All pathways risk	All pathways fract.
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.524E-08	0.3755
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.707E-09	0.0524
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.415E-08	0.5721
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.471E-07	1.0000

***CNRSI(i,p,t) includes contribution from decay daughter radionuclides

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Uranium Soils Investigation
Baseline Human Health Risk Assessment
Saddle Road
October 2009

Table of Contents

Part III: Intake Quantities and Health Risk Factors

Cancer Risk Slope Factors Summary Table

Risk Library: FGR 13 Morbidity

Menu	Parameter	Current Value	Base Case*	Parameter Name
Sf-1	Ground external radiation slope factors, 1/yr per (pCi/g):			
Sf-1	Ac-227+D	1.47E-06	3.48E-10	SLPF(1,1)
Sf-1	Pa-231	1.39E-07	1.39E-07	SLPF(2,1)
Sf-1	Pb-210+D	4.21E-09	1.41E-09	SLPF(3,1)
Sf-1	Ra-226+D	8.49E-06	2.29E-08	SLPF(4,1)
Sf-1	Th-230	8.19E-10	8.19E-10	SLPF(5,1)
Sf-1	U-234	2.52E-10	2.52E-10	SLPF(6,1)
Sf-1	U-235+D	5.43E-07	5.18E-07	SLPF(7,1)
Sf-1	U-238	4.99E-11	4.99E-11	SLPF(8,1)
Sf-1	U-238+D	1.14E-07	4.99E-11	SLPF(9,1)
Sf-2	Inhalation, slope factors, 1/(pCi):			
Sf-2	Ac-227+D	2.13E-07	1.49E-07	SLPF(1,2)
Sf-2	Pa-231	7.62E-08	7.62E-08	SLPF(2,2)
Sf-2	Pb-210+D	3.08E-08	1.58E-08	SLPF(3,2)
Sf-2	Ra-226+D	2.83E-08	2.82E-08	SLPF(4,2)
Sf-2	Th-230	3.40E-08	3.40E-08	SLPF(5,2)
Sf-2	U-234	2.78E-08	2.78E-08	SLPF(6,2)
Sf-2	U-235+D	2.50E-08	2.50E-08	SLPF(7,2)
Sf-2	U-238	2.36E-08	2.36E-08	SLPF(8,2)
Sf-2	U-238+D	2.36E-08	2.36E-08	SLPF(9,2)
Sf-3	Food ingestion, slope factors, 1/(pCi):			
Sf-3	Ac-227+D	6.53E-10	2.45E-10	SLPF(1,3)
Sf-3	Pa-231	2.26E-10	2.26E-10	SLPF(2,3)
Sf-3	Pb-210+D	3.44E-09	1.18E-09	SLPF(3,3)
Sf-3	Ra-226+D	5.15E-10	5.14E-10	SLPF(4,3)
Sf-3	Th-230	1.19E-10	1.19E-10	SLPF(5,3)
Sf-3	U-234	9.55E-11	9.55E-11	SLPF(6,3)
Sf-3	U-235+D	9.76E-11	9.44E-11	SLPF(7,3)
Sf-3	U-238	8.66E-11	8.66E-11	SLPF(8,3)
Sf-3	U-238+D	1.21E-10	8.66E-11	SLPF(9,3)
Sf-3	Water ingestion, slope factors, 1/(pCi):			
Sf-3	Ac-227+D	4.86E-10	2.01E-10	SLPF(1,4)
Sf-3	Pa-231	1.73E-10	1.73E-10	SLPF(2,4)
Sf-3	Pb-210+D	2.66E-09	8.81E-10	SLPF(3,4)
Sf-3	Ra-226+D	3.86E-10	3.85E-10	SLPF(4,4)
Sf-3	Th-230	9.10E-11	9.10E-11	SLPF(5,4)
Sf-3	U-234	7.07E-11	7.07E-11	SLPF(6,4)
Sf-3	U-235+D	7.18E-11	6.96E-11	SLPF(7,4)
Sf-3	U-238	6.40E-11	6.40E-11	SLPF(8,4)
Sf-3	U-238+D	8.71E-11	6.40E-11	SLPF(9,4)
Sf-3	Soil ingestion, slope factors, 1/(pCi):			
Sf-3	Ac-227+D	6.53E-10	2.45E-10	SLPF(1,5)
Sf-3	Pa-231	2.26E-10	2.26E-10	SLPF(2,5)
Sf-3	Pb-210+D	3.44E-09	1.18E-09	SLPF(3,5)
Sf-3	Ra-226+D	5.15E-10	5.14E-10	SLPF(4,5)
Sf-3	Th-230	1.19E-10	1.19E-10	SLPF(5,5)
Sf-3	U-234	9.55E-11	9.55E-11	SLPF(6,5)

Cancer Risk Slope Factors Summary Table (continued)

Risk Library: FGR 13 Morbidity

Menu	Parameter	Current Value	Base Case*	Parameter Name
Sf-3	U-235+D	9.76E-11	9.44E-11	SLPF(7,5)
Sf-3	U-238	8.66E-11	8.66E-11	SLPF(8,5)
Sf-3	U-238+D	1.21E-10	8.66E-11	SLPF(9,5)
Sf-Rn	Radon Inhalation slope factors, 1/(pCi):			
Sf-Rn	Rn-222	1.80E-12	1.80E-12	SLPFRN(1,1)
Sf-Rn	Po-218	3.70E-12	3.70E-12	SLPFRN(1,2)
Sf-Rn	Pb-214	6.20E-12	6.20E-12	SLPFRN(1,3)
Sf-Rn	Bi-214	1.50E-11	1.50E-11	SLPFRN(1,4)
Sf-Rn	Radon K factors, (mrem/WLM):			
Sf-Rn	Rn-222 Indoor	7.60E+02	7.60E+02	KFACTR(1,1)
Sf-Rn	Rn-222 Outdoor	5.70E+02	5.70E+02	KFACTR(1,2)

*Base Case means Default.Lib w/o Associate Nuclide contributions.

Risk Slope and Environmental Transport Factors for the Ground Pathway

Nuclide	Slope(i)*	ETFG(i,t) At Time in Years (dimensionless)							
(i)	t=	0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
Ac-227	3.480E-10	9.567E-01	9.567E-01	9.567E-01	9.567E-01	9.567E-01	9.567E-01	9.567E-01	9.567E-01
At-218	3.570E-09	9.702E-01	9.702E-01	9.702E-01	9.702E-01	9.702E-01	9.702E-01	9.702E-01	9.702E-01
Bi-210	2.760E-09	9.450E-01	9.450E-01	9.450E-01	9.450E-01	9.450E-01	9.450E-01	9.450E-01	9.450E-01
Bi-211	1.880E-07	9.453E-01	9.453E-01	9.453E-01	9.453E-01	9.453E-01	9.453E-01	9.453E-01	9.453E-01
Bi-214	7.480E-06	9.401E-01	9.401E-01	9.401E-01	9.401E-01	9.401E-01	9.401E-01	9.401E-01	9.400E-01
Fr-223	1.400E-07	9.502E-01	9.502E-01	9.502E-01	9.502E-01	9.502E-01	9.502E-01	9.502E-01	9.502E-01
Pa-231	1.390E-07	9.456E-01	9.456E-01	9.456E-01	9.456E-01	9.456E-01	9.456E-01	9.456E-01	9.456E-01
Pa-234	8.710E-06	9.400E-01	9.400E-01	9.400E-01	9.400E-01	9.400E-01	9.400E-01	9.400E-01	9.400E-01
Pa-234m	6.870E-08	9.393E-01	9.393E-01	9.393E-01	9.393E-01	9.393E-01	9.393E-01	9.393E-01	9.393E-01
Pb-210	1.410E-09	9.813E-01	9.813E-01	9.813E-01	9.813E-01	9.813E-01	9.813E-01	9.813E-01	9.813E-01
Pb-211	2.290E-07	9.399E-01	9.399E-01	9.399E-01	9.399E-01	9.399E-01	9.399E-01	9.399E-01	9.399E-01
Pb-214	9.820E-07	9.456E-01	9.456E-01	9.456E-01	9.456E-01	9.456E-01	9.456E-01	9.456E-01	9.456E-01
Po-210	3.950E-11	9.390E-01	9.390E-01	9.390E-01	9.390E-01	9.390E-01	9.390E-01	9.390E-01	9.390E-01
Po-211	3.580E-08	9.360E-01	9.360E-01	9.360E-01	9.360E-01	9.360E-01	9.360E-01	9.360E-01	9.360E-01
Po-214	3.860E-10	9.360E-01	9.360E-01	9.360E-01	9.360E-01	9.360E-01	9.360E-01	9.360E-01	9.360E-01
Po-215	7.480E-10	9.410E-01	9.410E-01	9.410E-01	9.410E-01	9.410E-01	9.410E-01	9.410E-01	9.410E-01
Po-218	4.260E-11	9.390E-01	9.390E-01	9.390E-01	9.390E-01	9.390E-01	9.390E-01	9.390E-01	9.390E-01
Ra-223	4.340E-07	9.496E-01	9.496E-01	9.496E-01	9.496E-01	9.496E-01	9.496E-01	9.496E-01	9.496E-01
Ra-226	2.290E-08	9.524E-01	9.524E-01	9.524E-01	9.524E-01	9.524E-01	9.524E-01	9.524E-01	9.524E-01
Rn-219	2.250E-07	9.461E-01	9.461E-01	9.461E-01	9.461E-01	9.461E-01	9.461E-01	9.461E-01	9.461E-01
Rn-222	1.740E-09	9.370E-01	9.370E-01	9.370E-01	9.370E-01	9.370E-01	9.370E-01	9.370E-01	9.370E-01
Th-227	3.780E-07	9.508E-01	9.508E-01	9.508E-01	9.508E-01	9.508E-01	9.508E-01	9.508E-01	9.508E-01
Th-230	8.190E-10	9.588E-01	9.588E-01	9.588E-01	9.588E-01	9.588E-01	9.588E-01	9.588E-01	9.588E-01
Th-231	2.450E-08	9.599E-01	9.599E-01	9.599E-01	9.599E-01	9.599E-01	9.599E-01	9.599E-01	9.599E-01
Th-234	1.630E-08	9.610E-01	9.610E-01	9.610E-01	9.610E-01	9.610E-01	9.610E-01	9.610E-01	9.610E-01
Tl-207	1.520E-08	9.403E-01	9.403E-01	9.403E-01	9.403E-01	9.403E-01	9.403E-01	9.403E-01	9.403E-01
Tl-210	0.000E+00	1.000E+00	1.000E+00	1.000E+00	1.000E+00	1.000E+00	1.000E+00	1.000E+00	1.000E+00
U-234	2.520E-10	9.643E-01	9.643E-01	9.643E-01	9.643E-01	9.643E-01	9.643E-01	9.643E-01	9.643E-01
U-235	5.180E-07	9.520E-01	9.520E-01	9.520E-01	9.520E-01	9.520E-01	9.520E-01	9.520E-01	9.520E-01
U-238	4.990E-11	9.912E-01	9.912E-01	9.912E-01	9.912E-01	9.912E-01	9.912E-01	9.912E-01	9.912E-01

* - Units are 1/yr per (pCi/g) at infinite depth and area. Multiplication by ETFG(i,t) converts to site conditions.

Amount of Intake Quantities QINT(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As pCi/yr at t= 0.000E+00 years

Radio-	Water Independent Pathways (Inhalation w/o radon)					Water Dependent Pathways					Total
Nuclide	Inhalation	Plant	Meat	Milk	Soil	Water	Fish	Plant	Meat	Milk	Ingestion*
Ac-227	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Pa-231	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Pb-210	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Ra-226	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Th-230	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
U-234	5.313E-03	0.000E+00	0.000E+00	0.000E+00	3.052E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.052E+01
U-235	7.312E-05	0.000E+00	0.000E+00	0.000E+00	4.200E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	4.200E-01
U-238	3.778E-03	0.000E+00	0.000E+00	0.000E+00	2.170E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.170E+01

* Sum of all ingestion pathways, i.e. water independent plant, meat, milk, soil
and water-dependent water, fish, plant, meat, milk pathways

Amount of Intake Quantities QINT9(irn,i,t) and QINT9W(irn,i,t) for Inhalation of
Radon and its Decay Products as pCi/yr at t= 0.000E+00 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent   Water-dep. == Water-dependent

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 0.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Ac-227	1.899E-13	0.0000	3.545E-16	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.246E-15	0.0000
Pa-231	2.975E-13	0.0000	2.102E-15	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.581E-14	0.0000
Pb-210	1.101E-17	0.0000	1.024E-18	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.585E-16	0.0000
Ra-226	4.854E-13	0.0000	2.095E-17	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.191E-15	0.0000
Th-230	5.521E-14	0.0000	2.913E-14	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.857E-13	0.0000
U-234	6.312E-10	0.0025	8.800E-10	0.0035	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.737E-08	0.0690
U-235	1.847E-08	0.0734	1.089E-11	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.443E-10	0.0010
U-238	1.978E-07	0.7864	5.319E-10	0.0021	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.559E-08	0.0620
Total	2.169E-07	0.8623	1.423E-09	0.0057	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.320E-08	0.1320

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 0.000E+00 years

Water Dependent Pathways

Radio-Nuclide	Water risk	Water fract.	Fish risk	Fish fract.	Plant risk	Plant fract.	Meat risk	Meat fract.	Milk risk	Milk fract.	All Pathways** risk	All Pathways** fract.
Ac-227	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.965E-13	0.0000
Pa-231	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.354E-13	0.0000
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.705E-16	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.876E-13	0.0000
Th-230	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.701E-13	0.0000
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.888E-08	0.0750
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.872E-08	0.0744
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.139E-07	0.8505
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.515E-07	1.0000

** Sum of water independent ground, inhalation, plant, meat, milk, soil
and water dependent water, fish, plant, meat, milk pathways

Excess Cancer Risks CNRS9(irn,i,t) and CNRS9W(irn,i,t) for Inhalation of
Radon and its Decay Products at t= 0.000E+00 years

Radon Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	7.374E-16	1.479E-17	1.855E-20	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	7.374E-16	1.479E-17	1.855E-20	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 0.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-Nuclide	Ground risk	Ground fract.	Inhalation risk	Inhalation fract.	Radon risk	Radon fract.	Plant risk	Plant fract.	Meat risk	Meat fract.	Milk risk	Milk fract.	Soil risk	Soil fract.
U-234	6.317E-10	0.0025	8.801E-10	0.0035	7.522E-16	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.737E-08	0.0690
U-235	1.847E-08	0.0734	1.089E-11	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.444E-10	0.0010
U-238	1.978E-07	0.7864	5.319E-10	0.0021	2.271E-21	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.559E-08	0.0620
Total	2.169E-07	0.8623	1.423E-09	0.0057	7.522E-16	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.320E-08	0.1320

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 0.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All pathways	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.888E-08	0.0750
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.872E-08	0.0744
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.139E-07	0.8505
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.515E-07	1.0000

***CNRSI(i,p,t) includes contribution from decay daughter radionuclides

Amount of Intake Quantities QINT(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As pCi/yr at t= 1.000E+00 years

Radio-	Water Independent Pathways (Inhalation w/o radon)					Water Dependent Pathways					Total
Nuclide	Inhalation	Plant	Meat	Milk	Soil	Water	Fish	Plant	Meat	Milk	Ingestion*
Ac-227	2.428E-11	0.000E+00	0.000E+00	0.000E+00	1.395E-07	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.395E-07
Pa-231	1.543E-09	0.000E+00	0.000E+00	0.000E+00	8.866E-06	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	8.866E-06
Pb-210	1.064E-13	0.000E+00	0.000E+00	0.000E+00	6.110E-10	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	6.110E-10
Ra-226	1.034E-11	0.000E+00	0.000E+00	0.000E+00	5.942E-08	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	5.942E-08
Th-230	4.777E-08	0.000E+00	0.000E+00	0.000E+00	2.744E-04	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.744E-04
U-234	5.301E-03	0.000E+00	0.000E+00	0.000E+00	3.045E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.045E+01
U-235	7.295E-05	0.000E+00	0.000E+00	0.000E+00	4.190E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	4.190E-01
U-238	3.769E-03	0.000E+00	0.000E+00	0.000E+00	2.165E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.165E+01

* Sum of all ingestion pathways, i.e. water independent plant, meat, milk, soil
and water-dependent water, fish, plant, meat, milk pathways

Amount of Intake Quantities QINT9(irn,i,t) and QINT9W(irn,i,t) for Inhalation of
Radon and its Decay Products as pCi/yr at t= 1.000E+00 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	5.721E-06	5.583E-08	4.177E-11	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	5.721E-06	5.583E-08	4.177E-11	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Ac-227	2.975E-13	0.0000	5.554E-16	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.786E-15	0.0000
Pa-231	3.960E-13	0.0000	2.798E-15	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.766E-14	0.0000
Pb-210	2.024E-17	0.0000	1.883E-18	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.211E-15	0.0000
Ra-226	7.677E-13	0.0000	3.313E-17	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.465E-15	0.0000
Th-230	7.355E-14	0.0000	3.881E-14	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.803E-13	0.0000
U-234	6.297E-10	0.0025	8.780E-10	0.0035	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.732E-08	0.0690
U-235	1.843E-08	0.0734	1.087E-11	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.438E-10	0.0010
U-238	1.974E-07	0.7864	5.306E-10	0.0021	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.556E-08	0.0620
Total	2.164E-07	0.8623	1.419E-09	0.0057	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.313E-08	0.1320

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Plant		Meat		Milk		All Pathways**	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Ac-227	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.079E-13	0.0000
Pa-231	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.465E-13	0.0000
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.233E-15	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.712E-13	0.0000
Th-230	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.926E-13	0.0000
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.883E-08	0.0750
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.868E-08	0.0744
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.134E-07	0.8505
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.510E-07	1.0000

** Sum of water independent ground, inhalation, plant, meat, milk, soil
and water dependent water, fish, plant, meat, milk pathways

Excess Cancer Risks CNRS9(irn,i,t) and CNRS9W(irn,i,t) for Inhalation of
Radon and its Decay Products at t= 1.000E+00 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	1.166E-15	2.339E-17	2.933E-20	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	1.166E-15	2.339E-17	2.933E-20	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
U-234	6.306E-10	0.0025	8.780E-10	0.0035	1.190E-15	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.733E-08	0.0690
U-235	1.843E-08	0.0734	1.087E-11	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.438E-10	0.0010
U-238	1.974E-07	0.7864	5.306E-10	0.0021	4.199E-21	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.556E-08	0.0620
Total	2.164E-07	0.8623	1.419E-09	0.0057	1.190E-15	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.313E-08	0.1320

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All pathways	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.883E-08	0.0750
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.868E-08	0.0744
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.134E-07	0.8505
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.510E-07	1.0000

***CNRSI(i,p,t) includes contribution from decay daughter radionuclides

Amount of Intake Quantities QINT(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As pCi/yr at t= 3.000E+00 years

Radio-	Water Independent Pathways (Inhalation w/o radon)					Water Dependent Pathways					Total
Nuclide	Inhalation	Plant	Meat	Milk	Soil	Water	Fish	Plant	Meat	Milk	Ingestion*
Ac-227	2.125E-10	0.000E+00	0.000E+00	0.000E+00	1.221E-06	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.221E-06
Pa-231	4.608E-09	0.000E+00	0.000E+00	0.000E+00	2.647E-05	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.647E-05
Pb-210	2.820E-12	0.000E+00	0.000E+00	0.000E+00	1.620E-08	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.620E-08
Ra-226	9.283E-11	0.000E+00	0.000E+00	0.000E+00	5.332E-07	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	5.332E-07
Th-230	1.430E-07	0.000E+00	0.000E+00	0.000E+00	8.213E-04	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	8.213E-04
U-234	5.276E-03	0.000E+00	0.000E+00	0.000E+00	3.031E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.031E+01
U-235	7.260E-05	0.000E+00	0.000E+00	0.000E+00	4.170E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	4.170E-01
U-238	3.751E-03	0.000E+00	0.000E+00	0.000E+00	2.155E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.155E+01

* Sum of all ingestion pathways, i.e. water independent plant, meat, milk, soil
and water-dependent water, fish, plant, meat, milk pathways

Amount of Intake Quantities QINT9(irn,i,t) and QINT9W(irn,i,t) for Inhalation of
Radon and its Decay Products as pCi/yr at t= 3.000E+00 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	5.133E-05	5.009E-07	3.748E-10	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	5.133E-05	5.009E-07	3.748E-10	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent   Water-dep. == Water-dependent

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Ac-227	5.970E-13	0.0000	1.114E-15	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.964E-14	0.0000
Pa-231	5.915E-13	0.0000	4.179E-15	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.120E-14	0.0000
Pb-210	5.384E-17	0.0000	5.008E-18	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.221E-15	0.0000
Ra-226	1.572E-12	0.0000	6.783E-17	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.095E-15	0.0000
Th-230	1.101E-13	0.0000	5.810E-14	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.168E-12	0.0000
U-234	6.268E-10	0.0025	8.738E-10	0.0035	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.724E-08	0.0690
U-235	1.834E-08	0.0734	1.081E-11	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.426E-10	0.0010
U-238	1.964E-07	0.7864	5.281E-10	0.0021	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.548E-08	0.0620
Total	2.154E-07	0.8623	1.413E-09	0.0057	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.297E-08	0.1320

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Plant		Meat		Milk		All Pathways**	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Ac-227	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.178E-13	0.0000
Pa-231	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.669E-13	0.0000
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.279E-15	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.579E-12	0.0000
Th-230	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.336E-12	0.0000
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.874E-08	0.0750
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.859E-08	0.0744
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.124E-07	0.8505
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.498E-07	1.0000

** Sum of water independent ground, inhalation, plant, meat, milk, soil
and water dependent water, fish, plant, meat, milk pathways

Excess Cancer Risks CNRS9(irn,i,t) and CNRS9W(irn,i,t) for Inhalation of
Radon and its Decay Products at t= 3.000E+00 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	2.387E-15	4.790E-17	6.005E-20	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	2.387E-15	4.790E-17	6.005E-20	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
U-234	6.284E-10	0.0025	8.739E-10	0.0035	2.435E-15	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.724E-08	0.0690
U-235	1.834E-08	0.0734	1.082E-11	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.427E-10	0.0010
U-238	1.964E-07	0.7864	5.281E-10	0.0021	1.130E-20	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.548E-08	0.0620
Total	2.154E-07	0.8623	1.413E-09	0.0057	2.435E-15	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.297E-08	0.1320

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All pathways	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.875E-08	0.0751
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.859E-08	0.0744
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.124E-07	0.8505
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.498E-07	1.0000

***CNRSI(i,p,t) includes contribution from decay daughter radionuclides

Amount of Intake Quantities QINT(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As pCi/yr at t= 1.000E+01 years

Radio-	Water Independent Pathways (Inhalation w/o radon)					Water Dependent Pathways					Total
Nuclide	Inhalation	Plant	Meat	Milk	Soil	Water	Fish	Plant	Meat	Milk	Ingestion*
Ac-227	2.145E-09	0.000E+00	0.000E+00	0.000E+00	1.232E-05	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.232E-05
Pa-231	1.511E-08	0.000E+00	0.000E+00	0.000E+00	8.679E-05	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	8.679E-05
Pb-210	9.809E-11	0.000E+00	0.000E+00	0.000E+00	5.635E-07	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	5.635E-07
Ra-226	1.021E-09	0.000E+00	0.000E+00	0.000E+00	5.863E-06	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	5.863E-06
Th-230	4.727E-07	0.000E+00	0.000E+00	0.000E+00	2.715E-03	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.715E-03
U-234	5.190E-03	0.000E+00	0.000E+00	0.000E+00	2.981E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.981E+01
U-235	7.142E-05	0.000E+00	0.000E+00	0.000E+00	4.102E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	4.102E-01
U-238	3.690E-03	0.000E+00	0.000E+00	0.000E+00	2.120E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.120E+01

* Sum of all ingestion pathways, i.e. water independent plant, meat, milk, soil
and water-dependent water, fish, plant, meat, milk pathways

Amount of Intake Quantities QINT9(irn,i,t) and QINT9W(irn,i,t) for Inhalation of
Radon and its Decay Products as pCi/yr at t= 1.000E+01 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	5.641E-04	5.506E-06	4.119E-09	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	5.641E-04	5.506E-06	4.119E-09	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+01 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Ac-227	2.412E-12	0.0000	4.502E-15	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.933E-14	0.0000
Pa-231	1.261E-12	0.0000	8.912E-15	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.518E-13	0.0000
Pb-210	4.361E-16	0.0000	4.057E-17	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.609E-14	0.0000
Ra-226	6.866E-12	0.0000	2.963E-16	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.099E-14	0.0000
Th-230	2.367E-13	0.0000	1.249E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.511E-12	0.0000
U-234	6.165E-10	0.0025	8.596E-10	0.0035	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.696E-08	0.0690
U-235	1.804E-08	0.0734	1.064E-11	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.387E-10	0.0010
U-238	1.932E-07	0.7864	5.195E-10	0.0021	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.523E-08	0.0620
Total	2.119E-07	0.8623	1.390E-09	0.0057	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.243E-08	0.1320

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+01 years

Water Dependent Pathways

Radio-	Water		Fish		Plant		Meat		Milk		All Pathways**	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Ac-227	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.496E-12	0.0000
Pa-231	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.422E-12	0.0000
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.656E-14	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.897E-12	0.0000
Th-230	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.872E-12	0.0000
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.844E-08	0.0750
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.829E-08	0.0744
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.090E-07	0.8505
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.457E-07	1.0000

** Sum of water independent ground, inhalation, plant, meat, milk, soil
and water dependent water, fish, plant, meat, milk pathways

Excess Cancer Risks CNRS9(irn,i,t) and CNRS9W(irn,i,t) for Inhalation of
Radon and its Decay Products at t= 1.000E+01 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	1.042E-14	2.091E-16	2.621E-19	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	1.042E-14	2.091E-16	2.621E-19	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+01 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
U-234	6.236E-10	0.0025	8.597E-10	0.0035	1.063E-14	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.696E-08	0.0690
U-235	1.804E-08	0.0734	1.065E-11	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.389E-10	0.0010
U-238	1.932E-07	0.7864	5.195E-10	0.0021	9.579E-20	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.523E-08	0.0620
Total	2.119E-07	0.8623	1.390E-09	0.0057	1.063E-14	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.243E-08	0.1320

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+01 years

Water Dependent Pathways

Radio-Nuclide	Water risk	Water fract.	Fish risk	Fish fract.	Radon risk	Radon fract.	Plant risk	Plant fract.	Meat risk	Meat fract.	Milk risk	Milk fract.	All pathways risk	All pathways fract.
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.845E-08	0.0751
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.829E-08	0.0744
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.090E-07	0.8505
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.457E-07	1.0000

***CNRSI(i,p,t) includes contribution from decay daughter radionuclides

Amount of Intake Quantities QINT(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As pCi/yr at t= 3.000E+01 years

Radio-	Water Independent Pathways (Inhalation w/o radon)					Water Dependent Pathways					Total
Nuclide	Inhalation	Plant	Meat	Milk	Soil	Water	Fish	Plant	Meat	Milk	Ingestion*
Ac-227	1.494E-08	0.000E+00	0.000E+00	0.000E+00	8.582E-05	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	8.582E-05
Pa-231	4.324E-08	0.000E+00	0.000E+00	0.000E+00	2.484E-04	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.484E-04
Pb-210	2.234E-09	0.000E+00	0.000E+00	0.000E+00	1.283E-05	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.283E-05
Ra-226	8.917E-09	0.000E+00	0.000E+00	0.000E+00	5.122E-05	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	5.122E-05
Th-230	1.385E-06	0.000E+00	0.000E+00	0.000E+00	7.957E-03	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	7.957E-03
U-234	4.951E-03	0.000E+00	0.000E+00	0.000E+00	2.844E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.844E+01
U-235	6.814E-05	0.000E+00	0.000E+00	0.000E+00	3.914E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.914E-01
U-238	3.521E-03	0.000E+00	0.000E+00	0.000E+00	2.022E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.022E+01

* Sum of all ingestion pathways, i.e. water independent plant, meat, milk, soil
and water-dependent water, fish, plant, meat, milk pathways

Amount of Intake Quantities QINT9(irn,i,t) and QINT9W(irn,i,t) for Inhalation of
Radon and its Decay Products as pCi/yr at t= 3.000E+01 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	4.921E-03	4.803E-05	3.594E-08	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	4.921E-03	4.803E-05	3.594E-08	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+01 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Ac-227	1.194E-11	0.0001	2.228E-14	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.926E-13	0.0000
Pa-231	3.056E-12	0.0000	2.159E-14	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.678E-13	0.0000
Pb-210	5.792E-15	0.0000	5.388E-16	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.465E-13	0.0000
Ra-226	4.233E-11	0.0002	1.827E-15	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.910E-13	0.0000
Th-230	5.870E-13	0.0000	3.097E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.227E-12	0.0000
U-234	5.882E-10	0.0025	8.201E-10	0.0035	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.618E-08	0.0690
U-235	1.721E-08	0.0734	1.015E-11	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.277E-10	0.0010
U-238	1.843E-07	0.7862	4.957E-10	0.0021	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.453E-08	0.0620
Total	2.022E-07	0.8624	1.326E-09	0.0057	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.095E-08	0.1320

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+01 years

Water Dependent Pathways

Radio-	Water		Fish		Plant		Meat		Milk		All Pathways**	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Ac-227	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.235E-11	0.0001
Pa-231	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.445E-12	0.0000
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.528E-13	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.252E-11	0.0002
Th-230	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.124E-12	0.0000
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.759E-08	0.0750
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.745E-08	0.0744
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.994E-07	0.8503
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.345E-07	1.0000

** Sum of water independent ground, inhalation, plant, meat, milk, soil
and water dependent water, fish, plant, meat, milk pathways

Excess Cancer Risks CNRS9(irn,i,t) and CNRS9W(irn,i,t) for Inhalation of
Radon and its Decay Products at t= 3.000E+01 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	6.417E-14	1.287E-15	1.614E-18	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	6.417E-14	1.287E-15	1.614E-18	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+01 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
U-234	6.311E-10	0.0027	8.204E-10	0.0035	6.546E-14	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.619E-08	0.0690
U-235	1.723E-08	0.0735	1.019E-11	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.285E-10	0.0010
U-238	1.844E-07	0.7862	4.957E-10	0.0021	1.449E-18	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.453E-08	0.0620
Total	2.022E-07	0.8624	1.326E-09	0.0057	6.546E-14	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.095E-08	0.1320

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+01 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All pathways	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.764E-08	0.0752
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.746E-08	0.0745
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.994E-07	0.8503
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.345E-07	1.0000

***CNRSI(i,p,t) includes contribution from decay daughter radionuclides

Amount of Intake Quantities QINT(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As pCi/yr at t= 1.000E+02 years

Radio-	Water Independent Pathways (Inhalation w/o radon)					Water Dependent Pathways					Total
Nuclide	Inhalation	Plant	Meat	Milk	Soil	Water	Fish	Plant	Meat	Milk	Ingestion*
Ac-227	7.986E-08	0.000E+00	0.000E+00	0.000E+00	4.587E-04	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	4.587E-04
Pa-231	1.222E-07	0.000E+00	0.000E+00	0.000E+00	7.018E-04	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	7.018E-04
Pb-210	4.977E-08	0.000E+00	0.000E+00	0.000E+00	2.859E-04	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.859E-04
Ra-226	8.937E-08	0.000E+00	0.000E+00	0.000E+00	5.133E-04	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	5.133E-04
Th-230	4.260E-06	0.000E+00	0.000E+00	0.000E+00	2.447E-02	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.447E-02
U-234	4.200E-03	0.000E+00	0.000E+00	0.000E+00	2.413E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.413E+01
U-235	5.780E-05	0.000E+00	0.000E+00	0.000E+00	3.320E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.320E-01
U-238	2.987E-03	0.000E+00	0.000E+00	0.000E+00	1.716E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.716E+01

* Sum of all ingestion pathways, i.e. water independent plant, meat, milk, soil
and water-dependent water, fish, plant, meat, milk pathways

Amount of Intake Quantities QINT9(irn,i,t) and QINT9W(irn,i,t) for Inhalation of
Radon and its Decay Products as pCi/yr at t= 1.000E+02 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	4.888E-02	4.771E-04	3.569E-07	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	4.888E-02	4.771E-04	3.569E-07	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+02 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Ac-227	5.644E-11	0.0003	1.053E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.856E-12	0.0000
Pa-231	8.085E-12	0.0000	5.712E-14	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.732E-13	0.0000
Pb-210	1.059E-13	0.0000	9.848E-15	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.333E-12	0.0000
Ra-226	3.711E-10	0.0019	1.602E-14	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.675E-12	0.0000
Th-230	1.690E-12	0.0000	8.920E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.793E-11	0.0001
U-234	4.990E-10	0.0025	6.957E-10	0.0035	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.373E-08	0.0689
U-235	1.460E-08	0.0732	8.610E-12	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.932E-10	0.0010
U-238	1.564E-07	0.7846	4.205E-10	0.0021	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.233E-08	0.0618
Total	1.719E-07	0.8625	1.126E-09	0.0056	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.628E-08	0.1318

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+02 years

Water Dependent Pathways

Radio- Nuclide	Water risk	Water fract.	Fish risk	Fish fract.	Plant risk	Plant fract.	Meat risk	Meat fract.	Milk risk	Milk fract.	All Pathways** risk	All Pathways** fract.
Ac-227	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.840E-11	0.0003
Pa-231	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.116E-12	0.0000
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.449E-12	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.728E-10	0.0019
Th-230	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.052E-11	0.0001
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.492E-08	0.0749
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.480E-08	0.0743
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.691E-07	0.8485
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.993E-07	1.0000

** Sum of water independent ground, inhalation, plant, meat, milk, soil
and water dependent water, fish, plant, meat, milk pathways

Excess Cancer Risks CNRS9(irn,i,t) and CNRS9W(irn,i,t) for Inhalation of
Radon and its Decay Products at t= 1.000E+02 years

Radon Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	5.576E-13	1.119E-14	1.402E-17	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	5.576E-13	1.119E-14	1.402E-17	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

(Columns Rn-222 through Bi-212: Radionuclides)

Water-ind. == Water-independent Water-dep. == Water-dependent

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+02 years

Water Independent Pathways (Inhalation excludes radon)

Radio- Nuclide	Ground risk	Ground fract.	Inhalation risk	Inhalation fract.	Radon risk	Radon fract.	Plant risk	Plant fract.	Meat risk	Meat fract.	Milk risk	Milk fract.	Soil risk	Soil fract.
U-234	8.718E-10	0.0044	6.964E-10	0.0035	5.688E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.375E-08	0.0690
U-235	1.466E-08	0.0736	8.773E-12	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.960E-10	0.0010
U-238	1.564E-07	0.7846	4.206E-10	0.0021	3.850E-17	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.233E-08	0.0619
Total	1.719E-07	0.8625	1.126E-09	0.0056	5.688E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.628E-08	0.1318

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+02 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All pathways	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.532E-08	0.0769
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.487E-08	0.0746
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.691E-07	0.8485
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.993E-07	1.0000

***CNRSI(i,p,t) includes contribution from decay daughter radionuclides

Amount of Intake Quantities QINT(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As pCi/yr at t= 3.000E+02 years

Radio-	Water Independent Pathways (Inhalation w/o radon)					Water Dependent Pathways					Total
Nuclide	Inhalation	Plant	Meat	Milk	Soil	Water	Fish	Plant	Meat	Milk	Ingestion*
Ac-227	1.866E-07	0.000E+00	0.000E+00	0.000E+00	1.072E-03	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.072E-03
Pa-231	2.286E-07	0.000E+00	0.000E+00	0.000E+00	1.313E-03	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.313E-03
Pb-210	4.910E-07	0.000E+00	0.000E+00	0.000E+00	2.820E-03	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.820E-03
Ra-226	6.036E-07	0.000E+00	0.000E+00	0.000E+00	3.467E-03	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.467E-03
Th-230	1.028E-05	0.000E+00	0.000E+00	0.000E+00	5.903E-02	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	5.903E-02
U-234	2.625E-03	0.000E+00	0.000E+00	0.000E+00	1.508E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.508E+01
U-235	3.613E-05	0.000E+00	0.000E+00	0.000E+00	2.075E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.075E-01
U-238	1.867E-03	0.000E+00	0.000E+00	0.000E+00	1.072E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.072E+01

* Sum of all ingestion pathways, i.e. water independent plant, meat, milk, soil
and water-dependent water, fish, plant, meat, milk pathways

Amount of Intake Quantities QINT9(irn,i,t) and QINT9W(irn,i,t) for Inhalation of
Radon and its Decay Products as pCi/yr at t= 3.000E+02 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	3.237E-01	3.159E-03	2.364E-06	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	3.237E-01	3.159E-03	2.364E-06	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent   Water-dep. == Water-dependent

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+02 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Ac-227	1.282E-10	0.0010	2.393E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.216E-12	0.0000
Pa-231	1.483E-11	0.0001	1.048E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.786E-12	0.0000
Pb-210	9.914E-13	0.0000	9.223E-14	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.931E-11	0.0005
Ra-226	2.410E-09	0.0190	1.040E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.088E-11	0.0001
Th-230	4.000E-12	0.0000	2.111E-12	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.243E-11	0.0003
U-234	3.118E-10	0.0025	4.347E-10	0.0034	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.578E-09	0.0676
U-235	9.125E-09	0.0719	5.381E-12	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.207E-10	0.0010
U-238	9.774E-08	0.7698	2.628E-10	0.0021	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.704E-09	0.0607
Total	1.097E-07	0.8643	7.055E-10	0.0056	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.652E-08	0.1301

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+02 years

Water Dependent Pathways

Radio-	Water		Fish		Plant		Meat		Milk		All Pathways**	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Ac-227	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.326E-10	0.0010
Pa-231	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.672E-11	0.0001
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.039E-11	0.0005
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.421E-09	0.0191
Th-230	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.854E-11	0.0004
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.324E-09	0.0734
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.251E-09	0.0729
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.057E-07	0.8326
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.270E-07	1.0000

** Sum of water independent ground, inhalation, plant, meat, milk, soil
and water dependent water, fish, plant, meat, milk pathways

Excess Cancer Risks CNRS9(irn,i,t) and CNRS9W(irn,i,t) for Inhalation of
Radon and its Decay Products at t= 3.000E+02 years

Radon Pathway	Radionuclides Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	3.550E-12	7.122E-14	8.928E-17	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	3.550E-12	7.122E-14	8.928E-17	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent   Water-dep. == Water-dependent

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+02 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
U-234	2.727E-09	0.0215	4.367E-10	0.0034	3.621E-12	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.685E-09	0.0684
U-235	9.268E-09	0.0730	5.725E-12	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.267E-10	0.0010
U-238	9.774E-08	0.7698	2.631E-10	0.0021	6.881E-16	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.710E-09	0.0607
Total	1.097E-07	0.8643	7.055E-10	0.0056	3.621E-12	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.652E-08	0.1301

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+02 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All pathways	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.185E-08	0.0933
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.400E-09	0.0740
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.057E-07	0.8326
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.270E-07	1.0000

***CNRSI(i,p,t) includes contribution from decay daughter radionuclides

Amount of Intake Quantities QINT(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As pCi/yr at t= 1.000E+03 years

Radio-	Water Independent Pathways (Inhalation w/o radon)					Water Dependent Pathways					Total
Nuclide	Inhalation	Plant	Meat	Milk	Soil	Water	Fish	Plant	Meat	Milk	Ingestion*
Ac-227	1.279E-07	0.000E+00	0.000E+00	0.000E+00	7.344E-04	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	7.344E-04
Pa-231	1.460E-07	0.000E+00	0.000E+00	0.000E+00	8.384E-04	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	8.384E-04
Pb-210	2.537E-06	0.000E+00	0.000E+00	0.000E+00	1.457E-02	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.457E-02
Ra-226	2.704E-06	0.000E+00	0.000E+00	0.000E+00	1.553E-02	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.553E-02
Th-230	1.827E-05	0.000E+00	0.000E+00	0.000E+00	1.049E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.049E-01
U-234	5.062E-04	0.000E+00	0.000E+00	0.000E+00	2.908E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.908E+00
U-235	6.972E-06	0.000E+00	0.000E+00	0.000E+00	4.005E-02	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	4.005E-02
U-238	3.602E-04	0.000E+00	0.000E+00	0.000E+00	2.069E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.069E+00

* Sum of all ingestion pathways, i.e. water independent plant, meat, milk, soil
and water-dependent water, fish, plant, meat, milk pathways

Amount of Intake Quantities QINT9(irn,i,t) and QINT9W(irn,i,t) for Inhalation of
Radon and its Decay Products as pCi/yr at t= 1.000E+03 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	1.193E+00	1.164E-02	8.710E-06	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	1.193E+00	1.164E-02	8.710E-06	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+03 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Ac-227	8.713E-11	0.0025	1.626E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.866E-12	0.0001
Pa-231	9.407E-12	0.0003	6.646E-14	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.132E-12	0.0000
Pb-210	5.046E-12	0.0001	4.694E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.019E-10	0.0086
Ra-226	1.066E-08	0.3029	4.598E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.809E-11	0.0014
Th-230	7.068E-12	0.0002	3.730E-12	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.498E-11	0.0021
U-234	6.014E-11	0.0017	8.384E-11	0.0024	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.654E-09	0.0470
U-235	1.761E-09	0.0501	1.038E-12	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.330E-11	0.0007
U-238	1.886E-08	0.5361	5.071E-11	0.0014	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.487E-09	0.0423
Total	3.145E-08	0.8939	1.405E-10	0.0040	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.593E-09	0.1021

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+03 years

Water Dependent Pathways

Radio-	Water		Fish		Plant		Meat		Milk		All Pathways**	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Ac-227	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.016E-11	0.0026
Pa-231	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.061E-11	0.0003
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.074E-10	0.0087
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.070E-08	0.3043
Th-230	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.578E-11	0.0024
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.798E-09	0.0511
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.785E-09	0.0507
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.040E-08	0.5798
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.518E-08	1.0000

** Sum of water independent ground, inhalation, plant, meat, milk, soil
and water dependent water, fish, plant, meat, milk pathways

Excess Cancer Risks CNRS9(irn,i,t) and CNRS9W(irn,i,t) for Inhalation of
Radon and its Decay Products at t= 1.000E+03 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	1.289E-11	2.587E-13	3.243E-16	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	1.289E-11	2.587E-13	3.243E-16	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent   Water-dep. == Water-dependent

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+03 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
U-234	1.072E-08	0.3047	8.833E-11	0.0025	1.315E-11	0.0004	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.076E-09	0.0590
U-235	1.858E-09	0.0528	1.268E-12	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.729E-11	0.0008
U-238	1.887E-08	0.5361	5.089E-11	0.0014	6.859E-15	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.490E-09	0.0423
Total	3.145E-08	0.8935	1.405E-10	0.0040	1.315E-11	0.0004	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.593E-09	0.1021

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+03 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All pathways	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.290E-08	0.3665
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.886E-09	0.0536
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.041E-08	0.5799
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.519E-08	1.0000

***CNRSI(i,p,t) includes contribution from decay daughter radionuclides

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Part III: Intake Quantities and Health Risk Factors

Cancer Risk Slope Factors Summary Table
Risk Library: FGR 13 Morbidity

Menu	Parameter	Current Value	Base Case*	Parameter Name
Sf-1	Ground external radiation slope factors, 1/yr per (pCi/g):			
Sf-1	Ac-227+D	1.47E-06	3.48E-10	SLPF(1,1)
Sf-1	Pa-231	1.39E-07	1.39E-07	SLPF(2,1)
Sf-1	Pb-210+D	4.21E-09	1.41E-09	SLPF(3,1)
Sf-1	Ra-226+D	8.49E-06	2.29E-08	SLPF(4,1)
Sf-1	Th-230	8.19E-10	8.19E-10	SLPF(5,1)
Sf-1	U-234	2.52E-10	2.52E-10	SLPF(6,1)
Sf-1	U-235+D	5.43E-07	5.18E-07	SLPF(7,1)
Sf-1	U-238	4.99E-11	4.99E-11	SLPF(8,1)
Sf-1	U-238+D	1.14E-07	4.99E-11	SLPF(9,1)
Sf-2	Inhalation, slope factors, 1/(pCi):			
Sf-2	Ac-227+D	2.13E-07	1.49E-07	SLPF(1,2)
Sf-2	Pa-231	7.62E-08	7.62E-08	SLPF(2,2)
Sf-2	Pb-210+D	3.08E-08	1.58E-08	SLPF(3,2)
Sf-2	Ra-226+D	2.83E-08	2.82E-08	SLPF(4,2)
Sf-2	Th-230	3.40E-08	3.40E-08	SLPF(5,2)
Sf-2	U-234	2.78E-08	2.78E-08	SLPF(6,2)
Sf-2	U-235+D	2.50E-08	2.50E-08	SLPF(7,2)
Sf-2	U-238	2.36E-08	2.36E-08	SLPF(8,2)
Sf-2	U-238+D	2.36E-08	2.36E-08	SLPF(9,2)
Sf-3	Food ingestion, slope factors, 1/(pCi):			
Sf-3	Ac-227+D	6.53E-10	2.45E-10	SLPF(1,3)
Sf-3	Pa-231	2.26E-10	2.26E-10	SLPF(2,3)
Sf-3	Pb-210+D	3.44E-09	1.18E-09	SLPF(3,3)
Sf-3	Ra-226+D	5.15E-10	5.14E-10	SLPF(4,3)
Sf-3	Th-230	1.19E-10	1.19E-10	SLPF(5,3)
Sf-3	U-234	9.55E-11	9.55E-11	SLPF(6,3)
Sf-3	U-235+D	9.76E-11	9.44E-11	SLPF(7,3)
Sf-3	U-238	8.66E-11	8.66E-11	SLPF(8,3)
Sf-3	U-238+D	1.21E-10	8.66E-11	SLPF(9,3)
Sf-3	Water ingestion, slope factors, 1/(pCi):			
Sf-3	Ac-227+D	4.86E-10	2.01E-10	SLPF(1,4)
Sf-3	Pa-231	1.73E-10	1.73E-10	SLPF(2,4)
Sf-3	Pb-210+D	2.66E-09	8.81E-10	SLPF(3,4)
Sf-3	Ra-226+D	3.86E-10	3.85E-10	SLPF(4,4)
Sf-3	Th-230	9.10E-11	9.10E-11	SLPF(5,4)
Sf-3	U-234	7.07E-11	7.07E-11	SLPF(6,4)
Sf-3	U-235+D	7.18E-11	6.96E-11	SLPF(7,4)
Sf-3	U-238	6.40E-11	6.40E-11	SLPF(8,4)
Sf-3	U-238+D	8.71E-11	6.40E-11	SLPF(9,4)
Sf-3	Soil ingestion, slope factors, 1/(pCi):			
Sf-3	Ac-227+D	6.53E-10	2.45E-10	SLPF(1,5)
Sf-3	Pa-231	2.26E-10	2.26E-10	SLPF(2,5)
Sf-3	Pb-210+D	3.44E-09	1.18E-09	SLPF(3,5)
Sf-3	Ra-226+D	5.15E-10	5.14E-10	SLPF(4,5)
Sf-3	Th-230	1.19E-10	1.19E-10	SLPF(5,5)
Sf-3	U-234	9.55E-11	9.55E-11	SLPF(6,5)

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Uranium Soils Investigation
Baseline Human Health Risk Assessment
Saddle Road
October 2009

Cancer Risk Slope Factors Summary Table (continued)

Risk Library: FGR 13 Morbidity

Menu	Parameter	Current Value	Base Case*	Parameter Name
Sf-3	U-235+D	9.76E-11	9.44E-11	SLPF(7,5)
Sf-3	U-238	8.66E-11	8.66E-11	SLPF(8,5)
Sf-3	U-238+D	1.21E-10	8.66E-11	SLPF(9,5)
Sf-Rn	Radon Inhalation slope factors, 1/(pCi):			
Sf-Rn	Rn-222	1.80E-12	1.80E-12	SLPFRN(1,1)
Sf-Rn	Po-218	3.70E-12	3.70E-12	SLPFRN(1,2)
Sf-Rn	Pb-214	6.20E-12	6.20E-12	SLPFRN(1,3)
Sf-Rn	Bi-214	1.50E-11	1.50E-11	SLPFRN(1,4)
Sf-Rn	Radon K factors, (mrem/WLM):			
Sf-Rn	Rn-222 Indoor	7.60E+02	7.60E+02	KFACTR(1,1)
Sf-Rn	Rn-222 Outdoor	5.70E+02	5.70E+02	KFACTR(1,2)

*Base Case means Default.Lib w/o Associate Nuclide contributions.

