3.0 SITE CHARACTERIZATION

The Phase II EE/CA field investigation for the Former Waikoloa Maneuver Area and Nansay Sites was initiated on 13 November 2000 and was completed on 1 May 2001. Using data collected during the EE/CA field investigation, a qualitative risk evaluation was performed (Chapter 4.0) to determine the most appropriate OE response actions for the site. The characterization of the Former Waikoloa Maneuver Area and Nansay Sites consisted of the following:

- Visual Reconnaissance
- Surface Clearance
- Geophysical Mapping
- Visual Surface Search
- Intrusive OE Sampling.

Details concerning each of these tasks and the results of the Phase II EE/CA field investigation are discussed further in the following sections.

The items recovered during the Phase II EE/CA field investigation were classified into one of three categories: UXO, OE scrap, or non-OE. UXO is a subset of OE and is defined by the CEHNC as: military munitions that have been primed, fuzed, armed, or otherwise prepared for action, and have been fired, dropped, launched, projected, or placed in such a manner as to constitute a hazard to operations, installation, personnel, or material, and remain unexploded either by malfunction, design, or any other cause.

OE is defined by the CEHNC as either: (1) Ammunition, ammunition components, chemical or biological warfare material or explosives that have been abandoned, expelled from demolition pits or burning pads, lost, discarded, buried, or fired. Such ammunition, ammunition components, and explosives are no longer under the accountable record control of any Department of Defense (DOD) organization or activity; or (2) “Explosive Soils,” as defined in Chapter 12.0.

OE scrap is nonhazardous and includes inert items such as 75mm shrapnel shells (expended), fuzes (expended), fragments of functioned ordnance, and small arms. Small arms do not indicate the potential for explosive hazard; subsequently, small arms are tallied separately and their locations are not included on the figures and plates in this EE/CA report.

Non-OE scrap is non-ordnance related items that include, but are not limited to: horseshoes, wire, banding material, aluminum cans, trash, auto parts, and nails.

Prior to conducting the Phase II EE/CA field investigation, the UXO Calculator was used as a guideline to estimate the number of acres to characterize each sector for OE (Appendix G). The UXO Calculator is a statistical engineering tool developed by the CEHNC that determines the acreage to be investigated based upon the size of the sector. The UXO Calculator assumes a random homogenous distribution of OE and requires that decisions pertaining to sampling sufficiency and target density estimation be made and updated during the EE/CA field investigation. The predetermined sampling acreage for each sector was continuously evaluated during the EE/CA field investigation based on the results of field activities and whether UXO was found in any given sector. Data collected in the investigated sectors were sufficient to characterize the sector and evaluate it using the OERIA (Chapter 4.0). The total acreage investigated in each sector and the results of the Phase II EE/CA field investigation are summarized by activity in the following sections. A complete summary of all Phase II EE/CA field activities (including sampling acreages and field investigation results) is presented in Section 3.3.1 (Summary of Results of Phase II EE/CA Field Investigation). Areas that could not be investigated during the EE/CA because right-of-entry was denied (as discussed in Section 2.1.2) are not discussed further in this chapter.

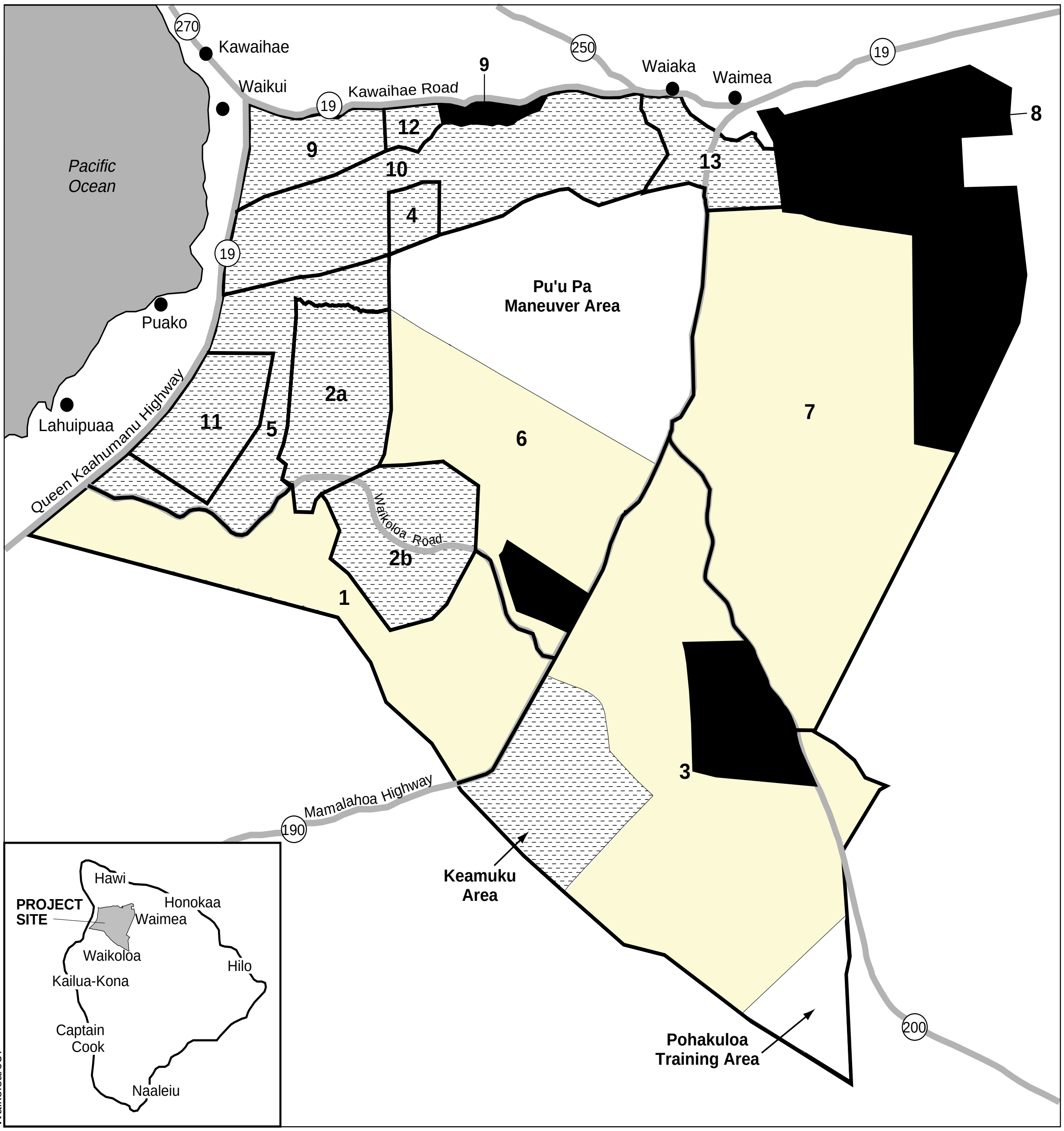
3.1 SITE INVESTIGATIONS

3.1.1 Visual Reconnaissance

Visual reconnaissance surveys were conducted in Sectors 1, 3, 6, and 7 (Figure 3-1) between 12 November 2000 and 22 December 2000. Record searches and the results of the EE/CA Reconnaissance and Site Prioritization Report (Earth Tech, 2000) identified these areas as having little or no military activity conducted on them in the past. The visual reconnaissance surveys were performed to determine if any of these areas required further investigation (i.e., geophysical mapping and OE sampling) at this time. The visual reconnaissance surveys were performed in these areas to identify any visible surface evidence of past military use of explosive ordnance (Plate 3-1). If OE or evidence of past military use was discovered in an area, visual reconnaissance was halted and the area was set aside for later investigation by means of geophysical mapping and intrusive OE sampling.

Areas Not Investigated. Areas where OE or OE scrap had been previously identified, active maneuver areas, or property where right-of-entry was not received, were excluded from the investigation within each sector identified for visual reconnaissance (see Figure 3-1). These areas included the Keamuku Area (OE previously found and removed from this area) in the southwest area of Sector 3, the Pohakuloa Training Area (active military training area) in the southernmost tip of Sector 3, and the Pu‘u Pa Maneuver Area (active military training area) in the north portion of Sector 6. A combined total of 3,854 acres in Sectors 3 and 6 were not included during the visual reconnaissance survey because right-of-entry was not granted in these areas.

Methodology. The visual reconnaissance surveys were conducted by three teams consisting of five field technicians under the supervision of one UXO supervisor. Team members were spaced approximately 50 feet apart, depending on ground cover, vegetation density, terrain, or the presence of other obstacles that could hinder a complete visual inspection of the area. Spacing



EXPLANATION

- Sector Boundary
- **5** Sector Number
- Active military training areas not investigated during the EE/CA
- Visual Reconnaissance investigation areas
- No right-of-entry areas excluded from EE/CA investigation
- Areas requiring geophysical investigation because OE or military operations have been previously identified

0 .75 1.5 3 Miles

Visual Reconnaissance Investigation Areas Former Waikoloa Maneuver Area and Nansay Sites

Figure 3-1

between each team was approximately 1,000 feet, but also varied depending on site conditions.

The reconnaissance survey transects were recorded by each team using continuously recording differentially-corrected global positioning systems (DGPS). The Hawai‘i State Plane (HSP) grid coordinate system was used and referenced to the North American Datum of 1983 (NAD83). The visual reconnaissance teams maintained a daily log that detailed pertinent activities and field conditions encountered during the survey. A map of the areas traversed by the visual reconnaissance teams was updated as the data collection progressed each day. Field equipment (i.e., DGPS and metal detectors) was operationally checked daily prior to work activities.

Visual reconnaissance activities consisted of visual inspection of each sector, looking for physical evidence of OE such as, but not limited to: OE, OE scrap, craters, basalt outcrop or substrate scarring, and changes in vegetation. Hand-held metal detectors were used to investigate areas of dense vegetation. When OE or suspect features were encountered, the field teams recorded the position by taking DGPS data points over/around the feature. The locations of the features were marked on field maps, and the feature was described in the field logbook maintained daily by each team.

Generally, a buffer area approximately 4,000 feet in all directions of a discovered OE-related item or feature was then identified for geophysical mapping and excluded from further investigation by visual reconnaissance. In some areas, multiple OE-related items were located while the visual reconnaissance teams were delineating the 4,000-foot buffer in an area. The 4,000-foot buffer areas were demarcated by physical terrain features (e.g., gullies) or existing infrastructure (e.g., roads and fences) to facilitate further investigations.

Earth Tech monitored and reviewed daily data collection, daily logs, and field maps and compared mapped paths to a master site map to ensure that appropriate coverage and production were achieved. Field notes were compared to the downloaded digital file data to ensure correspondence between the paths searched and the paths recorded.

Data collected during the visual reconnaissance surveys were continually incorporated into the project GIS to provide maps for daily project planning and visual reconnaissance team work assignments to ensure complete coverage and avoid duplication of reconnaissance efforts.

Data Transfer. Digital data were electronically transmitted to the Earth Tech office in Colton, California, via Internet connection, on a weekly basis. The data were then sent via digital format (in Microstation format) to the CEHNC on a biweekly basis.

Results of Visual Reconnaissance Investigation. Field crews walked 446 miles during the visual reconnaissance surveys (Plate 3-1). One UXO item, 75 OE scrap items, 818 small arms rounds, and 52 potential OE-related ground features (i.e., craters) were discovered. Table 3-1 summarizes the total acreage of each sector, the acres investigated and characterized by the visual reconnaissance teams, the acres excluded from geophysical mapping (based on the results of the visual reconnaissance survey), and the acres to be included in the geophysical mapping phase (see Section 3.1.2). A total of 31,356 acres were excluded from further investigation in the visual reconnaissance areas (Figure 3-2) because there was no evidence of OE, OE scrap, or other military use (i.e., craters or terrain scarring) in these areas. A total of 31,842 acres were designated for geophysical investigation (by means of sampling grids and geophysical transects) because OE scrap or potential OE-related ground features (i.e., craters) were discovered in these areas.

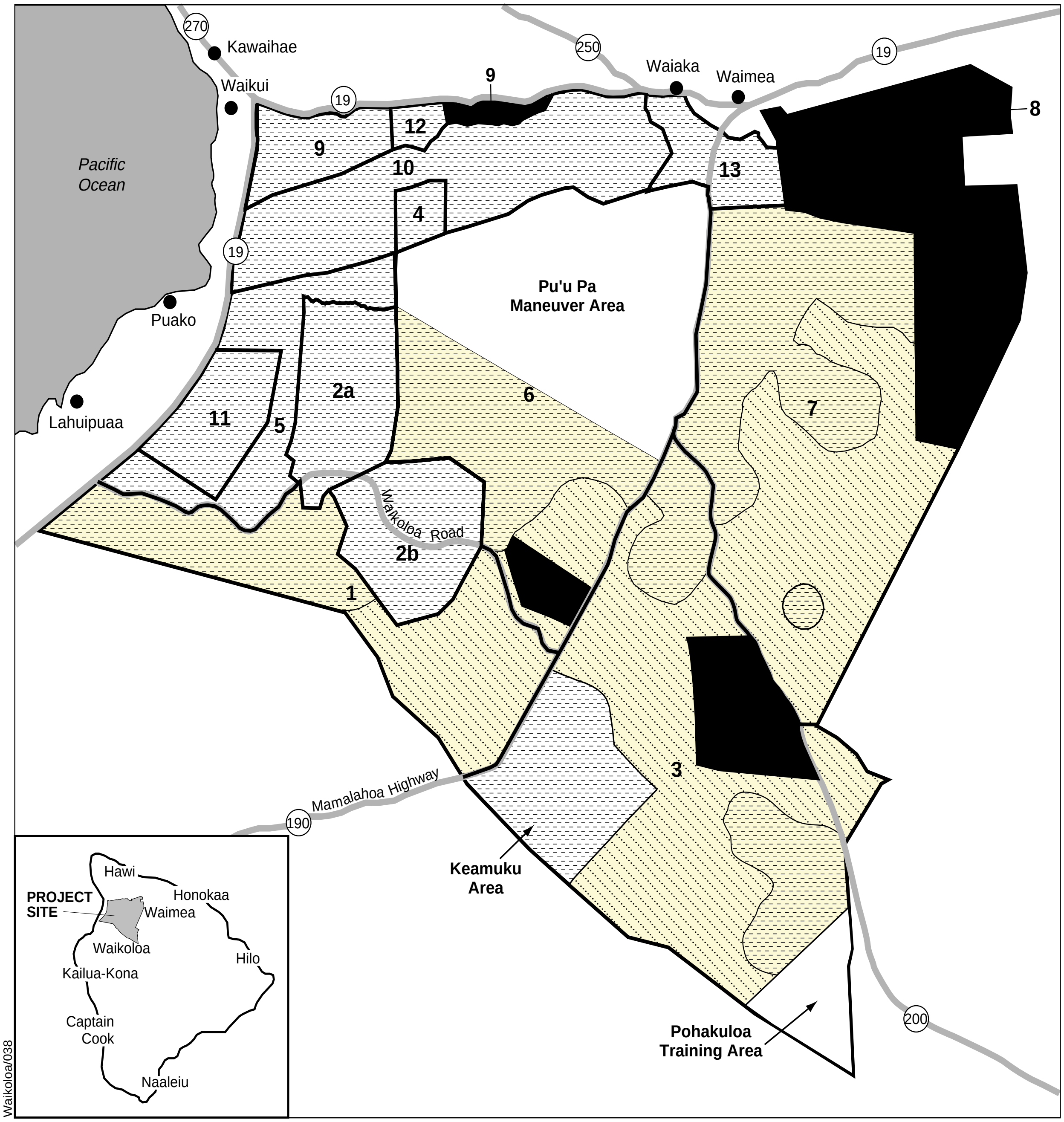
Table 3-1. Acres Characterized During Visual Reconnaissance

Sector	Total Acreage	Miles Walked	Acres Investigated	Acres Characterized[(a)]	Acres Excluded from Geophysical Mapping	Acres Delineated for Geophysical Mapping
1	10,193	40	1,455	10,193	5,140	5,053
3	28,058	139	5,054	22,814	12,785	10,029
6	22,501	35	1,273	8,590	2,089	6,501
7	21,601	232	8,436	21,601	11,342	10,259
Total	**82,353**	**446**	**16,218**	**63,198**	**31,356**	**31,842**

Note: (a) Acres Characterized is the sum total of the Acres Excluded from Geophysical Mapping and the Acres Delineated for Geophysical Mapping.

