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# MARINE RESOURCES STUDY
# FIELD SAMPLING RESULTS AND RISK ASSESSMENT

# MĀKUA MILITARY RESERVATION
# O`AHU, HAWAI`I

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**US Army Corps of Engineers**
Honolulu Engineer District
Environmental & Special Projects Branch
Building 252
CEPOH-PP-E
Fort Shafter, Hawaiʻi 96858-5440

*Prepared by:*

**Tetra Tech, Inc.**
737 Bishop Street, Suite 3020
Honolulu, Hawaiʻi 96813

# EXECUTIVE SUMMARY

Tetra Tech conducted a marine resources study to address the following objectives defined by the 2007 partial Settlement Agreement (SA) entered into by the Army and Malama Mākua:

- To evaluate whether fish, shellfish, limu (marine algae), and other marine resources near Mākua Beach or muliwai (estuaries or stream mouths), which area residents rely on for subsistence are contaminated by substances associated with proposed military training at Mākua;[1]
- To evaluate whether the potential that activities at Mākua Military Reservation (MMR) have contributed or will contribute to contamination in fish, shellfish, limu and other marine resources; and
- To evaluate whether the proposed training activities pose a human health risk to area residents who rely on marine resources for subsistence.

Multiple natural, civilian, and military sources of contamination exist throughout the state of Hawai'i (see Section 3.2). To evaluate whether military activities at MMR have contributed to contamination, it is necessary to estimate the contamination that might exist if military activities had not taken place (baseline contamination). Background sites on O'ahu were selected, and sampling at these sites provided an estimate of baseline contamination. Contamination at Mākua in excess of contamination at the background sites could potentially, but not definitively, be attributed to military activity. Tetra Tech sampled fish, shellfish, and limu[2] in the muliwai and nearshore waters of Mākua and fish and shellfish at the background sites. The background muliwai was at Nanakuli and the background for nearshore waters was next to Sandy Beach. The availability of marine resources for this study was limited by the size of the organisms and their population sizes at Mākua and the availability of equipment capable of collecting intact organisms. Several marine resources

[1]Throughout this document, "Mākua" refers to the general geographic area that includes Mākua Military Reservation, Mākua Beach, and the Mākua muliwai.
[2]Limu (marine algae) were collected only in the nearshore waters at Mākua.

identified as food by area residents were not available in adequate quantities for analysis of all the substances identified for this study; for example, it would require collecting several thousand individuals of snail species that residents are known to consume to supply adequate biomass for laboratory analyses; therefore, the fish, shellfish, and limu samples that were available in sufficient quantities and collected for this study were considered to be representative of the marine resources available at Mākua. Twenty-six fish samples (22 primary and four quality control [QC]), 12 shellfish samples (ten primary and two QC), and four limu samples (three primary and one QC) were collected. The species included striped mullet, Hawaiian flagtail, tilapia complex, medaka (Poeciliidae spp.), Picasso triggerfish, blackspot triggerfish, manybar goatfish, Christmas wrasse, blackspot sergeant, Samoan crab, rock crab, Kona crab, Hawaiian prawn, and helmet urchin.

To assess whether marine resources at MMR are contaminated with compounds potentially associated with proposed military training, all samples, except two shellfish samples, were analyzed for approximately 43 different substances. These included dioxans/furans, volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), organochlorine pesticides, explosives, and metals. The exceedingly small populations of two shellfish species (Hawaiian prawns and rock crabs), and therefore small quantities of biomass collected, limited the analysis of these samples to a subset of the 43 constituents. All the analytes (the suite of substances that the laboratory analyzed) have a wide range of natural and anthropogenic (man-made) sources. Only explosives and several metals are constituents of military munitions; all other analytes were included after public review of previous documents. Following are the results of the laboratory analyses.