Risk Slope and Environmental Transport Factors for the Ground Pathway

Nuclide (i)	Slope(i)*	ETFG(i,t) At Time in Years (dimensionless) t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
Ac-227	3.480E-10	9.567E-01	9.567E-01	9.567E-01	9.567E-01	9.567E-01	9.567E-01	9.567E-01	9.567E-01
At-218	3.570E-09	9.702E-01	9.702E-01	9.702E-01	9.702E-01	9.702E-01	9.702E-01	9.702E-01	9.702E-01
Bi-210	2.760E-09	9.450E-01	9.450E-01	9.450E-01	9.450E-01	9.450E-01	9.450E-01	9.450E-01	9.450E-01
Bi-211	1.880E-07	9.453E-01	9.453E-01	9.453E-01	9.453E-01	9.453E-01	9.453E-01	9.453E-01	9.453E-01
Bi-214	7.480E-06	9.401E-01	9.401E-01	9.401E-01	9.401E-01	9.401E-01	9.401E-01	9.401E-01	9.400E-01
Fr-223	1.400E-07	9.502E-01	9.502E-01	9.502E-01	9.502E-01	9.502E-01	9.502E-01	9.502E-01	9.502E-01
Pa-231	1.390E-07	9.456E-01	9.456E-01	9.456E-01	9.456E-01	9.456E-01	9.456E-01	9.456E-01	9.456E-01
Pa-234	8.710E-06	9.400E-01	9.400E-01	9.400E-01	9.400E-01	9.400E-01	9.400E-01	9.400E-01	9.400E-01
Pa-234m	6.870E-08	9.393E-01	9.393E-01	9.393E-01	9.393E-01	9.393E-01	9.393E-01	9.393E-01	9.393E-01
Pb-210	1.410E-09	9.813E-01	9.813E-01	9.813E-01	9.813E-01	9.813E-01	9.813E-01	9.813E-01	9.813E-01
Pb-211	2.290E-07	9.399E-01	9.399E-01	9.399E-01	9.399E-01	9.399E-01	9.399E-01	9.399E-01	9.399E-01
Pb-214	9.820E-07	9.456E-01	9.456E-01	9.456E-01	9.456E-01	9.456E-01	9.456E-01	9.456E-01	9.456E-01
Po-210	3.950E-11	9.390E-01	9.390E-01	9.390E-01	9.390E-01	9.390E-01	9.390E-01	9.390E-01	9.390E-01
Po-211	3.580E-08	9.360E-01	9.360E-01	9.360E-01	9.360E-01	9.360E-01	9.360E-01	9.360E-01	9.360E-01
Po-214	3.860E-10	9.360E-01	9.360E-01	9.360E-01	9.360E-01	9.360E-01	9.360E-01	9.360E-01	9.360E-01
Po-215	7.480E-10	9.410E-01	9.410E-01	9.410E-01	9.410E-01	9.410E-01	9.410E-01	9.410E-01	9.410E-01
Po-218	4.260E-11	9.390E-01	9.390E-01	9.390E-01	9.390E-01	9.390E-01	9.390E-01	9.390E-01	9.390E-01
Ra-223	4.340E-07	9.496E-01	9.496E-01	9.496E-01	9.496E-01	9.496E-01	9.496E-01	9.496E-01	9.496E-01
Ra-226	2.290E-08	9.524E-01	9.524E-01	9.524E-01	9.524E-01	9.524E-01	9.524E-01	9.524E-01	9.524E-01
Rn-219	2.250E-07	9.461E-01	9.461E-01	9.461E-01	9.461E-01	9.461E-01	9.461E-01	9.461E-01	9.461E-01
Rn-222	1.740E-09	9.370E-01	9.370E-01	9.370E-01	9.370E-01	9.370E-01	9.370E-01	9.370E-01	9.370E-01
Th-227	3.780E-07	9.508E-01	9.508E-01	9.508E-01	9.508E-01	9.508E-01	9.508E-01	9.508E-01	9.508E-01
Th-230	8.190E-10	9.588E-01	9.588E-01	9.588E-01	9.588E-01	9.588E-01	9.588E-01	9.588E-01	9.588E-01
Th-231	2.450E-08	9.599E-01	9.599E-01	9.599E-01	9.599E-01	9.599E-01	9.599E-01	9.599E-01	9.599E-01
Th-234	1.630E-08	9.610E-01	9.610E-01	9.610E-01	9.610E-01	9.610E-01	9.610E-01	9.610E-01	9.610E-01
Tl-207	1.520E-08	9.403E-01	9.403E-01	9.403E-01	9.403E-01	9.403E-01	9.403E-01	9.403E-01	9.403E-01
Tl-210	0.000E+00	1.000E+00	1.000E+00	1.000E+00	1.000E+00	1.000E+00	1.000E+00	1.000E+00	1.000E+00
U-234	2.520E-10	9.643E-01	9.643E-01	9.643E-01	9.643E-01	9.643E-01	9.643E-01	9.643E-01	9.643E-01
U-235	5.180E-07	9.520E-01	9.520E-01	9.520E-01	9.520E-01	9.520E-01	9.520E-01	9.520E-01	9.520E-01
U-238	4.990E-11	9.912E-01	9.912E-01	9.912E-01	9.912E-01	9.912E-01	9.912E-01	9.912E-01	9.912E-01

* - Units are 1/yr per (pCi/g) at infinite depth and area. Multiplication by ETFG(i,t) converts to site conditions.

Amount of Intake Quantities QINT(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As pCi/yr at t= 0.000E+00 years

Radio-	Water Independent Pathways (Inhalation w/o radon)					Water Dependent Pathways					Total
Nuclide	Inhalation	Plant	Meat	Milk	Soil	Water	Fish	Plant	Meat	Milk	Ingestion*
Ac-227	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Pa-231	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Pb-210	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Ra-226	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Th-230	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
U-234	1.063E-02	0.000E+00	0.000E+00	0.000E+00	1.526E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.526E+01
U-235	1.462E-04	0.000E+00	0.000E+00	0.000E+00	2.100E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.100E-01
U-238	7.556E-03	0.000E+00	0.000E+00	0.000E+00	1.085E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.085E+01

* Sum of all ingestion pathways, i.e. water independent plant, meat, milk, soil
and water-dependent water, fish, plant, meat, milk pathways

Amount of Intake Quantities QINT9(irn,i,t) and QINT9W(irn,i,t) for Inhalation of
Radon and its Decay Products as pCi/yr at t= 0.000E+00 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent   Water-dep. == Water-dependent

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 0.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Ac-227	1.017E-11	0.0000	3.797E-14	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.672E-13	0.0000
Pa-231	4.628E-12	0.0000	6.539E-14	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.785E-13	0.0000
Pb-210	2.485E-15	0.0000	4.624E-16	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.434E-14	0.0000
Ra-226	3.045E-11	0.0000	2.628E-15	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.871E-14	0.0000
Th-230	8.710E-13	0.0000	9.192E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.620E-12	0.0000
U-234	2.472E-09	0.0027	6.894E-09	0.0074	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.401E-08	0.0367
U-235	7.234E-08	0.0781	8.532E-11	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.785E-10	0.0005
U-238	7.748E-07	0.8369	4.166E-09	0.0045	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.054E-08	0.0330
Total	8.497E-07	0.9177	1.115E-08	0.0120	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.503E-08	0.0702

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 0.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Plant		Meat		Milk		All Pathways**	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Ac-227	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.037E-11	0.0000
Pa-231	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.972E-12	0.0000
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.729E-14	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.052E-11	0.0000
Th-230	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.410E-12	0.0000
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.337E-08	0.0468
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.290E-08	0.0787
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.095E-07	0.8744
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.258E-07	1.0000

** Sum of water independent ground, inhalation, plant, meat, milk, soil
and water dependent water, fish, plant, meat, milk pathways

Excess Cancer Risks CNRS9(irn,i,t) and CNRS9W(irn,i,t) for Inhalation of
Radon and its Decay Products at t= 0.000E+00 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	9.242E-14	1.854E-15	2.325E-18	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	9.242E-14	1.854E-15	2.325E-18	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 0.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
U-234	2.504E-09	0.0027	6.894E-09	0.0074	9.428E-14	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.401E-08	0.0367
U-235	7.235E-08	0.0781	8.542E-11	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.789E-10	0.0005
U-238	7.748E-07	0.8369	4.167E-09	0.0045	1.133E-18	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.054E-08	0.0330
Total	8.497E-07	0.9177	1.115E-08	0.0120	9.428E-14	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.503E-08	0.0702

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 0.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All pathways	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.341E-08	0.0469
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.292E-08	0.0788
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.095E-07	0.8744
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.258E-07	1.0000

***CNRSI(i,p,t) includes contribution from decay daughter radionuclides

Amount of Intake Quantities QINT(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As pCi/yr at t= 1.000E+00 years

Radio-	Water Independent Pathways (Inhalation w/o radon)					Water Dependent Pathways					Total
Nuclide	Inhalation	Plant	Meat	Milk	Soil	Water	Fish	Plant	Meat	Milk	Ingestion*
Ac-227	4.856E-11	0.000E+00	0.000E+00	0.000E+00	6.974E-08	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	6.974E-08
Pa-231	3.087E-09	0.000E+00	0.000E+00	0.000E+00	4.433E-06	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	4.433E-06
Pb-210	2.127E-13	0.000E+00	0.000E+00	0.000E+00	3.055E-10	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.055E-10
Ra-226	2.069E-11	0.000E+00	0.000E+00	0.000E+00	2.971E-08	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.971E-08
Th-230	9.555E-08	0.000E+00	0.000E+00	0.000E+00	1.372E-04	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.372E-04
U-234	1.060E-02	0.000E+00	0.000E+00	0.000E+00	1.522E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.522E+01
U-235	1.459E-04	0.000E+00	0.000E+00	0.000E+00	2.095E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.095E-01
U-238	7.538E-03	0.000E+00	0.000E+00	0.000E+00	1.082E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.082E+01

* Sum of all ingestion pathways, i.e. water independent plant, meat, milk, soil
and water-dependent water, fish, plant, meat, milk pathways

Amount of Intake Quantities QINT9(irn,i,t) and QINT9W(irn,i,t) for Inhalation of
Radon and its Decay Products as pCi/yr at t= 1.000E+00 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	1.144E-05	1.117E-07	8.354E-11	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	1.144E-05	1.117E-07	8.354E-11	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent   Water-dep. == Water-dependent

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Ac-227	1.139E-11	0.0000	4.250E-14	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.872E-13	0.0000
Pa-231	5.005E-12	0.0000	7.073E-14	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.012E-13	0.0000
Pb-210	2.907E-15	0.0000	5.408E-16	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.694E-14	0.0000
Ra-226	3.438E-11	0.0000	2.967E-15	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.757E-14	0.0000
Th-230	9.429E-13	0.0000	9.950E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.001E-12	0.0000
U-234	2.466E-09	0.0027	6.877E-09	0.0074	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.393E-08	0.0367
U-235	7.217E-08	0.0781	8.512E-11	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.774E-10	0.0005
U-238	7.730E-07	0.8369	4.157E-09	0.0045	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.047E-08	0.0330
Total	8.477E-07	0.9177	1.112E-08	0.0120	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.488E-08	0.0702

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Plant		Meat		Milk		All Pathways**	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Ac-227	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.161E-11	0.0000
Pa-231	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.377E-12	0.0000
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.038E-14	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.446E-11	0.0000
Th-230	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.939E-12	0.0000
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.327E-08	0.0468
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.273E-08	0.0787
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.076E-07	0.8743
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.237E-07	1.0000

** Sum of water independent ground, inhalation, plant, meat, milk, soil
and water dependent water, fish, plant, meat, milk pathways

Excess Cancer Risks CNRS9(irn,i,t) and CNRS9W(irn,i,t) for Inhalation of
Radon and its Decay Products at t= 1.000E+00 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	1.043E-13	2.093E-15	2.624E-18	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	1.043E-13	2.093E-15	2.624E-18	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent   Water-dep. == Water-dependent

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
U-234	2.502E-09	0.0027	6.878E-09	0.0074	1.064E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.393E-08	0.0367
U-235	7.218E-08	0.0781	8.523E-11	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.778E-10	0.0005
U-238	7.730E-07	0.8369	4.157E-09	0.0045	1.332E-18	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.047E-08	0.0330
Total	8.477E-07	0.9177	1.112E-08	0.0120	1.064E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.488E-08	0.0702

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All pathways	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.331E-08	0.0469
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.275E-08	0.0788
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.076E-07	0.8744
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.237E-07	1.0000

***CNRSI(i,p,t) includes contribution from decay daughter radionuclides

Amount of Intake Quantities QINT(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As pCi/yr at t= 3.000E+00 years

Radio-	Water Independent Pathways (Inhalation w/o radon)					Water Dependent Pathways					Total
Nuclide	Inhalation	Plant	Meat	Milk	Soil	Water	Fish	Plant	Meat	Milk	Ingestion*
Ac-227	4.250E-10	0.000E+00	0.000E+00	0.000E+00	6.103E-07	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	6.103E-07
Pa-231	9.217E-09	0.000E+00	0.000E+00	0.000E+00	1.324E-05	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.324E-05
Pb-210	5.640E-12	0.000E+00	0.000E+00	0.000E+00	8.099E-09	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	8.099E-09
Ra-226	1.857E-10	0.000E+00	0.000E+00	0.000E+00	2.666E-07	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.666E-07
Th-230	2.860E-07	0.000E+00	0.000E+00	0.000E+00	4.107E-04	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	4.107E-04
U-234	1.055E-02	0.000E+00	0.000E+00	0.000E+00	1.515E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.515E+01
U-235	1.452E-04	0.000E+00	0.000E+00	0.000E+00	2.085E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.085E-01
U-238	7.502E-03	0.000E+00	0.000E+00	0.000E+00	1.077E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.077E+01

* Sum of all ingestion pathways, i.e. water independent plant, meat, milk, soil
and water-dependent water, fish, plant, meat, milk pathways

Amount of Intake Quantities QINT9(irn,i,t) and QINT9W(irn,i,t) for Inhalation of
Radon and its Decay Products as pCi/yr at t= 3.000E+00 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	1.027E-04	1.002E-06	7.496E-10	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	1.027E-04	1.002E-06	7.496E-10	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent   Water-dep. == Water-dependent

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Ac-227	1.405E-11	0.0000	5.245E-14	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.311E-13	0.0000
Pa-231	5.755E-12	0.0000	8.132E-14	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.463E-13	0.0000
Pb-210	3.901E-15	0.0000	7.258E-16	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.167E-13	0.0000
Ra-226	4.315E-11	0.0000	3.724E-15	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.737E-14	0.0000
Th-230	1.086E-12	0.0000	1.146E-12	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.760E-12	0.0000
U-234	2.455E-09	0.0027	6.845E-09	0.0074	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.377E-08	0.0367
U-235	7.183E-08	0.0781	8.472E-11	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.751E-10	0.0005
U-238	7.694E-07	0.8369	4.137E-09	0.0045	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.032E-08	0.0330
Total	8.437E-07	0.9177	1.107E-08	0.0120	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.457E-08	0.0702

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Plant		Meat		Milk		All Pathways**	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Ac-227	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.433E-11	0.0000
Pa-231	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.182E-12	0.0000
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.213E-13	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.325E-11	0.0000
Th-230	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.992E-12	0.0000
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.307E-08	0.0468
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.239E-08	0.0787
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.038E-07	0.8743
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.193E-07	1.0000

** Sum of water independent ground, inhalation, plant, meat, milk, soil
and water dependent water, fish, plant, meat, milk pathways

Excess Cancer Risks CNRS9(irn,i,t) and CNRS9W(irn,i,t) for Inhalation of
Radon and its Decay Products at t= 3.000E+00 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	1.310E-13	2.627E-15	3.294E-18	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	1.310E-13	2.627E-15	3.294E-18	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
U-234	2.499E-09	0.0027	6.846E-09	0.0074	1.336E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.377E-08	0.0367
U-235	7.185E-08	0.0782	8.485E-11	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.757E-10	0.0005
U-238	7.694E-07	0.8369	4.137E-09	0.0045	1.807E-18	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.032E-08	0.0330
Total	8.437E-07	0.9177	1.107E-08	0.0120	1.336E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.457E-08	0.0702

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All pathways	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.312E-08	0.0469
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.241E-08	0.0788
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.038E-07	0.8743
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.193E-07	1.0000

***CNRSI(i,p,t) includes contribution from decay daughter radionuclides

Amount of Intake Quantities QINT(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As pCi/yr at t= 1.000E+01 years

Radio-	Water Independent Pathways (Inhalation w/o radon)					Water Dependent Pathways					Total
Nuclide	Inhalation	Plant	Meat	Milk	Soil	Water	Fish	Plant	Meat	Milk	Ingestion*
Ac-227	4.291E-09	0.000E+00	0.000E+00	0.000E+00	6.161E-06	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	6.161E-06
Pa-231	3.022E-08	0.000E+00	0.000E+00	0.000E+00	4.340E-05	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	4.340E-05
Pb-210	1.962E-10	0.000E+00	0.000E+00	0.000E+00	2.817E-07	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.817E-07
Ra-226	2.041E-09	0.000E+00	0.000E+00	0.000E+00	2.932E-06	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.932E-06
Th-230	9.454E-07	0.000E+00	0.000E+00	0.000E+00	1.358E-03	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.358E-03
U-234	1.038E-02	0.000E+00	0.000E+00	0.000E+00	1.491E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.491E+01
U-235	1.428E-04	0.000E+00	0.000E+00	0.000E+00	2.051E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.051E-01
U-238	7.380E-03	0.000E+00	0.000E+00	0.000E+00	1.060E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.060E+01

* Sum of all ingestion pathways, i.e. water independent plant, meat, milk, soil
and water-dependent water, fish, plant, meat, milk pathways

Amount of Intake Quantities QINT9(irn,i,t) and QINT9W(irn,i,t) for Inhalation of
Radon and its Decay Products as pCi/yr at t= 1.000E+01 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	1.128E-03	1.101E-05	8.238E-09	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	1.128E-03	1.101E-05	8.238E-09	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent   Water-dep. == Water-dependent

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+01 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Ac-227	2.550E-11	0.0000	9.521E-14	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.194E-13	0.0000
Pa-231	8.322E-12	0.0000	1.176E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.008E-13	0.0000
Pb-210	9.284E-15	0.0000	1.727E-15	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.777E-13	0.0000
Ra-226	8.338E-11	0.0001	7.196E-15	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.882E-13	0.0000
Th-230	1.582E-12	0.0000	1.669E-12	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.390E-12	0.0000
U-234	2.415E-09	0.0027	6.733E-09	0.0074	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.322E-08	0.0367
U-235	7.066E-08	0.0781	8.334E-11	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.674E-10	0.0005
U-238	7.568E-07	0.8368	4.070E-09	0.0045	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.983E-08	0.0330
Total	8.300E-07	0.9177	1.089E-08	0.0120	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.352E-08	0.0702

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+01 years

Water Dependent Pathways

Radio-	Water		Fish		Plant		Meat		Milk		All Pathways**	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Ac-227	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.602E-11	0.0000
Pa-231	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.941E-12	0.0000
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.887E-13	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.358E-11	0.0001
Th-230	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.164E-11	0.0000
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.237E-08	0.0468
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.121E-08	0.0787
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.907E-07	0.8743
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.044E-07	1.0000

** Sum of water independent ground, inhalation, plant, meat, milk, soil
and water dependent water, fish, plant, meat, milk pathways

Excess Cancer Risks CNRS9(irn,i,t) and CNRS9W(irn,i,t) for Inhalation of
Radon and its Decay Products at t= 1.000E+01 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	2.529E-13	5.074E-15	6.362E-18	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	2.529E-13	5.074E-15	6.362E-18	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent   Water-dep. == Water-dependent

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+01 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
U-234	2.500E-09	0.0028	6.735E-09	0.0074	2.580E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.322E-08	0.0367
U-235	7.069E-08	0.0782	8.355E-11	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.683E-10	0.0005
U-238	7.568E-07	0.8368	4.070E-09	0.0045	4.466E-18	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.983E-08	0.0330
Total	8.300E-07	0.9177	1.089E-08	0.0120	2.580E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.352E-08	0.0702

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+01 years

Water Dependent Pathways

Radio-Nuclide	Water risk	Water fract.	Fish risk	Fish fract.	Radon risk	Radon fract.	Plant risk	Plant fract.	Meat risk	Meat fract.	Milk risk	Milk fract.	All pathways risk	All pathways fract.
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.246E-08	0.0469
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.124E-08	0.0788
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.907E-07	0.8743
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.044E-07	1.0000

***CNRSI(i,p,t) includes contribution from decay daughter radionuclides

Amount of Intake Quantities QINT(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As pCi/yr at t= 3.000E+01 years

Radio-	Water Independent Pathways (Inhalation w/o radon)					Water Dependent Pathways					Total
Nuclide	Inhalation	Plant	Meat	Milk	Soil	Water	Fish	Plant	Meat	Milk	Ingestion*
Ac-227	2.988E-08	0.000E+00	0.000E+00	0.000E+00	4.291E-05	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	4.291E-05
Pa-231	8.648E-08	0.000E+00	0.000E+00	0.000E+00	1.242E-04	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.242E-04
Pb-210	4.468E-09	0.000E+00	0.000E+00	0.000E+00	6.416E-06	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	6.416E-06
Ra-226	1.783E-08	0.000E+00	0.000E+00	0.000E+00	2.561E-05	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.561E-05
Th-230	2.770E-06	0.000E+00	0.000E+00	0.000E+00	3.978E-03	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.978E-03
U-234	9.903E-03	0.000E+00	0.000E+00	0.000E+00	1.422E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.422E+01
U-235	1.363E-04	0.000E+00	0.000E+00	0.000E+00	1.957E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.957E-01
U-238	7.041E-03	0.000E+00	0.000E+00	0.000E+00	1.011E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.011E+01

* Sum of all ingestion pathways, i.e. water independent plant, meat, milk, soil
and water-dependent water, fish, plant, meat, milk pathways

Amount of Intake Quantities QINT9(irn,i,t) and QINT9W(irn,i,t) for Inhalation of
Radon and its Decay Products as pCi/yr at t= 3.000E+01 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	9.843E-03	9.606E-05	7.187E-08	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	9.843E-03	9.606E-05	7.187E-08	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent   Water-dep. == Water-dependent

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+01 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Ac-227	6.989E-11	0.0001	2.609E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.149E-12	0.0000
Pa-231	1.519E-11	0.0000	2.147E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.143E-13	0.0000
Pb-210	4.669E-14	0.0000	8.686E-15	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.396E-12	0.0000
Ra-226	2.764E-10	0.0003	2.386E-14	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.238E-13	0.0000
Th-230	2.954E-12	0.0000	3.117E-12	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.567E-11	0.0000
U-234	2.304E-09	0.0027	6.424E-09	0.0074	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.169E-08	0.0367
U-235	6.741E-08	0.0781	7.951E-11	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.459E-10	0.0005
U-238	7.221E-07	0.8365	3.883E-09	0.0045	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.846E-08	0.0330
Total	7.921E-07	0.9177	1.039E-08	0.0120	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.062E-08	0.0702

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+01 years

Water Dependent Pathways

Radio-	Water		Fish		Plant		Meat		Milk		All Pathways**	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Ac-227	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.130E-11	0.0001
Pa-231	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.632E-11	0.0000
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.452E-12	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.771E-10	0.0003
Th-230	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.174E-11	0.0000
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.042E-08	0.0468
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.794E-08	0.0787
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.544E-07	0.8740
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.631E-07	1.0000

** Sum of water independent ground, inhalation, plant, meat, milk, soil
and water dependent water, fish, plant, meat, milk pathways

Excess Cancer Risks CNRS9(irn,i,t) and CNRS9W(irn,i,t) for Inhalation of
Radon and its Decay Products at t= 3.000E+01 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	8.370E-13	1.679E-14	2.105E-17	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	8.370E-13	1.679E-14	2.105E-17	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+01 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
U-234	2.583E-09	0.0030	6.427E-09	0.0074	8.538E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.171E-08	0.0367
U-235	6.750E-08	0.0782	7.999E-11	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.480E-10	0.0005
U-238	7.221E-07	0.8365	3.883E-09	0.0045	2.508E-17	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.846E-08	0.0330
Total	7.921E-07	0.9177	1.039E-08	0.0120	8.538E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.062E-08	0.0702

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+01 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All pathways	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.072E-08	0.0472
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.803E-08	0.0788
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.544E-07	0.8740
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.631E-07	1.0000

***CNRSI(i,p,t) includes contribution from decay daughter radionuclides

Amount of Intake Quantities QINT(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As pCi/yr at t= 1.000E+02 years

Radio-	Water Independent Pathways (Inhalation w/o radon)					Water Dependent Pathways					Total
Nuclide	Inhalation	Plant	Meat	Milk	Soil	Water	Fish	Plant	Meat	Milk	Ingestion*
Ac-227	1.597E-07	0.000E+00	0.000E+00	0.000E+00	2.294E-04	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.294E-04
Pa-231	2.443E-07	0.000E+00	0.000E+00	0.000E+00	3.509E-04	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.509E-04
Pb-210	9.954E-08	0.000E+00	0.000E+00	0.000E+00	1.429E-04	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.429E-04
Ra-226	1.787E-07	0.000E+00	0.000E+00	0.000E+00	2.567E-04	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.567E-04
Th-230	8.520E-06	0.000E+00	0.000E+00	0.000E+00	1.223E-02	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.223E-02
U-234	8.400E-03	0.000E+00	0.000E+00	0.000E+00	1.206E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.206E+01
U-235	1.156E-04	0.000E+00	0.000E+00	0.000E+00	1.660E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.660E-01
U-238	5.973E-03	0.000E+00	0.000E+00	0.000E+00	8.578E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	8.578E+00

* Sum of all ingestion pathways, i.e. water independent plant, meat, milk, soil
and water-dependent water, fish, plant, meat, milk pathways

Amount of Intake Quantities QINT9(irn,i,t) and QINT9W(irn,i,t) for Inhalation of
Radon and its Decay Products as pCi/yr at t= 1.000E+02 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	9.776E-02	9.541E-04	7.139E-07	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	9.776E-02	9.541E-04	7.139E-07	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent   Water-dep. == Water-dependent

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+02 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Ac-227	2.465E-10	0.0003	9.204E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.055E-12	0.0000
Pa-231	3.440E-11	0.0000	4.861E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.070E-12	0.0000
Pb-210	5.167E-13	0.0000	9.614E-14	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.546E-11	0.0000
Ra-226	1.737E-09	0.0024	1.499E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.919E-12	0.0000
Th-230	7.275E-12	0.0000	7.678E-12	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.859E-11	0.0001
U-234	1.954E-09	0.0027	5.449E-09	0.0074	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.688E-08	0.0366
U-235	5.719E-08	0.0779	6.745E-11	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.783E-10	0.0005
U-238	6.125E-07	0.8345	3.294E-09	0.0045	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.414E-08	0.0329
Total	6.737E-07	0.9179	8.820E-09	0.0120	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.147E-08	0.0701

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+02 years

Water Dependent Pathways

Radio-	Water		Fish		Plant		Meat		Milk		All Pathways**	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Ac-227	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.515E-10	0.0003
Pa-231	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.696E-11	0.0001
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.607E-11	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.741E-09	0.0024
Th-230	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.354E-11	0.0001
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.429E-08	0.0467
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.763E-08	0.0785
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.400E-07	0.8719
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.340E-07	1.0000

** Sum of water independent ground, inhalation, plant, meat, milk, soil
and water dependent water, fish, plant, meat, milk pathways

Excess Cancer Risks CNRS9(irn,i,t) and CNRS9W(irn,i,t) for Inhalation of
Radon and its Decay Products at t= 1.000E+02 years

Radon Pathway	Radionuclides Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	5.214E-12	1.046E-13	1.311E-16	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	5.214E-12	1.046E-13	1.311E-16	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+02 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
U-234	3.698E-09	0.0050	5.456E-09	0.0074	5.318E-12	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.693E-08	0.0367
U-235	5.747E-08	0.0783	6.886E-11	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.844E-10	0.0005
U-238	6.125E-07	0.8345	3.295E-09	0.0045	3.931E-16	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.415E-08	0.0329
Total	6.737E-07	0.9179	8.820E-09	0.0120	5.319E-12	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.147E-08	0.0701

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+02 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All pathways	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.609E-08	0.0492
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.792E-08	0.0789
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.400E-07	0.8719
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.340E-07	1.0000

***CNRSI(i,p,t) includes contribution from decay daughter radionuclides

Amount of Intake Quantities QINT(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As pCi/yr at t= 3.000E+02 years

Radio-	Water Independent Pathways (Inhalation w/o radon)					Water Dependent Pathways					Total
Nuclide	Inhalation	Plant	Meat	Milk	Soil	Water	Fish	Plant	Meat	Milk	Ingestion*
Ac-227	3.732E-07	0.000E+00	0.000E+00	0.000E+00	5.360E-04	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	5.360E-04
Pa-231	4.572E-07	0.000E+00	0.000E+00	0.000E+00	6.565E-04	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	6.565E-04
Pb-210	9.820E-07	0.000E+00	0.000E+00	0.000E+00	1.410E-03	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.410E-03
Ra-226	1.207E-06	0.000E+00	0.000E+00	0.000E+00	1.734E-03	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.734E-03
Th-230	2.055E-05	0.000E+00	0.000E+00	0.000E+00	2.951E-02	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.951E-02
U-234	5.249E-03	0.000E+00	0.000E+00	0.000E+00	7.538E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	7.538E+00
U-235	7.225E-05	0.000E+00	0.000E+00	0.000E+00	1.038E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.038E-01
U-238	3.733E-03	0.000E+00	0.000E+00	0.000E+00	5.361E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	5.361E+00

* Sum of all ingestion pathways, i.e. water independent plant, meat, milk, soil
and water-dependent water, fish, plant, meat, milk pathways

Amount of Intake Quantities QINT9(irn,i,t) and QINT9W(irn,i,t) for Inhalation of
Radon and its Decay Products as pCi/yr at t= 3.000E+02 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	6.474E-01	6.318E-03	4.727E-06	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	6.474E-01	6.318E-03	4.727E-06	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent   Water-dep. == Water-dependent

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+02 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Ac-227	5.183E-10	0.0011	1.935E-12	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.523E-12	0.0000
Pa-231	5.980E-11	0.0001	8.450E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.599E-12	0.0000
Pb-210	4.177E-12	0.0000	7.772E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.249E-10	0.0003
Ra-226	1.010E-08	0.0216	8.713E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.278E-11	0.0000
Th-230	1.632E-11	0.0000	1.722E-11	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.656E-11	0.0002
U-234	1.221E-09	0.0026	3.405E-09	0.0073	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.680E-08	0.0359
U-235	3.574E-08	0.0763	4.215E-11	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.364E-10	0.0005
U-238	3.828E-07	0.8173	2.059E-09	0.0044	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.509E-08	0.0322
Total	4.305E-07	0.9191	5.528E-09	0.0118	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.237E-08	0.0691

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+02 years

Water Dependent Pathways

Radio-	Water		Fish		Plant		Meat		Milk		All Pathways**	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Ac-227	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.287E-10	0.0011
Pa-231	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.425E-11	0.0001
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.299E-10	0.0003
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.012E-08	0.0216
Th-230	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.201E-10	0.0003
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.142E-08	0.0457
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.602E-08	0.0769
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.000E-07	0.8539
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.684E-07	1.0000

** Sum of water independent ground, inhalation, plant, meat, milk, soil
and water dependent water, fish, plant, meat, milk pathways

Excess Cancer Risks CNRS9(irn,i,t) and CNRS9W(irn,i,t) for Inhalation of
Radon and its Decay Products at t= 3.000E+02 years

Radon Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	2.970E-11	5.959E-13	7.471E-16	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	2.970E-11	5.959E-13	7.471E-16	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent   Water-dep. == Water-dependent

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+02 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
U-234	1.133E-08	0.0242	3.422E-09	0.0073	3.029E-11	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.702E-08	0.0363
U-235	3.632E-08	0.0775	4.493E-11	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.485E-10	0.0005
U-238	3.828E-07	0.8173	2.061E-09	0.0044	5.919E-15	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.510E-08	0.0322
Total	4.305E-07	0.9190	5.528E-09	0.0118	3.030E-11	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.237E-08	0.0691

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+02 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All pathways	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.181E-08	0.0679
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.661E-08	0.0782
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.000E-07	0.8539
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.684E-07	1.0000

***CNRSI(i,p,t) includes contribution from decay daughter radionuclides

Amount of Intake Quantities QINT(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As pCi/yr at t= 1.000E+03 years

Radio-	Water Independent Pathways (Inhalation w/o radon)					Water Dependent Pathways					Total
Nuclide	Inhalation	Plant	Meat	Milk	Soil	Water	Fish	Plant	Meat	Milk	Ingestion*
Ac-227	2.557E-07	0.000E+00	0.000E+00	0.000E+00	3.672E-04	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.672E-04
Pa-231	2.919E-07	0.000E+00	0.000E+00	0.000E+00	4.192E-04	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	4.192E-04
Pb-210	5.074E-06	0.000E+00	0.000E+00	0.000E+00	7.287E-03	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	7.287E-03
Ra-226	5.408E-06	0.000E+00	0.000E+00	0.000E+00	7.767E-03	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	7.767E-03
Th-230	3.654E-05	0.000E+00	0.000E+00	0.000E+00	5.247E-02	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	5.247E-02
U-234	1.012E-03	0.000E+00	0.000E+00	0.000E+00	1.454E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.454E+00
U-235	1.394E-05	0.000E+00	0.000E+00	0.000E+00	2.002E-02	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.002E-02
U-238	7.204E-04	0.000E+00	0.000E+00	0.000E+00	1.035E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.035E+00

* Sum of all ingestion pathways, i.e. water independent plant, meat, milk, soil
and water-dependent water, fish, plant, meat, milk pathways

Amount of Intake Quantities QINT9(irn,i,t) and QINT9W(irn,i,t) for Inhalation of
Radon and its Decay Products as pCi/yr at t= 1.000E+03 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	2.386E+00	2.328E-02	1.742E-05	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	2.386E+00	2.328E-02	1.742E-05	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent   Water-dep. == Water-dependent

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+03 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Ac-227	3.444E-10	0.0026	1.286E-12	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.663E-12	0.0000
Pa-231	3.717E-11	0.0003	5.252E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.237E-12	0.0000
Pb-210	2.034E-11	0.0002	3.784E-12	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.084E-10	0.0046
Ra-226	4.293E-08	0.3239	3.705E-12	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.688E-11	0.0007
Th-230	2.833E-11	0.0002	2.990E-11	0.0002	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.503E-10	0.0011
U-234	2.355E-10	0.0018	6.568E-10	0.0050	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.240E-09	0.0244
U-235	6.897E-09	0.0520	8.135E-12	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.562E-11	0.0003
U-238	7.388E-08	0.5574	3.973E-10	0.0030	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.912E-09	0.0220
Total	1.244E-07	0.9384	1.101E-09	0.0083	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.061E-09	0.0533

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+03 years

Water Dependent Pathways

Radio-	Water		Fish		Plant		Meat		Milk		All Pathways**	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Ac-227	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.513E-10	0.0027
Pa-231	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.993E-11	0.0003
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.325E-10	0.0048
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.303E-08	0.3247
Th-230	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.085E-10	0.0016
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.132E-09	0.0312
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.951E-09	0.0524
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.719E-08	0.5824
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.325E-07	1.0000

** Sum of water independent ground, inhalation, plant, meat, milk, soil
and water dependent water, fish, plant, meat, milk pathways

Excess Cancer Risks CNRS9(irn,i,t) and CNRS9W(irn,i,t) for Inhalation of
Radon and its Decay Products at t= 1.000E+03 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	1.034E-10	2.074E-12	2.600E-15	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	1.034E-10	2.074E-12	2.600E-15	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+03 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
U-234	4.319E-08	0.3256	6.928E-10	0.0052	1.054E-10	0.0008	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.088E-09	0.0308
U-235	7.279E-09	0.0549	9.946E-12	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.352E-11	0.0004
U-238	7.390E-08	0.5572	3.986E-10	0.0030	5.535E-14	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.919E-09	0.0220
Total	1.244E-07	0.9377	1.101E-09	0.0083	1.055E-10	0.0008	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.061E-09	0.0532

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+03 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All pathways	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.808E-08	0.3625
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.342E-09	0.0554
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.722E-08	0.5822
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.326E-07	1.0000

***CNRSI(i,p,t) includes contribution from decay daughter radionuclides

SADDLE ROAD (STATE ROUTE 200)
Mamalahoa Highway (State Route 190) to Milepost 42
County of Hawai‘i, State of Hawai‘i
FHWA Project No. 200(00)

SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT

Submitted Pursuant to Section 42 U.S.C. 4332(2)(c)
and Chapter 343, Hawai‘i Revised Statutes by the

U.S. DEPARTMENT OF TRANSPORTATION
Federal Highway Administration (FHWA)
Central Federal Lands Highway Division
and
STATE OF HAWAI‘I
Department of Transportation (HDOT)
Highways Division

Cooperating Agencies
U.S. Army Garrison, Hawai‘i

Appendix F1
Archaeological Report

SCS Project Number 885-1.3

AN ARCHAEOLOGICAL INVENTORY SURVEY REPORT FOR 600 ACRES LOCATED ON LANDS OF KEʻĀMUKU, WAIKŌLOA AHUPUAʻA, SOUTH KOHALA DISTRICT, HAWAIʻI ISLAND, HAWAIʻI [TMK (3) 6-7-001:09]

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October 2009
FINAL DRAFT

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ABSTRACT

An Archaeological Inventory Survey was conducted along an approximately 600-acre study corridor across the lands of the Parker Ranch Keʻāmuku cattle station in the *ahupuaʻa* of Waikōloa, South Kohala District, Island of Hawaiʻi, TMK: (3) 6-7-001:09. The lands of Keʻāmuku were traditionally used as *pili* lands by the people of Waikōloa and Waimea. At the beginning of the post-Contact era, the area was given over to wild cattle. It was soon after fenced off and used by the Waimea Grazing and Agricultural Company (WGAC) for sheep and cattle ranching. Parker Ranch acquired the land in 1904 and still uses it for cattle grazing though the property is now owned by the U.S. Army. The present study corridor is the location for a segment (W-7 Alignment) of the proposed Saddle Road Extension between the existing Saddle Road near Kilohana to the Mamalahoa Highway along the border of South Kohala and North Kona.

There are seven archaeological sites in the project corridor, including five rock mounds (SIHP Sites 50-10-21-23528, 50-10-21-26875, 50-10-21-26876, 50-10-21-26877, and 50-10-21-26878), a segment of the old Waimea-Kona Belt Road (SIHP Site 50-10-21-20855), and remnants of a ranching-era fence (SIHP Site 50-10-21-23452).

Four of the rock mounds (Sites 23528, 26875, 26877, and 26878) correspond very roughly to the boundary between the Keʻāmuku cattle station lands and ranch lands to the southwest. This area is also the boundary between Waikōloa and Puʻuanahulu *ahupuaʻa*. Site 26875 contained a Kalopa Soda Works bottle and a roll of galvanized fence wire in its construction. A fifth rock mound (Site 26876) marks the intersection of two ranch roads along the southeast side of the Keʻāmuku cattle station lands. The ranching-era fence (Site 23452) appears to have been used early in the history of sheep and cattle ranching at Keʻāmuku. The original fence wire has been removed and it passes through the middle of several more recently fenced paddocks.

Four one meter by one meter test-units were excavated at rock mound Sites 26875, 26876, 26877, and 26878. Site 26875 contained a Kalopa Soda Works bottle and a roll of galvanized fence wire in its construction. No other artifacts or cultural material were recovered during the present study.

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INTRODUCTION

The Federal Highway Administration (FHWA), Central Federal Lands Highway Division and the Hawai‘i Department of Transportation (HDOT) have contracted with DMT Consultant Engineers to prepare a Supplemental Environmental Impact Statement (SEIS) for a segment (W-7 Alignment) of the proposed Saddle Road extension across lands of the former Parker Ranch Ke‘āmuku cattle station in the *ahupua‘a* of Waikōloa, South Kohala District, Island of Hawai‘i, TMK: (3) 6-7-001:09 (Figure 1). The proposed 200ft wide construction corridor (Area of Potential Effect) extends approximately ten miles from the existing Saddle Road near Kilohana to the Mamalahoa Highway at the border of North Kona and South Kohala (Figure 2). Scientific Consultant Services, Inc. (SCS) surveyed an approximately 600-acre study corridor (roughly 10 miles by 500ft wide) to identify and evaluate historical properties. The survey corridor extends 150ft beyond both sides of the 200ft wide construction corridor (APE).

The project is a federal undertaking and is subject to the procedures and policies of Section 106 of the National Historic Preservation Act (NHPA). In addition, cultural resources are considered under Section 4(f) of the DoT Act (49 U.S.C. 303), and the state of Hawai‘i historic preservation review process (H.R.S. Chapter 6E). Scientific Consultant Services (SCS), Inc. has performed the appropriate studies to inventory and evaluate the historical and cultural resources in compliance with the regulations above.