Visual Reconnaissance Investigation Area. Table 3-1 shows the acres investigated in Sectors 1, 3, 6, and 7 during visual reconnaissance. The acres investigated in each of these sectors is calculated by taking the total number of field technicians per team (five field technicians) and multiplying it by the horizontal path width that is covered. For example, in Sector 1, five field technicians walked side by side along a straight line path, each spaced approximately 50 feet apart, with 50 feet on either end of the path line. Using this information, the total path width is calculated to be 300 feet. The path width (300 feet) is multiplied by the number of miles (converted to 211,200 feet) traversed during visual reconnaissance to yield the total area covered by the visual reconnaissance team (63,360,000 feet). This area is converted to acres by dividing by 43,560 feet (number of feet in one acre), yielding 1,455 acres investigated by the visual reconnaissance team. The acreage investigated in each sector was tallied to yield a total of 16,218 acres investigated during visual reconnaissance.

Visual Reconnaissance Characterization Area. Table 3-1 shows the acres characterized during visual reconnaissance. The acres characterized is determined by adding two columns: acres excluded from geophysical mapping and acres delineated for geophysical mapping. Acres excluded from geophysical mapping are those where visual reconnaissance was performed and no visible surface evidence of past military use of explosive ordnance was found. Acres delineated for geophysical mapping was determined (as discussed



EXPLANATION

- Sector Boundary
- **5** Sector Number
- No right-of-entry areas excluded from EE/CA Investigation
- Active military training areas not investigated during the EE/CA
- Areas requiring no further investigation based on results of Visual Reconnaissance
- Areas requiring geophysical investigation based on results of Visual Reconnaissance
- Areas requiring geophysical investigation because OE or military operations have been previously identified

0 .75 1.5 3 Miles

Geophysical Investigation Areas Former Waikoloa Maneuver Area and Nansay Sites

Figure 3-2

previously) by delineating a 4,000-foot buffer area in all directions of a discovered OE-related item or feature. Once boundaries were drawn around the areas where further investigation was warranted, acreages were determined using Arcview^{TM} GIS Software.

Table 3-2 lists the number of UXO, OE scrap, small arms, and potential OE-related ground features found during the visual reconnaissance survey. The following sections summarize the results of the visual reconnaissance survey by sector.

Table 3-2. Results of Visual Reconnaissance

Sector	Sector Name	UXO	OE Scrap	Small Arms	Craters
1	Kaniku Lava Flow	--	21	--	--
3	Keamuku	--	--	804	3
6	Pu‘u Pa Maneuver Area	1	42	3	3
7	Holoholoku	--	12	11	46
Total		**1**	**75**	**818**	**52**

OE = ordnance and explosives
UXO = unexploded ordnance

Sector 1. OE scrap was encountered immediately at every location along Waikoloa Road (where the sector was entered) after the survey teams began to perform visual reconnaissance in the west region of this area. This suggests that OE scrap would continue to be encountered throughout the west portion of Sector 1. Therefore, 5,053 acres in the west area of Sector 1 was delineated for geophysical mapping (see Table 3-1). The southeast area of Sector 1 (5,140 acres) was excluded from geophysical mapping because the area was surveyed during visual reconnaissance and no OE or OE-related features were found (see Figure 3-2).

Sector 3. Based on the results of visual reconnaissance, 10,029 acres in Sector 3 were identified for geophysical mapping (see Table 3-1). The Pohakuloa Training Area was not investigated because it is still being used by the military (2,292 acres). No right-of-entry areas (2,952 acres) in Sector 3 were also excluded from visual reconnaissance. The remaining area in Sector 3 (12,785 acres) was excluded from geophysical mapping (see Figure 3-2) because the area was surveyed during visual reconnaissance, and no OE or OE-related features were found.

Sector 6. Based on the results of visual reconnaissance, 6,501 acres in Sector 6 were identified for geophysical mapping (see Table 3-1). Heavy concentrations of OE scrap were identified in Sector 6 immediately east of Waikoloa Village and one UXO item was found in the south-central region of Sector 6. The Pu‘u Pa Maneuver Area (13,009 acres) was not investigated because it is still being used by the military for training exercises. No right-of-entry areas (902 acres) in Sector 6 were also excluded from visual reconnaissance. The remaining area in

Sector 6 (2,089 acres) was excluded from geophysical mapping because the area was surveyed during visual reconnaissance and no OE or OE-related features were found (see Figure 3-2).

Sector 7. Based on the results of visual reconnaissance, 10,259 acres in Sector 7 were identified for geophysical mapping (see Table 3-1). OE scrap and evidence of military use (i.e., small arms), in addition to potential OE-related ground features (i.e., craters), were identified in several locations. The remaining area in Sector 7 (11,342 acres) was excluded from geophysical mapping because the area was surveyed during visual reconnaissance and no OE or OE-related features were found (see Figure 3-2).

3.1.2 Areas Geophysically Mapped

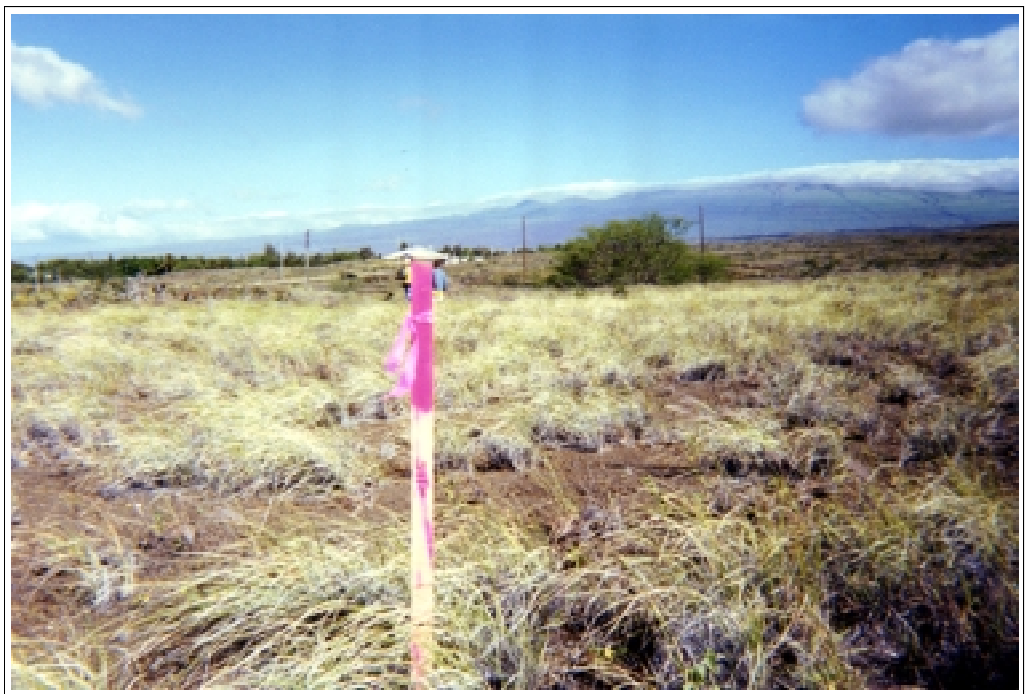
Areas Investigated. Areas at the Former Waikoloa Maneuver Area and Nansay Sites that were to be geophysically mapped were investigated by placement of OE sampling grids and traversing of random transects. OE sampling grids were established in Sectors 2a, 2b, 4, and 12 from November to December 2000. Grids were initially established in these four areas because they are used by the public every day; UXO has been recently discovered in three of the four areas (Sectors 2a, 4, and 12); and residential areas are expanding in three of the four areas (Sectors 2a, 2b, and 12). For the remaining sectors, OE characterization data were collected along geophysical transects randomly dispersed throughout each area.

Methodology. The grid survey crew consisted of one UXO technician, one GPS specialist, and one cultural resources monitor. A total of 239 grids (100 x 100 foot sampling areas) were surveyed and staked (Photograph 3-1 and Photograph 3-2) in Sector 2a (117 grids), Sector 2b (7 grids), Sector 4 (50 grids), and Sector 12 (65 grids). Grids were laid out oriented true north-south and marked with wood laths. The grids were randomly placed in areas known or suspected to contain ordnance and strategically placed in other areas such as undeveloped tracts and lots, parks, open spaces, and buffer areas around residential/occupied areas. No grids were established in sensitive (i.e., biological or cultural) resource areas. Table 3-3 shows the number of grids staked during the grid survey and the number of UXO, OE scrap, and small arms recovered while traversing between sectors and grids. The UXO items that were recovered during the grid survey were explosively destroyed by the UXO demolition team. Three additional grids were also surveyed and staked in Sector 6 in areas where UXO was recovered during OE sampling activities (see Section 3.2.12).

3.1.3 Surface Clearance

Areas Investigated. Prior to initiation of geophysical mapping activities, a surface clearance to remove OE, OE scrap, and metallic debris was conducted in each of the sampling grids in Sectors 2a, 2b, 4, 6, and 12. A surface clearance was also performed in advance of geophysical mapping activities

Photograph 3-1. Using GPS to survey in sampling grids.



Photograph 3-2. Placement of southwest corner grid stake.

Table 3-3. Results of Grid Survey

Sector Number	Sector Name	Number of Grids	Number of UXO	Number of OE Scrap	Number of Small Arms
2a	Waikoloa Village - West	117	1	6	--
2b	Waikoloa Village - East	7	--	2	--
4	Lalamilo Wind Farm	50	2	6	2
6	Pu‘u Pa Maneuver Area	3	--	--	--
12	O‘uli Parcel	65	--	22	6
Total		**242**	**3**	**36**	**8**

OE = ordnance and explosives
UXO = unexploded ordnance

along the random transect lines traversed by the geophysical mapping teams. The purpose of the surface clearance was to ensure the safety of the geophysical mapping team personnel and to reduce unnecessary surface targets during the geophysical mapping phase by locating, characterizing, and removing surface ordnance and metallic debris.

Methodology. UXO specialists assembled in line formation and advanced at a slow, continuous pace, visually inspecting the surface of each grid (by means of a search lane) for OE and metallic debris (Photograph 3-3). The surface clearance consisted of a systematic progressive search pattern within the delineated sampling grids. Each survey team path within the grid was 20 feet wide. This process was done continuously until the entire grid had been visually searched. When one grid was completed, the surface clearance team moved to another grid until all of the grids were completely searched.

UXO specialists searched in front of and adjacent to the geophysical teams during mapping of the random transects. The surface clearance consisted of a systematic progressive search pattern within 5 feet of either side of the geophysical mapping teams. Two UXO specialists walked in advance of each geophysical mapping team and removed OE and metallic debris within 5 feet of either side of the geophysical equipment path. The UXO specialists placed plastic pin flags every 50 feet along the outside line of the cleared path to direct the geophysical mapping teams to cleared areas. OE scrap and metallic debris greater than 1 inch by 2 inches in size was moved at least 5 feet beyond the edge of the southwest corner of the grid or at least 5 feet away from the geophysical transect. UXO that was found during this effort was blown in place, unless it was safe to move to a central location for detonation. All UXO found during the surface clearance was explosively destroyed by the UXO demolition team.

Table 3-4 summarizes the number of UXO, OE scrap, and small arms recovered during the surface clearance of both the sampling grids and the results of the surface clearance performed during the mapping of geophysical transects. UXO items that were discovered on the ground surface while teams traversed through each sector conducting daily field activities are also shown in Table 3-4.

Photograph 3-3. Surface clearance of OE and metallic debris.

Photograph 3-4. Geophysical mapping on Parker Ranch property.

Table 3-4. Results of Surface Clearance of Grids and Geophysical Transects

Sector Number	Sector Name	Number of UXO	Number of OE Scrap	Number of Small Arms
1	Kaniku Lava Flow	--	--	--
2a	Waikoloa Village - West	1	800	6
2b	Waikoloa Village - East	--	19	--
3	Keamuku	--	--	--
4	Lalamilo Wind Farm	1	194	3
5	Waikoloa Road	1	2	--
6	Pu‘u Pa Maneuver Area	2	4	40
7	Holoholoku	--	--	--
9	Kawaihae Road	2	--	--
10	Lalamilo State Lands	13	62	--
11	Puako Parcel	4	--	--
12	O‘uli Parcel	5	139	251
13	West Waimea/Kamuela Airport	1	--	--
Total		**30**	**1,220**	**300**

OE = ordnance and explosives
UXO = unexploded ordnance

3.2 GEOPHYSICAL MAPPING

On 22 January 2001, a two-person geophysical survey crew and lead geophysicist with TEM equipment were mobilized to the project site. Additional personnel were deployed during the following two weeks until three two-person geophysical survey teams with oversight from lead geophysicists were on site. Geophysical data processing protocols specific to the continuous-sampling TEM surveys to be conducted over portions of the former maneuver area were developed on site by the geophysical team and Earth Tech project geophysicist.

Approximately 200 acres were geophysically mapped in 12 of the 13 sectors using TEM arrays (Photograph 3-4). The specific survey parameters were determined from the geophysical equipment test plot results (Appendix B). The sequencing of the surveys was optimized to minimize transit time between mapping traverses and grids. The geophysical data were analyzed, and the results of the analysis were used to identify the locations of significant subsurface anomalies (i.e., those likely to be OE items). Once the subsurface anomalies were identified, their locations were reacquired for investigation by the OE sampling teams (see Section 3.2.12).

The geophysical investigation was conducted under the direction of Earth Tech's project geophysicist who monitored the data collection and reduction processes used and was responsible for reviewing the field data to assure complete coverage, measurement precision, representativeness, and geophysical reasonableness of the survey results.

3.2.1 Methodology and Instrumentation

TEM and magnetometer systems were evaluated during the Phase I EE/CA investigation, as documented in Section 2.5 of the *Engineering Evaluation/Cost Analysis, Former Waikoloa Maneuver Area-Parker Ranch Kamuela, Island of Hawai'i, Hawai'i* (Earth Tech, 1999a), to determine the best detection methodology to be deployed at the former maneuver area. These tests clearly demonstrated that magnetic methods were not suitable for detection of explosive ordnance-sized objects in the iron-rich volcanic soils of the Hawai'ian Islands. Accordingly, the Geonics EM-61 was selected for use during the EE/CA field investigations. At the current time, no other electromagnetic (EM) systems are available that can provide detection and productivity capabilities equal to that of the EM-61.

TEM refers to the way in which the instrument records the response measurement (timed) to follow the transmission of an EM pulse. Highly conductive objects (metal) retain electrical current longer than soil materials. The electrical potential measured at the receiver aboveground is initially strong, then diminishes to nothing over time as the amplitude of the current decays. The time interval during which the measurements are taken is that which best shows the persisting signal from the highly conductive target and misses the early, fast-diminishing returns from soil.

Background response levels for the measurement system to be deployed derive primarily from the characteristics of near-surface soils. The wavelengths of background responses are relatively much longer than those of finite-dimensioned objects and can be readily distinguished from the short, spike-like character of metallic (i.e., OE target) anomalies. The instrumentation, although affected by soil conductivity, is configured to omit from the data anomaly responses caused by small, finitely bounded concentrations of conductive soils or minerals.