Dioxins/furans were detected at a greater frequency in fish at the background site (seven of nine samples) than at Mākua (ten of seventeen samples). They were detected in all three fish samples from the background muliwai and eleven of twelve fish samples from the Mākua muliwai. Dioxins/furans were detected in four of six fish samples from the nearshore waters of the background site and were not detected in any of the five fish samples from the nearshore waters of Mākua. The principal sources of dioxins in air are combustion and incineration sources, such as incineration of solid waste, sewage sludge, and hospital wastes; high temperature steel production, smelting operations, and scrap metal recovery furnaces; and the burning of coal, wood petroleum products, and used tires for energy generation. Chemical manufacturing and process sources, such as manufacture of chlorine and chlorinated organic compounds, may result in emissions to air or water.

Only two VOCs were detected in any of the fish samples, acetone and m,p-xylene. Acetone was found in at least one sample from all five locations (Mākua and background) and is a common laboratory contaminant; it is often recorded as a false positive. Toluene and m,p-xylene were detected in two QC shellfish samples and one limu sample, respectively. Toluene was not detected in the primary shellfish samples, which suggests a false positive. Natural sources of toluene include volcanoes, forest and bush fires, and crude oil; m,p-xylene occurs naturally in petroleum, and VOCs are released into the environment primarily from petroleum refining. Other possible emitters of toluene are spilled gasoline, commercial and household painting and paint, varnish and lacquer removers, tobacco smoke, and consumer products that contain toluene.

The term SVOC is generally applied to organic compounds found in a range of products, including insect repellants, cosmetics, rubbing alcohol, liquid soap, detergents, decorative inks, lacquers, munitions, industrial and lubricating oils, wood preservatives, defoaming agents for paper/paperboard manufacturing, pesticide carriers, photographic film processing, plastic softening agents, and dielectric fluid in capacitors. Three SVOCs, bis(2-ethylhexyl)phthalate, diethyl phthalate, and di-n-butylphthalate, were detected in fish samples collected from the muliwai and nearshore sample locations. Di-n-butylphthalate was detected in all fish samples regardless of origin and is a common lab contaminant. Bis(2-ethylhexyl)phthalate was detected in four of the five samples collected from the Mākua nearshore area. Diethyl phthalate was detected in only the sample collected from the Sandy Beach nearshore area.

Aldrin and heptachlor were generally detected in samples from the nearshore areas but not in the muliwai; heptachlor epoxide was detected at higher concentrations in samples from the nearshore locations than in samples from the muliwai locations. Organochlorine pesticides analytes were not detected in shellfish samples, except for one aldrin detection in a shellfish sample collected in the nearshore area of Mākua. Aldrin, BHC-beta, heptachlor, and heptachlor epoxide were detected in the limu collected in the nearshore area of Mākua. Organochlorine pesticides were used historically throughout Oʻahu and the other main Hawaiian islands for termite control and in agriculture. These compounds can be transported by air and water, so their presence in fish, shellfish, and limu cannot be definitively attributed to activities at MMR.

Common military uses of RDX have been as an ingredient in plastic bonded explosives, or plastic explosives that have been used as explosive fill in almost all types of munition compounds. Civilian applications of RDX include fireworks, demolition blocks, as a heating fuel for food rations, and rodenticide. Perchlorate was detected in fish at both Mākua and the background site and in limu and one shellfish sample from Mākua. Nitroglycerin was detected in two fish samples from Mākua. RDX was detected in one fish sample from Mākua. Because the Bioconcentration factor for RDX is so low, a relatively high concentration of RDX would need to be present in the water to account for the RDX detection in the fish tissue. Given the amount of water circulation in the ocean, it is unlikely that the ocean water in the Mākua nearshore area would contain RDX at a sufficient concentration to result in the observed detection of RDX in the fish tissue sample. Furthermore, the analysis of RDX in fish tissue is prone to false positive detections resulting from matrix interference.