There are seven archaeological sites documented in the project, including five rock mounds (SIHP Sites 50-10-21-23528, 50-10-21-26875, 50-10-21-26876, 50-10-21-26877, and 50-10-21-26878), a segment of the old Waimea-Kona Belt Road (SIHP Site 50-10-21-20855), and remnants of a ranching-era fence (SIHP Site 50-10-21-23452). Four of the rock mounds (Sites 23528, 26875, 26877, and 26878) correspond roughly to the boundary between the Ke‘āmuku cattle station lands and ranch lands to the southwest. This area is also the boundary between Waikōloa and Pu‘uanahulu *ahupua‘a*. Site 26875 contained a Kalopa Soda Works bottle and a roll of galvanized fence wire in its construction. A third rock mound (Site 26878) appears to mark a possible hunting spot. A fourth rock mound (Site 26876) marks the intersection of two ranch roads along the southeast side of the Ke‘āmuku cattle station lands. The ranching-era fence (Site 23452) appears to have been used early in the history of sheep and cattle ranching at Ke‘āmuku. The original fence wire has been removed and it passes through the middle of several more recently fenced paddocks.

ENVIRONMENTAL SETTING

THE GEOGRAPHY OF WAIKŌLOA

Waikōloa is a large land-locked *ahupua'a* in South Kohala District (Figure 3). In the past it was an *'ili* of Waimea (see below). The western portion of Waikōloa is composed of moderately sloping *'a'ā* and *pāhoehoe* lava flows. This region is extremely dry (less than ten inches of rainfall annually), hot, and barren except for patches of fountaingrass (*Pennisetum setaceum*). The northeastern portion of Waikōloa is a large grassy plain bounded on the south and southwest by grass covered rolling hills (Figure 4).

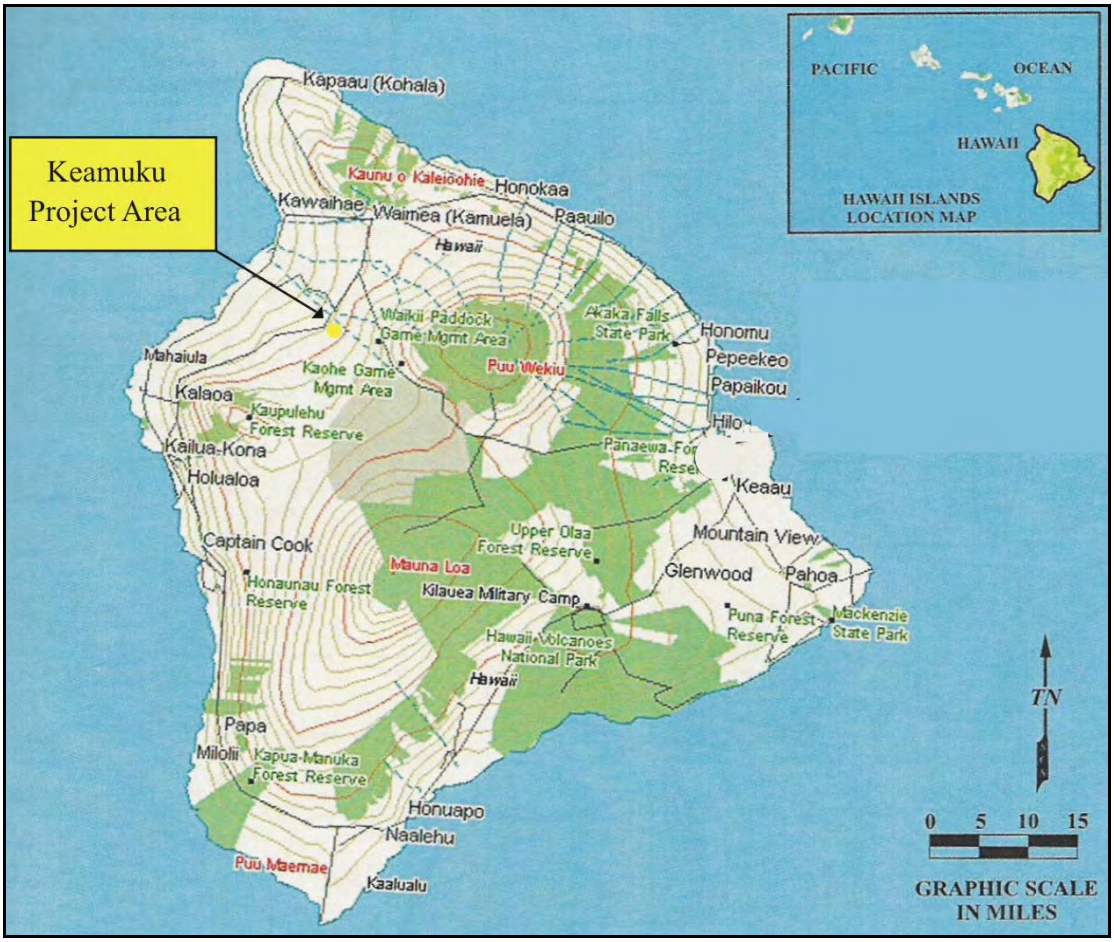

Figure 1: Hawai'i Island Map Showing Project Area Location.

LAVA FLOWS

The project area corridor is situated on gently sloping to level land that increases in elevation from 2,480 (756 m) to 5,240 (1,598 m) feet above mean sea level (amsl). Slopes range from 7% to 20% within the project area. The project area is located on a single Mauna Kea *'a'ā* flow dated to more than 10,000 years before present (ybp) (Wolfe and Morris 1996).

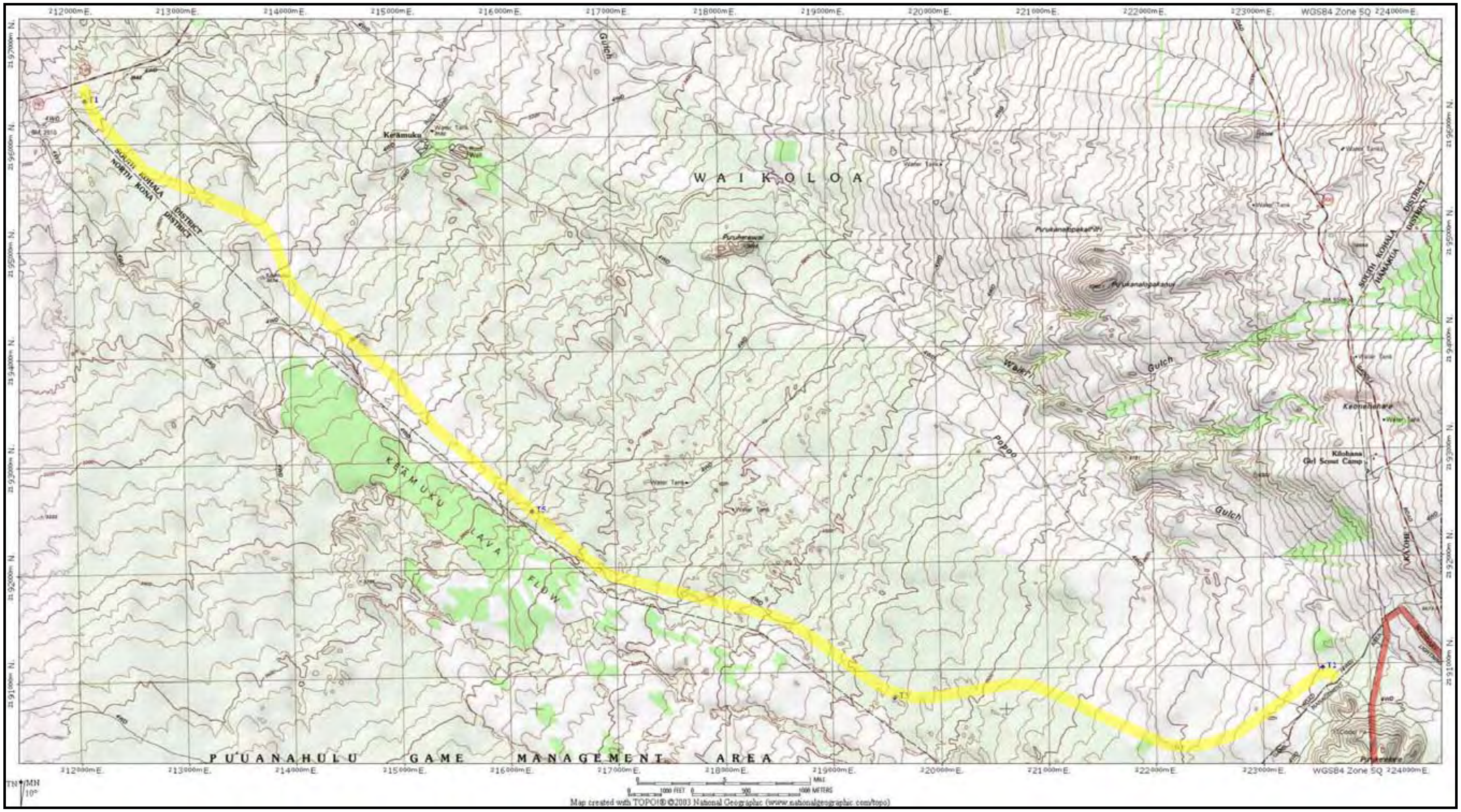

Figure 2: USGS TOPO Map Showing Project Area Location in Yellow.

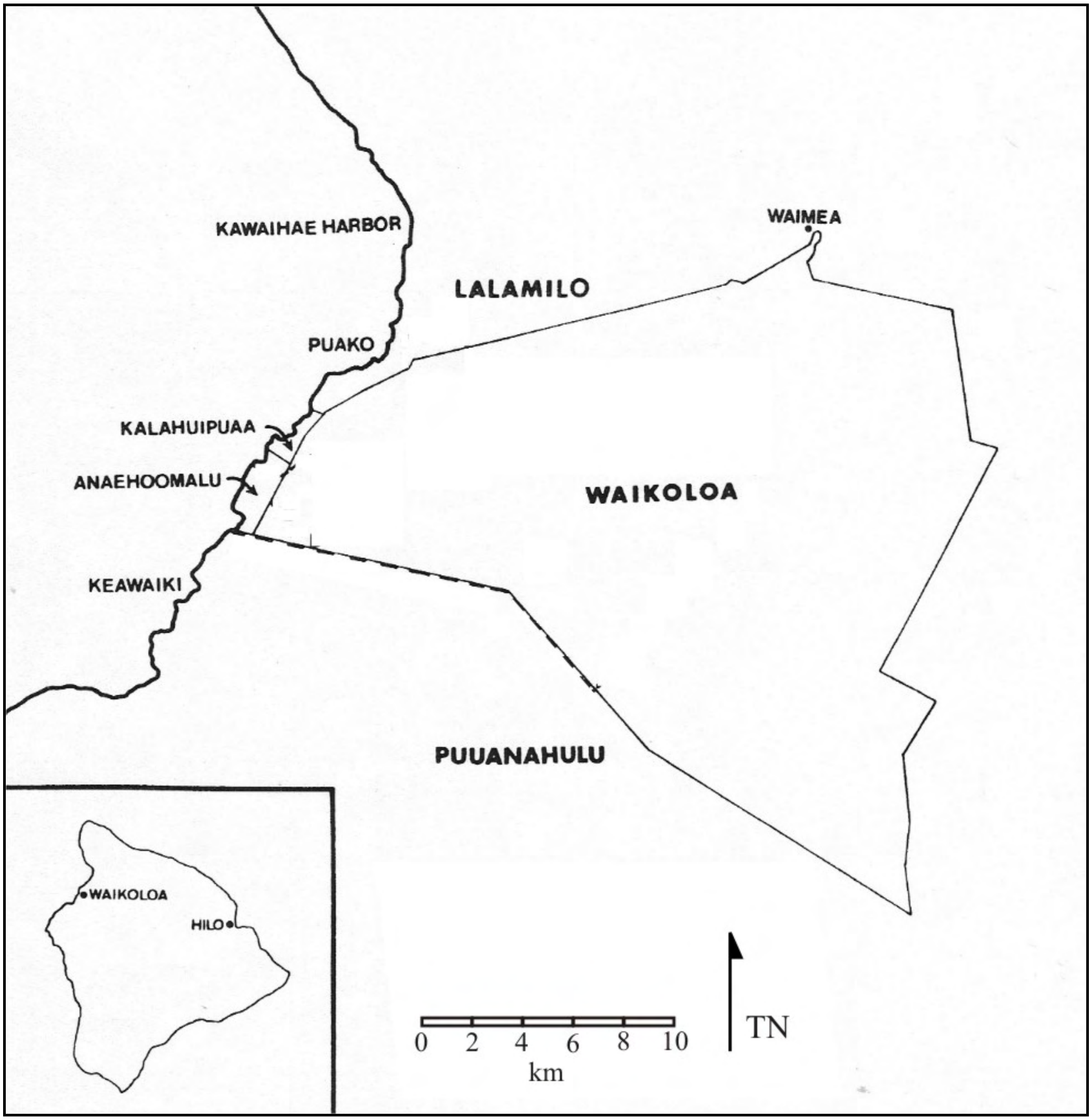

Figure 3: Waikōloa *Ahupuaʻa*.

Figure 4: Grasslands of Waikōloa.

SOILS

Soils in the project area belong to the Puʻu Pa and Kaimu series. Soil in the majority of the project area consist of Kaimu series (rKED) very dark brown extremely stony peat on a substratum of *aʻā* (Sato et al. 1973). Soil in the northern 1/8th of the corridor consist of Puʻu Pa (PVD) extremely stony very fine sandy loam. Both types of soil are characterized as poorly suited or unsuited to mechanized-farming (Soil Survey of the Territory of Hawaii 1955).

RAINFALL AND DRAINAGE

Average annual rainfall at the Keʻāmuku Sheep and Cattle Station between 1908 and 1947 was recorded (daily rain gauge readings) at 20.86 inches, and at 25.04 inches during the 15-year period between 1929 and 1943 (Parker Ranch Office Account Books and Rainfall Data). The average annual rainfall in the project area from 1942 to 1952 was approximately 25.59 inches. Rainfall on lands of the Keʻāmuku Sheep and Cattle Station is supplemented by fog and mist, and was collected on rooftop water catchment systems. Rally Greenwell recalled torrential rainfall about every 20 years while he was there (Rally Greenwell interview, Escott 2008). The Keʻāmuku Station rain gauge recorded daily rainfall readings as high as 7.28 inches. Natural drainage in the area runs from southeast to northwest and a seasonal gulch in the center of the project area channels water westward away from the site. Water in the Poʻopoʻo Gulch (see Figure 2), roughly 1.5 miles north of the project corridor, rises three to four feet during torrential rains and flooding and erosion affect the silty ground surface in the area.

WIND

The area of Waikōloa and Waimea are famous for the winds that blow down from the Kohala Mountains, the saddle area between Mauna Kea and Mauna Loa, and from the Hāmākua region. They are called the *ʻĀpaʻapaʻa* wind, and the Waikōloa and *Kaumuku* winds (Maly and Maly 2002: 21). In other sources there is a strong wind called the *Mūmuku* wind (Wilkes 1845, Bergin 2004: 15). The *ʻĀpaʻapaʻa* wind, and the Waikōloa wind is believed to bring moisture and rain, and the strong *Mūmuku* wind drives away the rain, stirs up the fine silt in the area, and carries it westward. The *Mūmuku* wind is famous even in Kawaihae, where residents there were forced to lash their canoes to rocks, stakes, or trees to keep them from being carried off (Doyle 1953: 48). According to Doyle (1953), the winds have decreased in strength and frequency because of deforestation.

VEGETATION

Vegetation also changed dramatically after the late 1700s (see blow). Large areas of the foothills of southern Waikōloa were once covered in *pili* grass (*Heteropogon contortus*). *Māmane* (*Sophora chysophylla*), *naio* (*Myoporum sandwicense*) and *ʻōhiʻa* (*Metrosideros polymorpha*) grew on the upper plains of Waimea and at upper elevations in the foothills of Mauna Kea and Mauna Loa. The suite of present day flora on the project area is dominated by introduced species.

Gerrish (2003), based on field survey, characterizes vegetation within the project area as Fountain Grass Pasture with Native Shrubs and Scattered Introduced Trees. This zone of vegetation extends from 2200 ft amsl to 3200 ft amsl, is heavily grazed by cattle, and is characterized by low plant diversity dominated by fountaingrass (*Pennisetum setaceum*).

Low shrubs of native *ʻaʻāliʻi* (*Dodonaea viscosa*) and ʻā*kia* (*Wikstroemia pulcherrima*) dot the hilly pastureland. Kikuyugrass (*Pennisetum clandestinum*) and Natal redtop

(*RhyncheIytrum repens*) grow in wetter areas along the dirt access roads. Introduced trees such as eucalyptus, olive (*Olea europaea*), and silk oak (*Grevillea robusta*) were planted at the Keʻāmuku Sheep and Cattle Station, and many volunteers are growing along the project area.

FAUNA

Several economically important animals within Waikōloa are documented in historical narratives and oral interviews. Native species include *kōlea*, or Golden Plover (*Pluvialis dominica fulva*); *ʻuaʻu*, or Hawaiian Petrel (*Pterodrama phaeopygia sandwichensis*); *nēnē*, or Hawaiian Goose (*Nesochen sandwichensis*). Polynesian-introduced species include the pig (*Sus scrofa*) . Several species of quail, pheasant, partridge, and turkey introduced during the Historic-era are still present at Keʻāmuku.

HISTORICAL AND CULTURAL CONTEXTS

EARLY SETTLEMENT AND EXPANSION

Archaeological evidence suggests Hawaiʻi was first settled between A.D. 0 and 700 by people sailing from the Marquesas (Cordy 2000). Early settlements on the Island of Hawaiʻi were founded on the windward shores in likely places such as Waipiʻo, Waimanu, and Hilo Bay. The windward, or *koʻolau* shores receive abundant rainfall and have numerous streams that facilitated agricultural and fishpond production (Maly and Maly 2002). The windward shores also provide rich benthic and pelagic marine resources.

Historical accounts of residential patterns, land-use, and subsistence horticulture are believed to be indicative of traditional practices developed long before contact with Europeans (McEldowney 1979). Early accounts of settlements along the windward shores describe the area as divided into several distinct environmental regions (Ellis 1963: 291-292). At Hilo Bay, from the coast to a distance of five or six miles scattered subsistence agriculture was evident, followed by a region of tall fern and bracken, flanked at higher elevations by a forest region between 10 and 20 miles wide, beyond which was an expanse of grass and lava (Ellis 1963:403).

The American Missionary C.S. Stewart wrote, “the first four miles of the country is open and uneven, and beautifully sprinkled with clumps, groves, and single trees of the bread-fruit, pandanus, and candle tree” (Stewart 1970:361-363). The majority of inhabitants (in 1825) lived within this coastal region (Ellis1969: 253). Taro, plantains, bananas, coconuts, sweet potatoes, and breadfruit were grown individually or in small garden plots. Fish, pig, dog, and birds were also raised and captured for consumption. Wood, such as *ʻōhiʻa* and *koa* for house construction, canoe building, and fires was obtained from the upland agricultural zone (McEldowney 1979:18-19), and from the dense forests above (Ellis 1963:236).

The dry leeward shores of Hawaiʻi Island presented a very different environment requiring a modified set of subsistence strategies. Archaeologists and historians are uncertain about the motives that lead to the establishment and spread of settlements on the leeward side of Hawaiʻi, but archaeological evidence suggests the process was underway between the A.D. 900s and 1100s (Cordy 2000). Coastal sites in South Kohala District, *makai* of Waikōloa, at Kalāhuipuaʻa and ʻAnaehoʻomalu and inland sites in the *ahupuaʻa* of Waimea (Figure 3) have been dated to the A.D. 800s to 900s (Kirch 1979: 198, Cordy 2000: 130).

The early coastal settlements are located on or adjacent to the dry rocky shoreline and consist of temporary habitation caves containing midden, fishing tools, and fish remains; and two possibly permanent habitation sites (Barrera 1971, Jenson 1989a, 1989b, 1990a, and 1990b). The earlier phases of occupation were likely temporary habitations used when fishing, and later permanent habitations associated with fishpond production. Cordy suggests people who lived at inland Waimea occasionally frequented the Kalāhuipuaʻa and ʻAnaehoʻomalu area for its anchialine pond and marine resources (Cordy 2000:131). The implication is that inland settlements and agriculture may have developed first, perhaps spreading from nearby Waimanu and Waipiʻo. Maly suggests that people living permanently along the dry shoreline shared extended family relations with people inland, allowing for an exchange system that distributed marine resources to inland agriculturalists and brought inland agricultural products to people at the coastal settlements (Maly and Maly 2002).

The fertile plain of Waimea, which receives 40 to 80 inches of rainfall annually and is watered by streams from the Kohala Mountains (the Waikōloa, Waiʻaka, and Keanuʻiʻomanō streams), was planted in taro and sweet potato. Sweet potato was the dominant crop at elevations that received from 30 to 60 inches (Cordy 2000: 135). At lower elevations in South Kohala District, especially along the coast, rainfall is less than thirty inches and soils are shallow or nonexistent. It is possible that mulching with rocks or cut plant materials allowed for a limited amount of root crop and arboreal agriculture in pockets of soil.

In Waimea and Kohala, new settlements and agricultural field systems continued to spread and intensify during the A.D. 1200s to 1400s. Permanent communities were developing at Lapakahi and along the coastal region from ‘Upolu Point to Kawaihae (Cordy 2000: 140). Temporary residences and an agricultural field system were also established in the uplands of the Waikōloa-Waimea area (Moffat and Fitzpatrick 1995, Maly and Maly 2002: 4). As communities grew and agriculture intensified during this period, polities began to form, along with competition between polities. Large polities influencing communities within modern district-size boundaries emerged in the 1300s (Cordy 2000: 142). Cordy notes that just north of the project area “two different settlement and political zones seem to have developed prior to the 1200s and to have lasted until late in prehistory—one focused on Waimea and Kawaihae in the south, and the other in north Kohala up to ‘Upolu Point” (Cordy 2000:385, footnote 15).

By the late 1700s extensive permanent field systems were well established in North Kohala, Waimea, and Lālāmilo (Clark 1981, Clark and Kirch 1983, Cordy 2000). The Lālāmilo swale land fields, described in Clark (1981) and Cordy (2000), were part of the Waimea Field System (Figure 5) and were the nearest agricultural lands to the Ke‘āmuku Sheep and Cattle Station project area (the field system is more than 18 km to the north). Cordy describes the fields as,

> rectilinear fields with terrace facings or low-ridged walls . . . fed by six major canals (one an extension out of the airport area) and a vast number of interlinking branches of these canals. The walled fields diminished to the south about half way to Pu‘u Huluhulu and Pu‘u Pā, where rainfall and soil quality drop—although the swales were still fed by canals (Cordy 2000: 310).

Banana, sweet potato, sugar cane, and dry land taro were cultivated in the fields by farmers who built C-shaped and L-shaped enclosures for temporary use and lived some distance away from the fields (Cordy 2000:310-311).

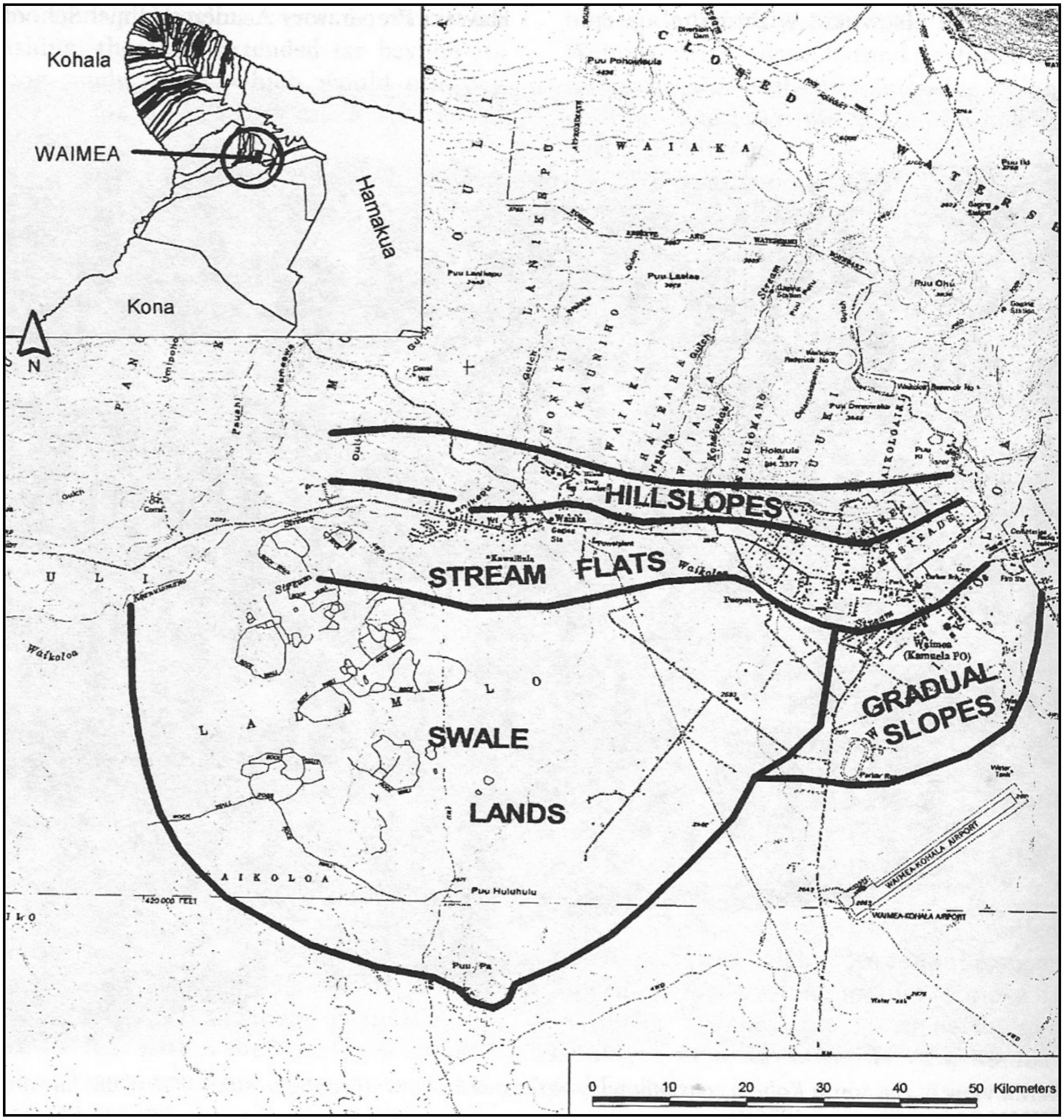

Figure 5: The Swale Lands of the Waimea Field System.

THE TRADITIONAL LAND DIVISIONS OF WAIMEA AND WAIKŌLOA

The traditional land divisions of Hawaiʻi, established during the 16th century recognized Kohala as one of the six districts (*moku-a-loko*) of the island. Waimea was a sub-district (*ʻokana* or *kalana*) of Kohala, and Waikōloa was an *ʻili* of Waimea. ʻŌuli, Waiʻaka, Lālāmilo, Puakō, Kalāhuipuaʻa, ʻAnaehoʻomalu, Kanakanaka, Alaʻōhia, Paulama, Puʻukalani, and Puʻukapu were also *ʻili* of Waimea. Other accounts state that Waimea was an *ahupuaʻa* that had the status of *moku* (Curtis Lyons, quoted in Maly and Maly 2002: 6).

TRADITIONAL ACCOUNTS OF EARLY WAIKŌLOA, WAIMEA, AND SURROUNDING LANDS

Traditional accounts (*moʻolelo ʻāina*) of Waikōloa, Waimea, and areas adjacent to lands of the Keʻāmuku Sheep and Cattle Station include legends and historical narratives documented in historic times by native Hawaiians and 19th century authors. The accounts refer to events that took place from the 13th century to the arrival of European explorers. None of the accounts pertain directly to lands within the project area, but do refer to lands directly north (Waikōloa, Waimea, and Lālāmilo), northwest (the coastal region from ʻAnaehoʻomalu to Puakō), east (Waikiʻi), and south (lands between Hualalai and Mauna Kea). Accounts include legends of supernatural entities that describe places they traveled to in this region, and also legends that tell the stories of deities and persons whose actions and namesakes are the origins of prominent natural features and places on the landscape. There are also historical narratives that describe battles between warring *aliʻi* and describe land traversed by warriors, and the place names where battles were fought.

Legends, Place Names, and Descriptions of the Land

The Heart Stirring Legend of Ka-Miki, published in the Hawaiian language newspaper *Ka Hoku o Hawaii* and translated by Maly (pertinent excerpts in Maly and Maly 2002) contains an extensive description of customs, lands, and places near the project area, as well as many places on the Island of Hawaiʻi. The legend is set in the 13th century but also reflects more recent influences (Maly and Maly 2002: 17). Underlined quotes in this report are from Maly's original and are his emphasis.

The District of Kohala is described in the legend as divided into smaller units that included:

> Large Kohala, little Kohala, inner Kohala, outer Kohala, Kohala of the ʻĀpaʻapaʻa wind, of Pili and Kalāhikiola, the two traveling hills. Indeed! They are the combined districts of this proud land brushed by the ʻĀpaʻapaʻa wind, maturing like love fondly in the bosom of love (*Ka Hoku o Hawaii*, March 22, 1917, translated in Maly and Maly 2002: 18).

Maly defines outer Kohala (Kohala *waho)* as the lands from Kawaihae to Waikōloa, and ʻAnaehoʻomalu. The Hawaiian language names for the smaller districts are as follows: large Kohala is Kohala *nui*, little Kohala is Kohala *iki*, inner Kohala is Kohala *loko*, outer Kohala is Kohala *waho*, Pili and Kalāhikiola are as written, and the two traveling hills is *Na-puʻu-haele-lua*.

Dr. Bergin describes the traditional boundaries of Kohala as divided into two major divisions. Kohala *Iloko* is the name of the windward lands east of ʻUpolu Point (Bergin 2004:15). Leeward Kohala is the second major division and is further divided into four zones that posses four distinctive types of terrain. Kohala *i waho* is the traditional name of the lands from ʻUpolu Point to Kahuā, north of Kawaihae. *ʻĀina* Kawaihae refers to the coastal area at present day Kawaihae. *Wai one* are the coastal plains south of Kawaihae to ʻAnaehoʻomalu. The k*ula* area refers to the Waimea plains area roughly ten miles inland.

Waikoloa without a *kahako* means "duck water" (Pukui *et al*. 1976), perhaps a reference to lands that attracted wetland ducks. In many references it is written with a *kahako* and means "northwest wind," perhaps a reference to the strong wind that blows through the area. If the *kahako* was over the last "o" it might be translated as "the long, sweet water." This might be a reference to the lack of water and its refreshing flavor when finally reached (Andrade interview, collected for Wolforth *et al*. 2004).

The Heart Stirring Legend of Ka-Miki also relates the origins of several place names in the area of South Kohala.

The region of Lālāmilo was named for the young chief Lālāmilo, grandson of Kanakanaka, an expert lawaiʻa hī-ʻahi (deep sea tuna lure fisherman) and Pilia-moʻo, a powerful priestess and ʻōlohe. Kanakanaka and Piliamoʻo were the parents of Nē'ula (a fishing goddess), and she married Puʻu-hīnaʻi a chief of the inlands, and they in turn were the parents of Lālāmilo. Kanakanaka's sister was the wind goddess, Waikōloa, for whom the lands are now named.

Lālāmilo gained fame as an expert ʻōlohe and fisherman. And through his wife Puakō, he came to possess the supernatural leho (cowry octopus lure) which had been an ʻōnohi (cherished) possession of Ha'aluea, a goddess with an octopus form... How this octopus lure came to rest on the reefs fronting this land remains a mystery. . .

Puakō was the daughter of Waʻawaʻa (kāne) and Anahulu (wahine), and the sister of: ʻAnaehoʻomalu (wahine); Pūʻālaʻa (kāne); and Maui-loa (kāne). Puakō's great desire was to eat heʻe (octopus), and Pūʻālaʻa was kept continually busy acquiring heʻe for Puakō, and getting paʻouʻou fish for ʻAnaehoʻomalu. When he could no longer provide sufficient numbers of fish for his sisters they left Puna and set out in search of suitable husbands who could provide for their needs.

Because of their great love for ʻAnaehoʻomalu and Puakō, Anahulu, Waʻawaʻa, their relatives and attendants also moved to the Kona - Kohala region and dwelt at sites which now bear their names; only Pūʻālaʻa remained in Puna. This is how Puʻu-Huluhulu, Puʻu-Iki, and Mauiloa came to be named; and Puʻu Anahulu (Ten day hill [ceremonial period]) was named for Anahulu, the chiefess wife of Waʻawaʻa (Puʻu Waʻawaʻa).

Arriving at Kapalaoa in the Kekaha lands of Kona, ʻAnaehoʻomalu married Nāipuakalaulani, son of the chiefess Kuaīwa of Kapalaoa. Puakō went on to Waima where she met with natives of that area, and was introduced to the chiefess Nēʻula, mother of Lālāmilo. When Nēʻula learned that Puakō greatly coveted heʻe, she told Puakō that her son was the foremost lawaiʻa ʻōkilo heʻe (octopus fisherman) of the region. And because Puakō was so beautiful, Nēʻula introduced her to Lālāmilo. Lālāmilo saw Puakō, and compared her to the foremost "heʻe" which he could catch (*Ka Hoku o Hawaii*, July 5 and 19, 1917, translated in Maly and Maly 2002: 22-23, underlined emphasis is Maly's).

Another *mo‘olelo ‘āina* collected by Maly (1999) relates the story of Kanikū and Kanimoe, two *mo‘o wahine* who were sisters and guardians of Kamehameha's fishpond Wainānāli‘i. They were covered by a lava flow when the *lua-i-Pele* came down to the coast and they and are now two stones in the flow. They are visible *makai* of the highway. Kanikū is an upright *pōhaku* and Kanimoe is behind (Keakealani interview, collected for Wolforth *et al*. 2004).

The Heart Stirring Legend of Ka-Miki contains several descriptions of weather and agriculture in Waimea-Waikōloa region and surrounding areas. The frequent strong westerly winds that originate in the Kohala Mountains and from Mauna Kea are called the *‘Āpa‘apa‘a* wind, and the Waikōloa and *Kaumuku* winds (Maly and Maly 2002: 21). In other sources there is the *mūmuku* wind (Wilkes 1845, Bergin 2004: 15). The winds in this region bring moisture and rain, and when strong, stir up the fine silt in the area and carry it westward. Many of the trees in Waimea lean in that direction from the constant buffeting they receive.

There is a rain called *nāulu* (southern rain storms) in *The Heart Stirring Legend of Ka-Miki* (Maly and Maly 2002: 25). Cultural informants recall the *ua nāula* that is a sudden downpour that disappears as quickly as it develops (Andrade interview, collected for Wolforth *et al*. 2004; Greenwell interview, collected for Maly and Maly 2002). Another legend tells of rain sent by Kahaloi-wai-a-ka-Nā‘ulu, the keeper of the *nā‘ulu* rain. He was said to live on a *pu‘u* in the Kohala Mountains where he could keep watch on his sister Pu‘u Anahulu. He would send his rains to shower Pu‘u Anahulu and Pu‘u Wa‘awa‘a when they were dry (Keakealani interview, collected for Wolforth *et al*. 2004).

Sources of water play a prominent role in *The Heart Stirring Legend of Ka-Miki*. *Ka-Miki* is tasked with retrieving the water of *Kāne* and *Kanaloa*, at the royal compound of Poli‘ahu and Lilinoe, below the sacred platform of *Pōhaku-a-Kāne* on Mauna Kea. He fills the *‘awa* bowl *Hōkū‘ula* with the water and returns to meet his brother *Maka-‘iole*.

> Ka-Miki then joined Maka-‘iole at Holoholokū on the plain of Waikōloa. And as they traveled across the plains on their way back to Hualālai, the wind goddess Wai-kō-loa (Water carried far) caused the water to splash over the brim of Hokū‘ula. Some of the water was carried afar by the wind and fell, forming a new spring.

> When the spring appeared, Pōhaku-a-Kāne fetched some of the water. Because Pōhaku-a-Kāne fetched some of the water, that place is called Wai-kiʻi (Fetched-water) to this day. This happened near the hills of Puʻu Kekeʻe.
>
> Pōhaku-a-Kā took the water he retrieved to the base of the cliffs of Mauna Kea and dug into the earthen plain of Pōhakuloa and placed the water there. From Pōhakuloa, the water flowed under ground and appeared as springs at several other places, including Ana-o-Hiku at Hanakaumalu. Honuaʻula, and Kīpaheʻe-wai on the slopes of Hualalai... (*Ka Hoku o Hawaii*, March 12, 1914, translated in Maly and Maly 2002: 21, emphasis Maly and Maly).

In another legend, *Hōkūʻula* is the name of the place where the great Akua Makuakua from Kahiki lived with the goddess Wao. Wao would journey to the Waimea hills, which were sacred for her to give birth. She was accompanied by her servants, whom she turned to stone each night to guard the land (Doyle 1953).

The origin of the large gulch ʻAuwaiakeakua situated east/west between Keʻāmuku and Waikiʻi was told to Maly by former residents of Waikiʻi Village. ʻAuwaiakeakua (Water channel of the gods) was built by *menehune* who abandoned the construction in fear of the coming dawn (Maly and Maly 2002: 27).

References to agriculture in *The Heart Stirring Legend of Ka-Miki* include:

> Lālāmilo arose and told his wife Puakō and his mother Nē'ula that he was going to the uplands to visit his father, sister, and the people who worked the upland plantations. Lālāmilo desired to eat the sugar cane and bananas and drink the ʻawa which grew on the hill of Poʻopoʻo. Poʻopoʻo was also the name of a makāula (seer) who saw to the continued peaceful dwelling of the people. . .
>
> Lālāmilo then departed and traveled up towards the residences and agricultural lands of Puʻu Hīnaʻi mā (*Ka Hoku o Hawaii*, July 5, 1917, translated in Maly and Maly 2002: 22, emphasis Maly and Maly).

Poʻopoʻo (dark headed) is the name of a gulch that is oriented southeast/northwest roughly 1.5 miles north of the project area. The area mentioned, Puʻu Hīnaʻi mā, is several miles west of the project area. It is also mentioned in the legend that *ʻawa* was grown at Poʻopoʻo (Maly and Maly 2002: 25).

The trail between Waimea and Mauna Kea also figures prominently in *The Heart Stirring Legend of Ka-Miki*. The trail that leads to "the whitened peaks" of "the sacred and astonishing mountain (Mauna Kea)" is a "lonely path" and a "damp dreary path" through "the mists that seem to crawl upon the forest growth" where people often go astray (Maly and Maly 2002: 19). Aside from the Poʻopoʻo gulch, none of the places mentioned above are near the project corridor.

Historical Narratives, the *Aliʻi*, and Warfare in the Region

Historical narratives set near the project area describe battles between warring *aliʻi*, land traversed by warriors, and the place names where battles were fought. There are five accounts of historical events that took place near the project area between the 14th and 18th centuries. The events are documented by Fornander (1996), Kalakaua (1990), Kamakau (1961), and Malo (1951), and are treated in detail by Maly (Maly and Maly 2002) and Wolforth (Wolforth *et al*. 2004).

The first event is the 14th century battle between Kamiole, a Kaʻū chief and Kalapana, the son of Kanipahu the sixth *moi* of the *Pili* line (Wolforth *et al*. 2004: 3-5). Kamiole and his warriors, reinforced by warriors from Kona, Hilo, and Puna had previously defeated Kanipahu at Kohala. Kalapana, with the aid of chiefs from Kohala and Hāmākua met Kamiole at ʻAnaehoʻomalu and defeated him.

The second event is the battle between Umi (ruler, A.D.1600-1620) and a chief from Kailua. An elder man named Kanuha recounted the events of the battle to Jules Remy, a Frenchman who arrived in Hawaii in 1851 (Maly and Maly: 2002: 9-10). The French version was translated and printed in the Hawaiian language newspaper *Ke Au Okoa* May 8, 15, and 22, 1865. The account was then translated into English by Maly (Maly and Maly 2002: 9-12). The version referred to in this report is drawn from Maly's translation.

Umi ruled the eastern side of the Island of Hawaiʻi, while a chief from Kailua ruled the western side. The chief from Kailua was reputed to have committed various evil deeds and Umi set out to defeat him. Maly's translation of the events follows:

> Umi marched to battle, joined by his famous warrior, Piimaiwaa, and his companions Koi and Omaokamau. Also with him were his favorite, Pakaa, and his priest Lono. . .
>
> Between Mauna Kea and Hualalai the chief and all his party traveled, with the thought of descending to Kailua. Keliiokaloa did not wait though, but instead, traveled with his warriors to meet Umi in battle. The two armies met on a broad open plain, surrounded by the three mountains, at the place [now] called Ahu a Umi. There, Laepuni and them (people who were unattached to a chief) fought with Umi. Umi was almost killed, but Piimaiwaa leapt in and helped him, it was he who turned the battle in the favor of Umi's side. There is not much else that is said, but, it is known that the chief of Kailua died in the battle. Thus, with this battle, the entire kingdom was gained by Umi. He became the chief that controlled the entire island of Hawaii. So that the battle would be remembered from generation to generation, he (Umi) built the stone altar, that remains to this day, the altar (ahua) of Umi... (Ke Au Okoa; Mei 22, 1865)
>
> ...He (Umi) also built a heiau (temple) below Pohaku Hanalei, it is called the altar (ahua) of Hanalei; and on the side of Mauna Kea, by where one travels to Hilo, he built the third of his temples, at the place called Puukekee [also written Puu Keekee in historical texts]; and there at Mauna Halepohaku he built the fourth of his temples; there, it is said, Umi dwelt with his many people. It is said that Umi was a chief who dwelt upon the mountain, it was because of his love of his people, that he (Umi) returned and dwelt in the middle of the island [Ahu-a-Umi], that is where he dwelt with his beloved people. His commoners lived along the shores, and they brought food for them (in the uplands), from one side of the island to the other... (Ke Au Okoa; Me*i* 22, 1865, translated in Maly and Maly 2002:10-12, emphasis is Maly’s).

The third historical event that took place near the project area is the battle between Lonoikamakahiki (ruler, A.D. 1640-1660) and rebel chiefs (most notably his elder brother Kanaloa-kua‘ana) encamped along the shore at ‘Anaeho‘omalu. Lonoikamakahiki and his Kona warriors were joined by forces from Ka‘ū at the border of Kohala and Kona, on inland ‘Anaeho‘omalu.

> The next day Lono marched down and met the rebels at the place called Wailea, not far from Wainanalii, where in those days a

> watercourse appears to have been flowing. Lono won the battle, and the rebel chiefs fled northward with their forces. At Kaunooa, between Puako and Kawaihae, they made another stand, but were again routed by Lono, and retreated to Nakikiaianihau, where they fell in with reinforcements from Kohala and Hamakua. Two other engagements were fought at Puupa and Puukohola, near the Heiau of that name, in both of which Lono was victorious (Fornander 1996:120-121).

A fourth battle was fought north of project area during the reign of Lonomakahiki. The king of Maui (Kamalālāwalu), desiring to take over the Island of Hawaiʻi, sent spies to discover the best place from which to launch an attack (Kamakau 1961). They returned after investigating the shores of Hawaiʻi and reported that Kohala would be easy to capture as the inhabitants lived only on the coast and were few in number (Kamakau 1961: 56). They further thought that,

> if Kohala was conquered, Kona, Ka-ʻu, and Puna would be easily taken, and they felt that Hilo and Hamakua would lend no assistance. This was true, for the chiefs of these districts were cousins of the chiefs of Maui (Kamakau 1961: 57).

Kamalālāwalu and his forces captured Puakō, and mislead by two old men of Kawaihae, marched to the dry grassy plain of Waimea (Waikōloa), and the hills of Hōkūʻula and Puʻu ʻOaʻoaka to await the warriors of Hawaiʻi. The warriors of Hawaiʻi took several routes to Waikōloa and stationed themselves around the forces of Maui. Fornander records:

> During the night and including the following morning the Kona men arrived and were assigned to occupy a position from Puupa to Haleapala. The Kau and Puna warriors were stationed from Holoholoku to Waikoloa. Those of Hilo and Hamakua were located from Mahiki to Puukanikanihia, while those of Kohala guarded from Momoualoa to Waihaka (Fornander 1917, quoted in Cordy 2000: 229).

Kamakau recorded:

> After Kama-lala-walu's warriors reached the grassy plain, they looked seaward on the left and beheld the men of Kona advancing toward them. The lava bed of Kaniku and all the land up to Hu'ehu'e was covered with the men of Kona. Those of Ka'u and Puna were coming down from Mauna Kea, and those of Waimea and Kohala were on the level plain of Waimea. The men covered the whole of the grassy plain of Waimea like locusts.

> Kamalalawalu with his warriors dared to fight. The battlefield of Pu'oa'oaka was outside of the grassy plain of Waimea, but the men of Hawaii were afraid of being taken captive by Kama, so they led (Kamalalawalu's forces) to the waterless plain lest Maui's warriors find water and hard, waterworn pebbles (Kamakau: 1961:58).

The two armies only skirmished in the beginning, soon turning into a full battle, and a final route of the forces of Maui (Kamakau 1961). Almost all of the chiefs and warriors of Maui were slain either on the field of battle or at the Kawaihae shoreline.