The transmitter generates 150 pulses per second, and induced signals are measured during the off time between pulses. Measurements are stacked, yielding effective sampling at 10 cycles per second. The electrical potential of the secondary signal is measured (in milliVolts [mV]) at each of the two receivers. Because the baseline response of each of the paired systems may differ, the background response was biased to a common modal value. This allows direct comparison of the signal characteristics between two or more EM-61s. No other data corrections were necessary.

Anomaly discrimination was accomplished by identification of discrete, sharp peaks above background response levels caused by metallic sources buried in the near surface (or twin peaks in the case of sources that are much smaller than the EM-61 antenna widths). Having a pair of receiving antennas allows different measurements to be made that can be used to estimate depth-to-target and reject surface clutter.

The EM-61s were deployed in an array of paired systems tied together to form one unity array. Transmitter moments are not field adjustable with these systems and the systems were not configured using the standard survey parameters provided by the instrument manufacturer. Detector standoff height was 16 inches. Given the variability of the ground surface caused by both vegetation and native rock, it is unlikely that any lower standoffs could be practically maintained during data collection.

A request was granted by the Parker Ranch for use of an area south of Holoholoku for a test plot. The test plot was used to bury representative inert OE targets to evaluate the performance capabilities and limitations of the geophysical and position locating equipment to be used for the geophysical mapping phase of the EE/CA. The area used is approximately three miles southeast of Waimea, Hawaiʻi.

Three geophysical mapping teams, each with a paired array, were evaluated at the test plot prior to deployment for geophysical mapping throughout the project site. Each of the arrays detected most of the buried inert OE items and metallic scrap placed in the evaluation plot. All were unable to detect essentially the same targets, specifically 81mm mortar rockets (partial rockets - the nose/fuzes were not present) at deeper depths (24 and 36 inches bgs). Each system was unable to consistently detect hand grenades at depths greater than 6 inches bgs. Additionally, the recorded response to geology (subcrops of iron-rich basalt) was in many cases indistinguishable from that caused by some of the buried OE items. This has resulted in a relatively high false-alarm rate.

As more ground-truthing data became available, as well as through manipulation and filtering of the geophysical data, continual efforts were made to reduce false alarms as an ongoing exercise throughout the EE/CA field activities.

3.2.2 Performance Criteria

Coverage of the grids and transects, detection performance, and reasonableness of the geophysical data were assured by daily reviews of the collected data and a comparison of processed results with the anomaly lists produced in the field for each grid investigated.

The analysis of the geophysical mapping data was performed separately by Zonge and Earth Tech geophysicists to verify the geophysical reasonableness of the collected field data and the geophysical data analyses. Data were checked for completeness and reasonableness using field notes, field maps, GeoSoft Software OASIS MONTAJ™, and Golden Software SURFER™. A portion of the data was audited by processing discretely bounded survey lane segments. QC processing of digital data included production of representative profiles that were used as a QC tool to compare visually discriminated locations with those anomaly locations identified by the color contour image.

Personnel, processing, and interpretive software were not replicated between Zonge and Earth Tech. The results of the analyses were used to determine if a grid or transect needed to be remapped or the data reprocessed. All data performance criteria, as outlined in the Final Master Work Plan Addendum, were met.

3.1.3 Geophysical Equipment Field Tests

Equipment Test Bed Construction. Earth Tech deployed a field crew comprised of the project geophysicist and a field technician in November 2000, to prepare and construct the geophysical equipment test plot for the former maneuver area, with the assistance of the CEHNC geophysicist. The test plot covered a 100-foot x 300-foot grid. Grid corners and survey fiducials were marked with rocks painted in high-visibility colors. Background geophysical data were collected within the test plot using a Geonics Ltd., EM-63. The EM-63 is a time-domain instrument that records the amplitude of a decaying secondary (induced) EM signal at 26 time gates and an equivalent EM-61 response. Data were collected using an optical encoder triggered record, high sampling rate, a 16-inch receiver antenna standoff, and a 3.3-foot line spacing. The additional decay gates were captured solely as a “target of opportunity” for future evaluation and were not considered in the equipment tests for the EE/CA field activities.

Earth Tech buried inert ordnance targets as described in the Geophysical Equipment Test Letter Report (Appendix B). Target locations were recorded in HSP NAD83 coordinates using Trimble PRO XRS (with differential corrections) DGPS. Depths to top of target (below ground surface) were measured with a survey tape. Preliminary target data were recorded over the equipment test plot with Geonics EM-63, EM-61, and EM-61-HH. All systems were set up following Geonics manuals for operation; EM-61-HH deployed at approximately 6-inch sensor standoff.

The geophysical test plot was designed to document depth of detection (Table 3-5) for the following: (1) the smallest OE item of concern (Mk2 hand grenade), (2) mid-size OE (60mm and 81mm mortar rockets), and (3) larger OE projectiles (105mm projectile). Inert OE items, provided by the CEHNC, were used.

Table 3-5. Equipment Field Test Target Depths

Target (quantity)	Quantity	Target Depth (inches bgs)
Mk2 hand grenade	6	3, 6, 9, 12, 15, 18
2.36-inch rocket	1	12
60mm target practice mortar (body only)	3	12, 18, 24
81mm mortar (body and fins only)	6	18, 24, 36
105mm projectile	4	6, 24, 35, 46

bgs = below ground surface
Mk = Mark
mm = millimeter

Test plot boundaries were reconfigured to create "randomized" target distribution (the initial target layout was along magnetic north-south lines) by rotating test plot alignment to true north-south. Targets were then not in rows parallel to survey transects. Reconfiguration resulted in a greater test plot area that incorporated a 0.34-acre zone in which additional targets could be placed. The realigned plot corners were rerecorded using DGPS.

Equipment Field Test Data Collection and Evaluation. Field measurements commenced on 22-23 January 2001, with equipment assembly and testing. Static and dynamic line tests were performed over ground surface targets to evaluate temporal and spatial data offsets, as well as to ensure as low as possible noise signature caused by arrayed systems (the same tests were performed for three arrays deployed to the project site).

Background response along calibrated tape was recorded at two different walking speeds. Data were then collected over a surface target (inert M69 grenade shell body) at approximately 2 feet per second in two directions of travel (two passes over target) to evaluate temporal/spatial data log, and then at 4 feet per second and then 1 foot per second to estimate amplitude response differences caused by transverse speed.

Dynamic position tests along an east-west line over discrete targets at ground level demonstrated that the TEM systems make repeatable measurements when traversing the source from either direction at normal or slower walking speeds. Faster traverses broaden and shift the anomaly peak, as a result of temporal position lags between the GPS and TEM records, as well as lags between measurement and the instant of the record (variation between where the system is when the data are collected versus recorded). Data position lag (approximately 1.6 feet) was incorporated into data processing algorithm; amplitude response differences due to traverse speeds tested were not significant.

The equivalent EM-61 background response over the preliminary test plot is presented as Figure 1 in Appendix B. Figures 2, 3, and 4 in Appendix B show target position overlain on the standard EM-61 data collected by each geophysical mapping team. The equipment test results indicated that small OE items (grenade sized) were consistently detected at depths up to 6 inches bgs; larger targets (60mm and 81mm mortar rockets) were detectable at 18 inches bgs and 105mm projectiles were detectable at 46 inches bgs.

To address concern over detection capabilities, a second test area was selected in a different soil type. In this second environment, 37mm projectiles were detectable to 12 inches bgs; 60mm and 81mm tail assemblies were detectable at 12 to 18 inches bgs.

The difference in detection appears related to iron-content and mineralogy changes. The equipment test plot was near a cinder cone that catastrophically blew out, scattering cinders and other debris over the area where the plot was situated. The second test area was in soils developed in situ and/or deposited by eolian and colluvial processes. It would appear that cinders have a significantly greater magnetization than other soils, resulting in greater electrical conductivity (i.e., "hot" rocks). Boulders, cobbles, and mineral grain deposits caused detectable EM responses to be mapped as potential OE-related anomalies. Consequently, a significantly greater number of false-positives (i.e., nothing was found at the original signal location) were investigated in areas of cinder-derived soils.

The EM-61-HH data contained amplitude steps as a function of battery power. This precluded use of the equipment as a detection and mapping system capable of useful discrimination of anomalies of interest. Low battery voltage results in a flattened, smoothed, low-amplitude response over the survey area. Full battery voltage over the plot using the same measurement parameters (sensor height and line spacing) results in a pronouncedly different response character. Consequently, the EM-61-HH was used only to recover anomaly locations during reacquisition, but not define what was, or was not, considered to be an anomaly to be investigated.

3.1.4 Survey Layout

GPS base stations were established at several locations on the former maneuver area to achieve complete coverage of the site (Photograph 3-5). All coordinates utilized the NAD83 in U.S. State Plane Feet, Hawaiʻi Zone 1. The geophysical mapping data were spatially referenced to the National Geodetic Survey control points listed in Table 3-6. Navigation was based on differential/real-time kinematic (RTK) GPS locations along each survey transect.

Photograph 3-5. Setting up global positioning system base station.

3.1.5 Field Data Collection

Production measurements along random transects began in January 2001 and lasted through April 2001. In addition, contiguous survey data were collected over randomly dispersed sampling grids distributed over areas where more detailed information was required. TEM data were collected over 216 miles of

Table 3-6. National Geodetic Survey Control Points, Island of Hawai'i

Control Point	Easting	Northing	Elevation (feet)
Holoholoku	1591352.36	415181.28	3,268.58
Sector 2 Power Lines[(a)]	1542626.23	393996.60	533.08
Kawaiwai 2	1559830.10	439151.28	1,626.74
Sector 4: Base 04.2[(a)]	1545313.48	419633.56	527.48
Sector 3: Ranch[(a)]	1564469.67	365417.13	1,565.07
Base 2.2[(a)]	1542626.73	394287.16	1,076.88
Kaiwi	1570067.01	390034.22	2,647.03
Y Point - Sector 6/7[(a)]	1576056.95	401395.08	2,600.19
Z Point - Sector 6[(a)]	1561075.62	396510.65	1,888.17
X Point - Sector 6[(a)]	1556639.74	393102.92	1,673.21
Bridge Point[(a)]	1562420.42	374899.05	2,567.02
Waiki'i Point	1585548.13	377705.38	4,234.81
Airport STAB	1580749.77	422491.45	2,663.29

Note: (a) Control point surveyed by Earth Tech using the Trimble 4800 GPS.

random transects and over 130 100-foot by 100-foot grids. Table 3-7 shows the total number of miles (via random transects) and the total number of grids geophysically mapped during the Phase II EE/CA field investigation. The total acreage mapped during the geophysical investigation is also shown in Table 3-7.

Of the 124 grids surveyed and staked in Sectors 2a and 2b, 48 were geophysically mapped (see Table 3-7); 76 grids could not be geophysically mapped due to rough terrain conditions that prohibited accessibility with the geophysical equipment and presented serious safety concerns for field personnel walking through the area with heavy equipment. Of the 50 grids surveyed and staked in Sector 4, 31 were geophysically mapped; 19 grids could not be geophysically mapped due to the proximity of cultural clutter and other post-1945 disturbances. Of the 65 grids surveyed and staked in Sector 12, 48 were geophysically mapped; the remaining 17 grids were not geophysically mapped because sufficient data had already been obtained to characterize the sector for OE.

Transect path progression was further randomized by the need to avoid large rocks, a'a lava fields, ravines, and/or densely overgrowth kiawe thickets. Data within the grids were collected such that coverage was as complete as possible. Lava boulders, outcrops, and flowers precluded complete coverage of some grids.

TEM data were collected using two Geonics, Ltd., 1-meter x 0.5-meter loop EM-61 high-sensitivity metal detectors with transmitters tied together to create a 6-foot wide ganged array. The equipment was mounted on wheels and man-towed at a slow walking pace (approximately 2-3 feet per second). TEM response was digitally captured as a time-stamped record in data loggers (Polycorder Model 720). TEM measurement stations were recorded using Leica DGPS. Recording DGPS base stations were established on known positions to

Table 3-7. Geophysically Mapped Grids and Transects

Sector Number	Sector Name	Miles of Transects Mapped	Number of Grids Mapped	Total Acreage Mapped
1	Kaniku Lava Flow	2.89	--	2.28
2a	Waikoloa Village - West	33.63	46	28.28
2b	Waikoloa Village - East	25.29	2	20.38
3	Keamuku	18.49	--	13.53
4	Lalamilo Wind Farm	5.64	31	11.56
5	Waikoloa Road	12.40	--	21.80
6	Pu‘u Pa Maneuver Area	19.70	3	16.21
7	Holoholoku	24.99	--	19.41
9	Kawaihae Road	7.00	--	5.52
10	Lalamilo State Lands	36.31	--	27.23
11	Puako Parcel	4.17	--	3.29
12	O‘uli Parcel	5.04	48	13.95
13	West Waimea/Kamuela Airport	20.48	--	16.14
Total		**216.03**	**130**	**199.58**

record and transmit correcting data to rover units. The rover GPS data were operated in an RTK GPS mode, allowing the operators to simultaneously navigate and record position coincident with the digitally captured TEM response. A DGPS receiver antenna was fixed in position at the trailing edge of the mid point of the arrays. EM electronics were carried by the geotechnician; GPS controller/radio link (for RTK capability) was carried by a second technician following about 6 to 10 feet behind the EM array.

Tying the two transmitters together allows a wider swath to be surveyed with a greater transmitter moment than can be obtained with a single system. However, in areas where the ganged array could not be deployed because of terrain and/or vegetation, single systems were used. The detection capabilities of these systems, although less than that of the ganged arrays, were sufficient to detect 37mm and larger subsurface targets, as verified over a secondary test area established in Sector 4.

The EM instrument and GPS clocks were synchronized for data collection. The EM instrument sampling rate was four readings per second; a time stamp was recorded for each record. DGPS data were collected at two positions per second. Data coordinates were determined by interpolating GPS coordinates and time-stamped geophysical response. This was accomplished using downloaded data stream and programs written for EM-61 and Leica RTK GPS data by Zonge.

3.1.6 Field Data Analysis

Anomaly discrimination was accomplished by identification of discrete response parameters distinct from background response levels. The TEM data were analyzed using automated picking algorithms developed by Zonge. The program generates a histogram to be used in identifying model responses in the data.

These are used to determine threshold criteria for each individual profile (Figure 3-3). A spheroidal model is calculated for the threshold peaks. Those anomalies with good fits to the calculated model were identified as potential OE targets.

An example anomaly plot is presented in Figure 3-4. The program outputs are comparatively calculated versus actual profiles over the anomalies and a summary image of the grid data. Figure 3-5 shows the output of the analysis overlain on the geophysical response image of a sampling grid. The lead and/or project geophysicist individually inspected these outputs. All anomalies greater than or equal to 25mV were selected for investigation. Those anomalies with lower amplitudes, but that possesses coherent contrast to the background response, as seen on the example provided by Figure 3-6, were added to the "dig list" for intrusive investigation.