All metals analyzed in this study are naturally occurring in the environment and are commonly found in plant and animal tissues as a result of natural metabolic processes. Indeed, some of these metals are considered essential nutrients for human health. The primary inputs of trace metals, above baseline levels on Oʻahu, include volcanic emissions, vehicle emissions, vehicle-associated wear, and agricultural fertilizer and pesticide inputs. The presence of naturally occurring metals in the environment makes it difficult to ascertain whether these metals could have been transported beyond the boundaries of MMR. Metals concentrations were similar among the fish samples collected from Mākua and the background muliwai. Furthermore, the metals concentrations were similar among the fish samples collected from nearshore areas of both Mākua and the background location. Shellfish metals concentrations in samples collected at Mākua were similar to those found at the background, with a few exceptions (Table 3-5). Greater concentrations of aluminum, barium, iron, and manganese were found in shellfish samples from Mākua muliwai, while zinc concentrations were higher in samples from the background. Twelve of 19 metals were detected in all limu samples, at concentrations ranging from less than 0.1 milligrams per kilogram (mg/kg) (thallium) to greater than 1,860 mg/kg (iron). Flegal et al. (1986) found concentrations of thallium in marine plankton similar to those found at Mākua (0.02 to 0.8 mg/kg) in the central Pacific. In the Black Sea of Turkey, Tuzen et al. (2008) found concentrations of iron, ranging from 99 to 3,949 mg/kg in marine algae, similar to those concentrations found at Mākua (67.4 to 1860 mg/kg). Arsenic was detected in limu in concentrations ranging from 4.56 to 109 mg/kg. These concentrations are comparable to concentrations found in marine algae in pristine regions of Antarctica, ranging from 5.8 to 152 mg/kg (Farias et al. 2007).

The results of laboratory analyses of the samples described above were incorporated into an evaluation of the potential risks to humans who may be exposed to environmental contaminants at Mākua Beach and the Mākua muliwai and compares those risks to risks determined for background locations on O'ahu. The difference between the risks calculated for the Mākua sites and the background locations is called the incremental risk. Several assumptions were required to complete this human health risk assessment, and they are presented in Table ES-1. These assumptions may greatly overestimate the potential human health risk at Mākua and the background sites. In addition to these assumptions, it is highly unlikely that a subsistence fisherman could rely entirely on the marine resources within the muliwai for 100 grams of fish everyday for 30 years. The muliwai are short-lived environments and are only intermittently open to the ocean. This significantly restricts the movement of marine resources into the muliwai to replenish depleted populations.

Table ES-2 is a summary of the carcinogenic risk aspect of the human health risk assessment. Although potentially overestimated, there are potential carcinogenic risks at both Mākua and the background sites. There are potential carcinogenic risks to consuming shellfish at both Mākua and the background muliwai at a subsistence level and to consuming fish in the nearshore waters of both Mākua and the background site at a subsistence and a recreational level. The potential risk is greater at Mākua than at the background site leading to an incremental risk. The potential risk is largely due to alpha-BHC, heptachlor epoxide, and bis(2-ethylhexyl) phthalate. There is a potential carcinogenic risk associated with shellfish in the nearshore waters of the background site but not at Mākua.

Table ES-3 is a summary of the noncarcinogenic hazard aspect of the human health risk assessment. A noncarcinogenic hazard potentially exists with a hazard index (HI) of greater than 1. A potential noncarcinogenic hazard exists at all sites, for all environmental media, and at both levels of consumption, except for shellfish in the nearshore waters of the background site consumed at recreational levels. Potential incremental hazard (hazard greater at Mākua than background sites) exists for subsistence and recreational consumption of shellfish in the Mākua muliwai. The potential hazard is largely due to manganese and cobalt. A potential