The alter (*Ke Ahu a Lono*) at the coastal boundary between Kona and Kohala is often described as an alter for "the warrior leaders and warriors of Lonoikamakahiki, built at the time he went to battle with Kamalalawalu" (Kihe in *Ka Hoku o Hawaii* Jan. 31-Feb. 14, 1924, translated by Maly 2002: 15). A second account ascribes *Ke Ahu a Lono* to the restoration of friendship between Lonoikamakahiki and Kapaihiahilina. Lonoikamakahiki built the *ahu* for offerings made to consecrate their reconciliation. The *Ahu a Lono* was also the place where offerings were gathered during the *Makahiki* (Andrade interview, collected for Wolforth *et al*. 2004).

Kamehameha also built (rebuilt) Puʻukoholā *heiau* (possibly completed by 1791) *mauka* of Mailekini *heiau* above Kawaihae (Kamakau 1961, Cordy 2000). Kinny (1913: 43) and Kamakau (1961: 154) suggest the construction undertaken by Kamehameha was a reconstruction of a previously built *heiau* reconsecrated to his god Kūkāʻilimoku. Kamehameha and his chiefs resided in Kawaihae during the construction and after, from 1792 to 1796 (Maly and Maly 2002: 16). Lonoikamakahiki, Alapaʻinui, Keaweʻāpala, and numerous lower chiefs often visited and stayed at Kawaihae, Puakō, and Waimea (Kamakau 1961: 182-183).

Historical narratives of the Waikōloa area underline its geographical location as a nexus of travel between often contending political centers (Figure 6). Trails from Kona to Kohala crossed the lava flats inland of ʻAnaehoʻomalu and Puakō. Trails stretched from the coast to Waimea. Other trails ran from Kona, south and then east of Hualalai, and down to Waimea or the coast. Trails from Hilo crossed the saddle, past Mauna Kea and Mauna Loa, and downhill to Lālāmilo where travelers could take trails either east or west. Trails were also used between the Waipiʻo-Hāmākua region and Waimea. The trails connected Kawaihae, Waimea, and leeward

Kohala to other centers of royal power and figured prominently in interregional conflict. Kawaihae was also a center of political power and the fishponds at ‘Anaeho‘omalu and Kalāhuipua‘a were *‘ili kūpono* from around the 12th century onward (Cordy 1987; Andrade interview, collected for Wolforth *et al*. 2004). The battles detailed above were fought several miles from the project corridor and there are no trails near the project corridor.

DESCRIPTIONS OF KOHALA, WAIMEA, AND WAIKŌLOA IN HISTORIC-ERA TRAVEL ACCOUNTS

By the late 1700s the Waimea area supported an estimated population of approximately 24,000, mostly inland (Wellmon 1969, Cordy 2000). Captain Cook’s journals from his arrival in 1779 describe the area along the coast of Kohala as unpopulated, with very few houses or agricultural fields (Beaglehole 1967). Fishing, aquiculture, salt production, and abrader production were carried out along the coast from Kawaihae to ‘Anaeho‘omalu (Vancouver 1967, Ellis 1969, Barrère 1971, Kirch 1975 and 1979, Cordy 2000). The majority of agricultural production was carried out in the foothills of the Kohala mountains and from Lālāmilo to the Waipi‘o Valley, especially along the Waimea’s three streams; Waikōloa, Wai‘aka, and Keanu‘i‘omanō. Large areas of the foothills of southern Waikōloa were covered in *pili* grass traditionally used for thatching. *Māmane* (*Sophora chysophylla*), *naio* (*Myoporum sandwicense*), *wauke* or paper mulberry (*Broussonetia papyrifera*), *‘iliahi* or sandalwood (*Santalum spicatum*), and *‘ōhi‘a* (*Metrosideros polymorpha*) grew on the plains of Waimea and at upper elevations in the foothills of Mauna Kea and Mauna Loa. Traditional resource extraction from these areas included *kapa* cloth made from *wauke* (Wilkes 1970: 217-218), m*āmane* limbs cut for adze handles, and birds trapped for their meat and feathers.

The arrival of Europeans and the Hawaiian people’s introduction to world markets drastically altered the distribution of population centers, agriculture, and cultural practices in Hawai‘i. In the Waimea-Waikōloa region, maritime trade and ranching slowly replaced traditional fishing, aquiculture and farming practices as chief economic activities. Sandalwood harvesting for China’s markets commenced in 1808 and reached a peak in the 1820s. Kamehameha held a monopoly on the collection and sale of sandalwood to foreign trading vessels.

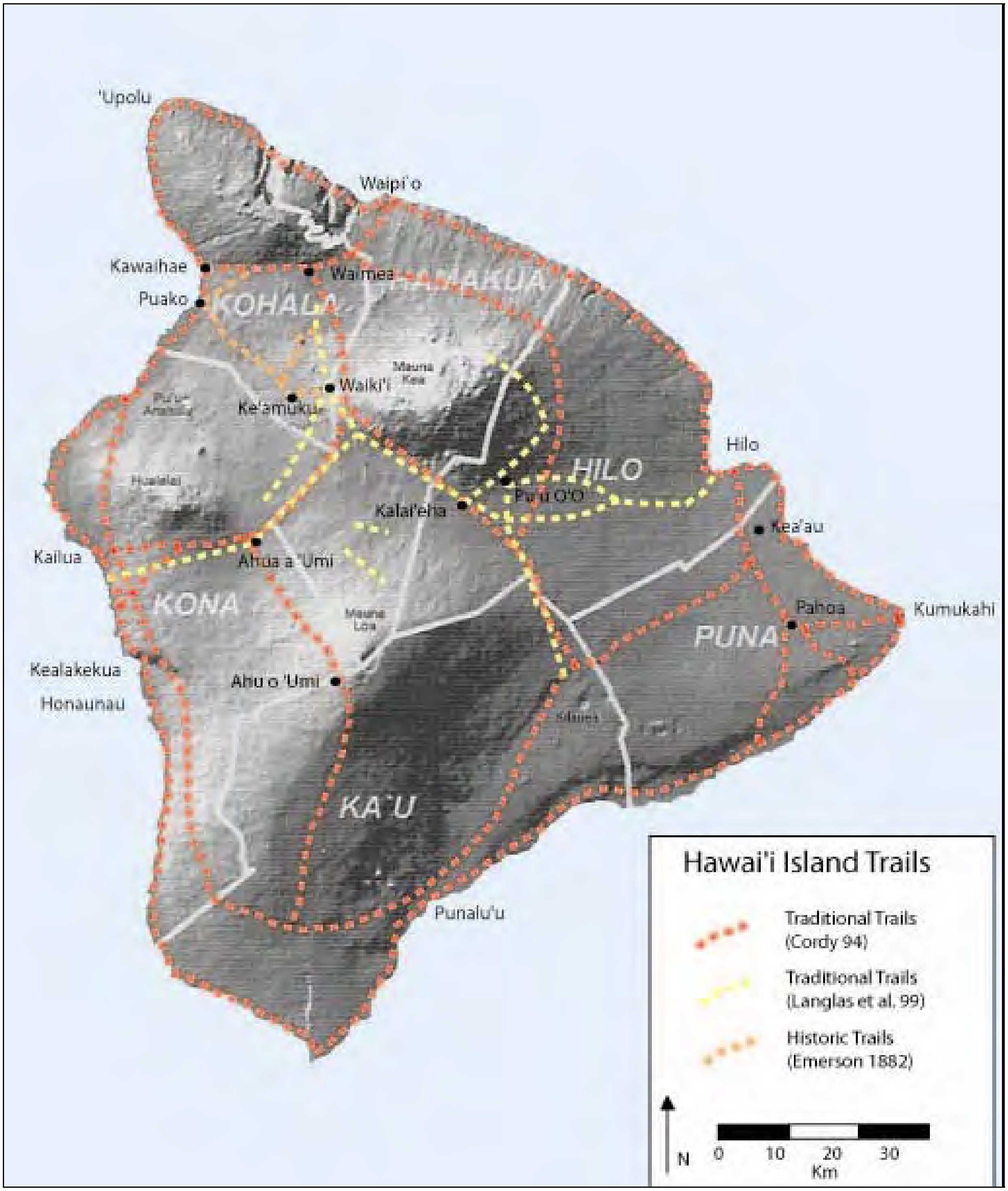

Figure 6: Hawai'i Island Trails.

Sandalwood trees were rapidly harvested from the Waimea-Waikōloa area and an island-wide *kapu* was placed on the cutting of sandalwood in 1830. The royal government next looked to ranching as a steady source of income. Sheep and cattle ranching provided wool, fresh meat, salted beef, tallow, and hides for local markets on Hawai‘i and O‘ahu, and for provisioning merchant and whaling vessels (until 1860).

Ranching has its roots in the first cattle and sheep brought to the island in 1793 by Vancouver. Six cows, one bull, four ewes, and two rams were released to prosper in the region of Waimea, Mauna Kea, Mauna Loa, and Hualalai (Vancouver 1967). Kamehameha placed a ten-year *kapu* on the killing of cattle so that they would have time to multiply (Ellis 1963: 291). Vancouver wrote:

> In this valley is a great tract of luxuriant, natural pasture, whither all the cattle and sheep imported by me were to be driven, there to roam unrestrained, to "increase and multiply" far from the sight of strangers, and consequently less likely to tempt the inhabitants to violate the sacred promise they had made; the observance of the which, for the time stipulated in their interdiction, cannot fail to render the extirpation of these animals a task not easily to be accomplished (Vancouver 1967(3):64).

Vancouver returned in 1794 with more cattle, sheep, goats, geese, and various plants and seeds. Two American captains, William Shaler and Richard Cleveland presented two horses to John Young in 1803. Cleveland later returned with more than 200 horses brought from California. Donkeys, mules and oxen were also imported for transportation and hauling.

By 1813 to 1815 cows began overrunning agricultural fields and became a danger to travelers and residents alike (Ellis 1963: 291, Wilkes 1970: 204). A wall, called *Kauliokamoa* for the King’s k*onohiki*, was constructed between 1813 and 1819 (Barrère 1983) to keep cattle in Waikōloa and off of agricultural land to the east (Lālāmilo and Waimea). The wall was located from roughly the northern border of Waikōloa to near Pu‘u Huluhulu and separated the less fertile annual grasslands from the perennial grasslands (Boundary Commission Book for Hawai‘i Vol. A, 6, 10; Wolforth *et al*. 2004).

John Parker was granted permission to hunt wild bullock for the crown in 1822. Wild cattle were captured in bullock pits seven to eight feet long by four feet wide covered with braches and a thin layer of dirt (Wilkes 1970: 204). They were also hunted with guns and were lassoed in later years, after the arrival of *vaqueros*, "Spaniards [Central and South Americans] with horses from California" (Wilkes 1970: 203). Ellis also described the nature of the herds and bullock hunting.

> Although there are immense herds of them, they do not attempt to tame any; and the only advantage they derive is by employing persons, principally foreigners, to shoot them, salt the meat in the mountains, and bring it down to the shore for the purpose of provisioning the native vessels. But this is attended with great labour and expense. They first carry all the salt to the mountains. When they have killed the animals, the flesh is cut off their bones, salted immediately, and afterwards put into small barrels, which are brought on men's shoulders ten or fifteen miles to the sea-shore (Ellis 1963: 291).

In 1830 Governor Kuakini moved to Waimea to oversee and improve government cattle. He ordered the construction of corrals and the widening and improvement of twelve miles of the Waimea to Kawaihae trail. Liholiho visited the same year to witness strides made in the nascent cattle ranching industry. It was hoped that the exportation of tallow, hides, and salted beef would supplant the defunct sandalwood trade as a major source of income. In 1835 William French opened a store in Waimea and began several ventures related to ranching, including tallow making, tanning, and saddle making (Bergin 2004: 156). Cowhide was tanned using the astringent bark of local trees (Wilkes 1970: 218). Other craftsmen included carpenters and a blacksmith.

The lion's share of French's trade involved supplying whaling ships and the local market with beef. A description of French's operation in 1840 describes their capture and shipment.

> Our principal object in taking the walk was to witness the marking of a lot of cattle that had been driven down from the mountains not long since. Great numbers of wild bullocks are caught in the mountains every year by the hunters: The lasso, the principal instrument in their capture is made of braided thong upon one end of which is a ring forming a slip noose which is thrown with astonishing precision around any part of the animal. Even while at

> a full gallop in pursuit, the hunter grasps his lasso and giving it two or three twirls around his head with his right hand, throws it unerringly and entangles his victim by the horns or limbs. . . For their capture a mode frequently resorted to by the hunters was to dig deep pits and cover them with underbrush and dirt. . . . The bullocks to be marked were driven into a pen towards which we directed our steps. They were noble animals and had been tamed by tying them singly with tame cattle for a time. . . . There were not far from 40 bullocks marked on this occasion intended for the Clementine in her trip down to Honolulu. They are then put into pasture to be fattened for the supply of ships visiting Honolulu in the fall season.
>
> This brig Clementine had upon its deck about 40 head of bullocks arranged closely together with their heads turned inwards. They were tied down by the horns to a strong framework of spars so that there was no danger of their getting loose (Olmstead, quoted in Bergin 2004: 156).

By 1840 bullock hunting had drastically reduced the numbers of wild cattle, driving them to higher and higher elevations of Mauna Loa and Mauna Kea (Wellmon 1969). A five-year *kapu* was placed on cattle hunting and lead to further efforts to tame, brand, and fence in herds on privately owned land (Wilkes 1970: 200). The decline of whaling and the *kapu* placed on killing cattle created economic hardship and population decline in the Waimea area. Wilkes reported that during this time there were still three or four stores operated by foreigners at Waimea (Wilkes 1970: 218). In 1880 George Bowser's "Directory and Tourists Guide" reported that,

> Waimea itself, although of immemorial age, and once populous, is now only a scattered village, with but two stores and a boarding and lodging house and coffee saloon (quoted in Maly and Maly 2002: 60, emphasis Maly's).

Grazing, the opening of new pastureland, and fires was denuding the forested plains of Waimea, and pushing the tree line to higher and higher elevations (Doyle 1953: 47-48). An article published in the S*andwich Island Monthly Magazine* in 1856, and quoted in Wolforth *et al.* 2004, described the deforestation in the following terms:

> It is in the memory of many foreigners now living there, when the whole of these plains were covered with a thick wood, to the very

> edge of the slope. Where now hardly a tree is to be seen for miles, we were informed by an old resident, that twenty-five years ago he lost himself with his team in the weeds. He also stated that at that time there was far more rain at Waimea than there is now, which indeed might be readily inferred, as clearing the land has been almost entirely effected by the cattle...At this moment they swarm the thick jungle that covers the windward or eastern slope towards Hamakua. They are now gradually destroying this, and thousands of old dead trees die of age, no young ones are seen taking their places, as during the last thirty or forty years, the cattle have eaten or trodden them down...At the present time the vapors and rain which are brought across the plain by the trade winds, are generally dissipated between Waimea Village and Lihue...But when some twenty-five or thirty years ago, woods extended over the whole plain and to the very edge of it, close on to this debatable ground–and when rain was in consequence more frequent over this district, the vapors and cold moist atmosphere, instead of being dissipated near Waimea Village, would necessarily have more frequently extended to the debatable ground... (February 1856:44-47).

A report written in 1877 by the Royal Commissioners on Development of Resources documents similar environmental impacts in the Kohala, Waimea, and Waikōloa area. The report states:

> The forests on the Kohala mountains are dying rapidly. The land is mostly for grazing purposes, though on the mountain potatoes of fine quality can be raised in large quantities. In sheltered places, coffee would doubtless grow, but owning to the sparseness of the population and the superior attractions to other parts of the district, this part will hardly soon be settled. The once fertile and populous plain of Waimea looked sterile and desolate when visited by the Commission-a painful contrast to Kohala loko on the other side of the mountain.
>
> The complaint of the people is well founded. The water they use is fouled in many places by cattle, horses and other animals, and as the stream is sluggish it has no chance to free itself of impurities, and the water used bb the people in their houses must be a cause of disease and death, especially to the children... It is little wonder that with his crops trodden out by the sheep or cattle of his stronger neighbors, his family sickened perhaps to death by the polluted Waters, that the small holder should yield to despair, and abandoning his homestead seek employment in some other district, usually without making another home...

The plains of Pukapu and Waimea are subject to high winds, aggravated by the loss of the sheltering forests of former days. The soil however is very good in many places for sugar cane and other products. To develop its best resources, efforts must be made to restore the forests and husband the supply of water at their sources to furnish a supply for agricultural purposes. At present the lands are used almost exclusively for grazing purposes. Although the proprietors and lessors are probably not averse to the establishment of agricultural enterprises, it is to be feared that the denudation of the neighboring mountains and plains of the forests will render the climatic conditions unfavorable to success.

It would seem that a wise appreciation of the best interests of this district, even of the grazing interests themselves, would lead to the decrease of the immense herds which threaten not only Waimea but even Hamakua with almost irreparable disaster. It is to be feared that they will in time render a large part of the land of little value even for grazing purposes. Owing to the increasing frequency and severity of droughts and consequent failure of springs. Some thousands of cattle are said to have died this last winter from want of water, and the works erected in Waimea for the purpose of trying out cattle have been idle for months for want of water.

The commission do not propose here to discuss fully the vexed Questions of the causes of the diminution of the forests, but in view of the fact that they are diminishing and the streams and springs diminishing a corresponding rations, also that with the cattle running upon the lands as at present, any effort to restore them must be futile and any hopes of their recuperation vain, the Government, if it would wish to preserve that part of the island of Hawaii from serious injury, must take some steps for reclaiming the forests.

In this connection we would say that it is unfortunate that large tracts of Crown and Government lands have been lately leased on long terms for grazing purposes, without conditions as to their protection from permanent injury, at rates much lower than their value even as preserves for Government purposes or public protection. The commission deem (*sic*) this a matter of grave importance, challenging the earnest attention of the Government, and involving the prosperity of two important districts (Report of the Royal Commissioners on Development of Resources 1877, quoted in Maly and Maly 2002: 58-59).

The impacts recorded above were the results of grazing sheep and cattle in the 80-year period after Vancouver landed the first of their kind. The history of herding and ranching these animals proceeds from hunting wild herds to the organization of ranching in an effort to consolidate ownership, improve breeding stock, and to prevent further degradation of the lands of Waimea and Waikōloa.

THE MĀHELE (1845)

Article IV of the Board of Commissioners to Quiet Land Titles was passed in December 1845 and began the legal process of private land ownership based on western law. The law established a board of five commissioners to oversee land claims and to issue patents and leases for valid claims. Many scholars believe that Kauikeaouli (Kamehameha III) was forced to establish laws in order to protect Hawaiian sovereignty and crown lands from foreigners who had already begun claiming ownership of land they were granted permission to use for homes and business interests (Daws 1968:111; Kuykendall 1938(1): 145 footnote 47, 152, 165-6, 170; Kame`eleihiwa 1992: 169-70, 176; Kelly 1983: 45, 1998). Among other things, the foreigners were demanding private ownership of land to secure their island investments (Kuykendall 1938(1): 138, 145, 178, 184, 202, 206, 271; Kame`eleihiwa 1992: 178).

As legal statutes defining the Māhele continued to evolve (up to 1850), the lands of the kingdom of Hawai‘i were divided among the king (crown lands), the *ali‘i* and *konohiki*, and the government. Once lands were thus divided and private ownership was instituted, the *maka`āinana* (commoners), if they had been made aware of the procedures, were able to claim the plots on which they had been cultivating and living as stipulated in the *Kuleana* Act (1849). These claims, however, could not include any previously cultivated or presently fallow land, *okipu`u*, stream fisheries, or many other resources traditionally necessary for survival (Kelly 1983, Kame`eleihiwa 1992:295, Kirch and Sahlins 1992). The right of claimants to land was based on the written testimony of at least two witnesses who could corroborate the claimant's long-standing occupation and use of the parcel(s) in question. The claimant was then awarded a patent for the property, subsequently called Land Commission Awards (LCAs) (Chinen 1961:16).

At least 26 claims were made for *kuleana* plots in Waikōloa (Maly and Maly 2002: 66). Table 2 below lists claims and awards within the lands of Waikōloa (adapted from Maly and Maly 2002: 66).

Table 1: Claims and Land Commission Awards in Waikōloa.

Applicant	LCA	Register	Testimony	Award Book
James Fay (Kimo Fe)	Helu 589	NR 2:281	*n/a*	*n/a*
James Hall (Kimo Holo)	Helu 672	FR 2:103	FT 5:67 & NT 4:48	MA 3:100
Edmund Bright (Braita)	Helu 986	FR 2:125	FT 5:67 & NT 4:43	MA 3:91
Kipikane (w.)	Helu 1117	*n/a*	NT 4:45 & FT 5:66	*n/a*
James Fay	Helu 2258	FR 2:147	NT 5:65-66	MA 3:52
Nahoena	Helu 3195	NR 8:50	NT 4:8	*n/a*
Makalahae	Helu 3684	NR 8:44	NT 4:33	MA 5:48-49
Waiahole	Helu 3738	NR 8:46	NT 4:34-35	MA 5:48-49
Auwae	Helu 3762	NR 8:47	NT 4:35-36	MA 5:46
Ohiaku	Helu 3783	NR 8:47-48	NT 4:39-40	MA 5:47
Opunui (w.)	Helu 3786	NR 8:48	NT 4:38	MA 4:287
I.A. Palea	Helu 3828	NR 8:380	NT 4:31-32	MA 5:46
Pauhala	Helu 3844	NR 8:51	NT 4:10	MA 5:51
J. Seaboy (Seabury)	Helu 4024	NR 8:55-56	NT 4:44	MA 5:49-50
James Hall	Helu 4036	FR 1:3	*n/a*	*n/a*
Wm. Beadle	Helu 4038	FR 3:2	FT 5:67 & NT 4:42	MA 3:9
Kaahukoo	Helu 4126	NR 8:64	NT 4:12	*n/a*
Kaumu	Helu 4129	NR 8:64	NT 4:37	MA 5:51
Keaulama	Helu 4184	NR 8:53-54	NT 4:36	
Kua	Helu 4215	NR 8:59-60	NT 4:24	MA 5:47
Kaulua	Helu 4231	NR 8:58	NT 4:25-26	MA 5:48
Manuwa	Helu 4505	NR 8:66	NT 4:20	MA 5:50
G.D. Hueu	Helu 8068	NR 8:70-71	NT 4:18-19	
Kipikane (w.)	Helu 8505	FR 3:19	FT 5:67 & NT 4:45	MA 3:55
G.D. Hueu	Helu 8521 B	NR 3:709	*n/a*	*n/a*
Laahiwa	Helu 9972	NR 8:169	*n/a*	*n/a*

THE LANDS OF G.D. HUʻEU (GEORGE DAVIS)

George Davis Huʻeu (George Davis) inherited and owned a large portion of the good grazing lands of Waikōloa. Kamehameha I had given the land to G.D. Huʻeu's father, Isaac

Davis, as an *‘ili kūpono* for services rendered during the conquest of the Hawaiian Islands. Local chiefs claimed some portions of his land when he died in testate in 1810 (Macrae 1972: 44). It became necessary for Isaac Davis’ friend John Young to ask the crown for stewardship of the property for Davis’ children’s sake. When the Davis children came of age, Young requested that,

> the King, Kaahumanu [Kina`u], Adams [Kuakini] and Rooke and all the Chiefs will let Isaac Davis’ children keep their father’s lands that King Kamehameha gave to him as a reward for assisting the King in his wars in conquering the islands of Hawaii, Maui, Molokai, and Oahu, and which I hope in God our young king will fulfill the wishes of his honored father (Collins 1951: 12-13).

Isaac Davis’ land (Royal Patent Grant 5671) was granted to George Davis Hu‘eu as an unsurveyed LCA (8521B) in 1865.

The lack of longtime residents to testify to the traditional boundaries, the nature of the existing survey maps, and various contradictory land claims created further problems concerning G.D. Hu‘eu’s land award. Early survey maps of the area depicted traditional boundaries in locations that are very different from those codified only five to ten years later.

The Wiltse map of 1860 Waimea places the boundary between North Kona and South Kohala Districts further north and east than its later accepted location.

The *mauka* boundary of Waimea, and so Waikōloa, are described in a letter from three Commissioners of Crown Lands based on the Wiltse map. The description of the boundary relating specifically to the area of Davis’ land and shown on the Wiltse map is as follows:

> Thence to Pumahoelua. Thence to a large rock marked “H.” Thence to Kuikahekili; then to Namahana on the line of Kona. Thence along the gulch called Poopoo, bordering the land called Puuanahulu to an ohia tree marked “H.” Thence to Puuiwaiwa. Thence to a point of rocks maked “H.” Thence along the line of Puuanahulu to Kahooalapiko, then to Puuhinei (Maly and Maly 2002: 82, emphasis Maly’s).

The remainder of the boundary between North Kona and South Kohala is much further north than the later, officially agreed apron boundary.

The extent of Davis' property was contested by the Crown in court in 1866, and was finally surveyed and mapped in 1867. Counsel for Davis contended the land granted by Kamehameha included the plains near the seacoast. Representatives of the Crown contended the grant consisted of the hill country only and no land on the Waikōloa plain. A.F. Judd recorded the court proceedings as follows:

> Conspicuous land marks, geographical points are the boundaries of districts and large lands; so Waikoloa has Puaapilau; Keahualono, Puukapele, and Puuhuluhulu, all hills, and not a low place on the plain and the meeting of two gulches in the plain, as alleged by the Crown, to the boundaries of Waikoloa. Puukapele and Keahualono are hills visible each from the other, and the two points establishing the base of the triangle (Handwritten notes of A.F. Judd November 28, 1866, Bergin collection).

The hills of Waikōloa were determined to be Davis' land and the plains along the seacoast remained possessions of the Crown. G.D. Hu‘eu's property contained:

> . . .a house lot in the ili of Waikoloa, the cattle corral in the ili of Nohoaina, the goat corral in the ili land of Paulama, and the house site there. There are four sections.
>
> The first section is the house site in the ili of Waikoloa, it has been enclosed and there are two houses within; one house for the school teacher, Kauahi, he has only a house there; the other one is for Hueu.
>
> To the uplands and outer area (waho) is the land of Uilama Pakele (William Beckley); the kula (plain or open) lands on the lower (makai) side are also his; and on the Kohala side is the Alanui hele (path) and the corral of Parker folks and William [Beadle]. It is his old land, gotten from his father, Aikake (Isaac). From KI [Kamehameha I]. Gotten by Aikake from Koapapaa. No one has objected.
>
> Parcel two is in the ili land of Nohaaina, a cattle corral. Uilama Pakele's land is mauka, and on all sides.

> [Parcel three] The goat corral in ili land of Paulama. Uilama Pakele is the only one who bounds it on all sides.
>
> Parcel 4. Keoni's house lot is to the upland side; the outer (waho) and shoreward (makai) sides are Uilama Pakele's land; towards Kohala is Leleiohoku's cattle corral. Hueu's interest is from Uilama. No one has objected.
>
> William Beckley, sworn and stated: I know this, and his interest is from me. I gave him these sections in 1845-1846. (Native Testimony Volume 4:18-19, translated in Maly and Maly 2002: 68-69).

William Beckley was an agent of the Crown entrusted with the management of cattle on Crown lands. Hu‘eu's property eventually became the lands of the Ke‘āmuku Sheep and Cattle Station. The project corridor is located along the southwest boundary of the property.

THE HISTORY OF RANCHING AT THE KE‘ĀMUKU SHEEP STATION

Ke‘āmuku, as recorded on the first and all survey maps since, translates as "cut-off lava" and refers to the lava flow and low prominence (3074 ft amsl) west of the Ke‘āmuku Sheep Station (Pukui et al. 1974: 102). Cultural informants specified that in the Waimea-Waikōloa area, the station and ranch have from time immemorial been called Ke‘āmoku. Both *muku* and *moku* can be translated as cut off, or severed, as an island or district is delineated from its surroundings (Andrews 2003: 402, 407). The Ke‘āmuku lava flow runs parallel to and along the boundary between Kona and Kohala for more than 10 kilometers and Ke‘āmuku might refer to the lava flow's function of delineating the two *moku* of Kona and Kohala.

The origin of organized sheep ranching in the Waimea region is credited to William French, who first arrived in Hawaii in 1819 as a representative of an American shipping venture involved in the sandalwood trade (Wellmon 1969: 49). By 1826 he was grazing sheep and cattle between Waimea and Kawaihae and by 1844 was exporting wool (Wellmon 1969: 57). French owned the Līhu‘e Livestock Farm and a home in Waimea (the historic Spencer House) (Bergin 2004: 156). French also established a store at Pu‘u Loa, and tallow works, a tannery, and blacksmith and carpentry shops (Bergin 2004: 156) in Waimea. French's ranching operation was taken over by Francis Spencer and partners after French's death in the mid-1850s (Bergin 2004: 157).

Francis Mcfarland Spencer (Born in England 1818, died 1897) arrived in Kawaihae in 1839 with his wife and two young children. For a time he ran the stagecoach from Kawaihae to Waimea, from Waimea to Kukuihaele, Honokaa, and Pauuilo (John Spencer interview, recorded by A. Wakayama 1983). Oxen, horses (Percherons), and mules were the primary draught animals for the stagecoach at that time. Spencer used his income to purchase land, and by the 1854 was operating a store and a sheep and cattle farm in Līhuʻe. Spencer's copartners in the Līhuʻe sheep farm were James Louzada and Henry Cornell (Maly and Maly 2002: 135). James Louzada was one of three "Spaniards" that were hired between 1930 and 1932 to hunt bullock on the island of Hawaiʻi. Spencer and Louzada imported six Saxon-merino crossed sheep in 1858 to improve their stock (Bergin 2004: 229). Spencer also operated a sheep farm at Puʻu Loa (his primary residence), which combined with his other ranching interests, was called F. Spencer and Company.

F. Spencer and Company entered into a partnership in 1861 with the newly formed Waimea Grazing and Agricultural Company (WGAC), owned and operated by Robert Cheshire Janion and his partner William H. Green (Maly and Maly 2002: 134). The WGAC, like all ranching operations in the area, was involved in bullock hunting and the production of salted beef and hides as well as sheep and cattle ranching. The new joint business venture, consolidated under the name of the Waimea Grazing and Agricultural Company, became the largest ranching operation of its time.

In 1865 Francis Spencer bought out the ranch operation of three Hawaiian ranchers who held a lease (General Lease No. 106) on the entire *ahupuaʻa* of Puʻu Anahulu adjacent to and west of Keʻāmuku (Maly and Maly 2002: 137). On July 2, 1868 G.D. Huʻeu leased his land in Waikōloa to William L. Green on behalf of the WGAC for $600 per year (Maly and Maly 2002: 139). The 20-year lease included all of the land awarded to G.D. Huʻeu under LCA Number 8521 B Parcel 1, except properties previously sold to William Claude Jones in October 1866 (Maly and Maly 2002: 137-139). The Huʻeu family was allowed to continue grazing their 1,000 cattle, 100 horses, and 1,000 sheep on the land under the terms of the lease.

The WGAC, in turn, leased the land to Francis Spencer, who leased the grazing rights to the WGAC. The lease, combined with previously owned/leased land (seven properties altogether) gave Francis Spencer and the WGAC the right to hunt wild (unbranded) cattle and sheep, and to graze their cattle, sheep, horses, and mules over a vast area of land from Hilo to Hāmākua, to South Kohala, and to Kona (Maly and Maly 2002: 137). William L. Green estimated that in 1870 100 “bush cattle” hides (also called “mountain hides”) per year could be taken from Keʻāmuku with a maximum return of 9.5 cents a hide (Maly and Maly 2002: 143). An early survey map drawn by Kaelemakula shows a “Hale o Spencer” (Spencer House) in the vicinity of the historic residence of the Keʻāmuku Sheep Station (Figure 7). Given the difficulties of early survey procedure, the Hale o Spencer is situated very close to the Keʻāmuku Sheep Station residence when plotted on the USGS Keamuku Quadrangle map (1982). It must be noted that the Kaelemakula map depicts the house on the southern bank of the gulch, not on the northern bank, as is the case with the location the residence at the Keʻāmuku Sheep Station. There are two possible locations along the Keʻāmuku gulch that are likely locations for the original house (suggested by archaeological investigations and map analysis) if the map is not incorrect. Cultural informants have maintained that the Keʻāmuku House at the Keʻāmuku Sheep Station is the original Spencer house.

An English traveler, Isabella Bird, passed through the Waimea area in 1873 and described the Spencer residence and sheep operations at Puʻu Loa.

> On clambering over the wall which surrounds my host's kraal of dwellings, I heard in the dusk strange, sweet voices crying rudely and emphatically, "Who are you? What do you want?" and was relieved to find that the somewhat inhospitable interrogation only proceeded from two Australian magpies. Mr. S. is a Tasmanian, married to a young half-white lady; and her native mother and seven or eight dark girls are here, besides a number of natives and Chinese, and half Chinese, who are employed about the place. Sheep are the source of my host's wealth. He has 25,000 at three stations on Mauna Kea, and, at an altitude of 6000 feet they flourish, and are free from some of the maladies to which they are liable elsewhere. Though there are only three or four sheep owners on the islands, they exported 288.526 lbs. of wool in 1872. Mr. S. has also 1000 head of cattle and 50 horses (Bird 1998: 147-148).

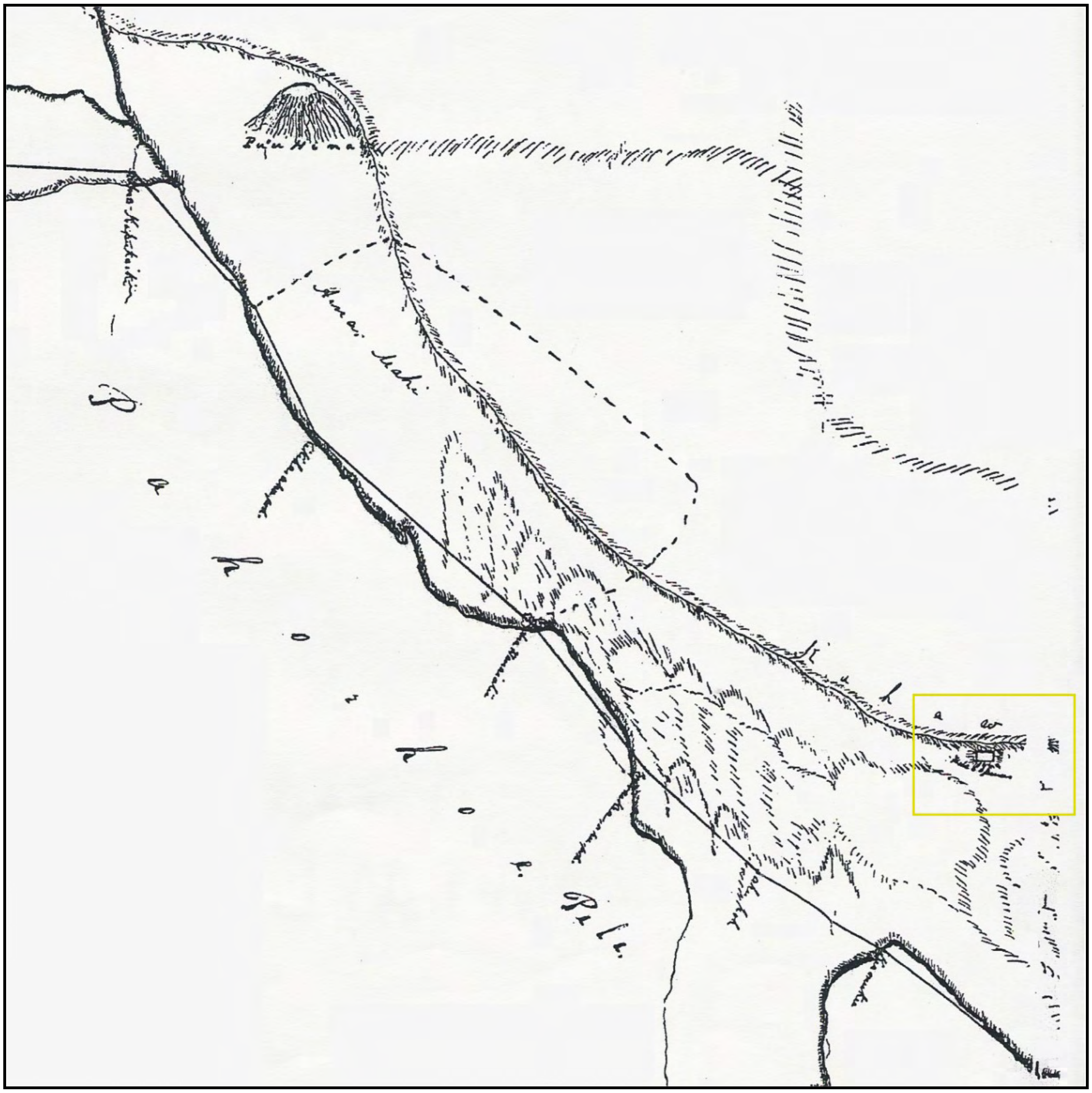

Figure 7: Kaelemakula Map Showing Hale o Spencer.

She also described the Spencer sheep station at Kalaiʻehā where Francis Spencer's oldest son Ashford (1847-1891) and his wife Puakalehua Awai lived.

> I have described the "foreign residences" elsewhere. Here is one of another type, in which a wealthy sheep owner's son, married to a very pretty native woman, leads for some months in the year, from choice, a life so rough, that most people would think it a hardship to lead it from necessity. There are two apartments, a loft and a "lean-to." The hospitable owners gave me their sleeping-room, which was divided from the "living-room" by a canvas partition.

> This last has a rude stone chimney split by an earthquake, holding fire enough to roast an ox. Round it the floor is paved with greatrough stones. A fire of logs, fully three feet high, was burning, but there was a faulty draught, and it emitted a stinging smoke. I looked for something to sit upon, but there was nothing but a high bench, or chopping-block, and a fixed seat in the corner of the wall. The rest of the furniture consisted of a small table, some pots, a frying-pan, a tin dish and plates, a dipper, and some tin pannikins. Four or five rifles and "shot-guns," and a piece of raw meat, were hanging against the wall. A tin bowl was brought to me for washing, which served the same purpose for everyone. The oil was exhausted, so recourse was had to the native expedient of a jar of beef fat with a wick in it.
>
> We were most hospitably received, but the native wife, as is usually the case, was too shy to eat with us, or even to appear at all. Our host is a superb young man, very frank and pre-possessing looking, a thorough mountaineer, most expert with the lasso and in hunting wild cattle. The "station" consists of a wool shed, a low grass hut, a hut with one side gone, a bell-tent, and the more substantial cabin in which we are lodged. Several saddled horses were tethered outside, and some natives were shearing sheep, but the fog shut out whatever else there might be of an outer world. Every now and then a native came in and sat on the floor to warm himself, but there were no mats as in native houses. It was intolerably cold. I singed my clothes by sitting in the chimney, but could not warm myself. A fowl was stewed native fashion, and some rice was boiled, and we had sheep's milk and some ice cold water, the drip, I think, from a neighbouring cave, as running and standing water are unknown.
>
> There are 9000 sheep here, but they require hardly any attendance except at shearing time, and dogs are not used in herding them. Indeed, labour is much dispensed with, as the sheep are shorn unwashed, a great contrast to the elaborate washings of the flocks of the Australian Riverina. They come down at night of their own sagacity, in close converging columns, sleep on the gravel about the station, and in the early morning betake themselves to their feeding grounds on the mountain. (Bird 1998: 232-233).

George Bowser also described Waimea and the Spencer sheep ranching interests in the following terms:

> ... Waimea has always been a place of some considerable importance, and there are around it several pretty homesteads,

> notably the residences of Mr. F. Spencer and the Reverend Mr. Lyons. From Mr. Spencer's veranda there is a striking view of Maunakea, the summit of which was at this time of the year still in its winter robe of snow. The snow never leaves this mountain-top entirely, but the position of the snow-line varies considerably with the season of the year, and also from one year to another, according to the weather which characterizes them. The country all round is chiefly suitable for grazing, and, besides innumerable wild cattle, descended, no doubt, from those which Vancouver gave to Kamehameha I, there are some 20,000 head depastured in the neighborhood, the property of Mr. Parker, who has, besides, some large droves of horses, probably numbering a thousand head in all. Mr. Spencer has turned his attention chiefly to sheep farming, and occupies a large tract of country with his flock of 15,000 sheep and 15,000 goats. Waimea itself, although of immemorial age, and once populous, is now only a scattered village, with but two stores and a boarding and lodging house and coffee saloon (Bowser 1880, quoted in Maly and Maly 2002:60, emphasis Maly's).

At some point between the end of 1871 and the beginning of 1876, the WGAC went out of business due to drought (Wellmon 1969). Francis Spencer formed the Puuloa Sheep and Stock Company out of his sheep stations in Waimea, Waikōloa, and Puʻu Anahulu (Wellmon 1969: 44). In October of 1876 he sold (mortgaged) his interest in the Puuloa Sheep Ranch to George W. Macfarlane (Maly and Maly 2002: 145). Macfarlane sold a fourth of the interest to W. L. Green including,

> ... Twenty one thousand sheep with one fourth increase of the same, all sheep stations on the Island of Hawaii aforesaid with the improvements, and everything appurtenant to said sheep stations, all waggons, oxcarts, spring waggon, working oxen, steers, cows and calves, horses, mares, mules and all the goods, wares and merchandise in the retail store in Lihue, Island of Hawaii... the wool press, vats, tanks, pots, and all the implements and appurtenances belonging to or appertaining to sheep raising which were conveyed to me by Francis Spencer... I the said George W. Macfarlane have granted, sold, assigned and set over, and by these presents do grant, bargain, sell, assign and set over unto the said W.L. Green, the undivided fourth interest in all the several leases of land in the Island of Hawaii aforesaid, as follows, the lese of the Ahupuaa of Waikoloa, the land called Beadles Hill or Hokuula, Pitman's lease, the land called Holuokawai, and Kalopa... (Bureau of Conveyances Lib. 54:185-186, quoted in Maly and Maly 2002: 145).

According to Maly, Spencer "still maintained a residence and station at Keʻāmuku through the 1880s and held his interests in the Puʻu Anahulu Ranch lease through 1895. A sketch of the Waikōloa area drawn by J. Perryman in 1882 shows a series of buildings labeled "Warren's Keamuku" at the location of the Keʻāmuku Sheep Station (Figure 8). Warren is most likely a reference to William Warren who used the name Jack Purdy and worked for William Green and the WGAC (Bergin 2004: 84-85). Francis Spencer died in 1897.

A.W. Carter purchased the Puuloa Sheep and Stock Company interests for $20,000 (Brennan 1972: 136) in January 1904 on behalf of Parker Ranch, including,

> the Keamuku Sheep Station. This was purchased from the MacFarlane interests and included 4,500 ewes, 800 lambs, 300 wethers, and an undisclosed number of rams of reasonable breed-mainly merino crosses. Also undisclosed was the exact number of semiwild range sheep that grazed in adjoining Kālawamauna, but estimates were between *2,000* and *2,500.* At the time of purchase there were substantial improvements, including a dwelling, men's quarters, and outbuildings that housed scales and equipment for shearing sheep and packing wool. Pens, corrals, and yards were left intact also. All told, A. W. acquired nearly *8,000* head of sheep, together with station improvements and equipment-but the centerpiece was the Lihuʻe *kuleana* (property) itself adjacent to Waimea, followed by the Keamuku lands, which included Kālawamauna (Bergin 2004: 230).

One of the outbuildings was a shearing barn that was photographed in the early 1960s before it was demolished (Figure 9).

Richard Smart wrote of the purchase and early sheep operations at Keʻāmuku in the newsletter *Paka Paniolo* noting that it

> . . . was purchased by Parker Ranch in February 1904 along with the stock numbering 6,175 sheep. Wool produced that year totaled 10,000 pounds. Mr. Frank Johnson was the manager of the Puuloa Sheep and Stock Ranch when it was purchased by Parker Ranch, and remained as manager of the station until 1906 when Mr. A.C. Aubrey became the manager (Richard Smart 1965, quoted in Maly and Maly 2002: 210).