3.1.7 Field Processing

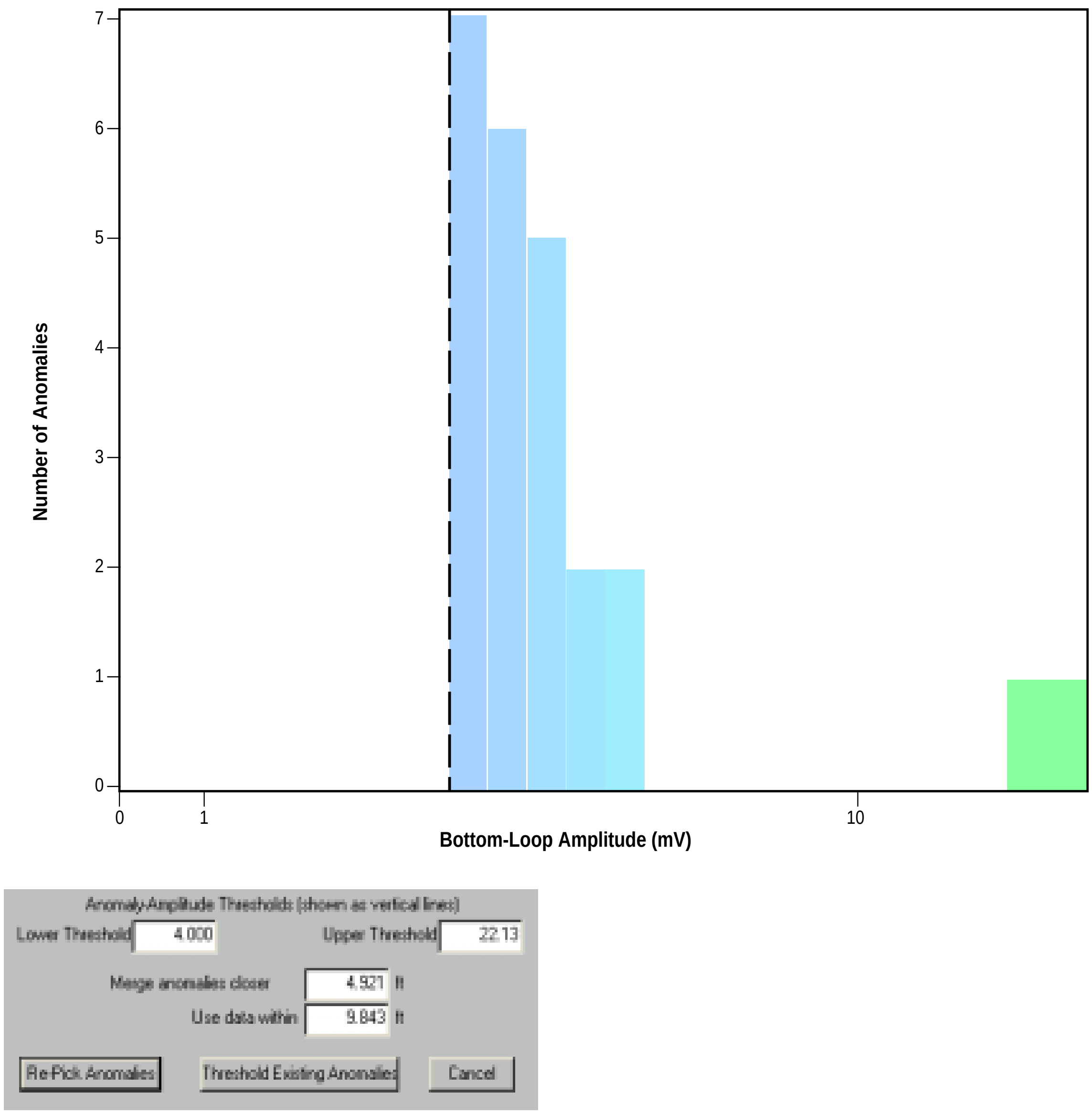
TEM data were dumped from the data loggers to a laptop personal computer (PC) at least twice a day and RTK GPS data were downloaded daily. Downloaded TEM data were in a block American Standard Code for Information Interchange (ASCII) format. GPS coordinates were saved into a tabular spreadsheet file with comma-separated values. Zonge data processing software merged the two data sets by interpolating GPS coordinates to TEM measurement position by referencing the time stamp (recorded as decimal hours). The merged data set presents northing and easting, top coil response (mV), bottom coil response (mV), a filtered response, and the mathematical difference between the top and bottom coil response in a single electronic file.

TEM data for each transect are presented as profile plots showing mV values along the vertical axis versus line distance along the horizontal axis. Positive amplitude peaks coherent across several data points and differentiable from background TEM response are discriminated as anomalous responses that may be representative of discrete metallic conductors buried in the near-surface soils. Peak widths are controlled by both anomaly source dimensions and depth below ground surface, where peak width over a compact conductive object is proportional to the object depth below ground surface.

Plan view map images summarize the data for each mapped grid. The response to geologic background was suppressed with a non-linear filter by smoothing the slowly varying response to geology. The result saves narrow, closed "spikes" of the late-time response to metallic objects.

3.1.8 Review of Field Data

Field quality control data processing was limited to a symbol posting of the measurement stations along the survey paths and generation of simple profiles of the data measured at each of the geophysical receivers of the array. A visual inspection of data was performed to identify any single-point anomalies, steps in response, or incoherent signal/excessive noise band-width.



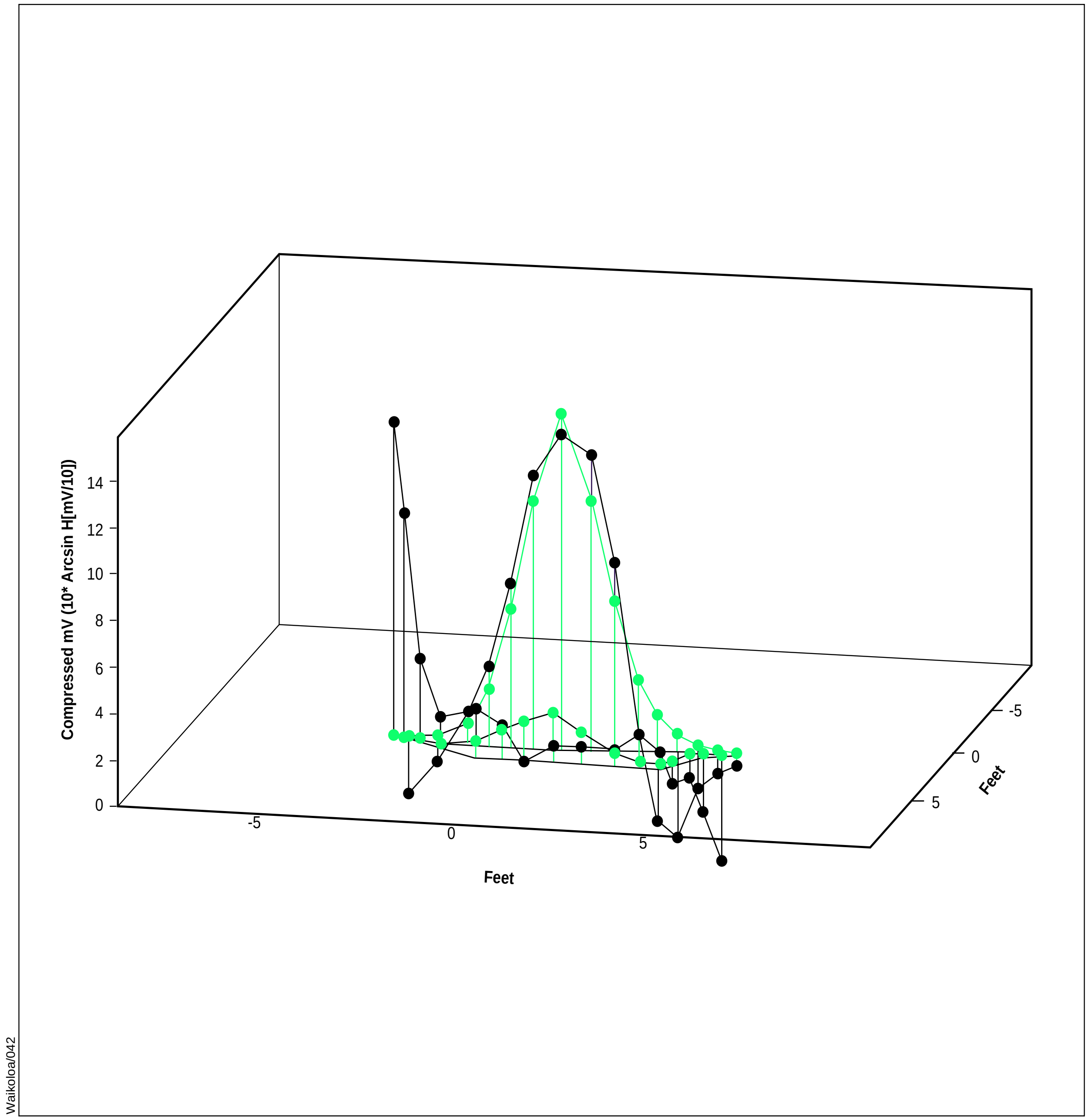
Waikoloa/041

EXPLANATION

Anomaly Amplitude Thresholds

Anomaly Lower and Upper Thresholds

Figure 3-3



EXPLANATION

● Measured Data

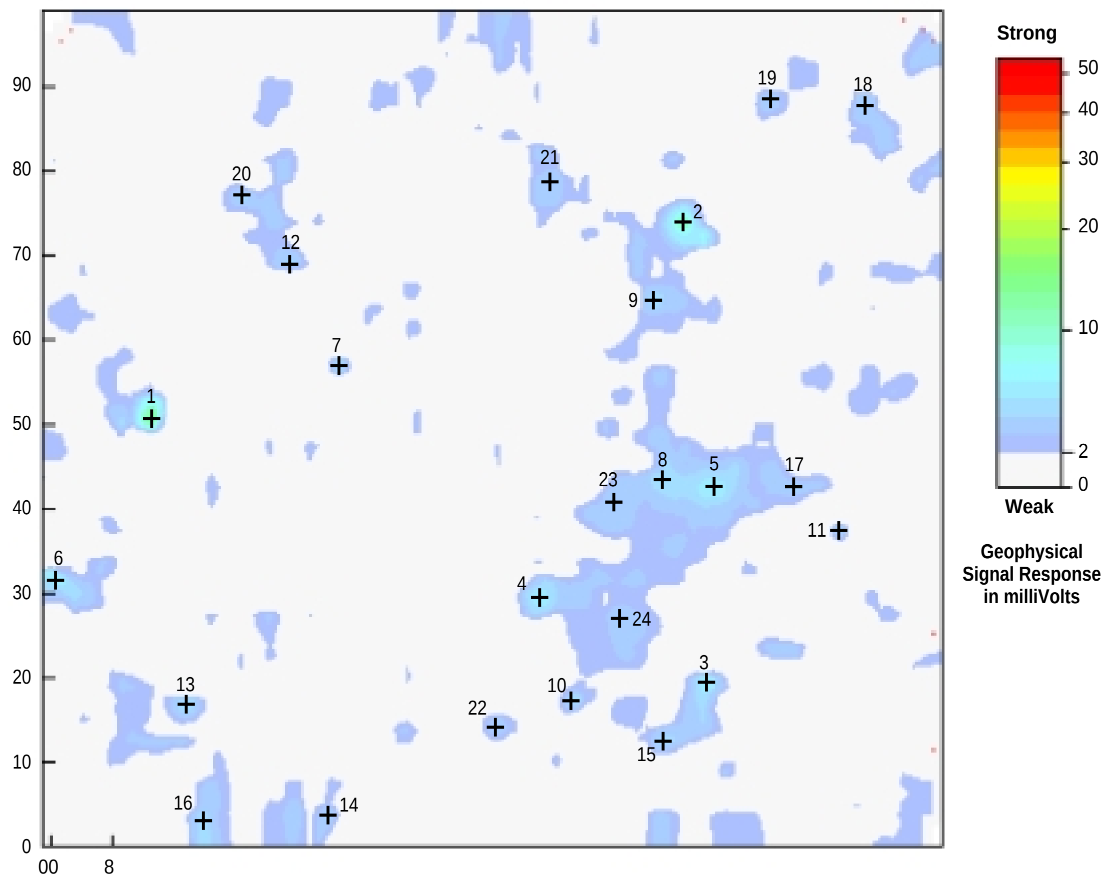
● Modeled Data

mV milliVolt

H Magnetic Field Strength

Geophysical Anomaly Profile Plot

Figure 3-4



Waikoloa/040

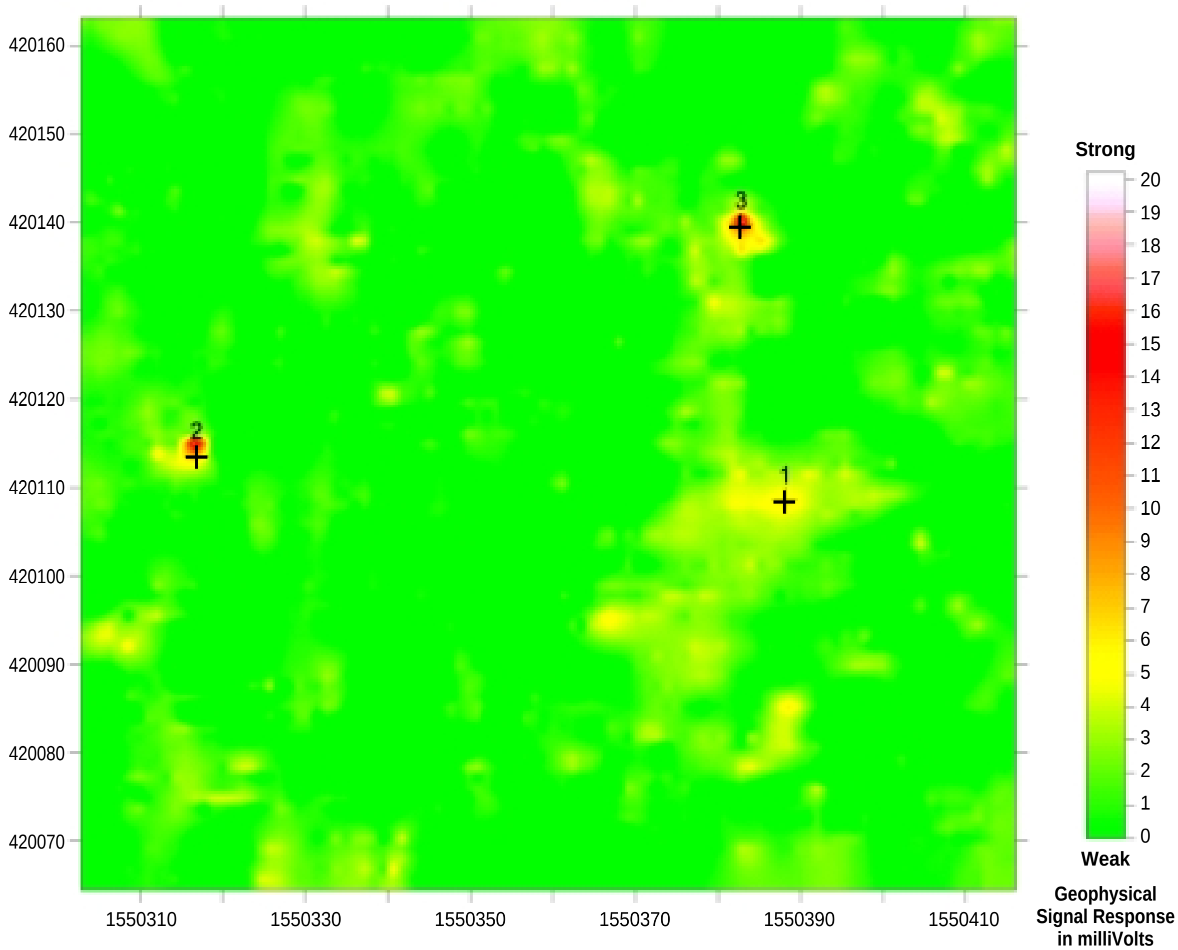
EXPLANATION

+ Anomaly Location

2 Anomaly Number

EM61 Bottom Loop Data

Figure 3-5



Waikoloa/030

EXPLANATION

+ Anomaly Location

2 Anomaly Number

Sample Grid Geophysical Data/ Dig Map

Figure 3-6

Quality control tests with each deployed TEM and GPS system over known sources and established positions demonstrated good repeatability of both TEM response and RTK GPS positioning. Standardization tests were conducted whenever the TEM systems were initiated and before they were shut down. This provided data at a minimum of at least twice for morning surveys and again, twice in the afternoon. For some grid surveys, standardization was conducted both before and after the grid was mapped.