**Table ES-1**
**Data Interpretation Assumptions, Scientific Justifications, and Effects on Risk Analysis**

<table>
<tr><th>Assumption</th><th>Scientific Justification</th><th>Effect on Risk Analysis</th></tr>
<tr><td>Assumption No. 1—All detected chemicals in fish, shellfish, and limu were considered as chemicals of potential concern (COPC).</td><td>In its standard guidelines for risk assessment, the US EPA consider only those chemicals with concentrations greater than background as COPCs; however, it was assumed that stakeholders were interested in all potential risks, not simply risks that could be higher at Mākua than the background sites.</td><td>This assumption could considerably overestimate the risks at both Mākua and at the background site.</td></tr>
<tr><td>Assumption No. 2—Chemical concentrations will be maintained at present levels.</td><td>In the absence of a data set describing changes in chemical composition of munitions proposed for use at MMR and the Mākua vicinity over time, the assumption was that current chemical concentrations in fish, shellfish, limu, and other marine resources will be maintained into the future. The assumption of steady state chemical concentrations is based on relatively constant levels of military activities overtime.<br><br>Advances in munitions technology will reduce potential future chemical loads from military activity into the Mākua vicinity.<br><br>An environmental monitoring program that is proposed to accompany the renewal of live-fire training will identify and minimize or eliminate chemical contaminants that can be attributed to military training from migrating off-site, thereby reducing or avoiding impacts on marine resources.</td><td>It is difficult to assess the effects of these assumptions on the risk analysis. Advances in munitions technology and an environmental monitoring program could reduce the future risk, resulting in overestimation of the risk; however, if compounds that could bioaccumulate were found to be migrating into the surrounding resources, the risk could be underestimated.</td></tr>
<tr><td>Assumption No. 3—Subsistence and recreational fishermen:<br>• Ingest fish 365 days/year. This is greater than 7 times the average per capita fish and shellfish consumption frequency in the US of 48 days/year;<br>• Are fishing at the site for 30 years (standard EPA default guidelines);<br>• Ingest the following quantities of fish, shellfish, limu, and other marine resources:<br><table><tr><th>Resource</th><th>Subsistence Fishermen</th><th>Recreational Fishermen</th></tr><tr><td>Fish</td><td>100.6 g/day</td><td>34.0 g/day</td></tr><tr><td>Shellfish</td><td>100.6 g/day</td><td>34.0 g/day</td></tr><tr><td>Limu</td><td>18.2 g/day</td><td>5.2 g/day</td></tr></table>These consumption rates are considerably higher than the likely ingestion rate of the species collected in this study and are over 50 times greater than the average ingestion rate for the general US population.</td><td>Data were not readily available quantifying the number of days per year that subsistence and recreational fishermen in Hawai‘i ingest fish, shellfish, or limu, the number of years a fisherman may fish at the site, or the ingestion rates of shellfish, limu, and other marine resources by subsistence and recreational fishermen in Hawai‘i.<br><br>The muliwai are short-lived environments and are only intermittently open to the ocean. This significantly restricts the movement of marine resources into the muliwai. It is highly unlikely that sufficient resources exist to provide this quantity of food source to support even one individual every day for thirty years.</td><td>These assumptions could vastly over-estimate the risk of ingesting fish, shell-fish, and limu, but were used to ensure that risks were not underestimated.</td></tr>
</table>

**Table ES-2**
**Summary of the Incremental Carcinogenic Risk from Ingesting Fish, Shellfish, and Limu at Mākua and the Background Site**

| Environment | Environmental Media | Fisherman | Risk/Location | | Incremental Risk | Contaminant of Potential Concern (COPC) for incremental risks |
|---|---|---|---|---|---|---|
| | | | Mākua | Background | | |
| **Muliwai** | Fish | Subsistence | | | | |
| | | Recreational | | | | |
| | Shellfish | Subsistence | E | E | U | |
| | | Recreational | | | | |
| **Nearshore** | Fish | Subsistence | E | E | E | Alpha-BHC, bis(2-ethylhexyl) phthalate, Heptachlor Epoxide |
| | | Recreational | E | E | U | |
| | Shellfish | Subsistence | | E | | |
| | | Recreational | | E | | |
| | Limu | Subsistence | E | | E | Arsenic |
| | | Recreational | E | | E | |

E = Exceeds the US EPA risk level for fish consumption.
U = Unlikely potential risk; chemical concentrations at both sites are elevated, but the incremental risk is below the US EPA risk level for fish consumption.