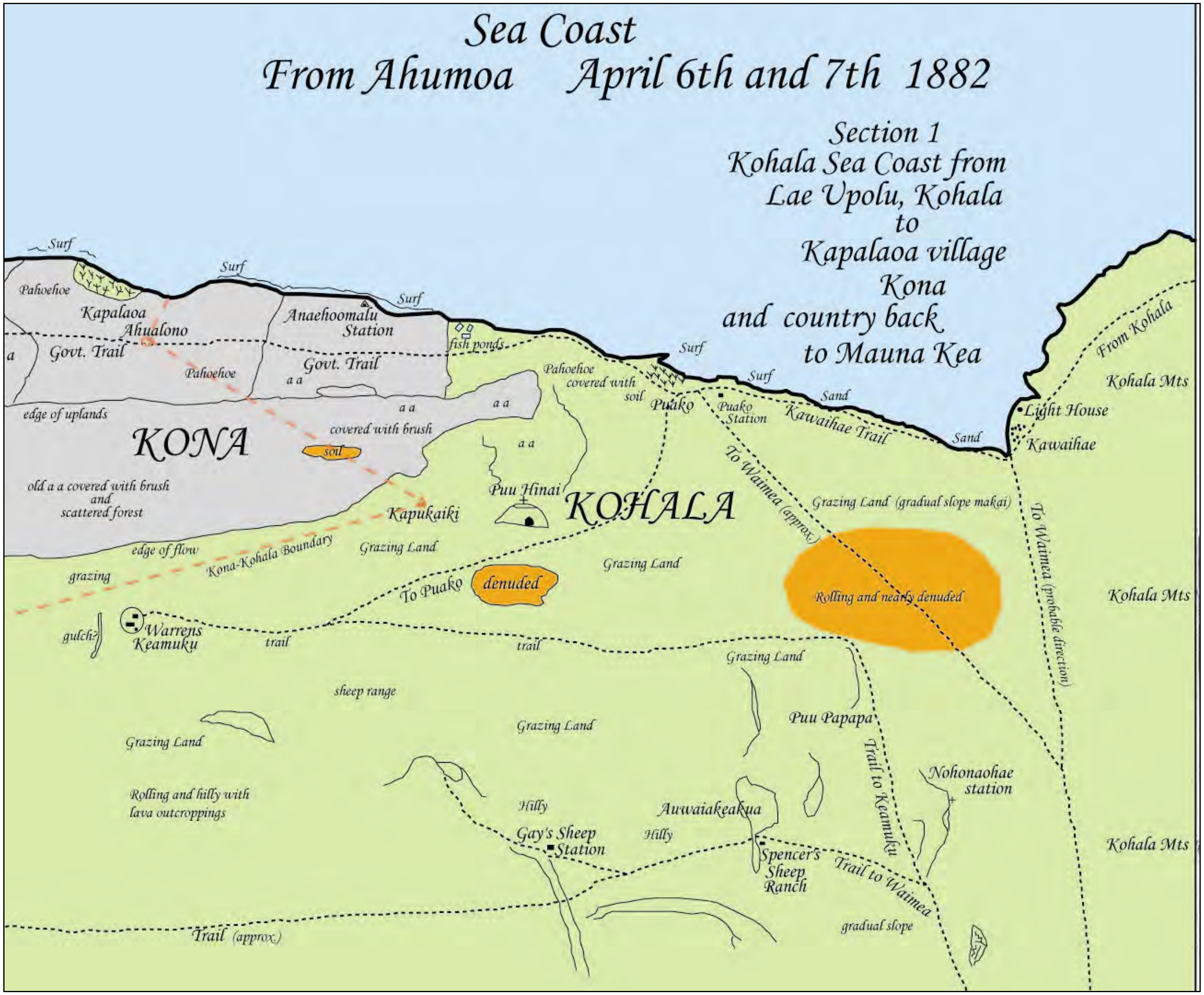

Figure 8: J. Perryman's 1882 Map of the Waikōloa Area.

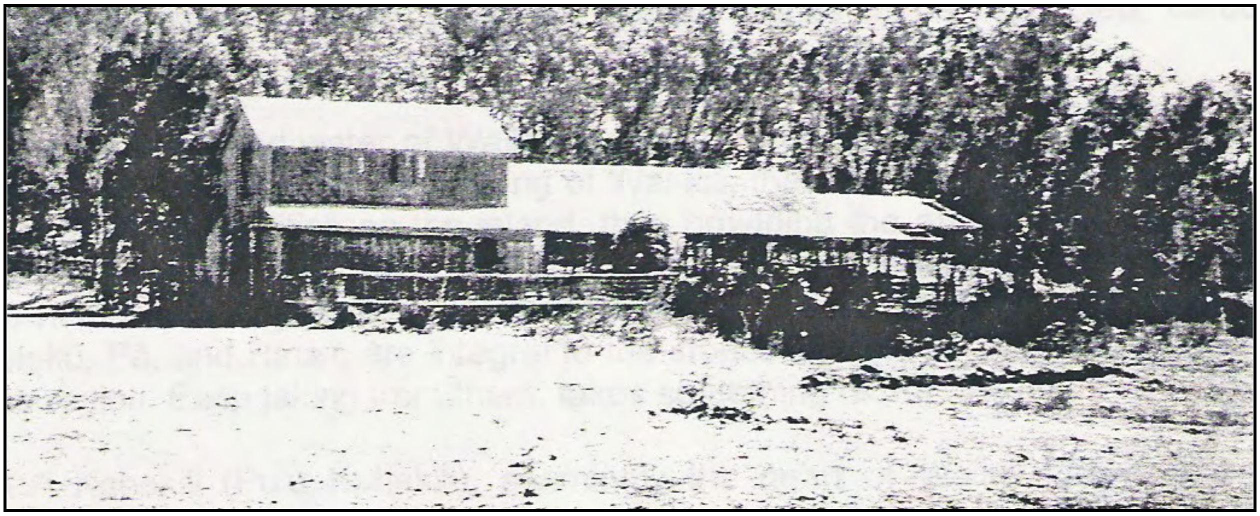

Figure 9: The Keʻāmuku Sheep Shearing Barn.

Yutaka Kimura, who began working at Keʻāmuku Section in 1919, was interviewed by Langlas and described early ranching at Keʻāmuku, before the purchase, as follows:

> Kimura was told that the sheep range was not fenced, but that two men with dogs kept the sheep from wandering away. A Hawaiian named Nahulu lived on the lower side, in a shack at Puʻu Hinei, and a Chinese named Akuna lived on the upper side, in another shack *makai* of Pu ʻu Keʻekeʻe. The Keʻamoku sheep operation ended not too long after Parker Ranch took it over. Mr. Kimura said that the sheep were taken from there up to Humuʻula "before my time." (Langlas *et al*. 1999: 46).

A.W. Carter began grazing cattle at Keʻāmuku Section in 1907 (Wellmon 1969). At that time there were eight employees listed as working at Keʻāmuku Section including, Condo (Kondo), Ah Kune, Ah Him, Mori, Suketa, Kanikubo, Yamamoto, Egawa, and Codeiro (Maly and Maly 2002: 173). By 1908 there were 18 employees, predominantly of Japanese descent (Maly and Maly 2002: 174). In March 1908 water was piped up to the Keʻāmuku Section *via* Waikiʻi. As a result, sheep and wool production from Parker ranch's Keʻāmuku Section continued to increase and improve as documented in the following *Paka Paniolo* article:

> By June 1908 the station had increased its stock to 10,997 sheep and produced 30,000 pounds of wool which was almost completely free of kikania (cockle burr). Therefore, Parker Ranch wool always brought good prices in Boston where it was marketed. Shearing was done early in the Spring before the kikania burrs had a chance to mature and harden and stick to the wool. For this reason also

> Parker Ranch wool was always preferred in the Islands as padding for the Hawaiian quilts. Speaking of quilts, Mrs. Theresa Quinn of Kohala was contracted to make a quilt for Queen Liliuokalani's bed at Washington Place during Governor Stainback's term of office. The wool for this quilt was donated by Parker Ranch (Richard Smart article 1965, quoted in Maly and Maly 2002: 210).

In 1914, after Parker Ranch acquired the Humuʻula Sheep Station, A.W. Carter began to phase out sheep at the Keʻāmuku Section. The invasion of *kīkānia* that lodged in sheep's wool and made sheep shearing unprofitable at other locations in the early 1900s did not immediately affect the sheep at Keʻāmuku Section. Wool continued to be produced at Keʻāmuku until around 1918 when the remaining sheep and equipment were finally transferred to Humuʻula (Maly and Maly 2002: 171-172, 206). A.W. Carter commented on his sheep ranching experiences writing,

> I do not profess to be a sheep man. My business has been primarily cattle. However, I have learned considerable about sheep with reference to our own peculiar conditions.
>
> The only experience that I have had with sheep has been with a special type of Merino and I have imported rams of this type from Australia. This is a wool type. By the importation of rams I have been able to raise the average wool clip to about eight pounds per animal and it is the type of wool that is desired in trade. I ship it to Boston, the headquarters of wool in the United States, and we get a very good price. For many years the wool clip continued to be profitable.
>
> The wethers and ewes were sent to the Honolulu market. The wethers dressed out at about 48 pounds. The real demand is for lamb.
>
> We are not in a position on this particular Ranch to go into the lamb business. I have raised a few lambs for our local supply on Hawaii by crossing the English Leicester, which is a large long-wool sheep, on Merino ewes and I think this is a good practice if anyone should want to follow that line of business.
>
> For many years I have used an arsenic dip to cure and prevent sheep scabs and finally eliminated it. I have continued however, to use a carbolic dip annually and I think that anyone running sheep must dip their flocks every 12 months to keep them clean.
>
> We are fortunate in not having any burrs and our wool is very

> clean as it comes from the sheep's back. Dirt and burrs, of course, depreciate the value [of] wool.
>
> The Merinos, which we use, are small, chunky animals, not like the large sized Merinos that you often see in Australia. We have a very rough and rugged country and we find that these do much better than heavier sheep. We run our sheep in paddocks; they are not herded. I have handled Southdowns and Shropshires but without much success (Bergin 2004: 236).

Sheep were dipped annually in a cement dipping vat at Keʻāmuku until they were transferred to the Humuʻula (Figure 10).

There were no automobiles in 1910 and very few in the 1920s, all transportation was by foot, horse, or by wagon, carriage and buggy (Figure 11). Three major cart roads led to and from the Keʻāmuku Section. The Keʻāmuku-Waimea trail was situated from Keʻāmuku, north past the eastern bases of Puʻu Papapa and Puʻu Nohonaohae (where it joined the trail to Spencer's sheep operations on Mauna Kea), and on to Waimea town (J.S. Emerson Field Book 251:83 and 109, in Maly and Maly 2002: 100-101). A second trail ran from Keʻāmuku, northwest past the east side of Puʻu Hinai, and down to Puakō (*ibid*). A third trail constructed in the 1800s is situated west of Keʻāmuku Station in the direction of Puʻu Hinai (Maly and Maly 2002: A-472). Two later dirt roads connected Keʻāmuku to Waikiʻi and to the Kona-Waimea Road. Rally Greenwell and Jiro Yamaguchi commuted by vehicle from Hale Kea (Parker Ranch headquarters) and Waimea to Keʻāmuku every day (Rally Greenwell interview, Jiro Yamaguchi interview collected for Maly and Maly 2002). A small crew of three two four hands lived at Keʻāmuku House (Rally Greenwell interview collected for Langlas *et al*. 1999).

Work at Keʻāmuku included weeding, fence mending, goat eradication, rain gauge reading, sheep dipping and shearing, and the tending and driving of cattle. The earliest cowboys and ranch hands were mostly Hawaiian and cowboys like Matsuichi Yamaguchi learned to speak

Figure 10: Dipping Sheep at Ke‘āmuku in 1906.

Figure 11: A Buckboard Wagon Used for Early Transportation at Parker Ranch.

fluent Hawaiian (Jiro Yamaguchi interview collected for Wolforth *et al*. 2004, and Ichiro Yamaguchi interview).

The Plaster Gang, usually comprised of a Hawaiian foreman, a *luna*, and Japanese crew, constructed new fences, mended fences, and removed noxious weeds. Fence checking was done once a month. It took a day to check the fence from the Waimea-Kona belt road to Puʻu Hinai and another day to check it from Puʻu Hinai to Puakō (Greenwell interview collected in Maly and Maly 2002). The type of fence post used for the construction of new fence lines was dependent primarily on location. Hardwood such as *kiawe* was preferred and used in places where it was close by, such as Puakō (Rally Greenwell interview). *Kiawe* was also transported for use as corner posts where strength was important. Most of the fence posts at Keʻāmuku are eucalyptus because they were grown there. Two types of Eucalyptus were used: red gum and blue gum. Red gum is easier to split and was used for central posts and the more solid blue gum was used for corner posts (Ichiro Yamaguchi interview).

The Plaster Gang also removed *Pampas*—a name ranchers commonly used to refer to fountaingrass (*Pennisetum setaceum*)—spreading from the Kona side, from lava flows (up to a mile within the flow) surrounding Keʻāmuku. As a result, Parker Ranch was free of fountaingrass. From the 1930s to1960s Parker Ranch worked to eradicate the *pānini* or prickly pear cactus (*Opuntia ficus-indica* and *O. cordobensis*). The cactus, brought from Mexico in 1809 for forage and moisture, was rampant by the early 1900s. Cactus eradication crews began working in the 1930s and cleared roughly 60,000 acres by 1965 (Bergin 2004: 272).

Sheep were dipped annually and were shorn two to three times a year. Lambs were shorn in February and rams and ewes were shorn in May or June. Parker Ranch employees, contract men, and day workers were carried out the shearing. Eight or nine men could shear roughly 100 sheep a day (Ichiro Yamaguchi interview). Sheep were lead by ramp into the pen in the center of the shear barn where men working at individual stations along the outside edges of the central pen would select sheep for shearing. Each station had a mechanical clipper attached to a single motor for clipping the wool.

Shorn sheep were pushed individually into an outside corral through a hatch in the side of the shear barn. Each man kept a count for pay purposes. The combing (highest grade wool) and tags (lower grade wool) were then baled in a manual wool press.

Nānā ʻāina men kept and eye on the land and watched over the cattle (Rally Greenwell interview). Their daily presence with the cattle kept them familiar with men and kept them *laka* (tame). A *nānā ʻāina* man knew the cycles of the environment and cattle. He was first to know when the calves were ready to drop, or when illness and death struck. He kept track of the water in paddocks and the state of the forage. The cowboy gang also ran the cattle from paddock to paddock depending on the rain. It was common to ride with a rifle to eradicate goats and to shoot older cattle to feed the pigs at Waikiʻi (Foreman Books for Parker Ranch, H.P.A. collection).

Wild pigs and plover (*kōlea*) were often shot to supplement provisions brought up from Waimea (Rally Greenwell interview). Rally remembered a smokehouse at the Keʻāmuku House where they smoked pork and mutton (Rally Greenwell interview collected in Maly and Maly 2002). Figs, peaches, and watermelon were grown at Keʻāmuku Station. Vegetables, hogs, and fowl raised at Waikiʻi, and meat butchered and cut in Waimea supplemented food at all Parker Ranch sections (Rally Greenwell interview). Most food supplies and other necessities were sent up from Waimea.

Three or four men lived at Keʻāmuku year round. Three unmarried men lived at Keʻāmuku House and went home to Waimea on weekends. Mr. Uyehara lived in a small cottage near the north gate and watched over the ranch on the weekends. Water for cooking, cleaning and bathing was collected from the shear barn roof (fog, dew, and mist more often than rain) before water was piped to Keʻāmuku. The piped water was stored in a metal tank until a redwood tank was constructed in 1945 (Ichiro Yamaguchi interview).

During World War II (between 1942 and 1945) portions of Parker Ranch were used for military training. The Army and Marines stationed some 30,000 to 50,000 men in Waimea. Tents and Quonset huts were located south of Waimea at Camp Tarawa. A firing range for artillery practice was set up and a dirt road for tank travel extended between Kawaihae and Pu`u

Ke`eke`e (Brennan 1974:164). The old wagon road Connecting Waimea to the Humu`ula area became the Saddle road, constructed by the Civilian Conservation Corps in 1943 (Langlas *et* al. 1999: 29). Jiro Yamaguchi noted that some 26,000 marines were training out by Puʻupā between the Waikiʻi and Keʻāmuku sections (Jiro Yamaguchi interview collected for Maly and Maly 2002).

Though the Keʻāmuku Section was off the beaten track, it was renowned for the size and health of the cattle raised there. Dr. Billy Bergin attributes the success of both sheep and cattle ranching at Keʻāmuku to its environment. The cool arid weather, "strong ground" and "strong grass" at Keʻāmuku are ideal conditions for raising healthy livestock (Bergin interview). Changes in weather patterns, improvement in transportation, and the impetus to consolidate and centralize operations in the late 1940s foreshadowed a process that would eventually close outlying sections such as Keʻāmuku and Waikiʻi (Bergin interview).

> Up until the late 1940s, the annual rains remained consistent. There was a time for planting and for rotating livestock through regional paddocks, and the weather could be counted on. This changed and by the early 1950s, crops were lost, and the ranch's feed planting program diminished, adjusting to the weather patterns (Maly and Maly 2002: 202).

Waikiʻi Village and ranch section closed and most of the houses there were moved to "Little Waikiʻi" in Waimea by 1957. Keʻāmuku continued as a ranch section and in 1962 general repairs were made (Malay and Maly 2002: 204). Only a small crew remained at Keʻāmuku, while other ranch hands commuted from Waimea. The hands were kept busy weeding and mending fences.

Further changes in ranching strategy at Parker Ranch led to the consolidation of herds (Rally Greenwell and Bergin, personal communication). Cattle were no longer moved (seasonally) from paddock to paddock within individual ranch sections as forage was depleted. As consolidation occurred Keʻāmuku became less necessary, or even economical to maintain on a full-time and full-scale basis. Richard Smart wrote in *Paka Paniolo* that:

> In the early days it was necessary to maintain Keamuku as an outpost camp as transportation and communication to and from the

> camp were difficult but with the modern means of communication of today the Keamuku area may be inspected and worked very readily from headquarters at Waikii. This was a decision by management in the interest of streamlining ranch operations.
>
> The present buildings at the Keamuku camp will eventually be dismantled. Standing there now are several interesting old buildings including an old shearing barn (Richard Smart 1965, quoted in Maly and Maly 2002: 209-210).

The house (bachelor's quarters) at the Keʻāmuku Section was moved to the grounds of the Japanese Church (*Hongwanji*) in Waimea, the shear barn was demolished, and the area around it bulldozed (Rally Greenwell interview).

Keʻāmuku was used for joint military operations in the 1980s that included a Korean contingent (Mark Yamaguchi, interview collected for Maly and Maly 2002). In 2005, Keʻāmuku was purchased by the U.S. Army for use as a STRYKER Brigade training area. The property is known as the Keʻāmuku Maneuver Area at the U.S. Army Pōhakuloa Training Area. Parker Ranch continues to use the property to pasture cattle.

There are no military training features within the project corridor. All of the archaeological features identified within the project corridor date to the time period the property was used for sheep and cattle ranching.

METHODOLOGY

ARCHIVAL METHODS

In addition to referencing available resources at SCS, archival research was conducted in the State Historic Preservation Division (SHPD) report database and library facility (Hilo, HI), the Hawaii County land records office, the *Waihona ʻAina Mahele* database website, the Hawaiian collections holdings at the University of Hawaiʻi-Hilo Library, and the Hawaii State Library system. Archival work consisted of general research on the history and archaeology of the project area, as well as specific searches of previous archaeological studies in and around the current project area. Historic land use data, land ownership, maps, and narrative information were obtained from the Hawaii County land records office, the *Waihona ʻAina Mahele* database website, and the University of Hawaiʻi, Hilo, Special Collections.

CONSULTATION

Oral interviews conducted by SCS with Jiro Yamaguchi, Rally Greenwell, Dr. Billy Bergin, and Ichiro Yamaguchi for lands of Keʻāmuku were used in the present study. In addition, oral interviews collected with John Spencer (Wakayama 1983) and others (Langlas *et al*. 1999) knowledgeable about the lands of Keʻāmuku were consulted.

FIELD METHODS

Inventory Survey work was conducted intermittently from September 16, 2008 to March 26, 2009 (320 man-hours total) by Suzan Keris, B.A. and Glenn Escott, M.A (Project Director). Bob Spear, PhD was the Principle Investigator for the project. There were four main field components to Inventory Survey process: pedestrian survey of the entire project area; plotting located sites on a project area map with Global Position System (GPS) Universal Transverse Mercator (UTM) units (Zone 5 North) using WSGS84 datum for all three sites; individual site mapping and recording; and hand excavations. Survey was conducted along east/west traverse lines at ten to 15 meter intervals apart. Observed cultural features were assigned temporary feature numbers. The site UTM was recorded at the site datum, which is marked with a metal tag.

Four sites (rock mounds) were selected for test excavation to determine several site characteristics including site function, construction method, and timing. Test-units were excavated as 0.5 x 0.5 meter and 1.0 x 1.0 meter dug in both natural and arbitrary 10 centimeter levels. These were used on features that were thought to have a high potential for yielding functional or temporal data, and used where vertical control would contribute to this data. Test-units were screened for cultural material through 1/8th inch mesh, and all units were stratigraphically profiled.

Cultural material was recorded by type on standard SCS excavation forms and collected. Soil colors were recorded using Munsell color charts, soil composition was recorded with the aid of the U.S. Department of Agriculture Soil Survey Manual on standard soil stratigraphy forms, and profiles were drawn. Overview photographs were taken of individual site features, sites, excavations, and the project area. Color photographs were taken with a 3.2 mega-pixel digital camera using a 20 cm long north arrow scale divided into 10 cm black and white increments.

LABORATORY METHODS

Inventory of midden and artifacts collected from the test excavations were analyzed and weighed. Bottle glass recorded during the current study was automatic bottle machine made (after 1900 to 1910). No earlier, dark green, hand blown or mould blown bottle glass was recorded during the current study. All field notes, maps, cultural material, and photographs pertaining to this project are currently being curated at the SCS facilities on the Island of Hawai‘i.

PREVIOUS ARCHAEOLOGICAL INVESTIGATIONS

Past archaeological investigations along the coast near the *ahupua'a* of Waikōloa are numerous. Several studies document sites on the inland plain of Waikōloa. Archaeological studies in the uplands of Waikōloa near the present project area are few in number. Sites from all three environmental areas function together in a cultural and economic sense, but are very different in their regional characteristics. This report briefly summarizes archaeological feature types common to the coastal and inland plain. Individual archaeological reports pertaining to upland Waikōloa and lands of Ke'āmuku are discussed in greater detail.

COASTAL ARCHAEOLOGICAL INVESTIGATIONS

More than 30 archaeological studies have been conducted along the coast from 'Anaeho'omalu Bay to Puakō (discussed in detail in the "Early Settlement and Expansion" section above). Coastal archaeological features include habitation sites (lava tubes, C-shapes, and platforms) and tool production sites associated with fishing. Fishhooks, octopus lures, and marine midden are common artifacts found at coastal sites.

Basalt extraction and abrader production features are located up to a half mile from the coast on lava fields. Small excavations in the lava likely used to trap birds for food are interspersed with abrader production features. Numerous trails connect the coastal habitation sites with these inland economic features.

ARCHAEOLOGICAL INVESTIGATIONS ON THE INLAND PLAINS TO THE UPLANDS OF WAIKŌLOA

The Mudlane-Waimea-Kawaihae Road Project surveyed a large strip of the Waimea (or Lālāmilo) Field System in Kawaihae, Lālāmilo, Waimea, and Mudlane (Barrerra and Kelly 1974, Kirch and Clause 1981, Athens 1981, Clark and Kirch 1983). The major result of this study was the documentation of an agricultural system that combined traditional irrigated pondfield cultivation and dryland cultivation to form an intensive "supplemental irrigation" form of cultivation (Kirch 1983: 527). Common agricultural features of the Waimea Field System include walled and rectilinear fields, terraces, and canals. An example of field distribution in one portion of the field system is depicted in above.

ACOE conducted a reconnaissance survey of a 60 m wide corridor along the PTA to Kawaihae tank trail (Figure 12). The project area covered an area from the inland plain to the uplands of Waikōloa. No cultural or archaeological resources were identified within the study area (Cox 1983).

Ogden Environmental and Energy Services, Inc. (OEES) conducted an archaeological inventory survey in central Waikōloa (Nees and Williams 2000a). Three pre-Contact era sites and several Historic period sites were recorded. Pre-Contact sites included the mid-17th century battlefield site at Puʻu Pa (battle between Lonoikamakahiki and Kamalālāwalu), two agricultural sites, and the prison camp located near the Kamakao Gulch.

Ogden Environmental and Energy Services, Inc. (OEES) conducted archaeological monitoring and reconnaissance survey on six parcels within the *ahupuaʻa* of Kawaihae 2, ʻOuli, Lālāmilo, Waikōloa, and Puʻukapu (Robins *et al*. 2001). The majority of the 153 sites are associated with military training (defensive positions). Fifty-three sites have features associated with the pre-Contact era or traditional Hawaiian practices (mainly habitation). The remaining sites are associated with Historic period ranching.

Two sites were recorded on Keʻāmuku ranch section lands, including a dryland agricultural complex (Site 22929) and a pre-Contact era temporary habitation (Site 22933). The former site is located within the crater of Puʻu Heʻewai and the latter within the crater of Puʻu Kanalopakanui.

Scientific Consultant Services, Inc. (SCS) conducted an archaeological inventory survey of 723 acres (292 hectares) for the proposed Saddle Road Extension corridor situated east of ʻAnaehoʻomalu Bay to approximately 300 m southeast of the present project area (Wolforth *et al*. 2006). Fifty-seven sites, located primarily at lower elevations, were identified. The majority of sites are associated with the extraction of scoriaceous lava, abrader production, and a network of trails that connect these sites to coastal habitation sites. Low and mid-elevation sites also include basalt extraction quarries and caves, including habitation/refuge caves.

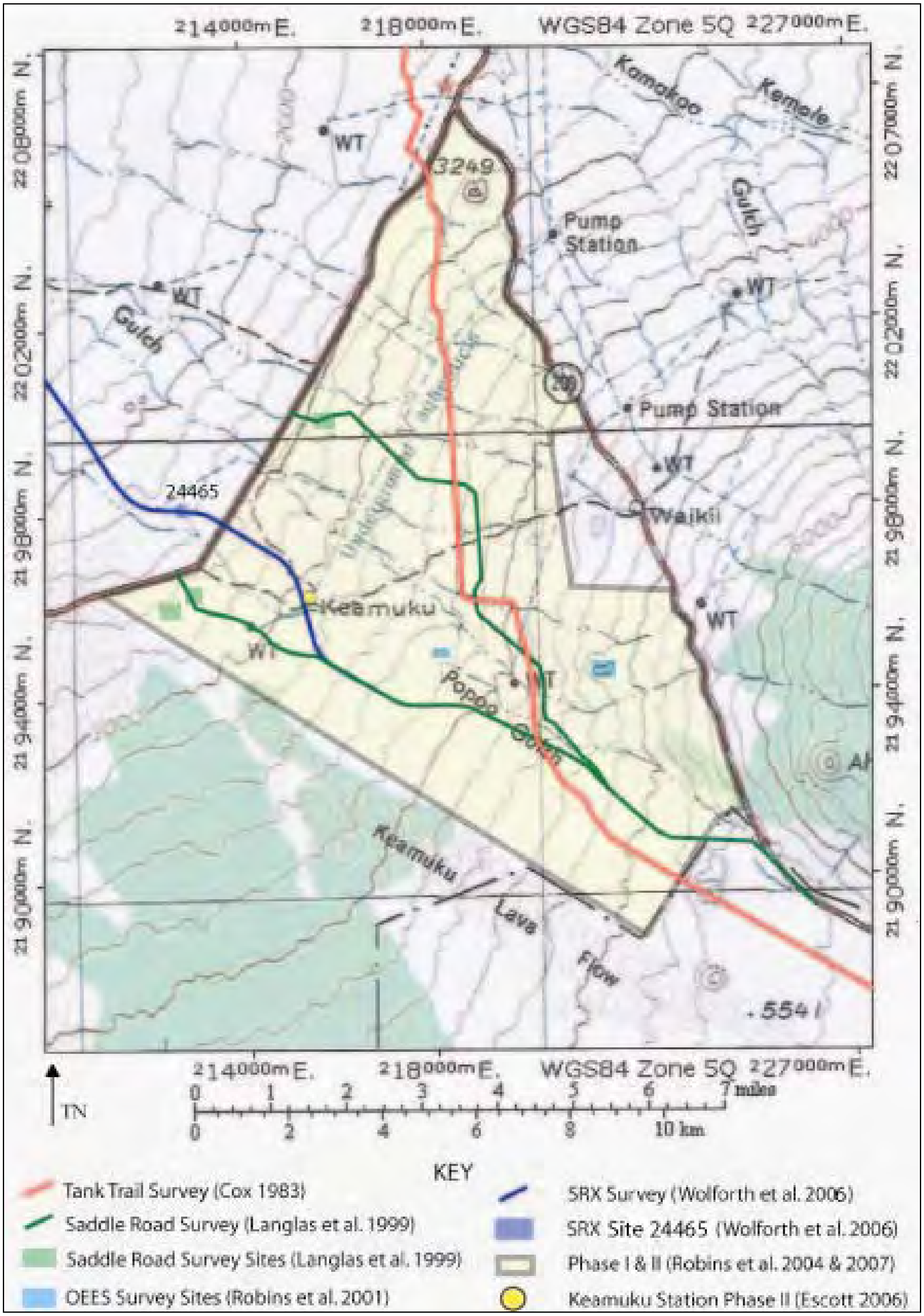

Figure 12: Previous Archaeological Projects on Lands of Ke'āmuku.

One site (Site 24465) was recorded in the upland Waikōloa region near the present project area (see Figure 12). Site 24465 is a multi-component site situated below the Mamalahoa Highway approximately 3.25 km northwest of the Keʻāmuku Sheep and Cattle Station (Wolforth *et al*. 2006:32-44)). The site consists of five features associated with pre-Contact and post-Contact era farming and ranching (Figure 13).

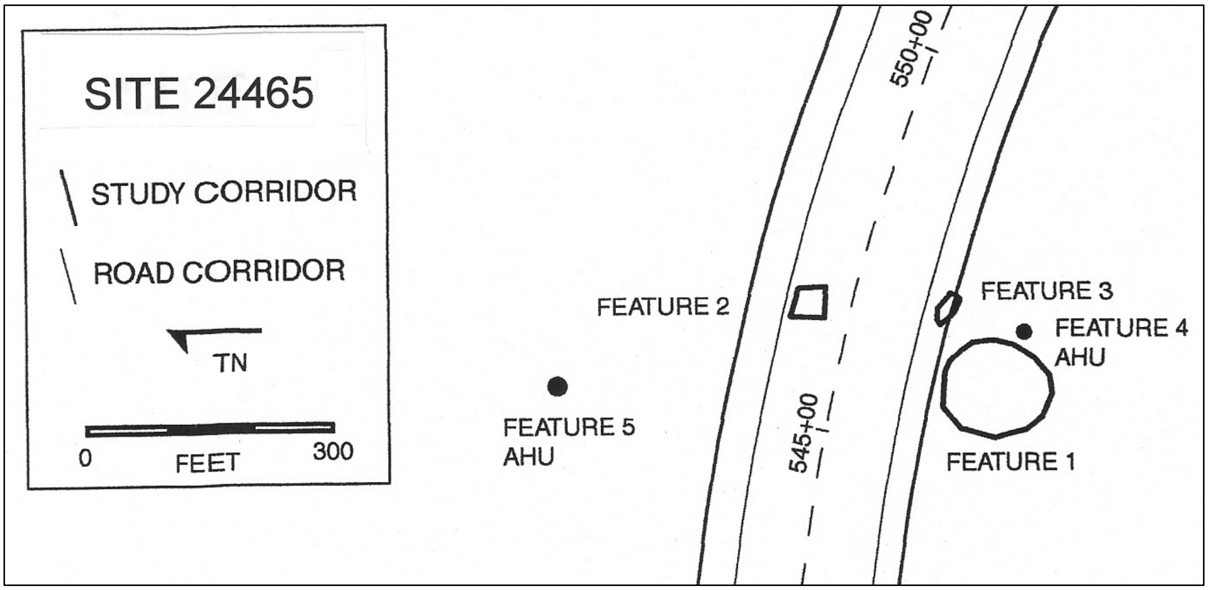

Figure 13: Site 24465 Planview.

Feature 1 is a roughly circular enclosure 37 to 40 meters in diameter, from 0.3 to 0.9 meters in height, and located at the southern edge of the site (Figure 14). It is constructed of dry-laid *pāhoehoe* (vesicular basalt) cobbles and boulders stacked three to five stones wide (1 to 2 meters) and four to five courses high. The ground surface within the enclosure is 40% exposed *pāhoehoe* and 60% shallow sediment with a dense cover of fountain grass. The interior ground surface is uneven and undulating, slopes gently to the northwest, and is dominated by 4 small hillocks at the center of the enclosure. The hillocks are the remains of pressure blisters in the *pāhoehoe* flow that left exposed outcrops ranging from 1.0 to 1.7 meters above the interior ground surface of the enclosure. No cultural remains were present within or around Feature 1.

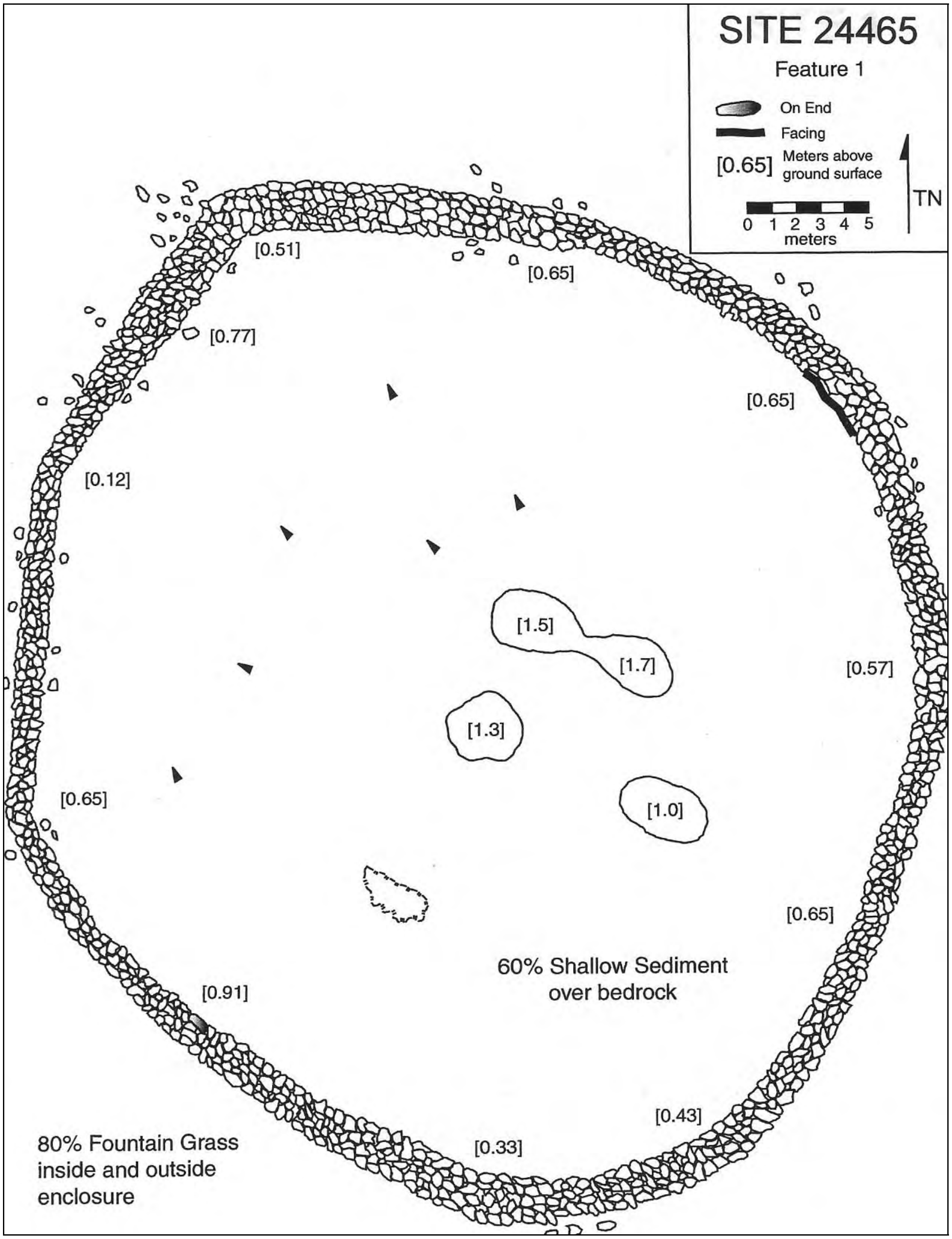

Figure 14: Site 24465 Feature 1 Plan.

Feature 2 is a rectangular enclosure 18 by 16 meters, from 0.2 to 0.6 meters in height, at the northern edge of the site (Figure 15). The enclosure is constructed of platy *pāhoehoe* cobbles stacked three to four courses high and three to four stones wide (1 to 2 meters). The walls appear to have been faced on both the interior and exterior by placing the platy *pāhoehoe* on end either on or in the ground surface. Numerous facing stones are still in position and many others have fallen over onto the ground surface around the perimeter of the enclosure. Four “entrances” exist in the enclosure walls and appear to be caused by cattle or goats passing in and out of the enclosure. The enclosure is in fair condition and has been altered by the action of ruminants grazing in and around it. The ground surface is level consisting predominantly of shallow sandy silt deposits supporting a 90% coverage of fountain grass. Ash and charred grass from recent burning is evident on the ground surface. A 4 cm wide by 70 cm long band of metal strapping and green bottle glass were located on the ground surface within the enclosure. No other cultural material was present in the vicinity of Feature 2.

Twenty Four shovel probes and two one by one meter test units were excavated at Feature 2. A *kukui* nut fragment submitted for radiocarbon dating returned a calibrated range of 1490 to 1660, with an intercept at AD 1640. The majority of artifacts recovered from both test units and shovel probes included early post-contact, dark green bottle glass, square-cut nail fragments, and other historic items, as well as marine shell fragments, and bone animal fragments.

Feature 3 is an oval enclosure measuring 15 by 8 meters, and from 0.4 to 0.6 meter in height (Figure 16). The enclosure is constructed of *pāhoehoe* cobbles stacked two to three courses high and two to three stones wide (1 to 2 m). The interior of the enclosure is level sediment with 25% fountain grass, and is 11 by 5 meters. There is roughly 6 meters of facing on the interior of the eastern portion of enclosure wall, but it lacks a formal entrance. Feature 3 is in fair condition and has been altered by ruminants grazing in the area. Numerous cobbles appear to have fallen out of the enclosure wall and are scattered on the surrounding ground surface. No cultural remains were present on the surface in the vicinity of Feature 3. A small amount of charred material was recovered from four shovel probes excavated at Feature 3. No cultural material was recovered from a one by one meter test-unit excavated at Feature 3.

Feature 4 and Feature 5 were identified as *ahu* (rock mounds) likely marking a trail or used for some other function.

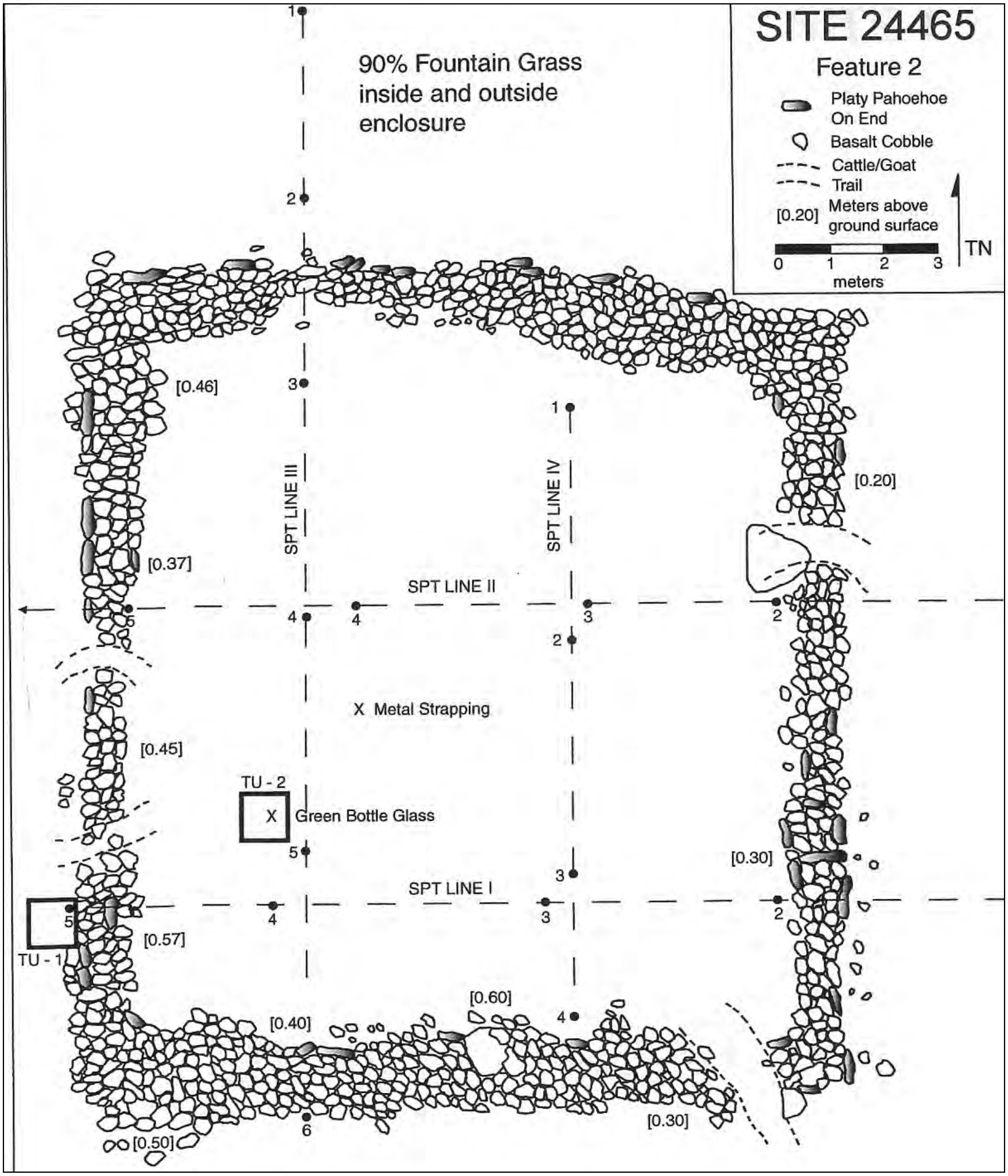

Figure 15: Site 24465 Feature 2 Plan.

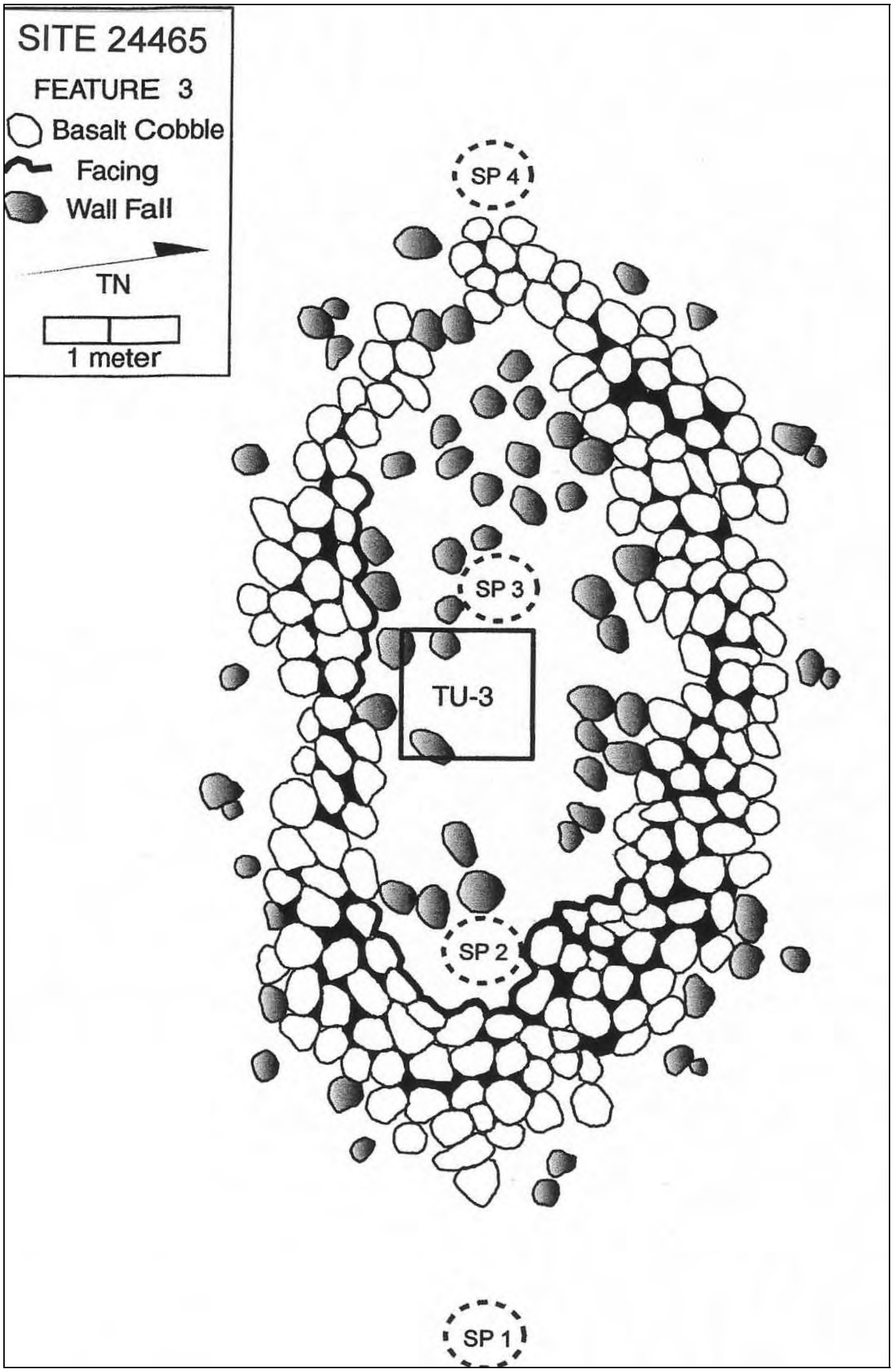

Figure 16: Site 24465 Feature 3 Plan.