Quality control tests with each deployed TEM and GPS system over known sources and established positions demonstrated good repeatability of both TEM response and RTK GPS positioning. Standardization tests were conducted whenever the TEM systems were initiated and before they were shut down. This provided data at a minimum of at least twice for morning surveys and again, twice in the afternoon. For some grid surveys, standardization was conducted both before and after the grid was mapped.

The results of the intrusive investigations were reviewed in comparison to the selected anomaly to assure source representativeness. Anomalies with unrepresentative sources discovered were reinvestigated; apparent false positives with no clear other-than-subsurface (e.g., terrain, clutter, vegetation, geology) sources were also reinvestigated.

Reinvestigation entailed reacquisition of location, resurvey with the EM system, and continued excavation if the anomaly was confirmed. Some locations were intrusively investigated even when no anomaly confirmation was found in order to confirm that the initial anomaly source was false.

Quality Control Summary. Prior to conducting geophysical mapping activities, the CEHNC project geophysicist buried inert ordnance items at various depths throughout the project site. The locations of the buried seeded targets were unknown to Earth Tech and the geophysical mapping crews. The seeded targets were buried in locations unknown to field crews to verify that the geophysical methods employed at the site would detect ordnance of these type and size at various depths. A brief letter report detailing the results of the seeded targets is presented as Appendix C.

The following items were also assessed to ensure data quality was maintained:

- **Precision.** The repeatability for each TEM system was separately recorded and remained within a specified value or the standard response obtained at the test plot near Holoholoku. Repeatability for the GPS systems was ± 0.3 feet.

- **Accuracy.** Final data resolution was such that properly reacquired anomaly locations were identified to within a 1.5-foot radius of the source location.

- **Completeness.** Geophysical mapping tracks were plotted over field maps to check for complete coverage of investigation areas. Unavoidable obstacles were identified in field notes and result in direct correspondence with missing data. No unexplained data drop-outs or inexplicable data shortages were found.

- **Representativeness.** All anomaly locations were investigated until the anomaly was adequately accounted for by the discovered source.
- **Reasonableness.** Variations or results not compatible with prior results or expectations were reviewed with the subcontractor geophysicist to determine causative features that may be present.

No geophysical field data were re-collected as a result of these reviews; however, the reviews did identify reacquisition problems in Sector 4. The affected anomaly locations were rerecovered and reinvestigated by the intrusive dig teams.

The HSP grid coordinates recorded for each survey grid and transect path were posted to a site map and compared with known topography and geographic references to ensure that the sampling data were accurately located within the study area. The field logs were reviewed each day to verify that data were collected following a continuous progression along the survey grids and random transects. If the survey progression was interrupted for a particular segment because of terrain or other considerations, the causes of the deviation and the actual mode of progression were fully described in the daily log notes.

The field review ensured that the survey path investigation was complete by verifying that the spatial data density (measurements per unit distance) was representative of the mapping effort described in the daily log. Field notes were compared to the downloaded digital file data to assure correspondence between grids/transect paths searched and grids/transect paths recorded.

3.1.9 Anomaly Identification

Data were processed on site utilizing an automated picking routine. The potential anomalies were screened by project geophysical staff. Anomalies clearly associated with linear or cultural clutter were discarded. The remaining anomalies with amplitudes greater than 25mV were selected for intrusive investigation. Anomalies with less than 25mV amplitudes were individually inspected and compared with field notes. Those anomalies with characteristic response shapes distinguishable from associated background responses were also selected for investigation. The amplitudes for these anomalies ranged from 6 to 24mV.

An ASCII-format tabulation of the anomalies was generated. The table included: anomaly number, northing and easting (HSP grid coordinates measured in feet), anomaly amplitude, and other anomaly attributes (i.e., estimated depth).

A total of 1,489 discrete anomalies were identified for intrusive investigation using an automatic target-picking algorithm developed by Zonge for the TEM data. Each of these was extracted from the survey data by anomaly threshold criteria developed for each sector within the former maneuver area. All anomalies greater than or equal to 25mV were investigated unless there was clear evidence in the field notes that these were caused by cultural features such as water lines, fences, or roadways. Additional anomalies with amplitudes less than 25mV were individually scrutinized. Those with coherent responses differentiable from the geologic background of the project areas were also selected for investigation. A total of 974 anomalies were selected for investigation by the reacquisition teams; the remaining anomalies did not warrant further investigation based on the criteria stated previously.

The locations of the geophysically mapped grids and transects in Sectors 1 through 13 are shown on Plate 3-1 at the end of Chapter 3.0. A detailed list by sector of UXO, OE scrap, and small arms recovered during the Phase II EE/CA field investigation is provided in Appendix D.

3.1.10 Visual Surface Search Transects

To collect data to characterize the sector for OE in areas where geophysical mapping was not feasible due to impassable terrain conditions (i.e., unstable a‘a lava rock), visual surface search transects were performed (Plate 3-1). These areas included the west region of Sector 1, the west regions of Sectors 2a and 2b, the central and south areas of Sector 5, and a majority of the area in Sector 11. The visual surface search transects were performed much like the visual reconnaissance surveys (see Section 3.1.1) except that a team of three to five UXO technicians were spaced only 5 feet apart. The UXO team visually searched the ground surface for OE or evidence of OE and noted any UXO or OE scrap locations by taking DGPS data points over/around the feature. The feature was then drawn on a field map and documented in a daily logbook maintained by each team member. Table 3-8 shows the sectors where the visual surface search transects were performed; number of miles traversed; the number of acres visually surveyed; and the number of UXO, OE scrap, and small arms recovered.

Table 3-8. Visual Surface Search Transects

Sector Number	Sector Name	Miles Traversed	Acres Surveyed	Number of UXO	Number of OE Scrap	Number of Small Arms
1	Kaniku Lava Flow	8.03	19.47	--	9	--
2a	Waikoloa Village - West	5.40	9.82	--	5	--
2b	Waikoloa Village - East	0.68	1.24	--	3	--
5	Waikoloa Road	6.50	11.35	--	38	--
11	Puako Parcel	16.25	39.39	--	258	--
Total		**36.86**	**81.27**	**0**	**313**	**0**

OE = ordnance and explosives
UXO = unexploded ordnance

3.1.11 Anomaly Investigation and Ordnance and Explosives Sampling Procedures

Geophysical anomaly locations identified by the geophysical data analysis process were provided to the anomaly reacquisition teams in HSP coordinates. Anomaly locations were recovered using an RTK GPS system to find the coordinates defined by the analysis of the geophysical data. Every anomaly requiring investigation, as identified through the geophysical data processing, was reacquired by the reacquisition team. The anomaly reacquisition teams used an EM-61 (the same type of instrument used for geophysical mapping) to pinpoint the center of the located anomaly (Photograph 3-6). If the EM-61 could not relocate the anomaly, the reacquisition teams investigated the nearby terrain and/or cultural clutter features to determine if these were potential anomaly sources. Anomalies that were caused by surface metallic debris (e.g., OE scrap, metal scrap, and horseshoes) were described by the reacquisition teams, but were not flagged for investigation by the OE sampling teams. Each relocated anomaly requiring subsurface investigation was marked with an annotated pin flag, listing the anomaly identification number.

Photograph 3-6. Reacquisition of geophysical anomaly.

A “dig sheet” listing the HSP coordinates of each anomaly flagged by the reacquisition teams and a “dig map” showing anomaly locations within the sector were provided to the OE sampling teams. Flagged anomalies were intrusively investigated (Photograph 3-7) until an anomaly source was positively identified (Photograph 3-8). The OE sampling teams utilized a hand-held EM-61 metal detector as a screening aid to ensure personnel safety during the progress of the excavation.

Photograph 3-7. OE sampling of geophysical anomaly.

Photograph 3-8. Recovery of OE scrap during intrusive sampling.

Data describing the anomaly sources discovered during the intrusive investigation process included a detailed description of the item, relative size, estimated weight, and depth below ground surface.

The exploratory excavations were left open until a UXO Supervisor had verified the absence of additional metal sources within the perimeter of the excavated pit.

All excavations were then backfilled and the ground surface restored to as near as practical to preexisting conditions.

All recovered items were evaluated in comparison to the mapped anomaly amplitude to ensure that the geophysical response signal for the anomaly was representative of the recovered item.

3.1.12 Anomaly Investigation and Ordnance and Explosives Sampling Results by Sector

Through the geophysical methods described previously, a total of 1,489 anomalies were identified for investigation throughout 12 of the 13 sectors. A total of 515 anomalies (35 percent) could not be investigated because homes, roads, schools, and other populated areas were within the minimum separation distance (MSD), meaning that occupants would have had to be evacuated prior to and during intrusive activities in this areas. Sufficient data were collected around these areas without having to propose evacuations. Of the 974 anomalies remaining, all of them were investigated with the following results: 4 anomaly sources (less than 1 percent) were UXO, 169 anomaly sources (17 percent) were OE scrap, 10 anomaly sources (1 percent) were small arms, and 625 anomaly sources (64 percent) were non-OE. A total of 166 anomalies (17 percent) were investigated and determined to be “false positives.” False positives are those anomalies that, when intrusively investigated, produced no metallic source. False positives, as described in Section 2.1.5, most typically occur as the result of geologic (including topographic) interference. Cultural interference (or noise) also causes false positives. Soil types in the east region of the former maneuver area (Sector 7) appear to contain a greater iron content than soils throughout the former maneuver area. These iron-rich soils and basalt cobbles cause geophysical false positives in these areas. In other areas, false positives were likely the result of geophysical anomaly sources immediately outside of the direct line random transect path.

The following paragraphs detail the findings of anomaly reacquisition and intrusive OE sampling activities at the Former Waikoloa Maneuver Area and Nansay Sites. Table 3-9 shows the total number of anomalies identified for investigation during the geophysical data processing, the number of anomalies investigated, and the number of anomaly sources that yielded UXO, OE scrap, small arms, non-OE, and false positives. The total number of anomalies containing UXO, OE scrap, small arms, and non-OE items (Table 3-9) will not equal the total number of items recovered at the site (Table 3-10) because in several instances, more than one item was found at one single anomaly location

Table 3-9. Results of Anomaly Investigation and OE Sampling

Sector	Total Number of Anomalies	Total Anomalies Investigated	Total Anomalies Not Investigated[(a)]	Anomaly Investigation Summary: UXO Anomaly Sources	OE Scrap Anomaly Sources	Small Arms Anomaly Sources	Non-OE Anomaly Sources	False Positives
1	16	12	4	--	1	--	10	1
2a	161	63	98	1	33	--	27	2
2b	45	36	9	--	2	--	29	5
3	56	51	5[(b)]	--	--	--	47	4
4	230	230	--	--	64	--	123	43
5	18	18	--	--	7	--	6	5
6	57	57	--	1	9	2	43	2
7	124	124	--	--	2	1	82	39
9	8	8	--	--	--	--	8	--
10	82	80	2[(b)]	1	33	--	39	7
11	4	3	1	--	--	--	3	--
12	105	85	20	1	17	5	51	11
13	583	207	376[(b)]	--	1	2	157	47
Total	**1,489**	**974**	**515**	**4[(c)]**	**169**	**10**	**625**	**166[(d)]**

Notes: (a) Anomalies could not be investigated because they were too close to roads or occupied structures for safe investigation.
(b) In Sector 3, one anomaly over the threshold value (25mV) was not investigated; two anomalies over the threshold value (25mV) were not investigated in Sector 10 and Sector 13 (see discussion on following page).
(c) Two UXO items were recovered on the surface.
(d) False positive ratio is high in Sectors 4, 5, and 7 due to soil types and off-transect sources (see Section 3.2.12).
OE = ordnance and explosives
UXO = unexploded ordnance

Table 3-10. OE Sampling Summary Table

Sector Number	Sector Name	Number of UXO	Number of OE Scrap	Number of Small Arms
1	Kaniku Lava Flow	--	1	--
2a	Waikoloa Village - West	1	143	--
2b	Waikoloa Village - East	--	3	--
3	Keamuku	--	--	--
4	Lalamilo Wind Farm	--	150	--
5	Waikoloa Road	--	24	--
6	Pu‘u Pa Maneuver Area	1	38	207
7	Holoholoku	--	2	2
9	Kawaihae Road	--	--	--
10	Lalamilo State Land	1	130	--
11	Puako Parcel	--	--	--
12	O‘uli Parcel	1	24	6
13	West Waimea/Kamuela Airport	--	1	2
Total		**4**	**516[(a)]**	**217[(a)]**

Note: (a) Number of OE scrap and small arms do not equal those shown in Table 3-9 as multiple items were recovered in a single anomaly source location.
OE = ordnance and explosives
UXO = unexploded ordnance

(i.e., there are more items than actual anomaly sources). The ordnance items recovered during the Phase II EE/CA field investigation are reported in detail in Appendix D.

Sector 1. There were 16 anomalies identified during the geophysical data analysis, 12 of which were investigated. Of this number, 1 anomaly source was

OE scrap, 10 anomaly sources were non-OE (83 percent), and 1 anomaly source was a false positive (i.e., nothing was found). Four of the 16 anomaly sources were within the MSD (i.e., too close to inhabited structures and main roads) and could not be investigated. The OE scrap item recovered in Sector 1 was found on the surface.

Sector 2a. There were 161 anomalies identified during the geophysical data analysis, 63 of which were investigated. Of this number, 1 anomaly source (2 percent) was UXO, 33 anomaly sources (52 percent) were OE scrap, 27 anomaly sources (43 percent) were non-OE, and 2 anomaly sources (3 percent) were false positives. A total of 98 of the 161 anomaly sources were within the MSD and could not be investigated. One UXO item (105mm projectile - HE) was recovered in Sector 2a during OE sampling (exposed on the surface). The depth of OE scrap recovered during intrusive OE sampling in Sector 2a was between 0 and 12 inches bgs.

Sector 2b. There were 45 anomalies identified during the geophysical data analysis, 36 of which were investigated. Of this number, 2 anomaly sources (6 percent) were OE scrap, 29 anomaly sources (80 percent) were non-OE, and 5 anomaly sources (14 percent) were false positives. Nine of the 45 anomaly sources were within the MSD and could not be investigated. The depth of OE scrap recovered during intrusive OE sampling in Sector 2b was between 0 and 3 inches bgs.

Sector 3. There were 56 anomalies identified during the geophysical data analysis, 51 of which were investigated. Of this number, 47 anomaly sources (92 percent) were non-OE and 4 anomaly sources (8 percent) were false positives. Four of the 56 anomaly sources were within the MSD and could not be investigated. One anomaly over the threshold value (25mV) was not investigated because the dig team was unable to recover the marked anomaly due to repeated removal of the anomaly flag by wind and/or animals.

Sector 4. There were 230 anomalies identified during the geophysical data analysis, all of which were investigated. Of this number, 64 anomaly sources (28 percent) were OE scrap, 123 anomaly sources (53 percent) were non-OE, and 43 anomaly sources (19 percent) were false positives. The depth of OE scrap recovered during intrusive OE sampling in Sector 4 was between 0 and 7 inches bgs.

Sector 5. There were 18 anomalies identified during the geophysical data analysis, all of which were investigated. Of this number, 7 anomaly sources (39 percent) were OE scrap, 6 anomaly sources (33 percent) were non-OE, and 5 anomaly sources (28 percent) were false positives. The depth of OE scrap recovered during intrusive OE sampling in Sector 5 was between 0 and 2 inches bgs.