**Table ES-3**
**Summary of the Noncarcinogenic Hazard from Ingesting Fish, Shellfish, and Limu at Mākua and the Background Site**

| Environment | Environmental Media | Fisherman | Hazard | | Incremental Hazard | COPCs for Incremental Hazard |
|---|---|---|---|---|---|---|
| | | | Mākua | Background | | |
| Muliwai | Fish | Subsistence | 20 | 47 | -- | |
| | | Recreational | 7 | 16 | -- | |
| | Shellfish | Subsistence | 14 | 9 | 5 | Manganese, cobalt |
| | | Recreational | 5 | 3 | 2 | |
| Nearshore | Fish | Subsistence | 7 | 5 | 2 | Nitroglycerin |
| | | Recreational | 2 | 2 | -- | |
| | Shellfish | Subsistence | 12 | 3 | 9 | Cadmium, perchlorate |
| | | Recreational | 4 | 1 | 3 | |
| | Limu | Subsistence | 58 | -- | -- | Arsenic |
| | | Recreational | 17 | -- | -- | |

Shaded = Noncarcinogenic hazard at Mākua is greater than background.

incremental hazard exists for subsistence consumption of fish in the nearshore waters of Mākua, largely due to nitroglycerin. A potential noncarcinogenic hazard exists for subsistence and recreational consumption of shellfish in the nearshore waters of Mākua, due to cadmium and perchlorate. A potential noncarcinogenic hazard exists from consuming limu in the nearshore waters of Mākua; the corresponding hazard at the background site is not available. This hazard is largely due to arsenic, which is a natural component of the earth's crust and is found in all environmental media. Volcanic action is the second most important natural source of arsenic. Anthropogenic sources of arsenic include smelting nonferrous metals, producing energy from fossil fuels, and manufacturing and using arsenic pesticides and wood preservatives. Elevated levels of arsenic in Hawai'i have been identified in soils from use of arsenic-based pesticides from the 1920s through the 1940s. The hazard attributed to arsenic is likely greatly overestimated because of the assumption that all arsenic in limu is in the toxic inorganic form. Frankenberger (2002) and Kirby et al. (2005) suggest that arsenic in limu may be greater than 50 percent inorganic; however, Farias et al. (2007) found arsenic concentrations of 5.8 to 152 mg/kg in pristine areas of Antarctica and the percentage of inorganic arsenic was 0.7 to 2.6 Percent. A similar range was found in limu at Mākua at 4.5 to 109 mg/kg. There are no data available on the speciation of arsenic in the species of limu that were collected in this study.

The potential risks and hazards identified in the human health risk assessment were largely due to eight compounds, including four metals (arsenic, cadmium, cobalt, and manganese), two organochlorine pesticides (alpha-BHC and heptachlor epoxide), and two explosives (nitroglycerin and perchlorate). Using data from this study and previous studies (described in Section 1.2 of this report), Table ES-4 identifies those environmental media in which these compounds were detected at elevated levels at Mākua. These data demonstrate that some of the same substances found at elevated levels in the marine resources at Mākua are also found in other environmental media and are a component of military munitions; however, there are a range of other possible natural and anthropogenic sources of these compounds.

Finally, a screening level ecological risk assessment was conducted to evaluate the potential for adverse effects on ecological receptors that may be exposed to chemicals in muliwai and nearshore waters. Data from the fish, shellfish, and limu sampling conducted as part of this study and data from muliwai sediment sampling conducted in 2003 were used in this assessment. Two sets of receptors were evaluated: (1) benthic invertebrates exposed to chemicals of potential ecological concern in sediments and (2) fish exposed to chemicals from multiple pathways, represented by measured concentrations in fish tissues. The results from the screening level ecological risk assessment indicated that there were no hazards to fish in the north muliwai, the south muliwai and the nearshore Mākua area, and that there was a potential hazard to benthic invertebrates from 2,3,7,8-tetrachlorodibenzo-*p*-dioxin in sediments in the south muliwai. The primary sources of dioxins are backyard burning of household refuse, medical waste incinerators, municipal waste combustion, coal-fire utility boilers, cement kilns, and diesel heavy duty trucks.