Site 24465 is a multicomponent site with a prehistoric occupation of unknown function, and a historic farmstead occupation dating to the mid-1800s. The physical characteristics of the stone enclosures suggest that they were created during prehistory. They are low, stone alignments lacking the core-fill indicative of historically created walls. They are too low to keep animals in or out, and this is reinforced by their lack of use by ranchers: Parker Ranch did not use these features in any way (Mark Yamaguchi interview). Although there are no distinctly prehistoric artifacts in the small material assemblage collected in this investigation, there is one *kukui* nut fragment. *Kukui* trees are not present in the area now, and it is unlikely that they were present in the area in the past. None of the historical or botanical research indicates that *kukui* trees were native to the region. The *kukui* nut fragment in the Site 24465 assemblage was brought to the area. The radiocarbon results indicate that the most likely time that it was brought to the site was around AD 1640. The nearby *ahu* (Feature 5) is also a typical prehistoric feature, and is similar in configuration to other trail markers in the project area and throughout Hawai‘i. The origin and function of the pair of *ahu* (Feature 4) near the large circular enclosure (Feature 1) is less clear, but they may also represent a trail pathway

The way that this set of features was used during prehistory is unclear. The nearby level pockets of soil may have been used for agriculture, and the enclosures may have been a habitation associated with that activity. There are numerous caves in the area, and the enclosures may have functioned as an activity node for people entering and using the caves. Battles were fought along the shoreline to the west of here, and the enclosures may be related to battle camps or battlefields in some way.

The historical component is associated with agriculture. The nearby level colluvial soils were used for farming in the 1800s (see Figure 4), and it has been passed down that pumpkin was one of the cultigens grown in the area (Mark Yamaguchi interview). The paucity of material remains suggests that the historical occupation was short in duration, or not very intensive.

ARCHAEOLOGICAL INVESTIGATIONS ON LANDS OF KE‘ĀMUKU

Paul H. Rosendahl, Ph.D., Inc (PHRI) conducted an archaeological inventory survey of two proposed Saddle Road alignments within the present project area (Langlas *et al*. 1999). PHRI recorded two historic sites on the property, including the Old Waimea-Kona Belt Road (Site 50-10-33-20855) and two Historic period enclosures (Site 50-10-33-20854).

Phase I (Robins *et al.* 2004) and Phase II (Robins *et al.* 2007) archaeological studies were conducted on the entire property of the Parker Ranch Ke‘āmuku Station by GANDA, and a Phase II study (Escott 2006; Johnson and Escott 2009 draft) was conducted by Scientific Consultant Services, Inc. on the primary work and living areas of the station (see Figure 12). GANDA documented 68 sites comprised of 265 features (Table 3) within the project area. Fifty two (76%) of the sites contain post-Contact features associated with ranching, habitation, and boundary markers. Four sites (6%) contain possible pre-Contact or early post-Contact era features, including a burial cave, a temporary habitation enclosure, a petroglyph, and a pictograph. Two (3%) sites had both pre- and post-Contact features. The period associations of ten (15%) sites were unclear and could not be determined.

The majority of features are rock mounds and cairns associated with ranching era land clearing, boundary demarcation, and the quarrying of rock for construction material (most likely for construction of the Kona-Waimea Belt Road. A number of terraces, enclosures, C-shapes, two rock shelters, and an L-shape are associated with temporary habitation and agriculture. Several walls are associated with ranching and agriculture. Sites are concentrated in the northern along the existing Mamalahoa Highway, in the vicinity of the Keʻāmuku Sheep and Cattle Station, along the southwestern edge of the Keʻāmuku Station Parcel, and to a lesser extent at north tip of the Keʻāmuku Station Parcel, and at two upland paddock areas (Figure 17).

Table 2: West PTA Acquisition Area, Phase I Sites (GANDA 2003: 39-42).

Site No.	Feature No.	Site/Feature Type	Probable Function	Age
20854	1-5	C-shape Complex	Habitation	Post-Contact
20855	1	Kona-Waimea Belt Road	Government road	Post-1916
21132	1-5	Mound complex	Construction Material	Post-Contact
22929	1-12	Terrace-Enclosure Complex	Habitation	Undetermined
22933	1	Rockshelter	Habitation	Undetermined
23467	1	Enclosure	Military	Post-Contact
23468	1-2	Mound Complex	Boundary Marker	Post-Contact
23472	1-2	Cairn complex	Boundary Markers	Post-Contact
23473	1-2	Mound complex	Markers	Post-Contact
23489	1	Mound	Land Clearing	Post-Contact
23490	1-2	Enclosure Complex	Temporary Habitation	Pre-Contact
23491	1	Mound	Boundary Marker	Post-Contact
23492	1	Wall section	Boundary Remnant	Post-Contact
23493	1	Mound	Land clearing	Post-Contact
23494	1	Cairn	Marker	Post-Contact
23495	1-5	Complex	Agriculture	Post-Contact
23496	1	Platform	Water tank foundation	Post-Contact
23498	1	Cairn	Marker	Post-Contact
23499	1-8	Complex	Cattle Watering/Agriculture	Post-Contact

Site No.	Feature No.	Site/Feature Type	Probable Function	Age
23500	1-2	Parallel walls	Possible cattle chute	Post-Contact
23501	1	Petroglyph	Rock art	Pre-Contact
23502	1	Cairn	Possible Marker	Undetermined
23503	1	Cairn	Possible Marker	Undetermined
23504	1	Cairn	Possible Marker	Undetermined
23505	1-2	Enclosure/Platform Complex	Habitation	Post-Contact
23506	1	Wall	Possible cattle chute	Post-Contact
23508	1	Terrace	Erosion Control	Post-Contact
23509	1-24	Mound Complex	Construction Material	Post-Contact
23510	1	Mound	Survey Marker	Post-Contact
23511	1	Enclosure	Temporary habitation	Pre-Contact/Post-Contact
23512	1-3	Enclosure/Mound Complex	Possible Habitation	Post-Contact
23513	1	Cairn	Boundary Marker	Post-Contact
23514	1	Cairn	Boundary Marker	Post-Contact
23515	1	Firing Position	Military Training	Post-Contact
23516	1	Ranch Road	Transportation	Post-Contact
23517	4	Cremation Remains	Burial	Modern
23518	1	Retaining Wall	Ranch Road	Post-Contact
23519	1-4	Complex	Habitation/ Animal Pen?	Post-Contact
23520	1-3	Mound Complex	Construction Material	Post-Contact
23521	1-7	Mound Complex	Construction Material	Post-Contact
23522	1-6	Mound complex	Construction Material	Post-Contact
23523	1-2	Terrace, Mound	Possible Habitation	Pre-Contact/Post-Contact
23524	1	Cairn	Marker	Post-Contact
23525	1-2	Mound	Survey Markers	Post-Contact
23526	1	Enclosure Remnant	Habitation	Post-Contact
23527	1	Pictograph	Rock art	Pre-Contact
23528	1	Cairn	Boundary Marker	Undetermined
23529	1	Mound	Boundary Marker	Post-Contact
23530	1	Cairn	Boundary Marker	Post-Contact
23531	1	Cairn	Boundary Marker	Post-Contact
23532	1	Cairn	Boundary Marker	Post-Contact
23533	1	Cairn	Boundary Marker	Post-Contact
23534	1	Mound	Boundary Marker	Post-Contact
23536	1	Mound	Boundary Marker	Post-Contact
23537	1	Mound	Boundary Marker	Post-Contact
23538	1	Mound	Land Clearing	Post-Contact
23539	1-100	Keʻāmuku Ranch Station	Sheep-cattle station: permanent habitation; animal pens	Post-Contact
23540	1	Retaining Wall	Road	Post-Contact
23541	1-3	Enclosure Complex	Animal Pens	Post-Contact
23542	1	C-Shaped Enclosure	Temporary Habitation/Hunting?	Post-Contact

Site No.	Feature No.	Site/Feature Type	Probable Function	Age
23543	1-83	Mound Complex	Construction Material	Post-Contact
23576	1-5	Concrete Pads	Foundation	Post-Contact
23579	1-33	Complex	Temporary Habitation; Agriculture; Boundary	Post-Contact
23580	1	Enclosure	Temporary Habitation	Post-Contact
23588	1	Faced Mound	Marker/Possible Shrine	Undetermined
23591	1	Lava Tube	Burial	Pre-Contact
23592	1	Mound	Possible Marker	Undetermined
23593	1-2	Mound Complex	Markers	Undetermined
23594	1	Mound	Marker	Undetermined
23597	1	Mound	Land Clearing	Post-Contact
23599	1-3	Mound Complex	Construction Material	Post-Contact
23600	1	Mound Complex	Land Clearing	Post-Contact
23620	1-3	Mound Complex	Land Clearing	Post-Contact

Sites highlighted blue are documented in Escott 2006 and Johnson and Escott 2009.

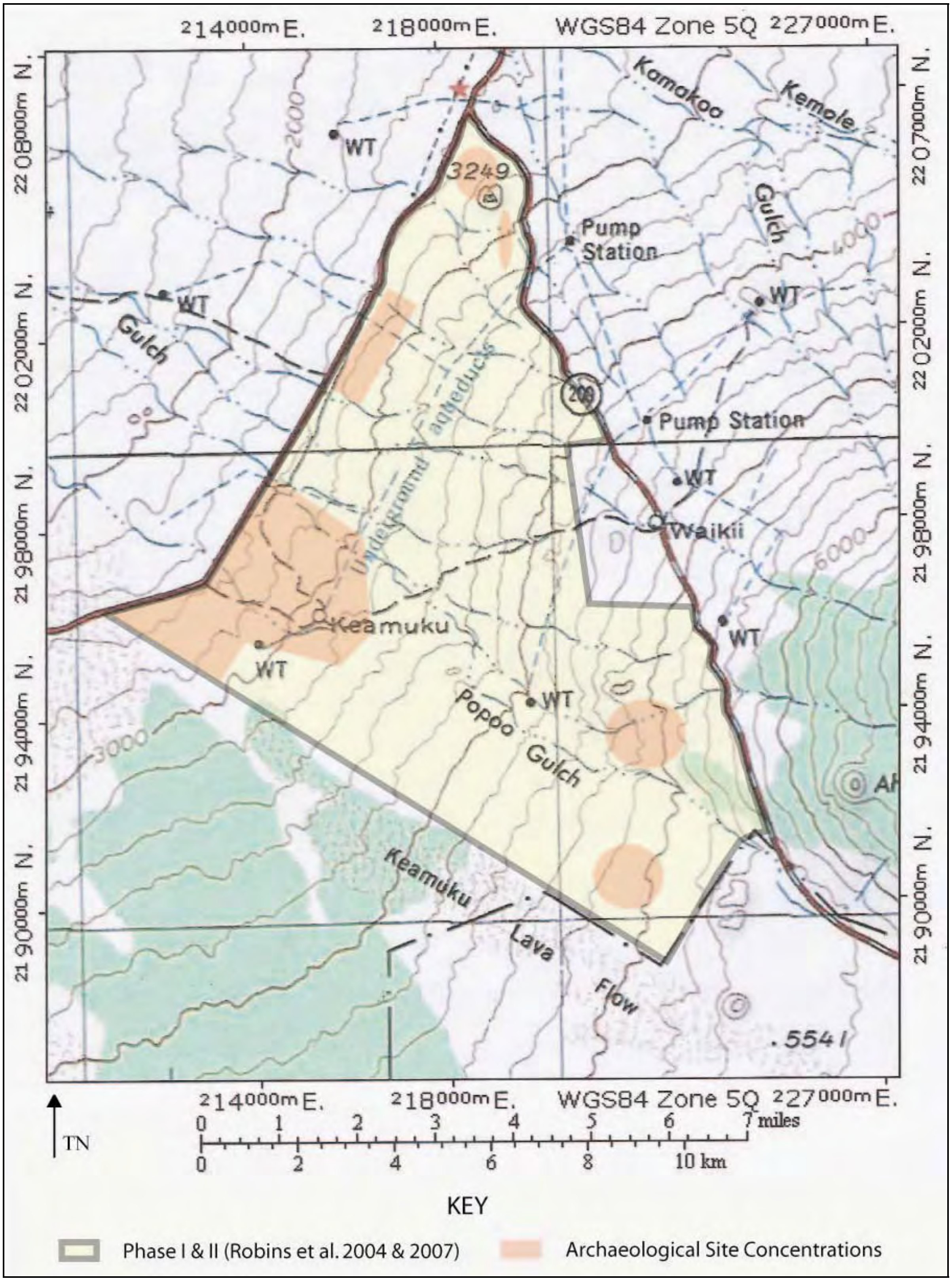

Figure 17: Archaeological Site Concentrations on the Keʻāmuku Station.

Phase II archaeological investigations at the Parker Ranch Keʻāmuku Station work and living area (Escott 2006; Johnson and Escott 2009 draft) suggest the station was first established during the mid-19th century as an early sheep ranching enterprise, combined with bullock hunting and the earliest attempts to domesticate wild cattle. Living quarters, processing facilities, walls, and corrals were constructed during this period. Early ranch layout, building construction techniques, material culture, and dietary regime suggest a synthesis of Hawaiian, Japanese, and Western cultures.

The sheep ranch facilities underwent further transformation and renovation after 1904 to accommodate cattle ranching, as reflected in the remains of fences, corrals, and dietary changes in the archaeological record. One of the major problems that confronted early ranchers at the Ke'āmuku Sheep and Cattle Station was the availability of water and changing rainfall patterns, both seasonally and annually. The ability to tap distant groundwater sources and to transport water to the ranch after 1908 enabled it to become one of the most fertile sections of Parker Ranch.

Features at the Ke'āmuku Sheep and Cattle Station were grouped into three activity areas: the Upper Corral Area, The Lower Corral Area, and the Ke'āmuku House Area. Excavations suggest that the Upper Corral Area was likely one of the earliest locations used at the ranch. The Lower Corral and Shear Barn Area was the processing center for sheep and cattle during the height of the ranching industry. The shear barn was later used to store saddle, tack, and tools after 1918 when the sheep were moved to the Humuʻula section of Parker Ranch.

EXPECTED ARCHAEOLOGICAL RESOURCES

Based on historical accounts, oral interviews, and previous archaeological studies, SCS expected that post-Contact rock mounds and other survey and boundary markers will be located within the study corridor. Although the land within the present study corridor has been previously surveyed (Robins *et al*. 2004), the thick cover of fountain grass might have concealed smaller features such as rock mounds. It is unlikely that larger features associated with ranching and habitation, such as rock walls, platforms and enclosures will be identified during the present study.

ARCHAEOLOGICAL INVENTORY SURVEY RESULTS

Three previously identified archaeological sites and four new sites were located in the present study corridor (Figure 18), including five rock mounds (SIHP Sites 50-10-21-23528, 50-10-21-26875, 50-10-21-26876, 50-10-21-26877, and 50-10-21-26878), a segment of the old Waimea-Kona Belt Road (SIHP Site 50-10-21-20855), and remnants of a ranching-era fence (SIHP Site 50-10-21-23452). Four of the rock mounds (Sites 23528, 26875, 26877, and 26878) correspond roughly to the boundary between the Keʻāmuku cattle station lands and ranch lands to the southwest. This area is also the boundary between Waikōloa and Puʻuanahulu *ahupuaʻa*. Site 26875 contained a Kalopa Soda Works bottle and a roll of galvanized fence wire in its construction. A fifth rock mound (Site 26878) appears to mark a possible hunting spot. Another rock mound (Site 26876) marks the intersection of two ranch roads along the southeast side of the Keʻāmuku cattle station lands. The ranching-era fence (Site 23452) appears to have been used early in the history of sheep and cattle ranching at Keʻāmuku. The original fence wire has been removed and it passes through the middle of several more recently fenced paddocks.

SITE 50-10-21-20855

FORM	Old Waimea-Kona Belt Road
FUNCTION:	Transportation
AGE:	Historic (1916-1922)
DIMENSIONS:	Length: 500.0m (E/W); Width: 6.0m; Height: 1.73m (max)
CONDITION:	Good
SURFACE ARTIFACTS:	None
EXCAVATION:	None

SITE 20855

Site 20855 is located at station 9+00, between the station left (LT) and station right (RT) boundary of the proposed corridor, at an elevation of 2,540ft (774m) amsl (see Figure 18). The site is the Old Waimea-Kona Belt Road surface and two causeways (Features 1 and 2). The road surface is oriented northeast/southwest, is approximately 4.0 meters wide, and is bare dirt. The road surface appears unaltered and is in good condition.

<u>Feature 1</u> is a causeway located along the east edge (Station 9+00 LT) of the study corridor (Figure 19). The road is constructed into the side of a northward sloping hill (Figure 20). Portion of the hillside south of the road have been removed to form a level road bed. The causeway is constructed under the north edge of the road to prevent it from collapsing down slope.

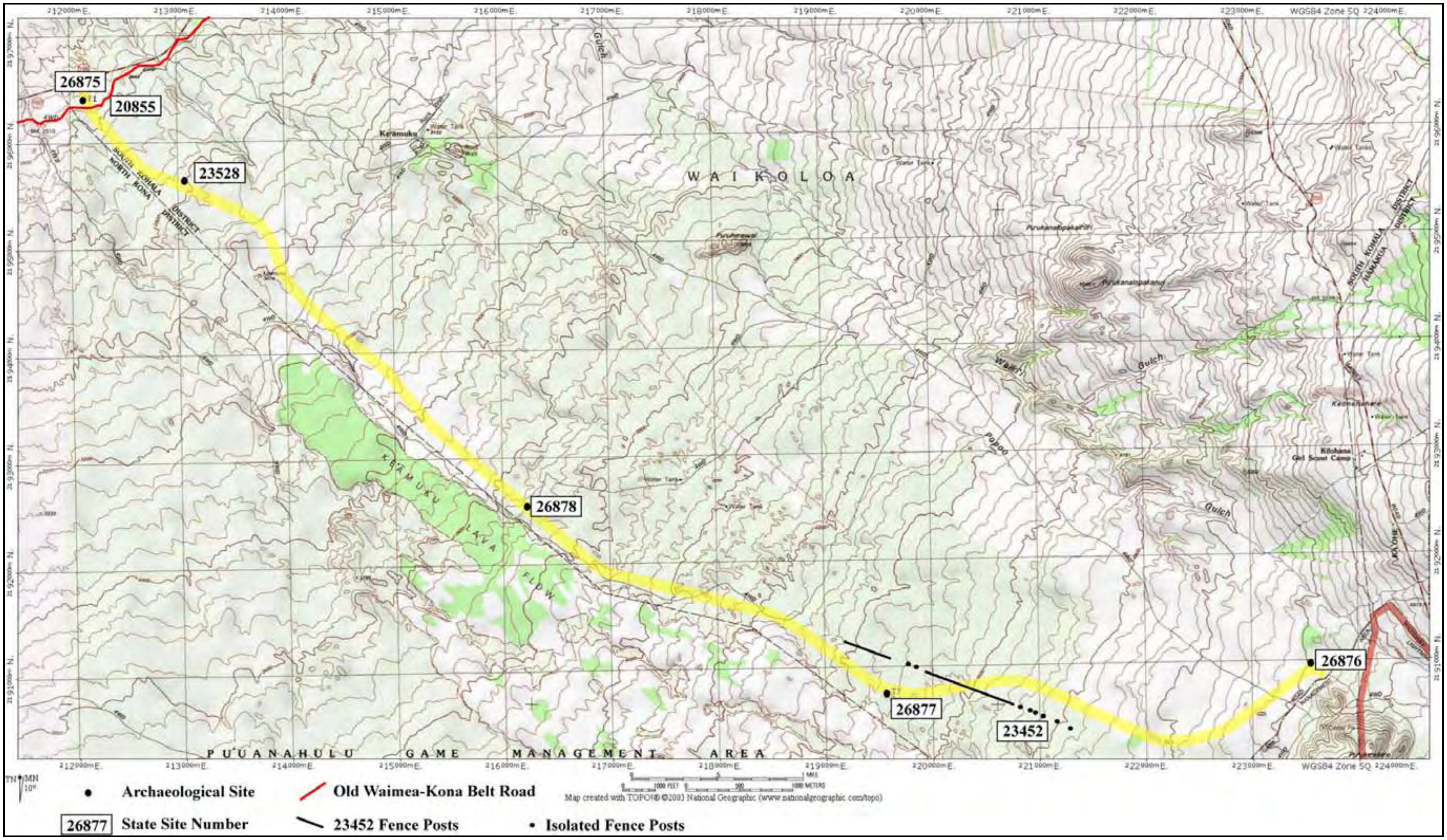

Figure 18: Location of Sites on USGS Topo Map.

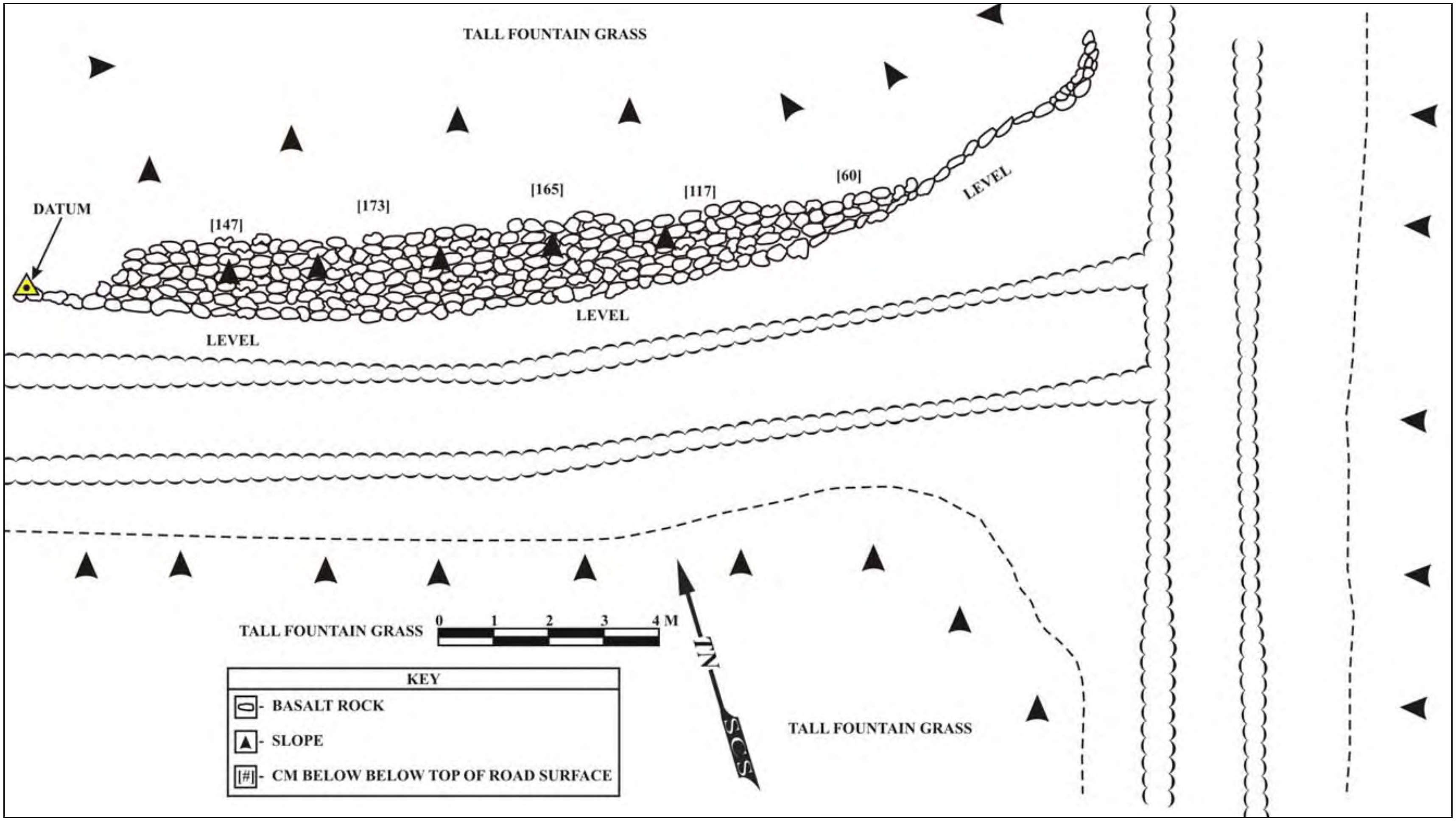

Figure 19: Site 20855 Feature 1 Planview.

Feature 1 is 20.40m long (east/west) by 6.0m wide, and is 1.73m high (maximum). The causeway is constructed of angular and subangular large cobbles and small boulders stacked one to six courses high along the north edge of the road (Figure 21). The rocks are well-fitted, well-faced, and slope outward away from the road edge (Figure 22). Feature 1 appears to be unaltered and is in good condition. Feature 1 is in the study corridor but is not in the proposed construction corridor, and will not be impacted by road construction.

Figure 20: Site 20855 Feature 1, View to East (1m scale).

Feature 2 is a causeway located along a two to three meter high elevation break at the west edge (Station 9+00 RT) of the study corridor (Figure 23). The causeway is constructed under the north edge of the road to prevent it from collapsing down slope. Feature 2 is approximately 50.0m long (east/west) by 6.0m wide, and is 1.50m high (maximum). The causeway is constructed of angular and subangular large cobbles and small boulders stacked one to eight courses high along the north edge of the road (Figure 24). The rocks are well-fitted, well-faced, and slope outward away from the road edge. There is a drainage culvert constructed under the road surface to allow water to pass under the road (Figure 25). The road surface is built up with pebbles and cobbles along its north edge (Figure 26). Feature 2 appears to be unaltered and is in good condition. Approximately 9.0m of Feature 2 are in the study corridor but not in the proposed construction corridor, and the causeway will not be impacted by road construction.

Figure 21: Site 20855 Feature 1, View to Southeast (1m scale).

Figure 22: Site 20855 Feature 1 Construction, View to Southeast (1m scale).

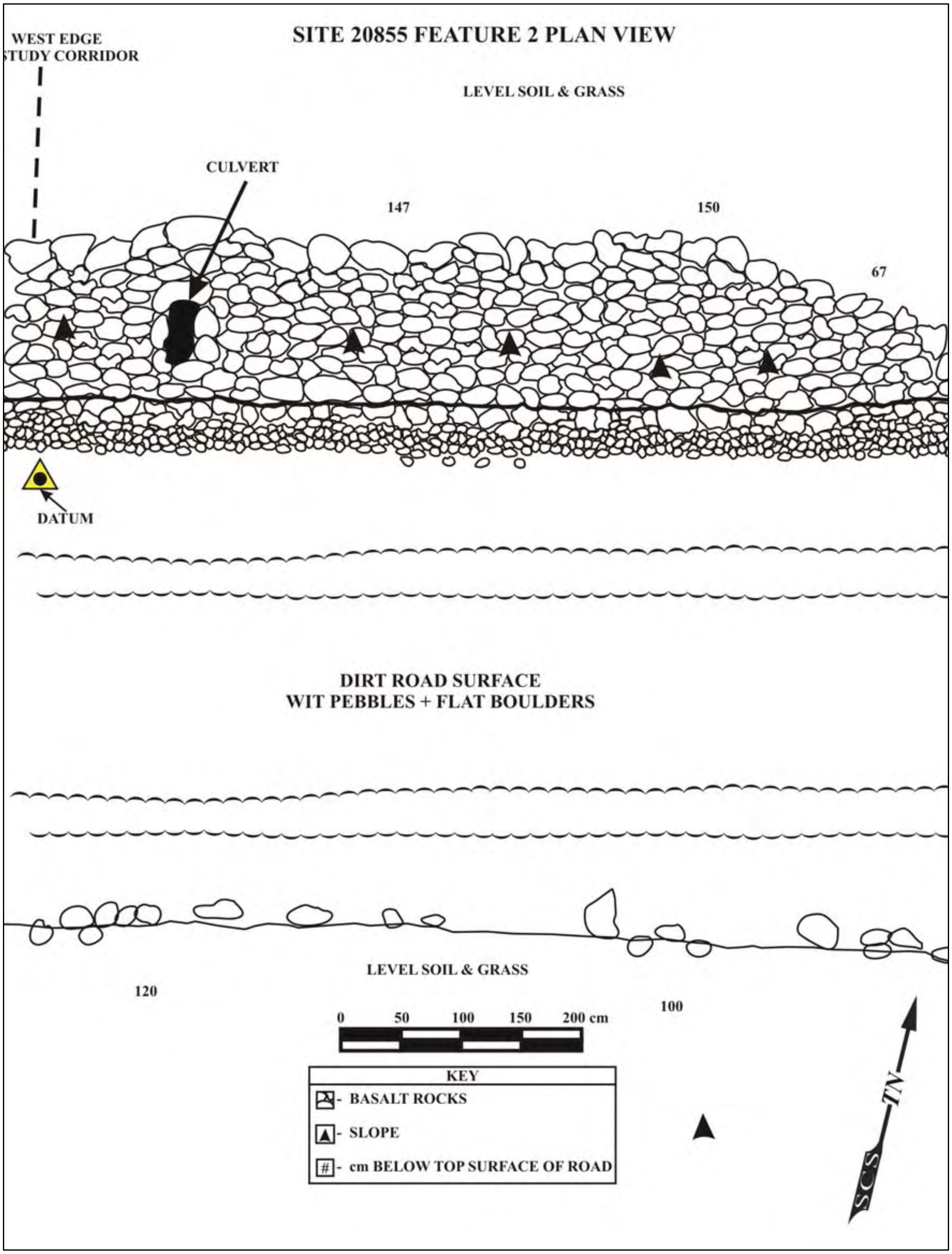

Figure 23: Site 20855, Feature 2 Planview.


Figure 24: Site 20855, Feature 2, View to Southwest (1m scale).


Figure 25: Site 20855, Feature 2 Culvert, View to South.


Figure 26: Site 20855, Feature 2 Road Surface, View to Southwest (20cm scale).

The original road was a wagon track, and this section of the Old Waimea-Kona Belt Road (Site 20855) was built on top of the wagon road in about 1920 (Langlas *et al*. 1999:81). The section of road documented in this study was constructed by prison laborers who were housed at a camp *makai* of the modern Saddle Road and Mamalahoa Highway intersection. Portions of the road east of Feature 1 up to the modern Saddle Road intersection were paved (*ibid*.). This portion is not paved. The Old Waimea-Kona Belt was approximately 63 km long. Numerous remnant segments of the road are evident on either side of the modern Mamalahoa Highway between Puʻuanahulu and Saddle Road.

Langlas recommended data recovery and interpretation for the portions of Site 20855 his study looked at (Langlas et al. 1999:147). An interpretive sign will be placed at a pull out constructed by the site near Features 1 and Feature 2 though they are outside of the construction corridor. Monitoring is recommended along the entire length of the proposed construction corridor during ground disturbance activities associated with this project.

SITE 50-10-21-23452

FORM	Fence Posts
FUNCTION:	Boundary marker/Fence in Ranch Animals
AGE:	Historic
DIMENSIONS:	Length: 0.9m (E/W); Width: 0.8m; Height: 0.65m (max)
CONDITION:	Fair
SURFACE ARTIFACTS:	None
EXCAVATION:	None

SITE 23452 (Previously Recorded by PTA Cultural Resources Staff)

Site 23452 is a remnant segment of ranching-era fence posts situated at 110˚/290˚ and located between station 339+00 LT and station 349+00 RT at an elevation of roughly 4,600 ft (1,402m) amsl (see Figure 18). The documented segments of the fence line are situated from the eastern boundary of the U.S. Army Pōhakuloa Training Area (PTA) to an area west of the current study corridor within the Keʻāmuku property (Figure 27).

The segment of fence line that crosses the present study corridor consists of fence posts of cut natural logs, either whole or halved, or quartered, and set into the ground surface. The log posts vary from 15cm to 20cm in diameter, and are roughly 120cm to 140cm above the modern ground surface (Figures 28, and 29). The fence wire has been removed, but there are some heavy gauge galvanized metal staples in the posts, that once held the wire to the posts. There are twenty fence posts standing in the study corridor and one post in the corridor that has fallen down.

Site 23452 is documented in many places within PTA, where it is in better condition. In some places along the fence line on PTA, there are signs stating that the fence marks the boundary of a game management area and no hunting is allowed. It is possible that the fence is related to early attempts to fence in cattle within owned property to keep them separate from the King's cattle. It might have later been used to separate private sheep and cattle land from state owned land (a game management area) to the south.

The fence line within the study corridor no longer has any wire and consists of fence posts only. It has been altered by ranching activity and is in poor condition.

Figure 27: Location of Site 23452 Fence Remnants on USGS Topo.

Figure 28: Site 23452 Representative Fence Post 1.

Figure 29: Site 23452 Representative Fence Post 2.

SITE 50-10-21-23528

FORM	Circular Rock mound
FUNCTION:	Boundary marker
AGE:	Historic
DIMENSIONS:	Length: 0.9m (E/W); Width: 0.8m; Height: 0.65m (max)
CONDITION:	Fair
SURFACE ARTIFACTS:	None
EXCAVATION:	None

SITE 23528 (Previously Recorded, Robins *et al*. 2004)

Site 23528 is located at station 48+00, between the centerline (CL) and the left (LT) boundary of the proposed corridor, at an elevation of 2,862ft (872.3m) amsl (see Figure 18). The site consists of a single circular rock mound situated at the top of a low ridge oriented 140˚ /320˚ (Figure 30 and 31). The ridge is approximately 15 to 20ft (4.5 to 6.0m) above the surrounding ground surface, in an area of rolling ridges and knolls with no panoramic view. The ridge surface is predominantly silt, with intermittent bedrock outcrops. The rock mound measures 0.9m (E/W) by 0.8m, is 0.65m in height, and is constructed of a large cobble and four small boulders stacked two courses high on a small boulder bedrock outcrop (Figure 32). The rock mound appears to be unaltered and is in good condition.

Figure 30: Site 23528, View to Northeast (20cm scale).

Site 23528 is in close proximity to several rock mounds along the southwest property boundary (Figure 33). Sites 23491, 23468 (not shown in Figure 33), 23513, 23514, 23528, 23529, 23530, 23531, 23532, 23533, 23536, 23537, 23538, 26875, 26876, and 26878 are either right along the southwest property boundary to roughly 500m northeast of it. This property boundary is also the boundary between Waikōloa and Puʻuanahulu ahupuaʻa, and North Kona and South Kohala. It is most likely that the rock mounds are the result of several early Historic to late Historic efforts to survey and record and mark these boundaries.

Figure 31: Site 23528, View to South (20cm scale).

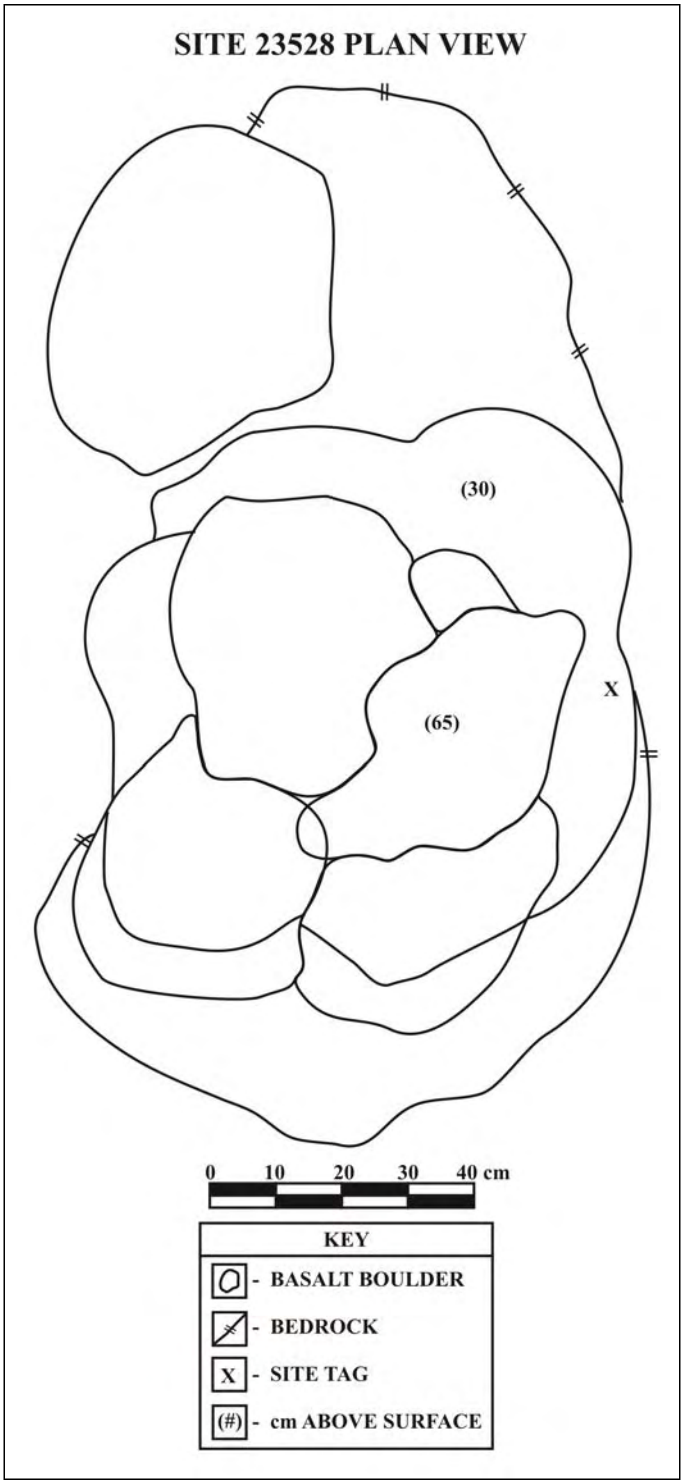

Figure 32: Site 23528 Planview.

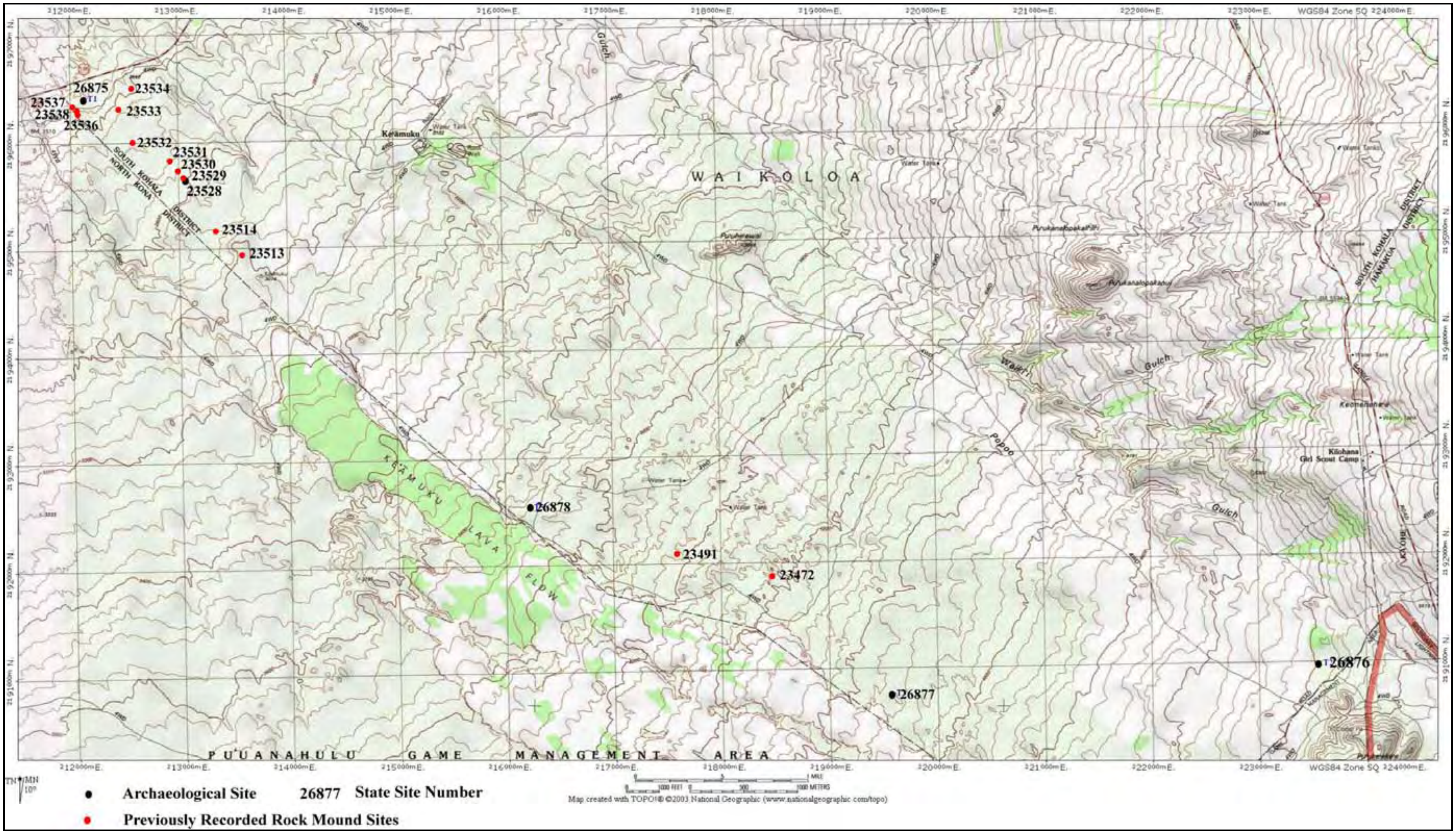

Figure 33: Rock Mound Boundary Sites Along SW Boundary of Ke'āmuku Parcel.

SITE 50-10-21-26875

FORM	Circular Rock mound
FUNCTION:	Boundary marker
AGE:	Historic
DIMENSIONS:	Length: 1.64m (56˚/236˚); Width: 1.30 m; Height: 0.58m (max)
CONDITION:	Fair
SURFACE ARTIFACTS:	Fence wire
EXCAVATION:	1m by 1m test-unit

Site 26875 (SCS Temporary Site 1)

Site 26875 is located 15.5m at 153˚ from station 6+00 RT, at an elevation of 2,530ft (771m) amsl (see Figure 18). The site consists of a circular rock mound situated at the top of a ridge (Figure 34). The ridge is approximately 100ft (30.48m) above the surrounding ground surface and is oriented 160˚/340˚. The rock mound measures approximately 1.64m (56˚/236˚) by 1.30m, and is 0.58m in height (Figure 35). It is constructed of a small subangular boulder resting on four small boulders of lesser size. The top boulder measures 0.59m x 0.42m. Directly beneath it along its northern periphery is a short roll of 1/8 inch heavy gauge galvanized fence wire (Figure 36).

Figure 34: Site 26875, View to East (20cm scale).