Sector 6. There were 57 anomalies identified during the geophysical data analysis, all of which were investigated. Of this number, 1 anomaly source (2 percent) was UXO, 9 anomaly sources (16 percent) were OE scrap, 2 anomaly sources (3 percent) were small arms, 43 anomaly sources (75 percent) were non-OE, and 2 anomaly sources (4 percent) were false positives. One UXO item (4.5-inch barrage rocket - HE) was recovered during OE sampling in Sector 6 at a depth of 6 inches bgs. OE scrap was recovered between 0 and 6 inches bgs.

Sector 7. There were 124 anomalies identified during the geophysical data analysis, all of which were investigated. Of this number, 2 anomaly sources (2 percent) were OE scrap, 1 anomaly source (1 percent) was small arms, 82 anomaly sources (66 percent) were non-OE, and 39 anomaly sources (31 percent) were false positives. The depth of OE scrap recovered during intrusive OE sampling in Sector 7 was between 0 and 4 inches bgs.

Sector 9. There were 8 anomalies identified during the geophysical data analysis, all of which were investigated. All 8 anomaly sources (100 percent) were non-OE.

Sector 10. There were 82 anomalies identified during the geophysical data analysis, 80 of which were investigated. Of this number, 1 anomaly source (1 percent) was UXO, 33 anomaly sources (41 percent) were OE scrap, 39 anomaly sources (49 percent) were non-OE, and 7 anomaly sources (9 percent) were false positives. The UXO item found during OE sampling (2.36-inch rocket with warhead - high explosive anti tank [HEAT]) was found on the surface. The depth of OE scrap recovered during intrusive OE sampling in Sector 10 was between 0 and 20 inches bgs. Two anomalies over the threshold value (i.e., 25mV) were not investigated because the dig team was unable to recover marked anomalies due to repeated removal of the anomaly flag (by either animals, people, or wind).

Sector 11. There were four anomalies identified during the geophysical data analysis, three of which were investigated. All three anomaly sources (100 percent) were non-OE. One anomaly was within the MSD and could not be investigated.

Sector 12. There were 105 anomalies identified during the geophysical data analysis, 85 of which were investigated. Of this number, 1 anomaly source (1 percent) was UXO, 17 anomaly sources (20 percent) were OE scrap, 5 anomaly sources (6 percent) were small arms, 51 anomaly sources (60 percent) were non-OE, and 11 anomaly sources (13 percent) were false positives. Twenty of the 105 anomalies were within the MSD and could not be investigated. The UXO item recovered from Sector 12 during OE sampling (81mm mortar - HE) was recovered 2 inches bgs. The depth of OE scrap recovered during intrusive OE sampling in Sector 12 was between 0 and 3 inches bgs.

Sector 13. There were 583 anomalies identified during the geophysical data analysis, 207 of which were investigated. Of this number, 1 anomaly source (less than 1 percent) was OE scrap, 2 anomaly sources (1 percent) were small arms, 157 anomaly sources (76 percent) were non-OE, and 47 anomaly sources

(23 percent) were false positives. A total of 374 of the 583 anomalies were within the MSD and could not be investigated. Two anomalies over the threshold value (i.e., 25mV) were not investigated because they were in the airfield area associated with the Waimea-Kohala Airport. The depth of OE scrap recovered during intrusive OE sampling in Sector 13 was between 0 and 6 inches bgs.

Depth Distribution of Recovered Ordnance and Explosives. Of the 974 anomaly sources that were investigated, 955 anomaly sources (98 percent) were recovered at depths ranging from 0 to 12 inches bgs (i.e., within the first foot). A total of 13 anomaly sources (1 percent) were recovered at depths ranging from 12 to 24 inches bgs, and 6 anomaly sources (1 percent) were recovered at depths ranging from 24 to 36 inches bgs. There were no anomalies recovered at depths greater than 36 inches bgs. The lack of recovery of metallic anomaly sources greater than this depth is consistent with the types and depth of soil found throughout the former maneuver area.

3.3 SOURCE, NATURE, AND EXTENT OF ORDNANCE AND EXPLOSIVES

3.3.1 Summary of Results of Phase II EE/CA Field Investigation

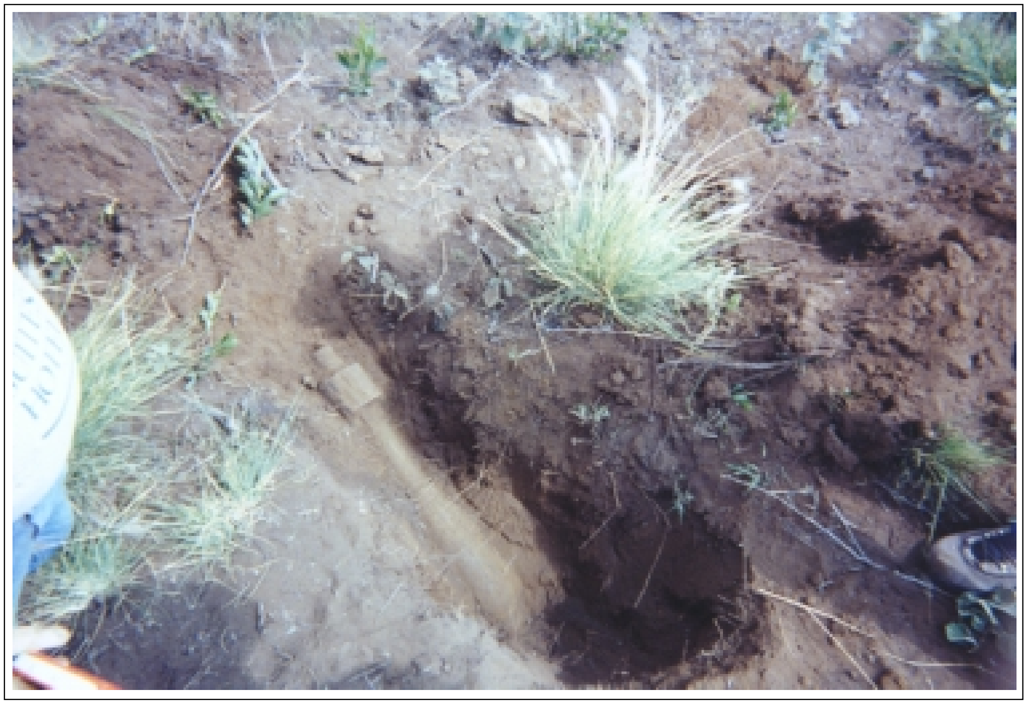
The following ordnance-related items were recovered during the Phase II EE/CA field investigation: 38 UXO items, 2,160 OE scrap items, and 1,343 small arms rounds (approximately 370 pounds). UXO was recovered in Sectors 2a, 4, 5, 6, 9, 10, 11, 12, and 13, while OE scrap was recovered in all of the sectors investigated. Photographs 3-9 through 3-12 show a few of the UXO items recovered during the EE/CA field investigation while Photograph 3-13 illustrates common types of OE scrap found throughout the former maneuver area. In some areas, small arms (Photograph 3-14) were also recovered.

The total number of UXO, OE scrap, and small arms items recovered during all Phase II EE/CA field activities (i.e., visual reconnaissance, grid survey, surface clearance, visual surface searches, and anomaly reacquisition and OE sampling) are shown in Table 3-11. The UXO items recovered and subsequently destroyed during the field investigation are tabulated in Table 3-12. The total acres investigated in each sector through visual reconnaissance, geophysical mapping, and visual surface searches are listed in Table 3-13. Figures 3-7, 3-8, 3-9, and 3-10 show a detailed sector by sector account of all UXO and OE scrap recovered during the Phase II EE/CA field investigation. In some cases, multiple UXO and OE scrap items were recovered in a single location. Multiple UXO locations are noted on these figures while multiple OE scrap items are only shown as a single point.

3.3.2 Demolition of Ordnance and Explosives

A total of 38 UXO items were recovered during the Phase II EE/CA field investigation and were destroyed by means of explosive demolition. Prior to the demolition of UXO, preparations were made in order to mitigate blast effects. This entailed the building of sandbag enclosures around the UXO item(s) to be

Photograph 3-9. UXO (155-millimeter projectile).



Photograph 3-10. UXO (4.5-inch barrage rocket).

Photograph 3-11. UXO (2.36-inch rocket).

Photograph 3-12. UXO (fuze from 75mm projectile).

Photograph 3-13. OE scrap.

Photograph 3-14. Small arms.

Table 3-11. Summary of Phase II EE/CA Field Investigation Results

Sector Number	Sector Name	Number of UXO	Number of OE Scrap	Number of Small Arms
1	Kaniku Lava Flow	--	31	--
2a	Waikoloa Village - West	3	954	6
2b	Waikoloa Village - East	--	27	--
3	Keamuku	--	--	804
4	Lalamilo Wind Farm	3	350	5
5	Waikoloa Road	1	64	--
6	Pu‘u Pa Maneuver Area	4	84	250
7	Holoholoku	--	14	13
9	Kawaihae Road	2	--	--
10	Lalamilo State Land	14	192	--
11	Puako Parcel	4	258	--
12	O‘uli Parcel	6	185	263
13	West Waimea/Kamuela Airport	1	1	2
Total		**38**	**2,160**	**1,343**

OE = ordnance and explosives
UXO = unexploded ordnance

destroyed that were proximal to houses or roadways (Photograph 3-15 and Photograph 3-16). Where needed, fire breaks were created using heavy equipment. In a few cases, due to the potential fire hazard, the local fire department watered down the area and remained on call during demolition activities to ensure that all fire precautions were being taken. Once all safety precautions were implemented, explosives purchased from Energy Enterprises (located in Hilo) were used to explosively destroy all UXO items (Photograph 3-17 and Photograph 3-18) recovered during the Phase II EE/CA field investigation.

3.3.3 Ordnance and Explosives Scrap Disposal Procedures

All OE scrap recovered during the EE/CA field investigation was collected, inspected, certified by the SUXOS as free of hazardous materials (Appendix E), and turned over to a scrap metal recycling facility.

3.3.4 Ordnance Penetration Analysis

A maximum ordnance penetration depth analysis was developed by the CEHNC to estimate the approximate depths at which OE could penetrate the surface at impact in relation to general soil and rock types that are similar to those characteristic of the former maneuver area. The penetration depths in these soil and rock types for the types of OE recovered during the Phase II EE/CA field investigation are summarized in Table 3-14. Penetration depths of OE into basalt, which is denser and more competent rock than limestone, will be less than that shown for limestone in Table 3-14. As noted in the table, these estimates are very conservative and assume that the soil and type is constant to the depths indicated. Penetration into rock is expected only for 155mm and larger projectiles. Any such penetration is thought to be less than 24 inches

Table 3-12. Former Waikoloa Maneuver Area and Nansay Sites UXO Summary Table

Sector Number	Number of UXO	UXO Type	UXO Depth (surface or inches bgs)
1	--	--	--
2a	1	75mm projectile - HE[a]	Surface
	1	75mm projectile - HE, unfuzed[c]	Surface
	1	105mm projectile - HE[d]	Surface
2b	--	--	--
3	--	--	--
4	1	2.36-inch rocket motor - fuzed[a]	Surface
	1	2.36-inch warhead - HEAT[a]	Surface
	1	75mm projectile - HE[e]	Surface
5	1	155mm projectile - HE[e]	Surface
6	1	105mm projectile - HE, unfuzed[b]	Surface
	1	4.5-inch barrage rocket - HE[d]	6
	1	60mm mortar - Illumination round[e]	Surface
	1	81mm mortar - HE[e]	Surface
7	--	--	--
9	1	81mm mortar - WP[a]	Surface
	1	Mk2 hand grenade - HE[e]	Surface
10	1	75mm projectile - HE, unfuzed[c]	Surface
	1	M9 rifle grenade - HEAT[c]	Surface
	1	Mk2 grenade fuze[c]	Surface
	1	60mm mortar - HE[c]	Surface
	1	2.36-inch rocket with warhead - HEAT[d]	Surface
	2	M9 rifle grenade fuze[e]	Surface
	1	155mm projectile - HE[e]	Surface
	2	2.36-inch rocket with warhead - HEAT[e]	Surface
	1	81mm mortar - WP[e]	Surface
	2	60mm mortar - HE (M49A2)[e]	Surface
	1	60mm mortar fuze[e]	Surface
11	3	75mm projectile - HE[e]	Surface
	1	M54 PTTF fuze[e]	Surface
12	1	37mm projectile - HE, unfuzed[c]	Surface
	2	60mm mortar - HE, fuzed[c]	Surface
	1	60mm mortar - HE[c]	Surface
	1	81mm mortar - HE[d]	2
	1	Mk2 hand grenade - HE[e]	Surface
13	1	Mk2 hand grenade - HE[e]	Surface
Total UXO	**38**		

Notes: (a) UXO items recovered during grid survey.
(b) UXO items recovered during visual reconnaissance survey.
(c) UXO items recovered during surface clearance.
(d) UXO items recovered during OE sampling.
(e) UXO items recovered while traversing between grids and sectors.

bgs = below ground surface
HE = high explosive
HEAT = high explosive anti tank
Mk = Mark
mm = millimeter
PTTF = powder train time fuze
UXO = unexploded ordnance
WP = white phosphorus

Table 3-13. Acreage Investigated by Sector at the Former Waikoloa Maneuver Area and Nansay Sites