**Table ES-4**
**Summary of Potential Chemical Migration Pathways**

| Chemical of Potential Concern (COPC) | Military Munitions | Air | Soil | Groundwater | Surface Water | Streambed Sediments | Muliwai Sediments | Fish | Shellfish | Limu |
|---|---|---|---|---|---|---|---|---|---|---|
| **Aldrin** | | | | | | E | | E | E | |
| **Alpha-BHC** | | | | E | | E | | E | | |
| **Arsenic** | ✓ | ✓ | | E | | | | | | E |
| **bis(2-ethylhexyl)phthalate** | | | | E | | | | E | | |
| **Cadmium** | ✓ | ✓ | | | | | | | E | |
| **Cobalt** | ✓ | | | | | | | | E | |
| **Dioxins/furans** | | | E | | E | E | E | | | |
| **Heptachlor epoxide** | | | | | | | | E | | |
| **Manganese** | ✓ | | | | | | | | E | |
| **Nitroglycerin** | ✓ | | | | | | | E | | |
| **Perchlorate** | ✓ | | | | E | | | | E | |

**Notes:**
**E (water and sediments)** = Exceeds Preliminary Remediation Goal for soil/sediment or Maximum Contaminant Level for water.
**E (fish, shellfish, limu)** = Incremental risk exceeds US EPA risk level for fish consumption or a hazard index of 1;
✓ = Present in trace concentrations (i.e., at a concentration slightly above the laboratory's analytical level of detection).

Hazards to shellfish in the north and south muliwai did not exceed those at the Nanakuli background muliwai. Hazards at the nearshore habitat at Mākua were equivocal in that the hazard index for Kona crabs was greater than that at the Sandy Beach background site, but the hazard index for helmet urchins was less than background. The hazard index for Kona crabs was predominantly due to cadmium, copper, and zinc in tissues. The potential hazard to crabs from copper is uncertain because tissue concentrations in crabs could be compared only to those in sea urchins, which are expected to have lower body burdens of copper than crabs due to their physiology.

Several lines of evidence were considered in evaluating the potential for risks to organisms in the Mākua muliwai and nearshore waters: the number of chemicals with calculated HQs above 1, the magnitudes of HQs above 1, likely sources of chemicals, confidence in toxicity values, cumulative risks represented by HIs, and comparisons of site HIs to HIs from background sites. Based on the weight of evidence, limited hazards were identified:

- North muliwai—No hazards to benthic invertebrates, shellfish, or fish;
- South muliwai—Potential hazard to benthic invertebrates from dioxans/furans in sediments; no hazards to shellfish or fish; and
- Nearshore waters—Potential hazards to Kona crabs from cadmium, copper, and zinc but no hazards to sea urchins; no hazards to fish.

In accordance with the 2007 partial SA entered into by the Army and Malama Mākua, the Army "…shall complete one or more studies to whether fish, limu, shellfish, and other marine resources near Mākua Beach and in the muliwai on which area residents rely for subsistence are contaminated by substances associated with the proposed training activities at MMR… evaluate the potential that activities at MMR have contributed or will contribute to any such contamination and whether the proposed training activities at MMR pose a human health risk to area residents that rely on marine resources for subsistence." This study was an investigation of the resources at Mākua and background sites and provides the information necessary to answer these questions posed in the SA.

1) Determine whether fish, shellfish, limu, and other marine resources near Mākua Beach or muliwai, which area residents rely on for subsistence, are contaminated by substances associated with the proposed training at Mākua.

This study has identified a number of substances in fish, shellfish, and limu that are also known to be by-products of the type of military training being proposed at MMR. These substances are RDX, perchlorate, arsenic, chromium, cobalt, nitroglycerin, and manganese. While other substances may be products or by-products of military training and civilian and industrial activities, these are the substances for which a potential health risk may exist. Though these and other substances may be by-products of military training at MMR, they are also linked to natural and anthropogenic sources, such as fireworks, rodenticides, gasoline, and volcanic rock. In fact, a comparison of the site data with the available background data shows little if any difference between substances found in the Mākua area and the background sites. Compounds identified for analysis by the SA are not unique to military training and are found at both Mākua and background sites; therefore, proposed military activities are anticipated to have little influence on contaminant levels within marine resources in the Mākua nearshore or muliwai areas.