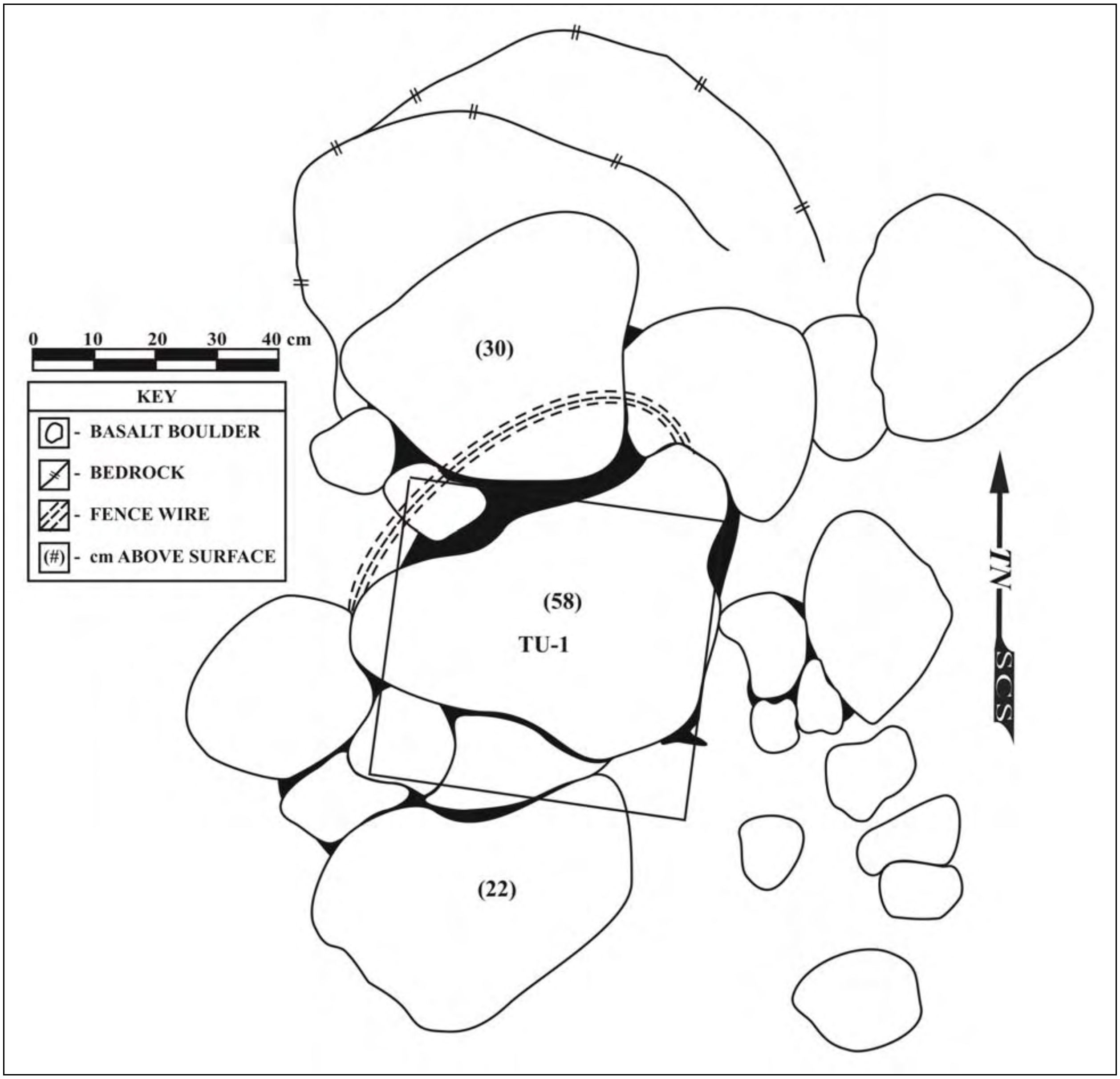

Figure 35: Site 23875 Planview.

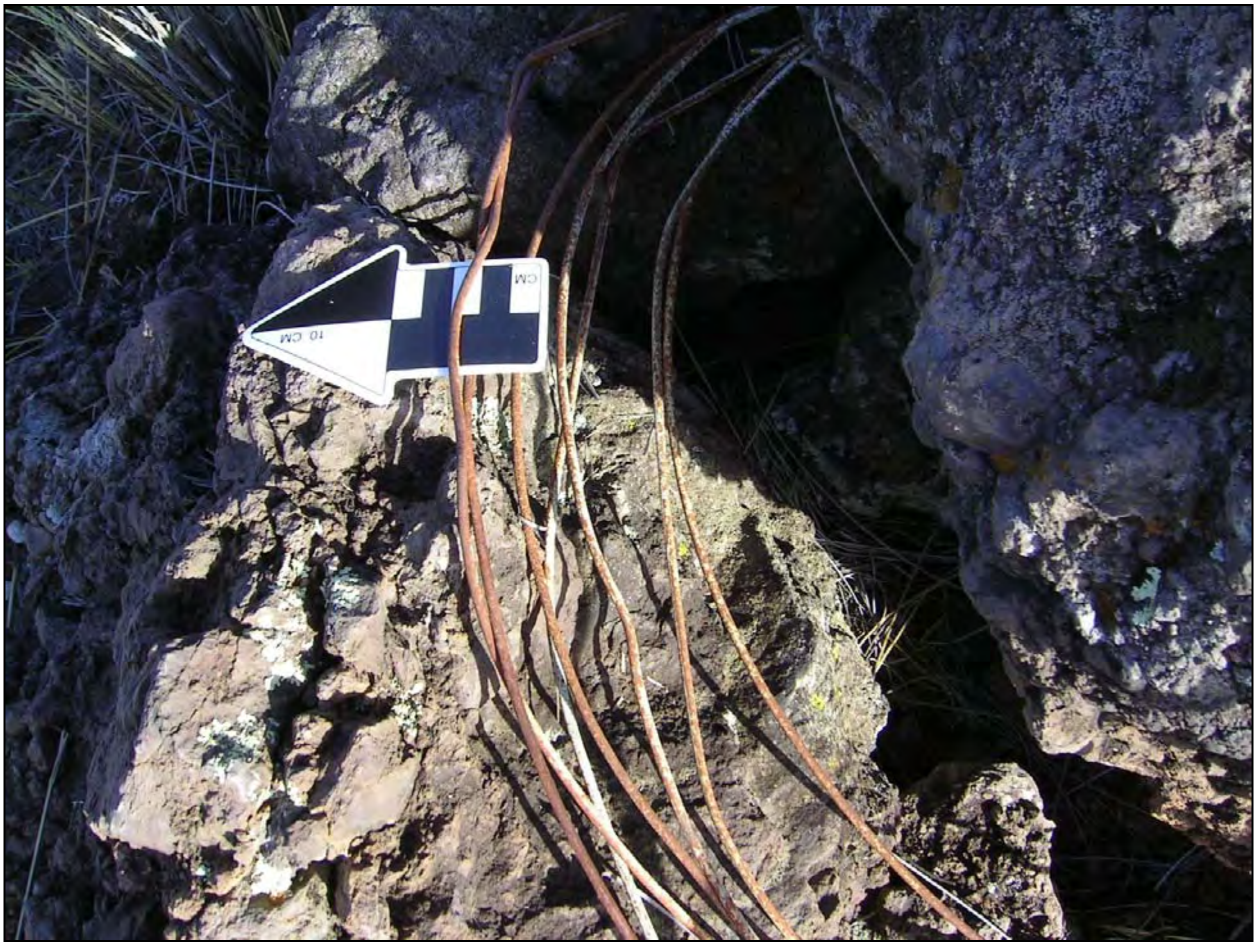

Figure 36: Site 26875 Close Up of Fence Wire, View to East (20cm scale).

Site 26875 Test-Unit 1 Excavation Description

A single 50cm by 50cm test-unit (TU-1) was excavated in the center of the rock mound at Site 26875. TU-1 contained an architectural layer and three stratigraphic layers, was excavated as six roughly 10cm levels, and terminated on bedrock at 50cm below the modern ground surface (Figure 37).

Architectural Layer (0-58cm above modern ground surface) contained five angular and subangular basalt small boulders resting approximately 5cm deep in loose sandy silt (Layer I). A rolled up length of heavy gauge galvanized fence wire and a Kalopa Soda Works bottle (Figure 38) were recorded in the Architectural Layer.

Layer I/1 (0-10cmbs) was very dark grayish brown (10YR3/2) loose, aeolian sand and silt with five angular and subangular basalt small cobbles and pebbles, and 1% small grass roots. Layer I did not contain cultural material.

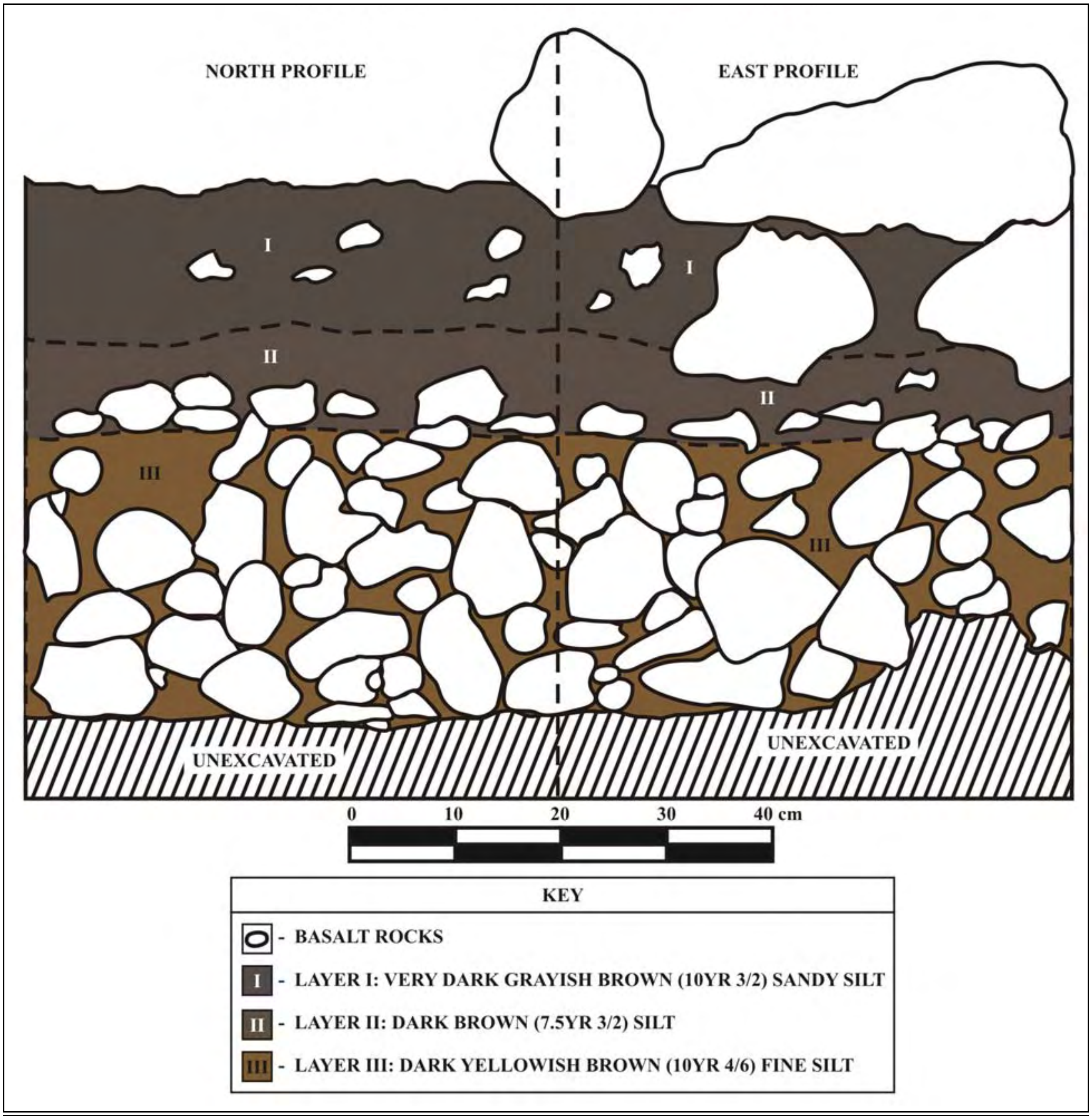

Figure 37: Site 26875, Feature 1, Test-Unit 1 North and East Profiles.

Layer I/2 (10-15cmbs) was similar to Layer I/1 and did not contain cultural material.

Layer II/1 (15-25cmbs) was dark brown (7.5YR3/2) loose to soft, coarse to fine sand and silt with 30% small to large angular and subangular basalt cobbles and 10% small grass roots. Layer II/1 did not contain cultural material.

Figure 38: Kalopa Soda Works Bottle (TU-1).

Layer III/1 (25-35cmbs) was very dark yellowish brown (10YR4/6) soft, fine sandy silt with 50% small to large angular and subangular basalt cobbles and 5% small grass roots. The basalt cobbles appear to be the top of an ‘a‘a lava flow. Layer III/1 did not contain cultural material.

Layer III/2 (35-45cmbs) was similar to Layer III/1 and did not contain cultural material.

Layer III/3 (45-50cmbs) was similar to Layer III/2 material and is predominantly ‘a‘a lava bedrock with a small amount (25%) of dark yellowish brown silt. Layer III/3 did not contain artifacts and terminated on bedrock.

Site 26875 Summary

A length of fence wire and a Kalopa Soda Works bottle were the only artifacts recovered from Site 26875, TU-1. The bottle is an automatic bottle mchine (ABM) type bottle likely manufactured after 1920. The rocks that make up the architecture of the rock mound appear to be roughly 5cm to 7cm below the modern ground surface. The small amount of deposition and the historic artifacts indicate that the rock mound was constructed during the Historic era.

Site 26875 is in close proximity to several rock mounds along the southwest property boundary (see Figure 33). Sites 23491, 23468 (not shown in Figure 33), 23513, 23514, 23528, 23529, 23530, 23531, 23532, 23533, 23536, 23537, 23538, 26875, 26876, and 26878 are either right along the southwest property boundary to roughly 500m northeast of it. This property boundary is also the boundary between Waikōloa and Pu‘uanahulu ahupua‘a, and North Kona and South Kohala. It is most likely that the rock mounds are the result of several early Historic to late Historic efforts to survey and record and mark these boundaries.

SITE 50-10-21-26876

FORM	Rectangular Rock mound
FUNCTION:	Marker
AGE:	Historic
DIMENSIONS:	Length: 2.0m (E/W); Width: 1.5m; Height: 0.75m (max)
CONDITION:	Fair
SURFACE ARTIFACTS:	None
EXCAVATION:	1m by 1m test-unit

SITE 26876 (Temporary Site 2)

Site 26876 is located 45.0m at 234˚ from station 460+00 LT, at an elevation of 5,200ft (1584.96m) amsl (see Figure 18). The site consists of a single rock mound situated on a low rise at the east (*mauka*) edge of a relatively level swale area within close proximity to three modern ranch roads (Figure 39). The rise is approximately 20m (E/W) by 10m, and 1to 2m in height.

Figure 39: Site 26876, Feature 1 Rock Mound, View to Northeast (10cm scale).

The swale surface is composed predominantly of loose silt with intermittent bedrock outcrops. Fountain grass and *‘a‘āli‘i* are also present. The rock mound measures approximately 2.0m (E/W) by 1.5m and is 0.75m in height (Figure 40). It is constructed of angular slabby *pahoehoe* large cobbles and small boulders piled on the ground with no formal construction elements. There is no formal stacking or facing evident in the rock mound construction. The slabby *pahoehoe* rocks are piled onto a segment of bedrock outcrop measuring 1.9m in length and 0.55m above the surrounding ground surface.

Site 26876 Test-Unit 1 Excavation Description

A single 1.0m by 1.0m test-unit (TU-1) was excavated in the center of the rock mound at Site 26876. TU-1 contained an architectural layer and five stratigraphic layers, was excavated as eleven roughly 10cm levels, and terminated on bedrock at 110cm below the modern ground surface (Figure 41).

Architectural Layer (0-75cm above modern ground surface) contained angular slabby basalt small boulders and large cobbles resting approximately 5cm to 7cm deep in loose sandy silt (Layer I). No artifacts or cultural material was recovered from the architectural layer.

Layer I (0-4cmbs) was very dark grayish brown (10YR2/2) loose, coarse aeolian sand and organic detritus with 5% small angular and subangular basalt cobbles and 1% small grass roots. Layer I is an “O” Horizon organic duff material. Layer I did not contain cultural material.

Layer II/1 (4-15cmbs) was very dark brown (10YR2/2) soft, coarse to fine sand and silt with 40% small to large angular and subangular basalt cobbles and 10% small grass roots. The base of the rock mound terminated at roughly 8cmbs in Layer II/1. Layer II/1 did not contain cultural material.

Layer II/2 (15-25cmbs) was similar to Layer II/1 and contained only 60% small to large angular and subangular basalt cobbles and 5% small grass roots. Layer II/2 did not contain cultural material.

Layer III/1 (25-35cmbs) was dark brown (7.5YR3/4) soft, fine sandy silt with 70% small to large angular and subangular basalt cobbles and 1% small grass roots. Layer III/1 did not contain cultural material.

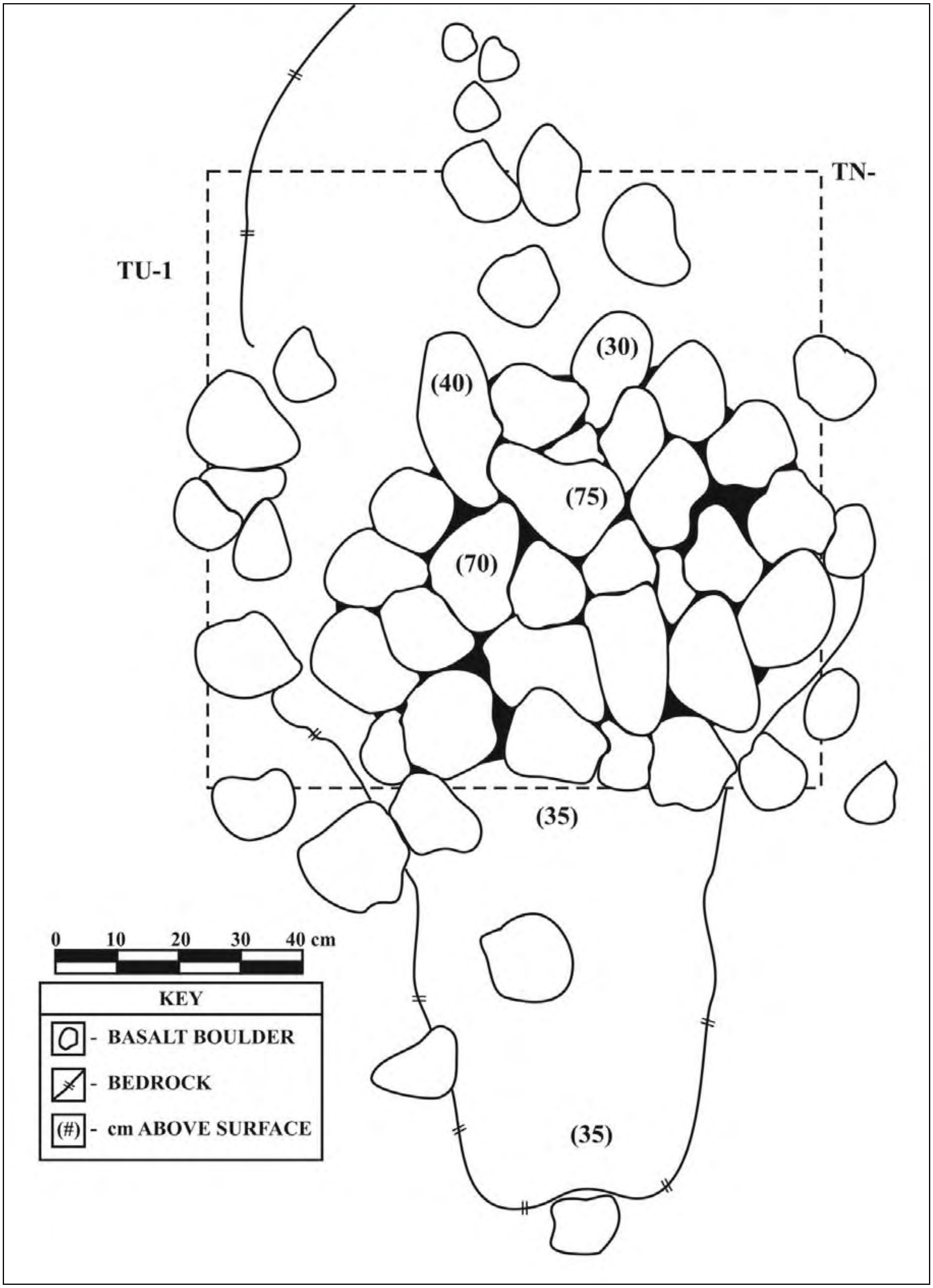

Figure 40: Site 26876, Feature 1 Planview.

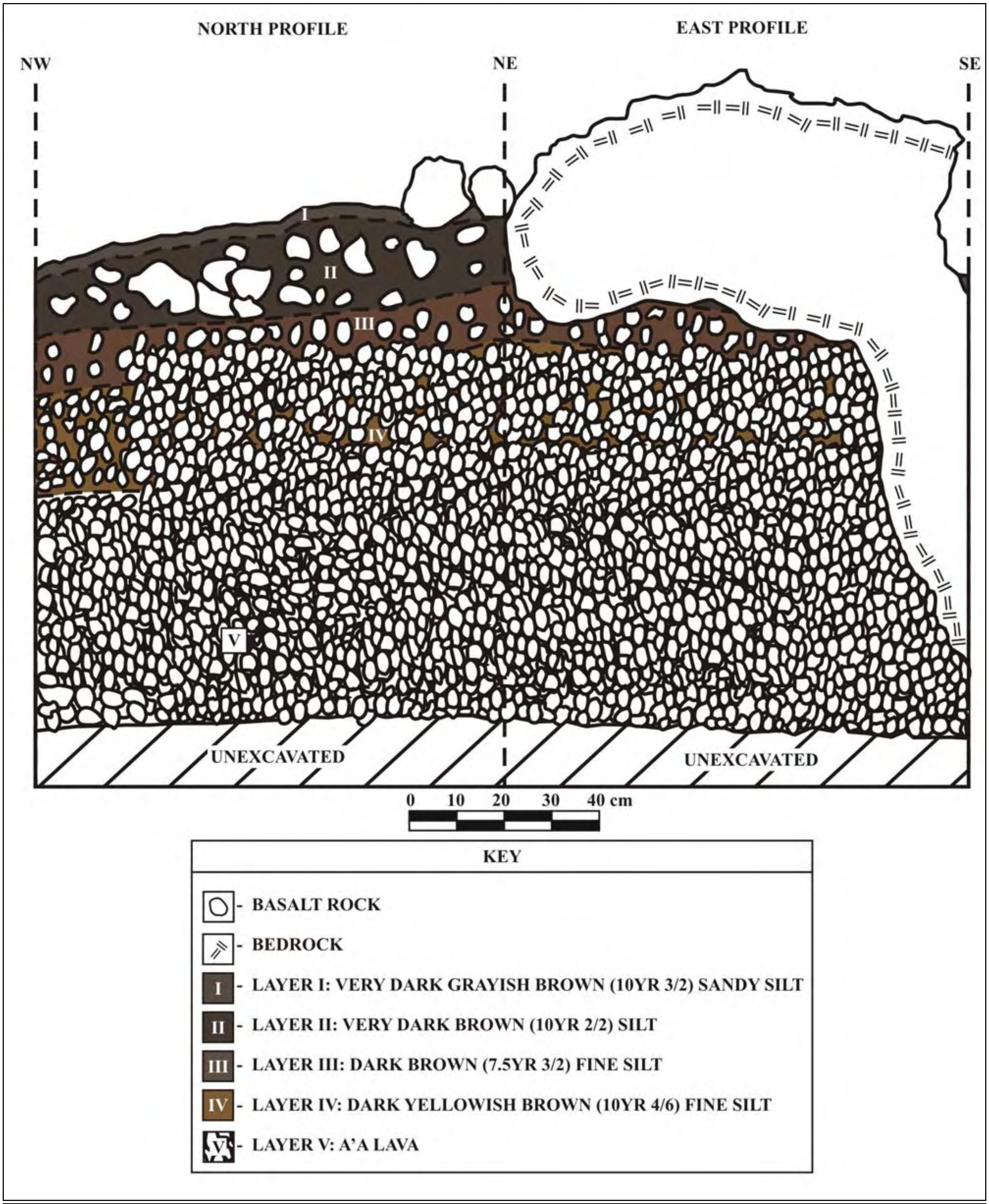

Figure 41: Site 26876, Feature 1, TU-1 North and East Profiles.

Layer IV/1 (35-45cmbs) was dark yellowish brown (10YR4/6) soft, very fine sandy silt with 81% small to large angular and subangular basalt cobbles and pebbles, and no roots. Layer IV/1 did not contain artifacts.

Layer IV/2 (45-55cmbs) was similar in composition to Layer IV/1 and did not contain artifacts.

Layer V (55-110cmbs) was 100% *'a'a* lava flow bedrock excavated in five 10 cm levels. Layer V did not contain any sediment, did not contain artifacts, and terminated on bedrock.

Site 26876 Summary

The rock mound at Site 26876 appears to be a ranch feature associated with the three dirt ranch roads that intersect nearby. The rock mound is located on a low rise visible from two of the ranch roads near where they intersect. It is possible it marks that intersection. The rock mound does not appear to be altered and is in good condition.

SITE 50-10-21-26877

FORM	Rectangular Rock mound
FUNCTION:	Boundary marker
AGE:	Historic
DIMENSIONS:	Length: 1.04m (E/W); Width: 0.9m; Height: 0.6m (max)
CONDITION:	Fair
SURFACE ARTIFACTS:	None
EXCAVATION:	1m by 1m test-unit

SITE 26877 (Temporary Site 3)

Site 26877 is located 85m at 300 ˚ from station 324+00 CL, at an elevation of 4,500ft (1371.6m) amsl (see Figure 18). The site consists of a single rock mound at the top of a hill (Figure 42). The hill measures approximately 100m (N/S) by 25m and is 15m in height. The mound is situated near the peak of the hill, and is most visible from the west (*makai*), and the east (*mauka*), but is less visible from the north. The rock mound measures 1.04m (E/W) by 0.9m and is 0.6m in height (Figure 43). It is composed predominantly of small boulders with a few large cobbles filling in the gaps, and although there is no stacking or facing it is relatively well constructed. The mound rests on a boulder bedrock outcrop.

Figure 42: Site 26877, Feature 1, View to NE.

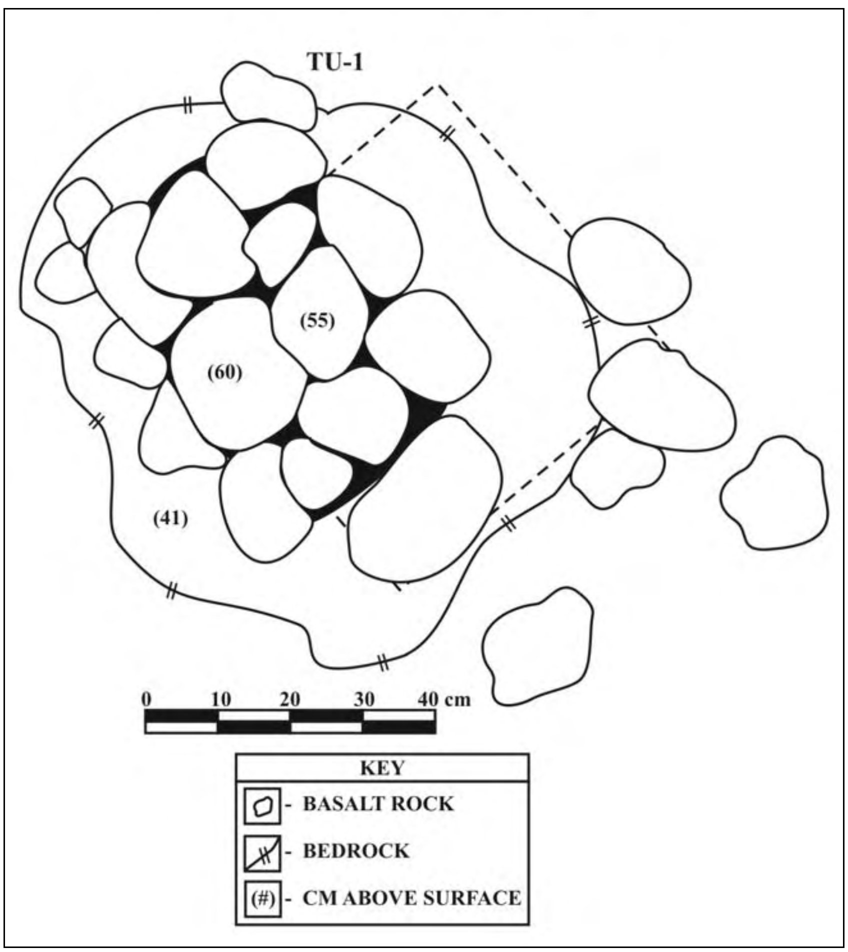

Figure 43: Site 26877, Feature 1 Planview.

Site 26877 Test-Unit 1 Excavation Description

A single 50cm by 50cm test-unit (TU-1) was excavated in the center of the rock mound at Site 26877. TU-1 contained an architectural layer and three stratigraphic layers, and terminated on bedrock at 25cm below the modern ground surface (Figure 44).

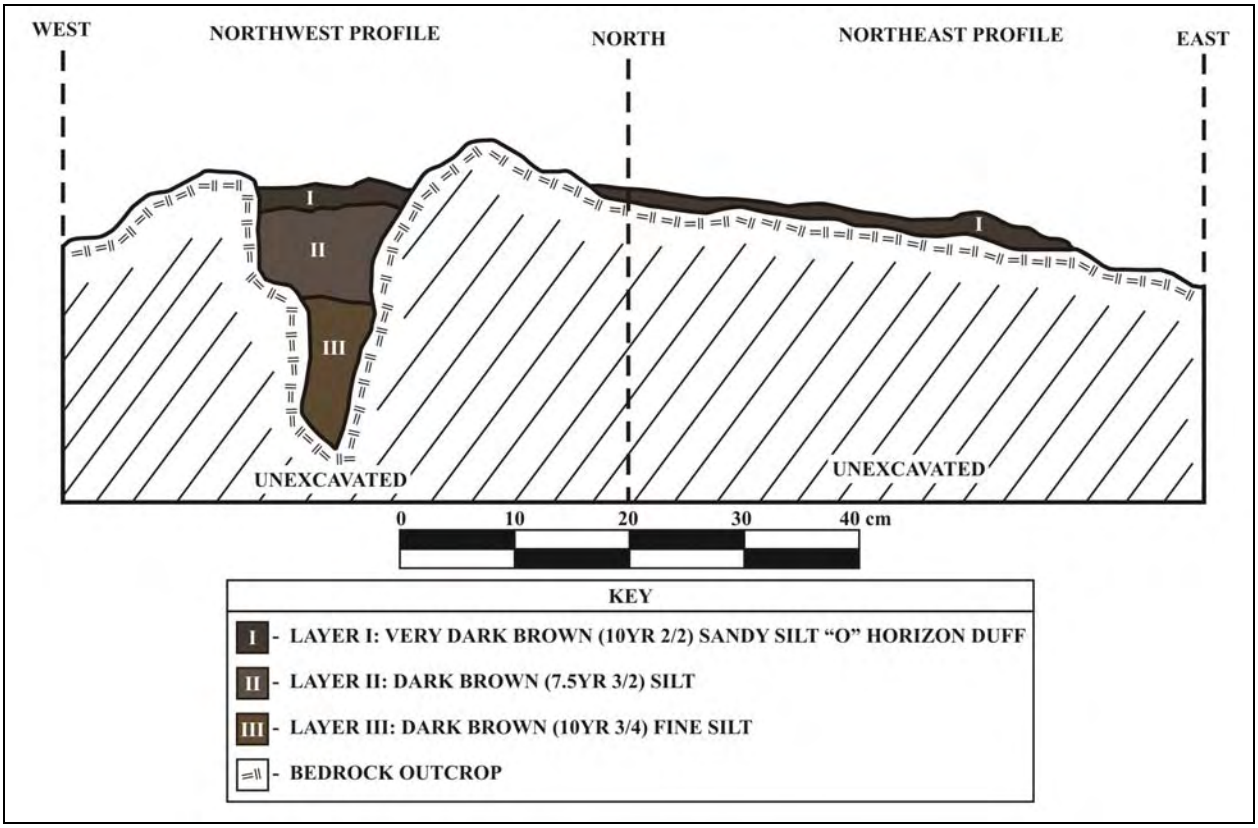

Figure 44: Site 26877, Feature 1, TU-1 Northwest and Northeast Profiles.

Architectural Layer (0-60cm above modern ground surface) contained 14 angular and subangular basalt small boulders and large cobbles resting approximately 5cm deep in loose sandy silt (Layer I) on a bedrock outcrop. The Architectural Layer did not contain artifacts.

Layer I (0-2cmbs) was very dark grayish brown (10YR2/2) loose, aeolian sand and organic detritus with no inclusions or roots. Layer I was a classic "O" Horizon and did not contain cultural material. Layer I terminated at the top of a boulder bedrock outcrop in TU-1, except for the presence of a Layer II material in a northwest/southeast oriented crevice through the center of the bedrock boulder.

Layer II (2-10cmbs) was dark brown (7.5YR3/2) loose to soft, fine sand and silt with no inclusions and no roots. Layer II did not contain cultural material.

Layer III (10-25cmbs) was dark brown (10YR3/4) soft, fine silt with no inclusions and no roots. Layer III/1 did not contain cultural material and terminated on bedrock.

Site 26877 Summary

Site 26877 is in close proximity to several rock mounds along the southwest property boundary (see Figure 33). Sites 23491, 23468 (not shown in Figure 33), 23513, 23514, 23528, 23529, 23530, 23531, 23532, 23533, 23536, 23537, 23538, 26875, 26876, and 26878 are either right along the southwest property boundary to roughly 500m northeast of it. This property boundary is also the boundary between Waikōloa and Puʻuanahulu ahupuaʻa, and North Kona and South Kohala. It is most likely that the rock mounds are the result of several early Historic to late Historic efforts to survey and record and mark these boundaries.

SITE 50-10-21-26878

FORM	Oval Rock mound
FUNCTION:	Boundary marker
AGE:	Historic
DIMENSIONS:	Length: 1.25m (140˚/320˚); Width: 1.0m; Height: 0.45m (max)
CONDITION:	Fair
SURFACE ARTIFACTS:	Modern trash
EXCAVATION:	1m by 1m test-unit

Site26878 (Temporary Site 5)

Site26878 is located 13m at 60˚ from station 195+00CL, at an elevation of 3700ft (1127.76m) amsl (see Figure 18). The site consists of a single rock mound at the top of a hill (Figure 45). The hill is 15 to 20m high with unobstructed views in all directions (Figure 46). The rock mound is situated near the western perimeter of the hill top, within close proximity to two olive trees. The rock mound measures 1.25m (140˚/320˚) by 1.0m and is 0.45m in height (Figure 47). It is constructed of angular and subangular large cobbles and small boulders, loosely piled (two courses high) on a bedrock outcrop. The mound has the appearance of having been disturbed by ungulates and humans, an indication that at one time it may have been greater in height. An abundance of trash, i.e. food, beverage and tobacco containers are present on the ground surface immediately west of the rock mound.


Figure 45: Site 26878, View to West (10cm scale).


Figure 46: View to West from Site 26878 Hillside.

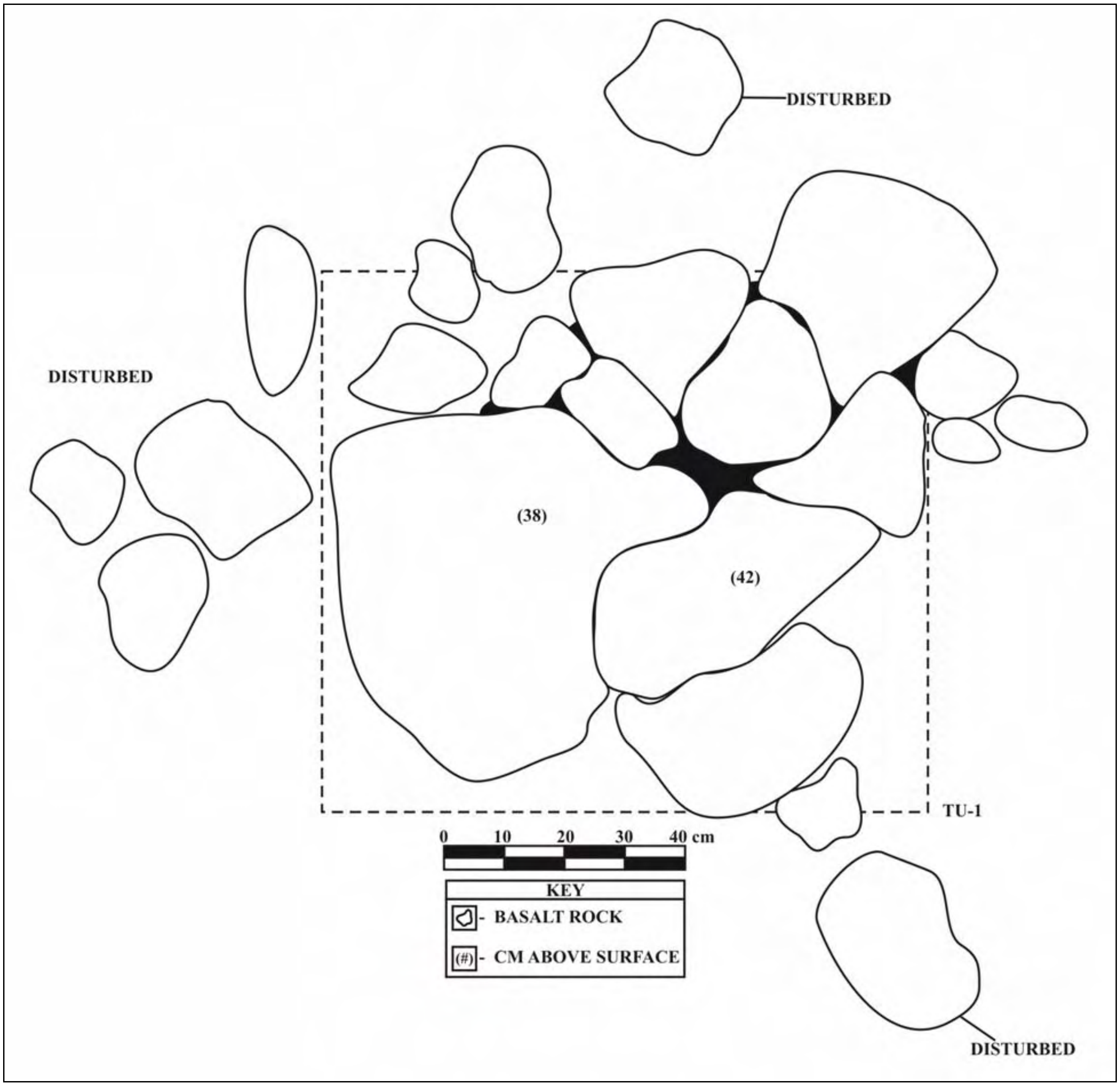

Figure 47: Site 26878 Planview.

Site 26878 Test-Unit 1 Excavation Description

A single 1.0m by 1.0m test-unit (TU-1) was excavated in the center of the rock mound at Site 26878. TU-1 contained an architectural layer and three stratigraphic layers, and terminated on bedrock at 30cm below the modern ground surface (Figure 48).

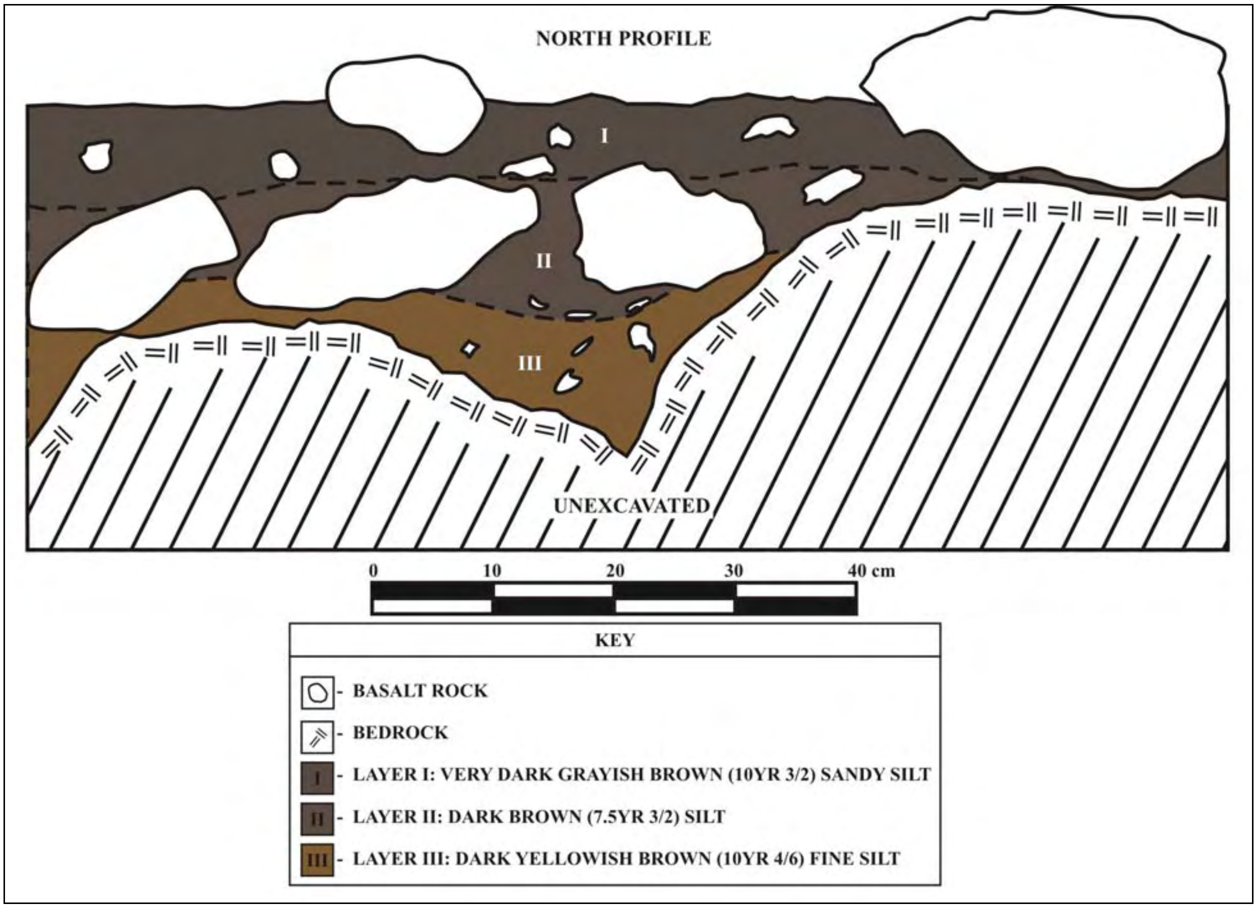

Figure 48: Site 26878, Feature 1, TU-1 North Profile.

Architectural Layer (0-42cm above modern ground surface) contained seven angular and subangular basalt small boulders and large cobbles resting approximately 5cm to 7cm deep in loose sandy silt (Layer I). The Architectural Layer did not contain artifacts.

Layer I (0-10cmbs) was very dark grayish brown (10YR2/2) loose, aeolian sand and fine silt with 10% pebbles and small cobbles, and 20% fine grass roots. Layer I did not contain cultural material.

Layer II (10-20cmbs) was dark brown (7.5YR3/2) loose, fine sand and silt with 30% pebbles to large cobbles and 10% fine grass roots. Layer II did not contain cultural material.

Layer III (20-30cmbs) was dark yellowish brown (10YR4/6) soft, fine silt with 30% pebbles to large cobbles and 10% fine grass roots Layer III/1 did not contain cultural material and terminated on bedrock.

Site 26878 Summary

Site 26878 is in close proximity to several rock mounds along the southwest property boundary (see Figure 33). Sites 23491, 23468 (not shown in Figure 33), 23513, 23514, 23528, 23529, 23530, 23531, 23532, 23533, 23536, 23537, 23538, 26875, 26876, and 26878 are either right along the southwest property boundary to roughly 500m northeast of it. This property boundary is also the boundary between Waikōloa and Puʻuanahulu ahupuaʻa, and North Kona and South Kohala. It is most likely that the rock mounds are the result of several early Historic to late Historic efforts to survey and record and mark these boundaries.

There was also a moderate amount of modern trash (soda and food cans, and a plastic snuff tobacco tin) scattered on the ground surface at the site. It is likely that the area was used as a hunting spot, and/or lunch spot in the recent past. The hillside allows good views to the west and the two olive trees provide shade and cover.

CONCLUSION

Three previously identified archaeological sites and four new sites were located in the present study corridor, including five rock mounds (SIHP Sites 50-10-21-23528, 50-10-21-26875, 50-10-21-26876, 50-10-21-26877, and 50-10-21-26878), a segment of the old Waimea-Kona Belt Road (SIHP Site 50-10-21-20855), and remnants of a ranching-era fence (SIHP Site 50-10-21-23452). Four of the rock mounds (Sites 23528, 26875, 26877, and 26878) correspond roughly to the boundary between the Keʻāmuku cattle station lands and ranch lands to the southwest. This area is also the boundary between Waikōloa and Puʻuanahulu *ahupuaʻa*. Site 26875 contained a Kalopa Soda Works bottle and a roll of galvanized fence wire in its construction. The rock mound at Site 26878 appears to also mark a possible hunting spot. A fifth rock mound (Site 26876) marks the intersection of two ranch roads along the southeast side of the Keʻāmuku cattle station lands. The ranching-era fence (Site 23452) appears to have been used early in the history of sheep and cattle ranching at Keʻāmuku. The original fence wire has been removed and it passes through the middle of several more recently fenced paddocks.

DISCUSSION

All of the sites recorded within the current study area corridor are Historic era ranching features, and a road. They are primarily boundary markers (rock mounds and a fence line). This makes sense since they are located along the edge of a traditional boundaries—that of private land divisions between Parker Ranch land and the Hind family ranch to the south; the boundary between North Kona and South Kohala: and the boundary between Waikoloa and Puʻuanahulu *ahupuaʻa*. The rock mounds, and even fence Site 23452, are roughly from along the modern boundary up to 500m north of the modern boundary. Given methods of surveying during the mid 1800s to early 1900s these differences are not unexpected. The single archaeological site unrelated to ranching is the Old Waimea-Kona Belt Road built in the 1920s.