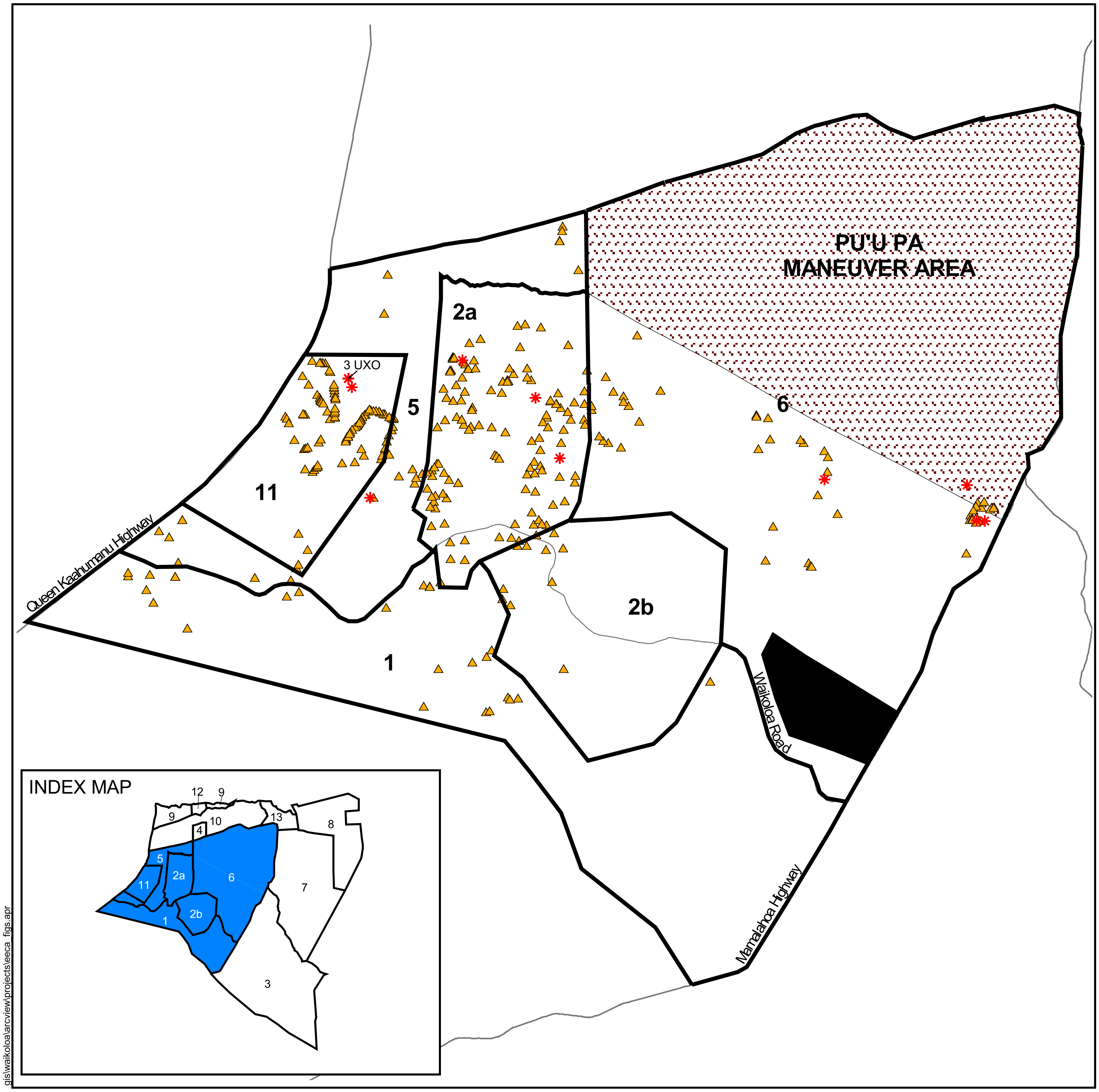
Sector Number	Sector Name	UXO Calculator Sampling Acreage	Acres Investigated: Visual Reconnaissance	Geophysical Mapping	Visual Surface Searches	Total Acreage Investigated
1	Kaniku Lava Flow	4.7	1,455	2.28	19.47	1,476.75[(a)]
2a	Waikoloa Village - West	23.0	--	28.28	9.82	38.1
2b	Waikoloa Village - East	23.0	--	20.38	1.24	21.62
3	Keamuku	4.7	5,054	13.53	--	5,067.53[(a)]
4	Lalamilo Wind Farm	22.7	--	11.56	--	11.56
5	Waikoloa Road	23.0	--	21.80	11.35	33.15
6	Pu‘u Pa Maneuver Area	23.0	1,273	16.21	--	1,289.21[(a)]
7	Holoholoku	4.7	8,436	19.41	--	8,455.41[(a)]
9	Kawaihae Road	23.0	--	5.52	--	5.52
10	Lalamilo State Land	23.0	--	27.23	--	27.23
11	Puako Parcel	23.0	--	3.29	39.39	42.68
12	O‘uli Parcel	22.5	--	13.95	--	13.95
13	West Waimea/Kamuela Airport	23.0	--	16.14	--	16.14
Total		**243.3**	**16,218**	**199.58**	**81.27**	**16,498.85**

Note: (a) Acreages for Sectors 1, 3, 6, and 7 are high due to visual reconnaissance in these areas.
UXO = unexploded ordnance

below ground surface. Since these projectiles are longer than the expected maximum penetration depth into rock, the actual penetration will have been no greater than the thickness of any overlying soil.

Based on previous soil surveys and data collected during the Phase II EE/CA field investigation, soil development throughout the former maneuver area was found to be localized and very shallow. During the Phase II EE/CA field investigation, bedrock was generally encountered 6 to 24 inches below ground surface in areas characterized by lava flows, while other areas generally showed soil development to depths of 48 inches below ground surface (and deeper in some areas). Table 3-15 shows the estimated soil depths for each sector at the former maneuver area based upon data collected during the Phase II EE/CA field investigation and soil characteristics discussed in Chapter 2.0.

Soils are most developed in the east region of the former maneuver area (Sectors 3, 7, and 8) and typically range from 12 to 48 inches below ground surface and can be deeper in isolated areas. In the central portion of the former maneuver area (west half of Sector 2, Sector 4, Sector 6, east half of Sector 9, east half of Sector 10, Sector 12, and Sector 13), soil depth begins to gradually decrease (0-12 inches below ground surface) and eventually thins out even further to the west (Sectors 1, 2, 5, 9, 10, and 11). It is very important to note that although soils are more developed in the east area of the former maneuver area, there were no UXO or large concentrations of OE scrap recovered in these



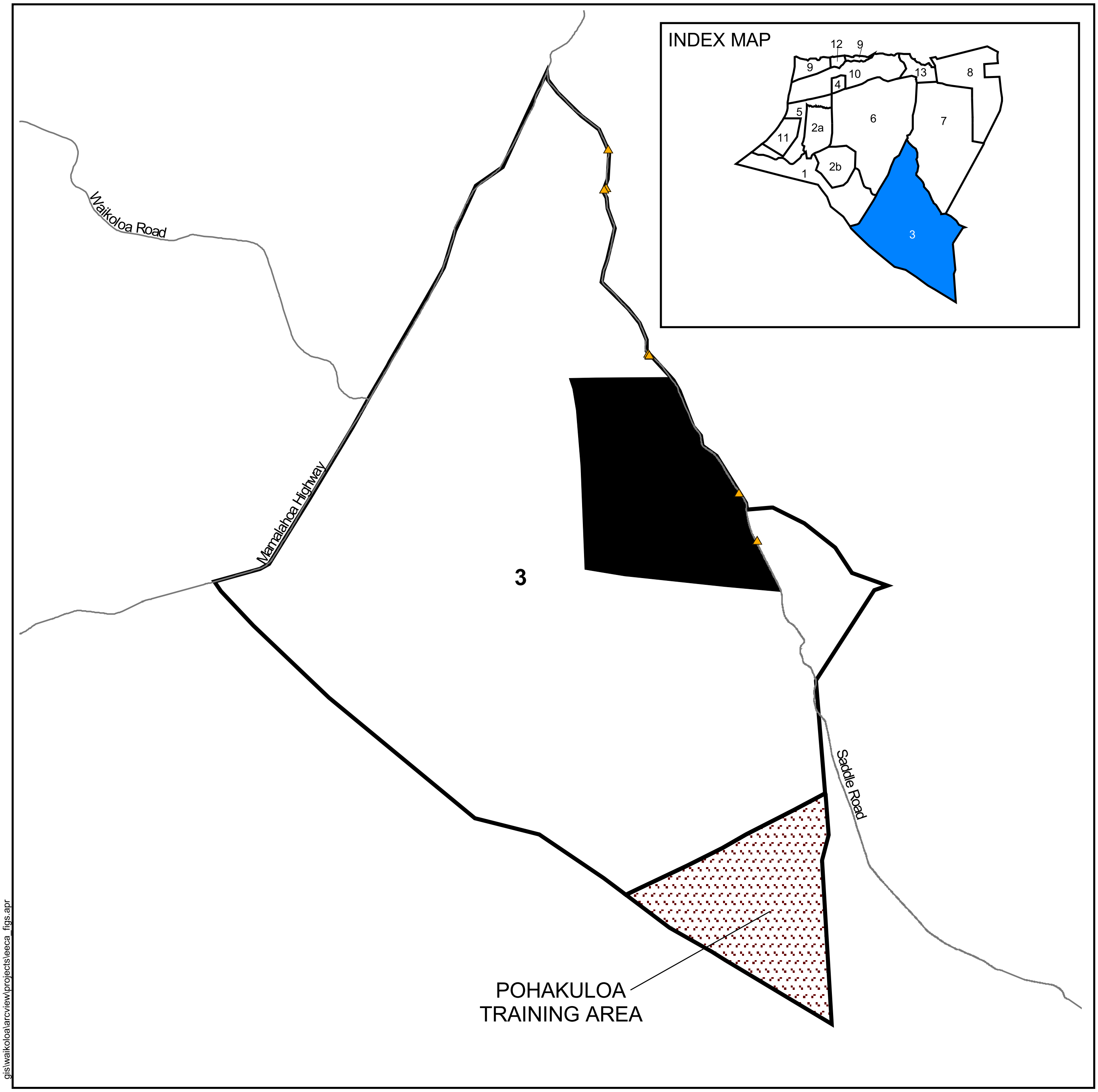
EXPLANATION

- UXO
- OE Scrap
- 6 Sector Number
- Roads
- Active military training areas not investigated during the EE/CA
- No right-of-entry areas not investigated during the EE/CA

0 10,000 Feet

EE/CA Field Investigation Results Sectors 1, 2, 5, 6 and 11 Former Waikoloa Maneuver Area and Nansay Sites, Hawai'i

Figure 3-7



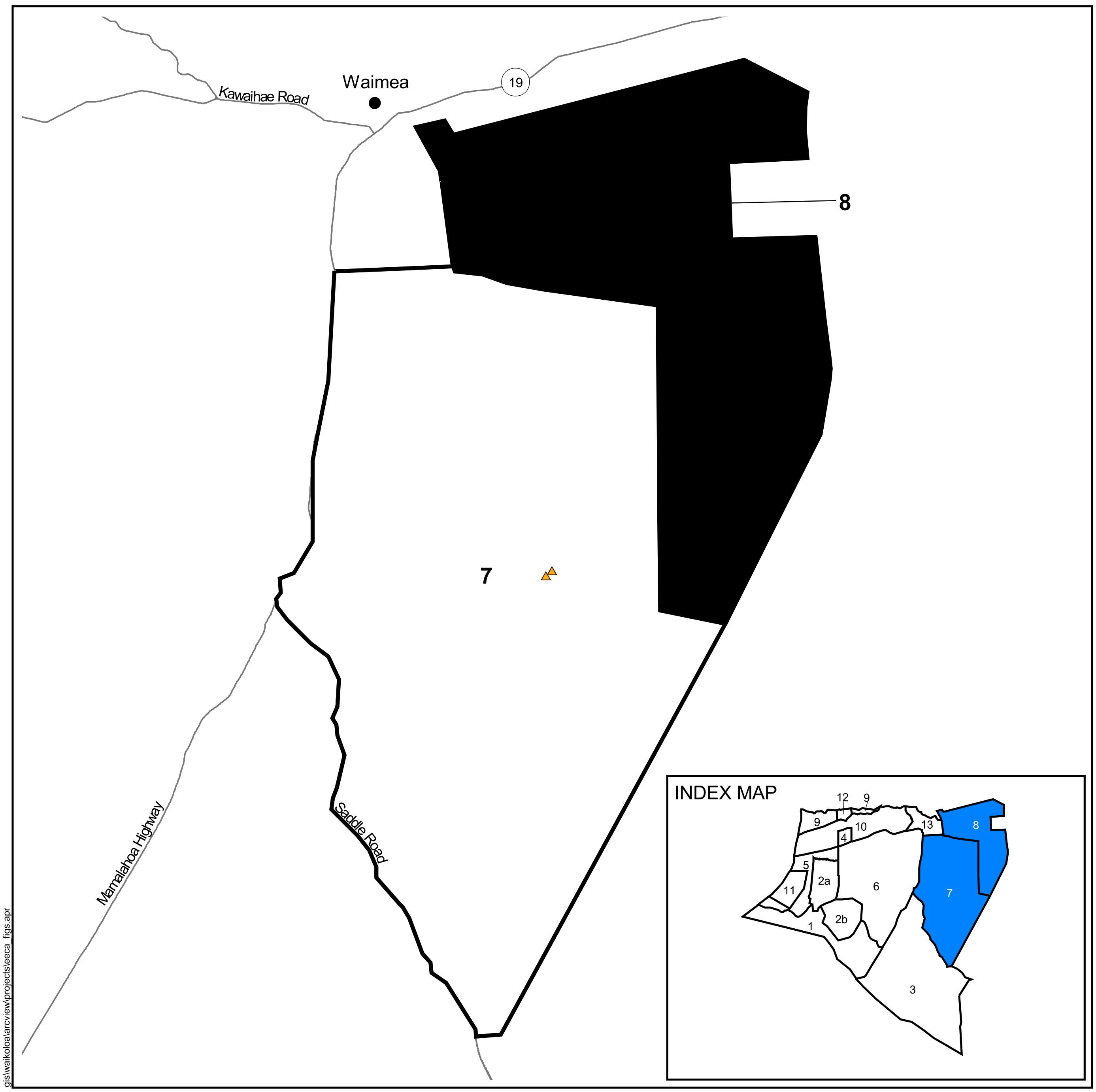
EXPLANATION

- OE Scrap
- 3 Sector Number
- Roads
- Active military training areas not investigated during the EE/CA
- No right-of-entry areas not investigated during the EE/CA

0 10,000 Feet

EE/CA Field Investigation Results Sector 3 Former Waikoloa Maneuver Area and Nansay Sites, Hawai'i

Figure 3-8



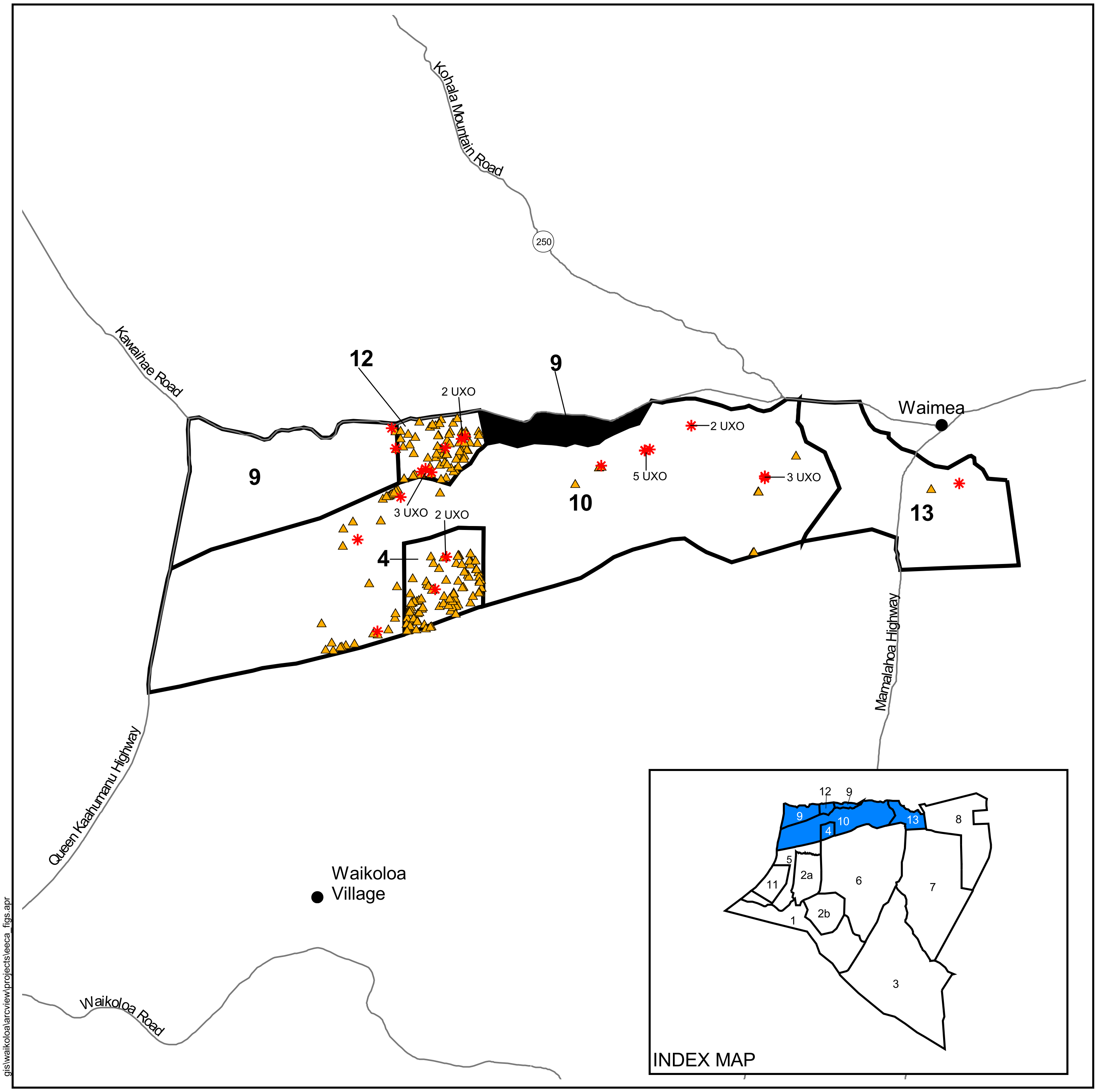
EXPLANATION

- ▲ OE Scrap
- **7** Sector Number
- —— Roads
- ■ No right-of-entry areas not investigated during the EE/CA

0 10,000 Feet

EE/CA Field Investigation Results Sectors 7 and 8 Former Waikoloa Maneuver Area and Nansay Sites, Hawai'i

Figure 3-9



EXPLANATION

- UXO
- OE Scrap
- 12 Sector Number
- Roads
- No right-of-entry areas not investigated during the EE/CA

0 10,000 Feet

EE/CA Field Investigation Results Sectors 4, 9, 10, 12 and 13 Former Waikoloa Maneuver Area and Nansay Sites, Hawai'i

Figure 3-10

Photograph 3-15. UXO technicians building sand-bag enclosure.