Although marine resources other than fish, shellfish, and limu were not tested, the sampling was representative of other marine resources within the Mākua area. It is reasonable to suggest that other marine resources occupying similar trophic levels and ecological niches contain similar substances and concentrations as those detected in fish, limu, and shellfish collected as part of this study. Regardless, on authorization to implement the proposed training at MMR, the Army will conduct a long-term water quality monitoring program to assess current and future water quality. A monitoring program will provide the Army with another tool to evaluate potential pathways for substances to migrate beyond the boundaries of MMR.

2) Evaluate the potential that activities at MMR have contributed or will contribute to contamination in fish, shellfish, limu and other marine resources.

Per the requirements of the 2001 SA, the Army investigated soil, surface water, groundwater, and air for potential contamination associated with proposed training activities at MMR. These studies also evaluated whether there was a potential for contaminants to be transported off of MMR. Based on the data from these studies, there is no obvious pattern or pathway for migration of substances from MMR to the muliwai and nearshore areas. However, several substances detected in the marine resources were also detected in environmental media on MMR (air, soil, and water). This suggests there is a potential but as of yet unsubstantiated pathway for substances to migrate from MMR to marine resources.

Thus, there is some potential for past and future release of substances from activities at MMR. However, the low levels of most substances detected during these investigations support the position that if 60 years of live-fire training has not resulted in significant detectable levels of most substances in the area, then future live-fire activities at MMR would be expected to be likewise insignificant. For those substances detected at higher levels, their occurrence in the area cannot uniquely be attributed to military activities because there are and have been many natural and anthropogenic sources that contribute substances to the Mākua area.

Based on the results of the past investigations, the Army was required to conduct a marine study to determine if contaminants were also found in the marine resources consumed by residents. This study found that a number of substances identified for analysis were detected in these marine resources. Although this and other reports have not provided any definitive evidence that links military training to resource contamination, these reports also do not definitively exclude the possibility that such substances in the fish, shellfish, and limu are a result of activities conducted at MMR. However, it needs to be reemphasized that there are numerous other natural and anthropogenic sources that contribute substances to the Mākua and background areas.

3) Whether the proposed training activities pose a human health risk to area residents who rely on marine resources for subsistence.

This third question posed by the SA calls for a definitive answer concerning whether future training at MMR will result in the release of substances that will, with certainty, contaminate marine resources consumed by local residents for subsistence. This question cannot be answered with certainty because it relies on predictions of the effects of future activities and assumptions based on the assessment of effects from past activities at MMR. Therefore, from a scientific standpoint, we must predict whether or not future training at MMR is likely to cause a human health risk from consumption of marine resources.

It is not likely that future training at MMR will result in the release of substances sufficient to contaminate marine resources around Mākua and to cause a risk to area residents who consume marine resources for subsistence. As stated throughout this section and the overall document, the substances identified for analysis that were found in biota within the Mākua area could be associated with many past and present natural and anthropogenic causes that are not unique to past training at MMR. In addition, based on the general similarity of carcinogenic and noncarcinogenic health risks between the Mākua area and the background sites, it is apparent that the Army's past activities at MMR are not independently responsible for any human health risks from the substances detected in marine resources. Considering the level of substances found within the Mākua area, the numerous sources with which these substances are associated, and the ability of these substances from multiple sources to be transported by rain flow and ocean currents, it is not likely that future activities at MMR alone would contribute substances to the marine environment at a level sufficient to cause a human health risk. Even though it is not likely that future activities at MMR alone would cause this risk to human health, they could add to existing contamination in marine resources.

However, on authorization to resume live-fire training at MMR, the Army would evaluate the potential impacts from the proposed training by conducting a long-term monitoring program to detect if there is a potential for substances to migrate off the installation and into the Mākua nearshore and muliwai areas. If a substance were identified during monitoring, the Army would conduct further analysis to verify the detection. If the identified substance were detected above the USEPA acceptable risk level, then the Army would take appropriate action to correct the situation and prevent or minimize the potential for the substance to be released into the muliwai or nearshore areas of Mākua. In accordance with the requirements of the 2001 SA, before finalizing a long-term program to monitor detected contaminants, the Army would provide a 60-day public comment period on the scope of and protocol for such monitoring.