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SADDLE ROAD (STATE ROUTE 200)
Mamalahoa Highway (State Route 190) to Milepost 42
County of Hawai‘i, State of Hawai‘i
FHWA Project No. 200(00)

SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT

Submitted Pursuant to Section 42 U.S.C. 4332(2)(c)
and Chapter 343, Hawai‘i Revised Statutes by the

U.S. DEPARTMENT OF TRANSPORTATION
Federal Highway Administration (FHWA)
Central Federal Lands Highway Division
and
STATE OF HAWAI‘I
Department of Transportation (HDOT)
Highways Division

Cooperating Agencies
U.S. Army Garrison, Hawai‘i

Appendix F2
Section 106 Correspondence and List of Section 106 Consulted Parties

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U.S. Department of Transportation
Federal Highway Administration

Central Federal Lands Highway Division

12300 West Dakota Avenue
Lakewood, CO 80228

October 26, 2009

In Reply Refer To:
HFPD-16

Ms. Theresa Donham
State Historic Preservation Division
40 Po'okela Street
Hilo, HI 96720

Dear Ms. Donham:

We are contacting you at this time to continue consultation on the Saddle Road (SR 200) highway improvement project. As you know the Federal Highway Administration (FHWA) and the Hawaii Department of Transportation (HDOT), with the cooperation of the Department of the Army, plans to reconstruct and pave Saddle Road from the Mamalahoa Highway (SR 190) easterly to mile post 6 of Saddle Road, Island of Hawaii.

In 2006, the Department of the Army purchased a property known as the Ke'āmuku parcel for training which included most of Section I of the proposed Saddle Road. In order to provide a safe separation of civilian transportation and military training, the U.S. Army has requested the Federal Highway Administration and the Hawaii Department of Transportation to relocate the alignment for this section of the Saddle Road to near the southern boundary of Ke'āmuku. A Draft Supplemental Environmental Impact Statement (DSEIS) is being prepared to address this realignment. This DEIS presents the action alternatives and the No Action Alternative and evaluates the impacts associated with the proposed improvement of Section I (as defined in the original EIS) of the Saddle Road, which extends from Mamalahoa Highway (SR 190) to Milepost 42 near the western end of the existing Saddle Road improvements completed to date. Most of the length of Sections II and III of the Saddle Road, which extends between Mileposts 42 and 9, have already been completed, are under construction, or are in the final design stage of development as described in the Final EIS for the entire project completed in 1999.

The two alternatives under consideration are; W-3, the Recommended Alternative in the Final EIS for the project in 1999 and the other, W-7 is a new alternative. The No Action Alternative would continue use of the existing alignment. The No Action Alternative, which was not selected in the 1999 EIS for reasons of safety for motorists and non-motorized traffic, circulation, and land use impacts, would continue use of the existing alignment. As it has already been rejected, the No Action Alternative is not under consideration in this SEIS and is referenced for baseline purposes only, as is W-3. If it is not feasible to construct W-7, FHWA and DOT expect to build W-3, the alternative selected in the 1999 ROD.

Both alternatives would build a new two-lane roadway with shoulders and a uphill climbing lane and a design speed of 55 to 62 miles per hour. In Section I, the existing Saddle Road is a narrow, winding, two-lane road with steep grades, sharp curves, poor pavement, and no shoulders. The existing road connects Mamalahoa Highway (State Highway 190) with the U.S. Department of the Army's Pohakuloa Training Area (PTA), and within PTA at Milepost 42 it connects to a section of the Saddle Road that is undergoing or has undergone improvement and realignment as far as Milepost 19. Both Alternatives would improve pavement condition, increase safety and capacity, improve quality of traffic flow, decrease cross-island travel times, and stimulate economic growth and development. Only W-7, however, would minimize conflict between civilian motorists and military training units.

The Hawai'i Department of Transportation (HDOT), with the assistance of the Federal Highway Administration (FHWA), Central Federal Lands Highway Division, has contracted with DMT Consultant Engineers to prepare a Supplemental Environmental Impact Statement (SEIS) for the proposed W-7 Alternative that traverses lands of the former Parker Ranch Ke'āmuku cattle station in the Ahupua'a of Waikōloa, South Kohala District, Island of Hawai'i, TMK: (3) 6-7-001:09. The W-7 Alternative extends approximately ten miles from the existing Saddle Road near Kilohana (mile post 42) to the Mamalahoa Highway at the border of North Kona and South Kohala (6 miles south of Waimea). Scientific Consultant Services, Inc. (SCS) surveyed a 600-acre cultural resource inventory study corridor (roughly 10 miles by 500 feet wide) to identify and evaluate historic properties. The survey corridor extends 150 feet beyond both sides of the 200-foot wide area of potential effects (APE) which is the actual width of the right-of way/construction corridor. This was done to allow for avoidance of identified historic properties where feasible through preliminary highway design.

There are seven archaeological sites documented in the study corridor, including five rock mounds (SIHP Sites 50-10-21-23528, 50-10-21-26875, 50-10-21-26876, 50-10-21-26877, and 50-10-21-26878), a segment of the old Waimea-Kona Belt Road (SIHP Site 50-10-21-20855), and remnants of a ranching-era fence (SIHP Site 50-10-21-23452). Four of the rock mounds (SIHP Sites 50-10-21-23528, 50-10-21-26875, 50-10-21-26877, and 50-10-21-26878) correspond roughly to the boundary between the Ke'āmuku cattle station lands and ranch lands to the southwest. This area is also the boundary between Waikōloa and Pu'uanahulu Ahupua'a. Site SIHP 50-10-21-826875 contained a Kalopa Soda Works bottle and a roll of galvanized fence wire in its construction. Site 50-10-21-26878 appears to mark a possible hunting spot. Site 50-10-21-26876 marks the intersection of two ranch roads along the southeast side of the Ke'āmuku cattle station lands. The ranching-era fence (Site 50-10-21-23452) appears to have been used early in the history of sheep and cattle ranching at Ke'āmuku. The original fence wire has been removed and it passes through the middle of several more recently fenced paddocks. A copy of the report entitled *An Archaeological Inventory Survey Report for 600 acres Located in lands of Ke'amuku, Waikoloa Ahupuua'a, south Kohala district, Hawai'I [TMK (3) 6-7-001:09]* is enclosed.

The five rock mounds and historic fence line are within the study corridor, but are located outside of the APE, and will be avoided with the current preliminary highway design. We have enclosed preliminary highway design plan sheets that document avoidance of the five rock mounds and historic fence line.

The Waimea-Kona Belt Road (SIHP Site 50-10-21-20855) was previously determined eligible for the National Register of Historic Places under criterion "d" by the FHWA following the cultural resource survey of the W-3 Alternative. The Hawai'i SHPO concurred with the FHWA's determination and signed a Memorandum of Agreement (MOA) with the FHWA and the Office of Hawaiian Affairs to mitigate adverse effects to Site 50-10-21-20855. Mitigation consists of preparation of a mitigation plan which provides for a pull off and interpretive sign to be constructed adjacent to the Site.

In accordance with 36 CFR 800.4(d) (1) and for the purposes of Section 106 of the National Historic Preservation Act, it is the finding of the FHWA, as lead agency, that Sites 50-10-21-23528, 50-10-21-26875, 50-10-21-26876, 50-10-21-26877, 50-10-21-23452,and 50-10-21-26878 are outside of the APE and will not be affected by the proposed W-7 Alignment. Since they are outside of the APE, they will not be evaluated for National Register of Historic Places eligibility. In addition, it is the finding of the FHWA that Site 50-10-21-20855, the Waimea-Kona Belt Road, cannot be avoided by the proposed W-7 Alternative and will be adversely affected. The FHWA will notify the Advisory Council on Historic Preservation of the adverse effect and amend the existing Memorandum of Agreement to provide mitigation for the adverse effect to Site 50-10-21-20855. In accordance with the existing MOA for the Saddle Road Project, the FHWA will continue to provide a full time Archaeological monitor for all clearing, grubbing, and excavation activities during project construction. We ask for your concurrence with our finding of "no historic properties affected" for the six sites that are outside of the APE and our finding of adverse effect for Site 50-10-21-20855, the Waimea-Kona Belt Road.

If you have any questions, please call Mr. Stephen Hallisy, Archeologist/Environmental Protection Specialist, at (720) 963-3685 or write to the above address, Attention: Environment HFHD-16.

Sincerely yours,

David Gedeon, P.E.
Project Manager

Enclosure

cc with enclosure:

Office of Hawaiian Affairs, 711 Kapi'olani Blvd., Ste. 500, Honolulu, HI 96813

Mr. Ken Tatsuguchi, State Department of Transportation, Highways Division, Planning Branch, 869 Punchbowl Street, Honolulu, HI 96813

Colonel Matthew T. Margotta, Department of the Army, US Army Installation Management Command, Pacific Region, Headquarters, United States Army Garrison, Hawaii, 851 Wright Avenue, Wheeler Army Airfield, Schofield Barracks, Hawaii 96857-5000

Mr. Alvin Char, Chief, Environmental Division, Directorate of Public Words, United States Army Garrison, 948 Santos Dumont Avenue, Sheeler Army Airfield, bldg. 105, Schofield Barracks, HI 96857-5013

LIST OF NATIVE HAWAIIAN ORGANIZATIONS BEING CONSULTED AS PART OF SECTION 106 CONSULTATION

Clyde Nāmuʻo, Administrator
Office of Hawaiian Affairs
711 Kapiolani Blvd., Suite 1250
Honolulu HI 96813

Ruby McDonald
Office of Hawaiian Affairs
75-5706 Hanama Place, Ste. 107
Kailua-Kona HI 96740

Lukella Ruddle
OHA, Hilo Office
162 A Baker Avenue
Hilo HI 96720-4869

Aliʻi ʻAimoku Paul K. Neves, Chairperson
Royal Order of Kamehameha I
1162 Kalanianaole Ave
Hilo HI 96720

Chairperson
Association of Hawaiian Civic Clubs
P.O. Box 1135
Honolulu HI 96807

President
Council on Native Hawaiian Advancement
33 South King Street, Suite 513
Honolulu HI 96813

Hawaiʻi Island Burial Council
74-383 Kealakehe Parkway
Kailua-Kona HI 96740

Hawaiʻi Maoli
P.O. Box 1135
Honolulu HI 96807

Ike ʻAina Native Hawaiian Trust
P.O. Box 4192
Honolulu HI 96812

SADDLE ROAD (STATE ROUTE 200)
Mamalahoa Highway (State Route 190) to Milepost 42
County of Hawai‘i, State of Hawai‘i
FHWA Project No. 200(00)

SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT

Submitted Pursuant to Section 42 U.S.C. 4332(2)(c)
and Chapter 343, Hawai‘i Revised Statutes by the

U.S. DEPARTMENT OF TRANSPORTATION
Federal Highway Administration (FHWA)
Central Federal Lands Highway Division
and
STATE OF HAWAI‘I
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Highways Division

<u>Cooperating Agencies</u>
U.S. Army Garrison, Hawai‘i

Appendix G
Section 7 ESA Correspondence

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U.S. Department of Transportation
Federal Highway Administration

Central Federal Lands Highway Division

12300 West Dakota Avenue
Lakewood, CO 80228

October 28, 2009

In Reply Refer To:
HFPM-16

Loyal Mehrhoff, PhD.
Field Supervisor
U.S. Fish and Wildlife Service
300 Ala Moana Blvd, Room 3-122
Honolulu HI 96813

Subject: Saddle Road (State Route 200) Improvement Project: Māmalahoa Highway (State Route 190) to Milepost 6 Project. Reinitiation of Section 7 Consultation for the West Side W-7 Alignment. US Fish & Wildlife Service (USFWS) Log # 1-2-98-F-01.

Dear Dr. Merehoff,

The Federal Highway Administration (FHWA), Central Federal Lands Highway Division is seeking concurrence from your office that the proposed action will not likely adversely affect any listed species known from the Island of Hawai'i.

The limits of the W-7 alignment extend from Milepost (MP) 42 located just to the east of the Department of the Army's Pōhakuloa Training Area's (PTA) Ke'āmuku parcel eastern boundary to the projects western terminus along Māmalahoa Highway (State Route 190) (Figure 1).

General Project Description

The purpose of the Saddle Road Improvement Project is to provide a safe and efficient route for access along the entire route and for cross-island traffic between East and West Hawai`i. The proposed improvements will address five general types of needs: roadway deficiencies, conflicts with and hazards of military training operations, capacity, safety, social demand and economic development. Upon completion, the improved 48-mile long Saddle Road will meet the current American Association of State Highway and Transportation Officials (AASHTO) design standards for rural arterials and provide adequate capacity to handle anticipated traffic volumes for the next 20 years.

A Final Environmental Impact Statement and Record of Decision for the Saddle Road improvements were completed in 1999. As part of the EIS process, twelve action alternatives incorporating use of the existing alignment and potential new alignments were considered. The project was divided into four different sections (Sections I, II, III, and IV) for purposes of alternative development and selection, as well as project scheduling (Figure 2).

RECOVERY.GOV

In the intervening years since the release of the EIS, the Department of the Army has purchased a large section of land in the Keʻāmuku area from Parker Ranch. This development has caused the originally selected alignment, W-3, in Section I to less adequately fulfill one of the key purposes and needs of the proposed improvement project, namely the separation of military training activity from the general driving public using the Saddle Road. Another alignment, W-7, has been proposed and studied to fulfill the need to separate civilian traffic from military training activities. A supplemental environmental impact statement SEIS is being prepared to address this new alignment.

The W-7 alignment gently slopes from east to west, from an elevation of ~ 5800-feet, above mean sea level (ASL), along the existing Saddle Road, down slope to where it will intersect the existing Māmalahoa Highway at ~ 2493-feet ASL. The alignment is roughly 10.3 miles long, with approximately 8.9 miles of the route located within TMK: 6-7-001:041: and the remaining 1.4 miles of the alignment going through a portion of the main PTA training area (Figure 1).

FHWA is proposing to build a two-lane hot asphalt concrete paved roadbed, two 12-foot travel lanes with two 8 foot paved shoulders, and a 6-foot wide ditch in locations where the new roadway will be cut. Because of the grades, an uphill passing lane would be provided for most of the length of W-7, as it passes through the Keʻāmuku parcel and is illustrated as Typical Section A (Figure 3). The road will be designed to accommodate 60 mile an hour traffic speeds, a minimum curve radius of 230-meter (754 foot), an 8 percent maximum super elevation, simple curves with 67 percent of runoff on tangent, and an 8 percent maximum grade.

Project Area

The project area is on the west-facing slope of Mauna Kea, on the leeward side of the island. Annual rainfall is in the neighborhood of 20-inches a year, with the upper reaches somewhat drier. The terrain present along the alignment is composed of a mix of *ʻaʻā* and *pāhoehoe* lava flows disgorged from Mauna Kea more than 14,000 and 65,000 years ago during the Pleistocene Age. Additionally there are surficial alluvial deposits in many areas, which were washed down from Mauna Kea at the end of the last ice age. Along the southern boundary of the area several small fingers of *ʻaʻā* from the Keʻāmuku flow, deposited by Mauna Loa between 200 and 750 years ago overlay portions of the older Mauna Kea flows (Wolfe and Morris 1996).

The vast majority of the site has been extensively altered by decades of cattle grazing and is now largely a pasture of introduced grasses with scattered shrubs and very few trees. The vegetation between the eastern terminus of the project and approximately the 4200 foot level is dominated by fountain grass (*Pennisetum setaceum*), with sparse amounts of *ʻaʻalilʻi* (*Dodenea viscosa*), and numerous other alien grasses and Madagascar ragwort (*Senecio madagascariensis*). At the lower elevations in this section there are also pockets of buffelgrasss (*Cenchrus ciliaris*), Guinea grass (*Panicum maximum*), and Kikuyu grass (*Pennisetum clandestinum*). Between the 4300 foot and 4600 foot elevation the makeup of the vegetation is similar to that found in the lower section, except that in this zone the native species are dominate, with large dense stands of *ʻaʻaliʻi* making up to 50% of the ground cover. Between the 4300-foot elevation and the boundary of the Keʻāmuku parcel and PTA proper the habitat is similar to the previously described ones, but with varying densities of the component species, as is to be expected in pastureland that is grazed on a rotational basis. Between approximately 5200-feet ASL and the eastern terminus of the project the substrate is markedly different than that found lower on the alignment, in this area is made up of alluvial and colluvial sand and gravel deposited by the erosion of Mauna Kea by the melting of the last ice cap. On this substrate the dominate plant is the endemic shrub *'aheahea* (*Chenopodium oahuense*).

Consultation History

The history of FHWA's consultation with the USFWS beginning in 1990 and culminating in the issuance of a BO on July 27, 1998 is detailed on pages 1 through 5 of that BO (USFWS Log #1-2-98-F-01). Since the original BO was completed, FHWA and its consultants have had numerous meetings with the USFWS to discuss ongoing issues over the implementation of the conditions included in the original BO. Additionally, FHWA reinitiated Section 7 consultation with the USFWS in July 2009 to address additional species and Critical Habitat that were listed and designated between the issuance of the original BO in 1998 and the present. These issues pertained to Sections II, III and IV as defined in the EIS. That consultation was concluded with the issuance of a BO on September 11, 2009 (USFWS Log #2009-F-0314).

FHWA, HDOT, project consultants and USFWS met on August 27, 2009 to discuss the new W-7 alignment, view maps, and discuss the findings of the biological surveys that were completed as part of the NEPA process for this new alignment. The parties met again on October 15, 2009 to discuss the Section 7 consultation, at which time the FHWA informed the USFWS that they have determined that by implementing the minimization measures outlined in this document that the proposed action is not likely to adversely affect any listed species and is therefore seeking concurrence from the USFWS of this determination. At that meeting and through subsequent discussions with the Service it was agreed that the FHWA would consult with the Service over potential project impacts to Blackburn's sphinx's moth (*Manduca blackburni*), Nēnē (*Branta sandvicensis*), Hawaiian Hawk (*Buteo solitarius*) Hawaiian Petrel (*Pterodroma sandwichensis*), Newell's Shearwater (*Puffinus auricularis newelli*), Hawaiian hoary bat (*Lasiurus cinereus semotus*) and *Haplostachys haplostachya*. The moth, Nēnē, petrel bat and haplostachys are listed as endangered species and the shearwater as a threatened species.

Biological Surveys and Results

Prior to the onset of field surveys both the project botanist and zoologist consulted with the design team to alert them of any historically known issues with endangered species within the general proposed area of the W-7 alignment that will need to be avoided during development of the design. There were no known real issues with avian and mammalian species, though botanical studies conducted within the Ke'āmuku parcel in 2002, found three endangered plant species near the southern border of the Ke'āmuku property (Arnett 2002). These three, *Haplostachys haplostachya,* (common name: *honohono*) a perennial mint with showy white flowers; *Stenogyne angustifolia* (no common name) a twining mint, and *Vigna o-wahuensis* (no common name) which is a very rare legume vine. Prior to 2002, *Haplostachys* and *Stenogyne* were only known to exist within PTA and nowhere else. Arnett (2002) recorded and mapped the location of over 8,000 *Haplostachys,* 11 *Stenogyne*, and 74 *Vigna* within Ke'āmuku. The proposed W-7 alignment was carefully designed to avoid all of the known locations of these endangered species.

Biological surveys were conducted on the W-7 alignment in 2008 and 2009. Botanical surveys were conducted in September 2008, and an additional botanical survey searching for

Haplostachys haplostachya, Stenogyne angustifolia, and *Vigna o-wahuensis* was mounted in May 2009 (Garrish 2009). Avian and mammalian surveys were conducted in June 2009 (David 2009).

No avian, mammalian or botanical species currently listed as endangered, threatened or proposed for listing under either federal or State of Hawai'i endangered species were detected within the W-7 alignment corridor (David 2009, Gerish 2009).

Potential Impacts to Protected Species

The principal potential threat that the development of the W-7 alignment poses to Blackburn's sphinx moth is if clearing and grubbing activities associated with construction of the roadway were to remove host plants used by this species. During the course of the biological surveys conducted for the project none of the native host plants used by this species were found, nor was the alien host plant, tree tobacco (*Nicotiana glauca*) encountered (Gerrish 2009).

Although not detected during the course of the faunal surveys the endangered Nēnē have been recorded in small numbers within the Ke'āmuku parcel in the recent past (David 1996, Lena Schnell, personal communication 2009). Nēnē nest at the Big Island Country Club and at Pu'uwa'awa'a, which are located some 7 and 10 miles respectively south of the southwestern terminus of the W-7 alignment. Nēnē have been recorded being attracted to some roadways especially during the non-breeding season at other locations on the island. Birds have been observed loafing, feeding on short grass and other plants, walking on the roadways, and taking gravel from the side of the road. If a population develops within the Ke'āmuku parcel there is the potential that birds could be attracted to the roadway at some as yet unidentified location and put at risk of being hit by motorists.

The principal potential threat that the development of the project poses to Hawaiian Hawks is if vegetation-clearing activities were to remove an active hawk-nesting tree. Hawaiian Hawks are not known from the Ke'āmuku area, and furthermore there are no suitable nest trees within, or close to the W-7 alignment (David 2009).

The principal potential threat that the development and operation of the proposed project poses to Hawaiian Petrels and Newell's Shearwaters are associated with birds potentially being downed after becoming disoriented by lights associated with night time construction, and following build-out by street lights that may be required for public safety. With that said, it should be stated that very few downed seabirds have been documented on the leeward side of the island over the past 35 years.

The principal potential impact that the development of the proposed project poses to Hawaiian hoary bats is during the clearing and grubbing phases of construction. Clearing woody vegetation greater than 15-feet tall (the preferred size of roost trees) during the pupping season could potentially cause harm to bats. As bats use multiple roosts within their home territories the potential disturbance resulting from the removal of the vegetation is likely to be minimal. During the pupping season, females carrying their pups may be less able to rapidly vacate a roost site as the vegetation is cleared; additionally, adult female bats may leave their pups in the roost tree while they themselves forage, leaving very small pups unable to flee a tree that is being felled. Potential adverse effects from such disturbance can be avoided or minimized by not clearing such vegetation (i.e., clearing of trees taller than 15-feet tall) between April 15 and August 15, the period in which bats are potentially at the greatest risk of being harmed by roost tree removal. Fortunately there is no suitable bat roosting habitat within the ROW.

The principal potential impact that the development of the proposed project poses to the haplostachys population located south of the proposed roadway, and immediately adjacent to the eastern boundary of the Ke'āmuku parcel is that an unplanned wildfire started by a catalytic converter, discarded lit cigarette or other roadway-associated perturbation could spread into the Army's haplostachys enclosure.

Potential Impacts to Critical Habitat

There is no federally delineated Critical Habitat for any listed species within the project corridor, as such - the construction and operation of the W-7 alignment will not result in modification or deleterious impacts to any delineated Critical Habitat units.

Proposed Minimization Measures

The project proposes to implement the following minimization measures to ensure that the construction and operation of the proposed W-7 alignment does not result in adverse impacts to any listed species:

- To minimize collateral damage to areas outside of the ROW, the Special Contract Requirements will mandate that all construction activity shall be restricted to within the clearly delineated ROW and that entry and exit into the ROW by all construction personnel and equipment shall be at previously identified and marked non-sensitive areas.
- Special Contract Requirements will be incorporated into the construction documents directing the contractor's work consistent with specific minimization commitments that are outlined in this section and in the BO for the project. The Contract Officer will have the authority to shut down construction should violations of Special Contract Requirements be detected; furthermore, the project engineer will be responsible for ensuring compliance with all environmental restrictions and minimization measures.
- A comprehensive manual outlining and discussing the environmental commitments contained in the original ROD, BO and Special Contract Requirements will be prepared. This document will be prepared by the FHWA in accordance with their environmental team policy, which ensures that the environmental team closely follows the entire project to its completion.
- If nighttime work will be required in conjunction with the development of the project, all lights will be shielded and, or directed at the ground to reduce the potential for interactions of nocturnally flying Hawaiian Petrels and Newell's Shearwaters with external lights and man-made structures.
- No nighttime construction will occur during the peak seabird fallout period, namely between September 15 and December 15 annually.
- Any streetlights that may be installed, as part of this action will be shielded. This minimization measure would serve the dual purpose of minimizing the threat of

disorientation and downing of Hawaiian Petrels and Newell's Shearwaters, while at the same time complying with the Hawaii County Code §14 – 50 *et seq.* which requires the shielding of exterior lights so as to lower the ambient glare caused by unshielded lighting to the astronomical observatories located on Mauna Kea.

- No smoking will be permitted during construction within the construction site, nor will any fires be permitted within the project corridor.

- These measures and in some cases prohibitions will be included as part of Special Contract Requirements, which will be incorporated in the construction contract documents.

- To reduce the potential threat of wildfires being started by careless smokers or drivers driving or parking on grassy verges on the north side of the roadway between mile marker 41 and the eastern boundary of the Keʻāmuku parcel an expanded and modified typical section for the roadway that will both reduce the likelihood of accidental ignition from unintentional road sources (car fires, catalytic converters, cigarettes, etc.) and assist in creating a firebreak and fuelbreak on the north side of the roadway will be constructed in this section. This section is illustrated as Typical Section B (Figure 4). This expanded Typical Section will consist of:

    - Two 12-foot travel lanes with 8-foot paved shoulders.
    - An 8-foot strip of pavement on the north side of the highway, which would serve as a firebreak, with a four-inch high curb on the outside.
    - At the outside edge of the firebreak a wire fence with metal posts would be constructed to a height of four feet on the edge of the pavement to discourage off pavement travel by motorists.

- As W-7 enters Keʻāmuku and descends towards Māmalahoa Highway, the primary wildfire concern shifts towards preventing fires from Saddle Road spreading southwards, towards the western boundary of the *Haplostachys haplostachya* exclosure. The Typical Section between the Keʻāmuku parcel boundary towards Māmalahoa Highway is illustrated in Figure 4 as Typical Section C, and would consist of the following features:

    - Three 12-foot travel lanes with a paved 8-foot shoulders, with a four-inch high-extruded asphalt curb at the outside of the shoulder on the south side of the road. This would create a 52-foot wide paved surface that would serve as a firebreak, as well as a curb to protect against thrown cigarette butts or other thrown material and will prevent motorists from driving off of the roadway onto grassy areas.

It should be borne in mind that the proposed road will be located within the PTA training facility, which has an extensive fire minimization and mitigation program in place in accordance with the Biological Opinions that have been issued at the conclusion of the two Section 7 consultations that the US Army has recently completed. The proposed W-7 alignment will create an additional firebreak within the PTA, which will be between 40 and 52 feet wide. This road will also allow very rapid response by PTA and County of Hawaiʻi firefighting personnel in the event that a fire does occur within the general project area. To put that statement into perspective of fire responsiveness, the center of the W-7 alignment is approximately 10 miles from the PTA fire station, and approximately the same distance from the Waikoloa fire station. As the new road will be designed to accommodate 60 mile an hour traffic, both fire stations could respond in a very short period of time to any wildfire that might occur within the general project area. These areas would otherwise be extremely difficult to access from the existing Saddle Road, thus result in extremely long response times. Additionally, the Army is currently constructing five firefighting dip tanks within the Keʻāmuku parcel to provide onsite water to be used to fight any wildfires that may ignite within the general area.

- At the current time there is no known conflict between Nēnē and the proposed W-7 alignment. At such time as such a conflict arises FHWA plans to address the issue with a multi-pronged approach mimicking the measures that have been agreed to, to minimize vehicle Nēnē interactions along a portion of the recently constructed Saddle Road that are detailed in the September 11, 2009 BO. The measures fall into the following categories, and may well be augmented following field trials with measures that are being implemented between approximately the 29 and 30.2-mile markers (not within the scope of this consultation). These measures, if determined to be necessary, will include the following:

    - The erection of a permanent fence along both the north and south sides of the roadway within any section that appears to attract Nēnē on a regular basis. The fence will be placed as close to the roadside as is permissible under ASHTO federal safety guidelines.
    - Vegetation will be removed between the aforementioned fence and the edge of the roadway, this will be accomplished either by the use of herbicides, or by paving the area.
    - The loose gravel along the roadside in any such identified area will be secured with a tacking agent, or asphalt paving, so that Nēnē are unable to gather gravel for use in their crops.
    - FHWA will install enhanced Nēnē crossing and traffic advisory signs to warn motorists of the potential danger they pose to Nēnē along any such identified roadway section.

We look forward to working with you and your staff toward a successful consultation on these important issues. In summation, we are seeking concurrence from your office that by implementing the proposed minimization measures presented above that the proposed action is not likely to adversely affect the listed species discussed above. If you require any additional information or have questions regarding this submittal, please contact Dave Gedeon at 720-963-3723, Melissa Dickard at 720-963-3691, or Reggie David, Rana Biological Consulting, Inc. at 808-329-9141.

Sincerely yours,

Rick Suarez, P.E.
Division Engineer

cc:
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Mr. Glenn Yasui, HDOT
Mr. Alvin Char CIV USA IMCOM

bcc:
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Mr. Reggie David, Rana Biological Consulting, Inc.
A. Wong, FHWA - Hawaii
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M. Dickard
D. Gedeon

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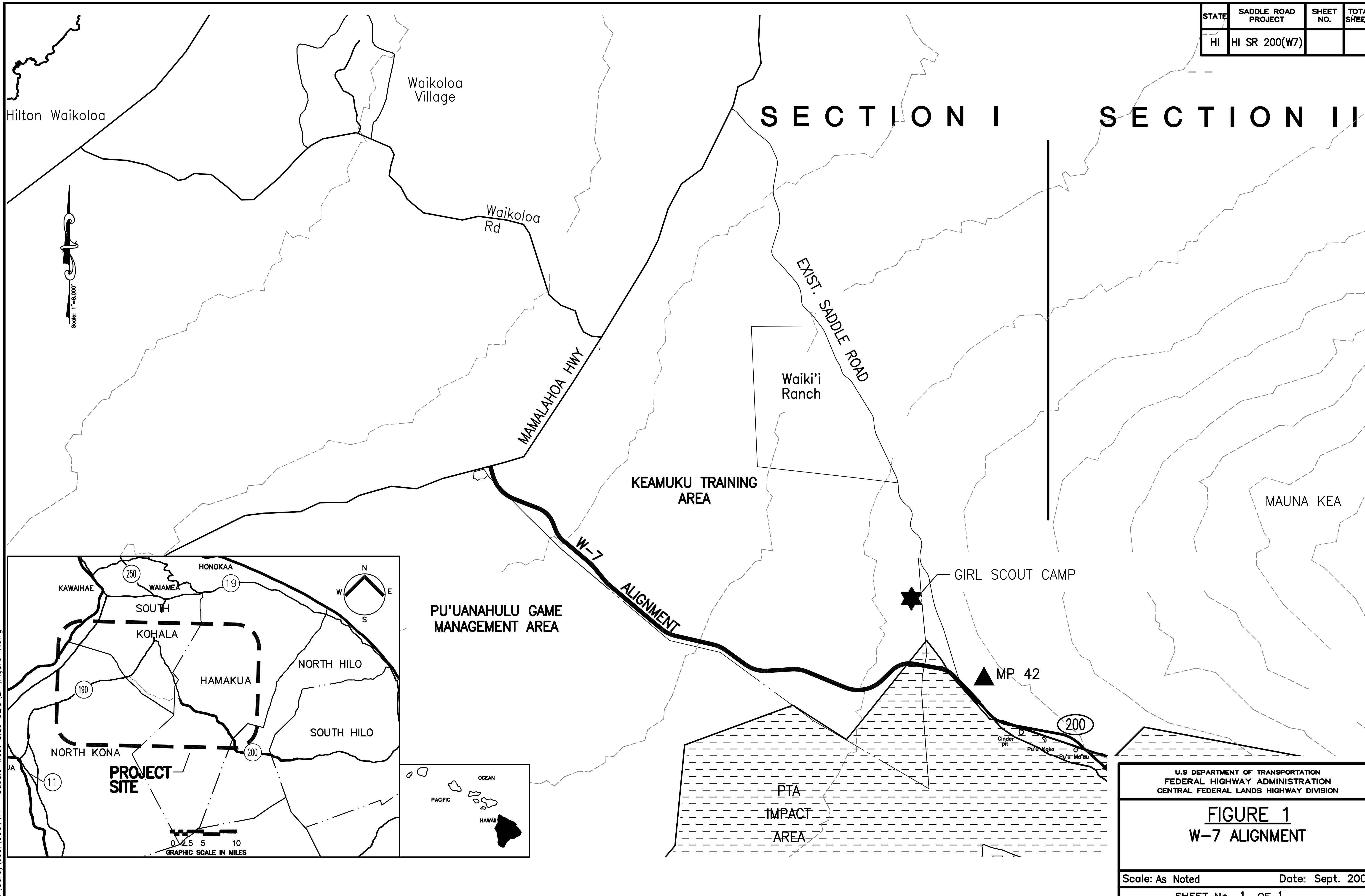


O:\Oproj\Joel\99011A – Saddle West Side SEIS\BA\Figure 1.dwg

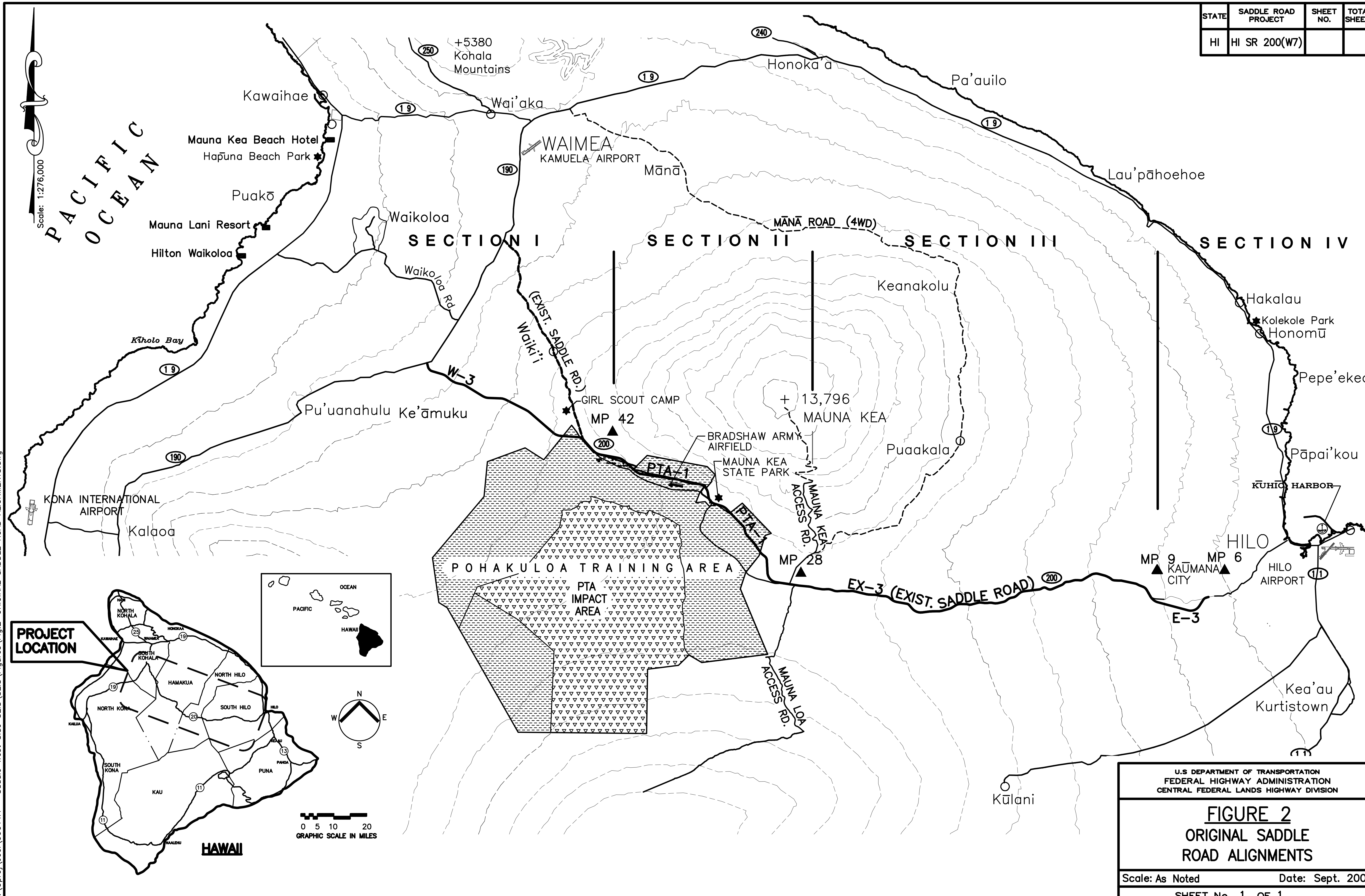
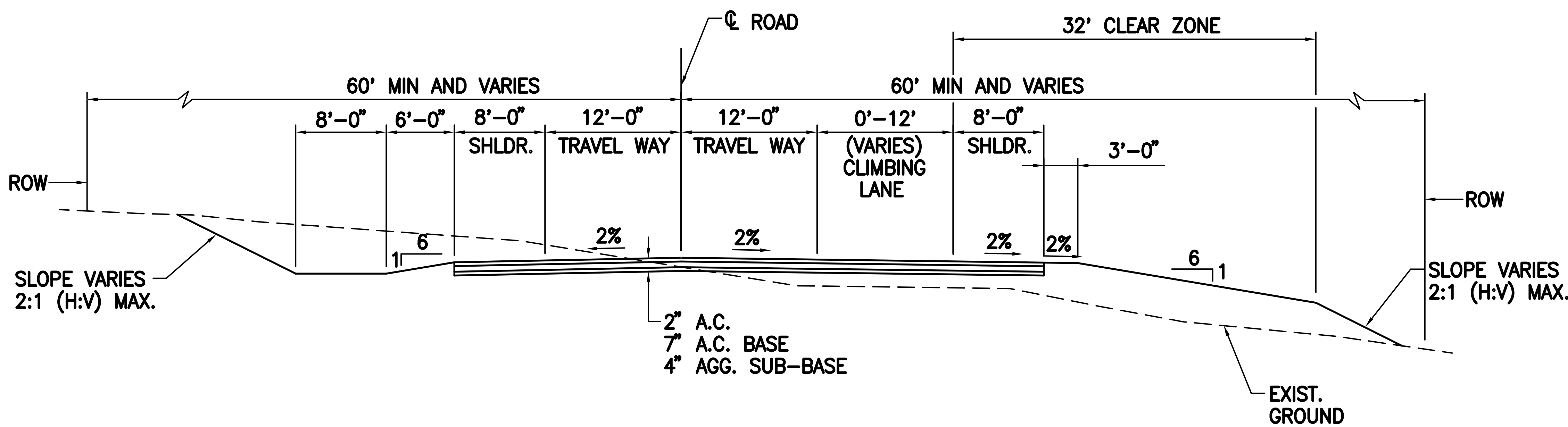


FIGURE 2
ORIGINAL SADDLE ROAD ALIGNMENTS

STATE	SADDLE ROAD PROJECT	SHEET NO.	TOTAL SHEETS
HI	HI SR 200(W7)		



TYPICAL SECTION INSTALLED FROM HWY 190 TO STATION 340+00.
AUXILIARY LANES FOR THE INTERSECTION IS NOT SHOWN.

TYPICAL SECTION A

NOT TO SCALE

U.S DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
CENTRAL FEDERAL LANDS HIGHWAY DIVISION

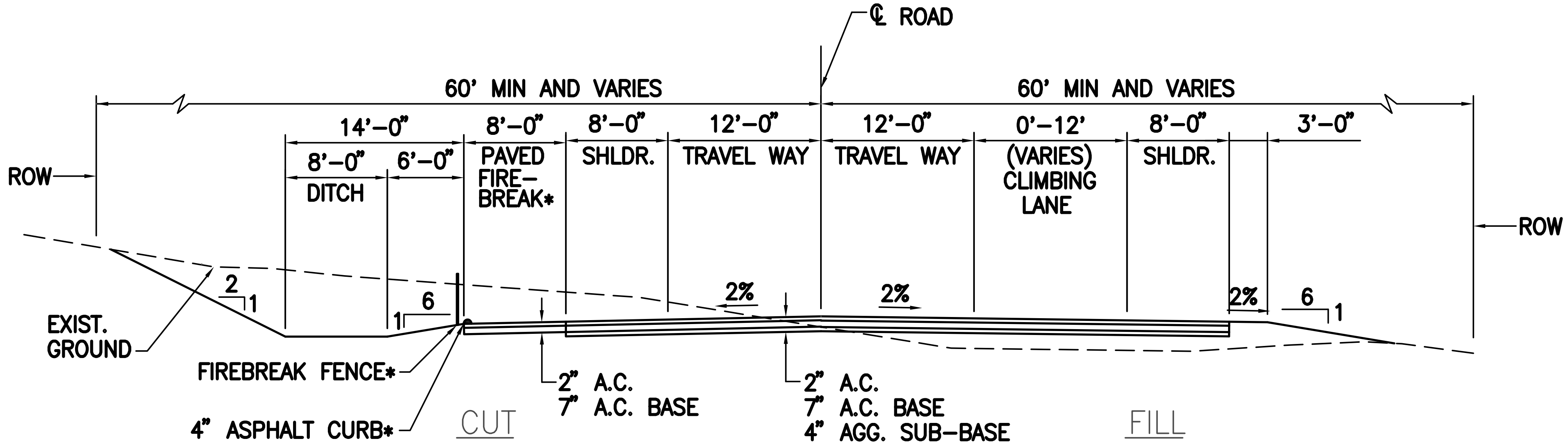
FIGURE 3
ROAD TYPICAL SECTION A

Scale: N.T.S. Date: Sept. 2009

SHEET No. 1 OF 1

O:\Oproj\Joel\99011A-Saddle West Side SEIS\BA\Figure 3.dwg

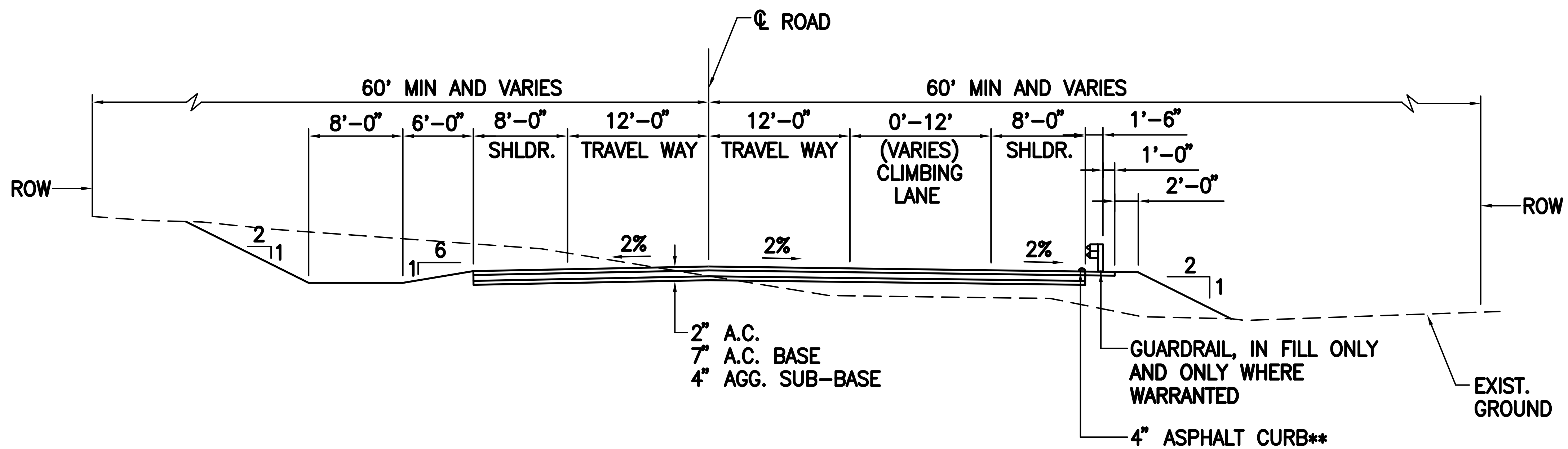
STATE	SADDLE ROAD PROJECT	SHEET NO.	TOTAL SHEETS
HI	HI SR 200(W7)		



*PAVED FIREBREAK, ASPHALT CURB, AND FIREBREAK FENCE INSTALLED ON NORTH SIDE FROM STATION 467+00 TO THE NEW SADDLE ROAD NEAR MP 41 (STATION 544+37).

TYPICAL SECTION B

NOT TO SCALE



**ASPHALT CURB INSTALLED ON SOUTH SIDE FROM STATION 340+00 TO 466+00 IN CUT AND FILL CONDITIONS.

TYPICAL SECTION C

NOT TO SCALE

U.S DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
CENTRAL FEDERAL LANDS HIGHWAY DIVISION

FIGURE 4

ROAD TYPICAL SECTIONS B & C

Scale: N.T.S. Date: Sept. 2009

SHEET No. 1 OF 1