Photograph 3-16. Five-inch naval projectile being prepared for demolition.

Photograph 3-17. Detonation of UXO (81mm mortar).

Photograph 3-18. Detonation of UXO (75mm high explosive projectile).

Table 3-14. Maximum Ordnance Penetration Depths

	Penetration (inches bgs)[a]			
Ordnance	Sand	Loam	Clay	Basalt[c]
Grenade (Mk2)	0.0	0.0	0.0	0.0
37mm HE (M63)	46.8	62.4	94.8	< 8.0
Grenade (M9 Rifle)	1.2	2.4	2.4	< 1.0
60mm mortar HE (M49A1)	13.2	18.0	27.6	< 3.0
2.36-inch rocket (M6A1)	4.8	6.0	9.6	< 1.0
75mm HE (M48)	58.8	76.8	117.6	< 10.0
81mm mortar HE (M43A1)	32.4	42.0	64.8	< 6.0
81mm mortar, illumination[b]	--	--	--	--
105mm HE (M1)	92.4	121.2	184.8	< 15.0
4.5-inch barrage rocket[b]	--	--	--	--
155mm HE (M107)	168.0	196.8	336.0	< 27.0

Notes: (a) All penetration depths are based on munition impact at muzzle velocity and are normal to the surface. These are extremely conservative estimates because munitions typically have slowed considerably by the time they impact, and they usually impact at a shallow angle rather than normal to the surface. Source: EM 1110-1-4009, 23 June 2000.

(b) Penetration depth analysis has not been completed for these munitions; however, depth penetration would be similar to like size and weight munitions that have been analyzed.

(c) Limestone depths of penetration were used instead of basalt. Limestone is more dense than basalt; therefore, ordnance would be likely to penetrate depths less than those shown.

< = less than
bgs = below ground surface
HE = high explosive
Mk = Mark
mm = millimeter

Table 3-15. Estimated Soil Depths

Sector Number	Sector Name	Estimated Soil Depths (inches bgs)
1	Kaniku Lava Flow	0-6
2a	Waikoloa Village - West	0-12
2b	Waikoloa Village - East	0-24
3	Keamuku	0-48
4	Lalamilo Wind Farm	0-12
5	Waikoloa Road	0-5
6	Pu‘u Pa Maneuver Area	0-36
7	Holoholoku	0-48
9	Kawaihae Road	0-12
10	Lalamilo State Land	0-24
11	Puako Parcel	0-10
12	O‘uli Parcel	0-12
13	West Waimea/Kamuela Airport	0-48

Note: (a) Soil depths based on typical conditions observed during the EE/CA field investigation and the data presented in *Soil Survey, Island of Hawai‘i, Hawai‘i, U.S. Soil Conservation Service, U.S. Department of Agriculture, 1973.*

bgs = below ground surface

areas, while the sectors with clusters of OE scrap and UXO have little soil development. These data suggest that in the areas where UXO was recovered, if UXO were present in these areas, it would likely be on the surface or very close to the surface (0 to 12 inches below ground surface).

While the maximum theoretical depth of penetration of OE exceeds the estimated soil thickness in Table 3-15, the actual depth of penetration for the OE will be less than the soil thickness because the basalt substrate will not allow greater penetration. Based on OE sampling results, it is unlikely that OE would be present at depth without some evidence of OE found at the ground surface or in the very near surface (i.e., 0 to 12 inches below ground surface).

3.4 DESCRIPTION OF HAZARDS OF ORDNANCE AND EXPLOSIVES RECOVERED DURING THE PHASE II EE/CA FIELD INVESTIGATION

The following paragraphs summarize the types of UXO recovered during the Phase II EE/CA field investigation and the purpose/function of each item. Table 3-16 lists the types of UXO recovered, a brief description of the OE hazard, the condition or state it was found, and the sensitivity associated with the item. For each of the UXO items recovered, an individual would have to perform some deliberate act to be exposed to OE risk. In terms of sensitivity, UXO items that are classified as "very sensitive" are likely to detonate with very little effort (e.g., simple touch or movement). UXO items that are classified as "sensitive" are likely to detonate with moderate effort (e.g., dropping the item, striking it, driving over it, or exposing it to extreme heat). UXO items classified as a "residual risk" are those that would require extreme effort (i.e., cutting the item, drilling into it, mutilating it, or crushing it) to detonate.

Table 3-16. Characteristics of UXO Recovered During Phase II EE/CA Field Investigation

OE Type	OE Hazard	Condition	Sensitivity
Mk2 hand grenade	Likely to cause fatal injury	Armed (fuzed)	Very sensitive
M9 rifle grenade (HEAT)	Likely to cause fatal injury	Armed (fuzed)	Very sensitive
60mm mortar HE	Likely to cause fatal injury	Armed (fuzed)	Very sensitive
60mm mortar illumination	Likely to cause major injury	Armed (fuzed)	Very sensitive
81mm mortar HE	Likely to cause fatal injury	Armed (fuzed)	Very sensitive
81mm mortar white phosphorus	Likely to cause major injury	Armed (fuzed)	Very sensitive
2.36-inch rocket warhead	Likely to cause fatal injury	Armed (fuzed)	Very sensitive
4.5-inch barrage rocket	Likely to cause fatal injury	Armed (fuzed)	Very sensitive
Rocket motors (2.36-inch and 4.5-inch)	Likely to cause major injury	Armed	Sensitive
37mm projectile	Likely to cause fatal injury	Unarmed (no fuze)	Residual risk
75mm projectile	Likely to cause fatal injury	Armed (fuzed)	Very sensitive
75mm projectile	Likely to cause fatal injury	Unarmed (no fuze)	Residual risk
105mm projectile	Likely to cause fatal injury	Armed (fuzed)	Very sensitive
105mm projectile	Likely to cause fatal injury	Unarmed (no fuze)	Residual risk
155mm projectile	Likely to cause fatal injury	Armed (fuzed)	Very sensitive
155mm projectile	Likely to cause fatal injury	Unarmed (no fuze)	Residual risk
M54 fuze	Likely to cause minor injury	Unknown (assumed armed)	Sensitive
M9 rifle grenade fuze	Likely to cause minor injury	Unknown (assumed armed)	Sensitive
Mk2 grenade fuze	Likely to cause minor injury	Unknown (assumed armed)	Sensitive

EE/CA = engineering evaluation/cost analysis
HE = high explosive
HEAT = high explosive anti tank
Mk = Mark
mm = millimeter
OE = ordnance and explosives
UXO = unexploded ordnance

Mk2 Hand Grenade. This grenade contains 2 ounces of explosive filler (trinitrotoluene [TNT]), is designed to be hand thrown, and projects high velocity fragments in a 360-degree pattern. A single fragment may project at a distance of up to 650 feet.

M9 Rifle Grenade (HEAT). The M9 rifle-fired grenade is thin cased, contains 4 ounces of explosive filler (pentolite), and is designed to penetrate armored vehicles. Case fragments may project in a 360 degree pattern up to 350 feet while the shaped charge liner slug may project as a single fragment up to 2,580 feet.

60mm Mortar. Two versions of this mortar were found during the Phase II EE/CA field investigation. The high explosive version contains 7 ounces of explosive filler (Composition B) and is designed to project high velocity fragments in a 360-degree pattern. Fragments may project to a distance of up to 1,080 feet.

The illumination version of this mortar is designed to burn extremely hot and produce a bright light for night missions. Although OE with illumination fillers are less hazardous than high explosive or white phosphorus (WP) rounds, they can still be extremely dangerous to individuals handling them.

81mm Mortar. Two versions of this mortar were recovered during the EE/CA field investigation. The HE version contains 20.6 ounces of explosive filler (Composition B) and is designed to project high velocity fragments in a 360-degree pattern. Fragments may project to a distance of up to 1,233 feet. The WP version of this mortar is designed to burn extremely hot and produce a thick cloud of white smoke. The burster tube, which detonates to open up the mortar and expose the WP to air, is not designed to produce high velocity fragments, but may produce some fragments for a short range. Unused or remaining WP may spontaneously ignite when exposed to air.

2.36-inch Rocket Warhead. The 2.36-inch rocket warhead contains 8 ounces of explosive filler (pentolite) and is designed to penetrate armored vehicles. Case fragments may project in a 360-degree pattern at a distance of up to approximately 809 feet.

4.5-inch Barrage Rocket. This rocket contains 104 ounces of explosive filler (TNT), is designed to be deployed from mobile vehicles against hard targets, and projects high velocity fragments in a 360-degree pattern. Fragments may project to a distance of up to 1,883 feet.

Rocket Motors (2.36-inch and 4.5-inch Rockets). Rocket motors associated with the 2.36-inch and 4.5-inch rockets contain rocket propellant that burns extremely hot and can cause violent movement of the motor.

37mm Projectile. This projectile contains 1.34 ounces of explosive filler (TNT), is designed to be deployed from land-based gun platforms, and projects high-velocity fragments in a 360-degree pattern. Fragments may project to a distance of up to 1,181 feet.

75mm Projectile. This projectile contains 23.7 ounces of explosive filler (AMATOL), is designed to be deployed from land-based gun platforms, and projects high velocity fragments in a 360-degree pattern. Fragments may project to a distance of up to 1,701 feet.

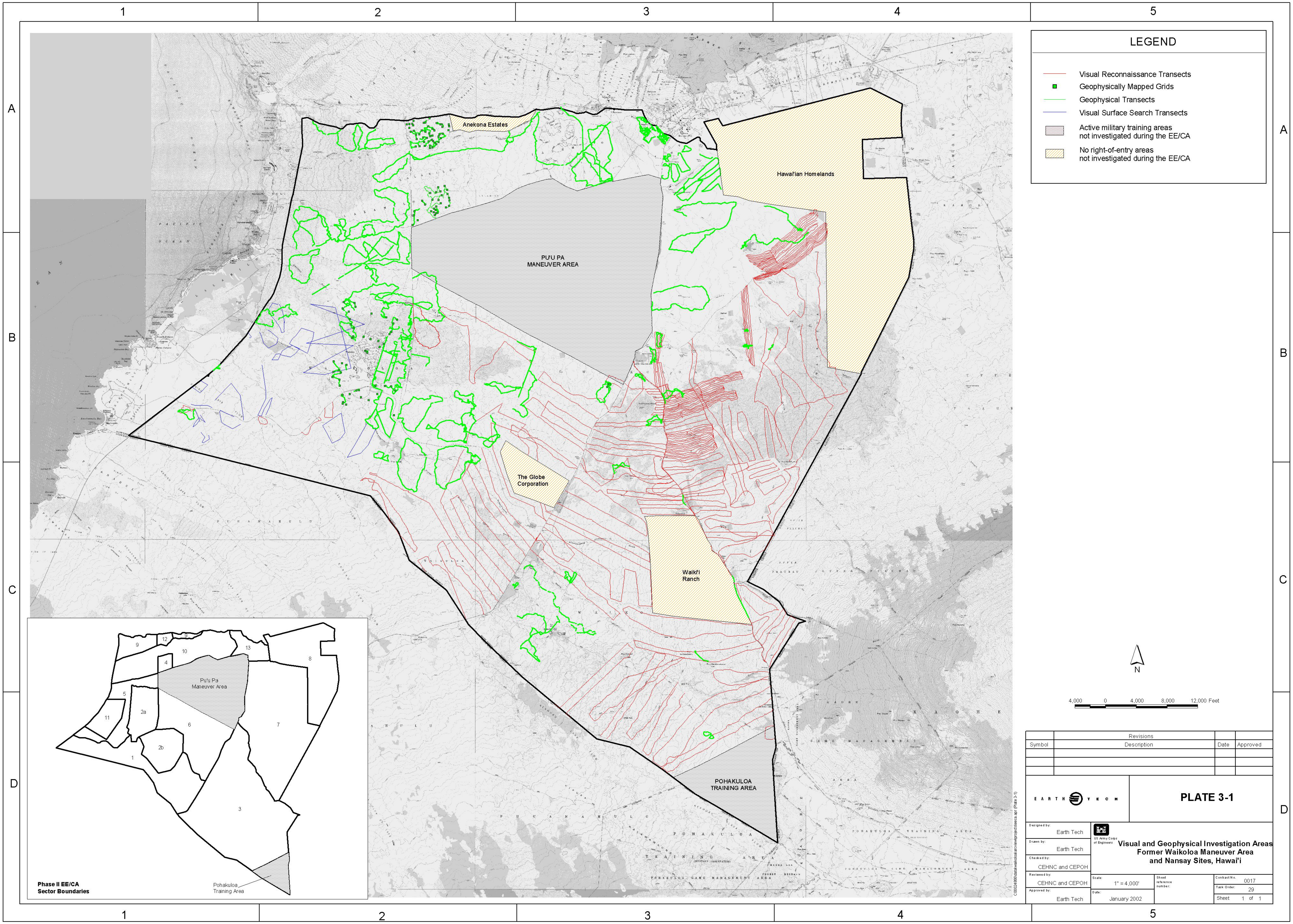
105mm Projectile. This projectile contains 80 ounces of explosive filler (Composition B), is designed to be deployed from land-based gun platforms, and projects high-velocity fragments in a 360-degree pattern. Fragments may project to a distance of up to 1,939 feet.

155mm Projectile. This projectile contains 248 ounces of explosive filler (Composition B), is designed to be deployed from land-based gun platforms, and projects high-velocity fragments in a 360-degree pattern. Fragments may project to a distance of up to 2,577 feet.

M54 Fuze. This fuze is associated with the 75mm and 105mm projectiles and contains a very small quantity of explosives and functions as the detonator of the projectile it is attached to. Fuzes are not designed to project fragments.

M9 Rifle Grenade Fuze. This fuze is associated with the M9 rifle grenade and contains a very small quantity of explosives and functions as the detonator of the grenade it is attached to. Fuzes are not designed to project fragments.

Mk2 Grenade Fuze. This fuze is associated with the Mk2 grenade and contains a very small quantity of explosives and functions as the detonator of the grenade it is attached to. Fuzes are not designed to project fragments.



Symbol	Description	Date	Approved

EARTH TECH

PLATE 3-1

Designed by:	Earth Tech
Drawn by:	Earth Tech
Checked by:	CEHNC and CEPOH
Reviewed by:	CEHNC and CEPOH
Approved by:	Earth Tech

US Army Corps of Engineers

Visual and Geophysical Investigation Areas
Former Waikoloa Maneuver Area
and Nansay Sites, Hawai'i

Scale:	1" = 4,000'
Date:	January 2002
Sheet reference number:	
Contract No.	0017
Task Order:	29
Sheet	1 of 1