SECTION 3
ANALYTICAL RESULTS

3.1 ANALYTICAL RESULTS

All of the analytical results for this muliwai sediment sampling program are presented in the analytical tables in Appendix C. These tables are presented as one table per analytical method, except for the particle size analyses. The particle size results and graphs of these results are presented in Appendix D.

Table 3-1 presents a summary of all of the analytical results by sample area for all of the analytical methods except for the metals analyses and the particle size analyses. Table 3-2 presents a summary of the metals analyses by sample area. Below are discussions of these analytical results by their respective method.

For comparison purposes, the footers in the tables in Appendix C list the 2002 USEPA Region IX PRGs (USEPA 2002), U.S. EPA Generic Soil Screening Levels for groundwater protection (assuming DAF1 – no attenuation by the soil) (USEPA 2002); Hawai'i Tier I Soil Action Levels for areas with annual rainfall less than 200 cm/yr and assuming no drinking water source threatened (HDOH 2000), and U.S. EPA Region 5 Ecological Screening Levels for sediments (USEPA 2003). It should be kept in mind that each of these criteria have important limitations on their applicability to the conditions and environment of the study area, as discussed further below.

3.2 METALS RESULTS (USEPA METHODS 6010B AND 7471A)

Samples were analyzed by USEPA Method 6010B for aluminum, antimony, arsenic, barium, cadmium, chromium, cobalt, copper, lead, selenium, silver, vanadium, zinc. The samples were also analyzed for mercury by USEPA Method 7471A. All of the samples were analyzed for each of these metals. The results of these analyses are presented by their respective method number in the two tables in Appendix C.

Table 3-1
Summary of Analytical Results

May 19, 2003 through May 23, 2003

	Dry Muliwai	North Muliwai	South Muliwai	North Background	South Background
Metals	See Metals Summary	See Metals Summary	See Metals Summary	See Metals Summary	See Metals Summary
Explosives					
RDX	All ND	One = 230 µg/kg	All ND	All ND	All ND
BTEX					
Benzene	All ND	Two = 0.040 to 0.044 µg/kg	All ND	NA	NA
Toluene	One = 0.24 µg/kg	Six = 0.3 to 0.7 µg/kg	Four = 0.3 to 0.6 µg/kg	NA	NA
Ethylbenzene	One = 0.6 µg/kg	Four = 0.3 to 2 µg/kg	Five = 0.6 to 1 µg/kg	NA	NA
Xylenes (total)	One = 0.9 µg/kg	Four = 0.29 to 1 µg/kg	Four = 0.7 to 1.1 µg/kg	NA	NA
OC Pesticides					
4,4-DDT	All ND	One = 0.1 µg/kg	All ND	NA	NA
Chlorinated Herbicides					
Bentazon	All ND	All ND	One = 46 µg/kg	NA	NA
Pentachlorophenol	One = 2 µg/kg	All ND	One = 0.823 µg/kg	NA	NA
Picloram	All ND	All ND	One = 0.4 µg/kg	NA	NA
SVOCs					
bis(2-Ethylhexyl)-phthalate	All ND	One = 22 µg/kg	All ND	NA	NA
Pentachlorophenol	All ND	All ND	One = 230 µg/kg	NA	NA
Pyrene	All ND	All ND	One = 77 µg/kg	NA	NA
Dioxins/Furans					
1,2,3,4,6,7,8,9-OCDD	All ND	One = 0.15 µg/kg	All ND	NA	NA
2,3,7,8-TCDD	All ND	All ND	One = 0.03 µg/kg	NA	NA
Other Analytes					
Nitroglycerin	All ND	All ND	All ND	NA	NA
Perchlorate	All ND	All ND	All ND	NA	NA
Cyanide	All ND	All ND	All ND	NA	NA
Nitrite	All ND	All ND	All ND	NA	NA
Nitrate	One = 10.1 mg/kg	Six = 3.9 to 19.5 mg/kg	Five = 4.1 to 13 mg/kg	NA	NA
TOC	All ND	Three = 510 to 1990 mg/kg	Four = 560 to 3270 mg/kg	NA	NA

Notes:

1) Fifty-four sediment samples collected for metals and explosives analyses
Four primary samples and one duplicate sample from the Dry Muliwai
Twenty-two primary samples and one duplicate sample from the North Muliwai
Seventeen primary samples and one duplicate sample from the South Muliwai
Three primary samples and one duplicate sample from the North Background Mākua Site
Three primary samples and one duplicate sample from the South Background Mākua Site

2) Twelve sediment samples collected for all additional analyses
One primary sample and no duplicate samples from the Dry Muliwai
Five primary samples and one duplicate sample from the North Muliwai
Four primary samples and one duplicate sample from the South Muliwai

Table 3-2
Summary of Metals Results

Off-site Sampling in Muliwai Ponds May 19, 2003 through May 23, 2003					
	Dry Muliwai	**North Muliwai**	**South Muliwai**	**North Background**	**South Background**
	(mg/kg)	**(mg/kg)**	**(mg/kg)**	**(mg/kg)**	**(mg/kg)**
Aluminum	1,100 to 1,550	796 to 49,700	36 to 67,500	22,600 to 25,100	30,200 to 54,700
Antimony	0.94 to 1.80	0.67 to 3.70	0.71 to 1.20	All ND	All ND
Arsenic	5.5 to 6.4	0.26 to 5.60	0.35 to 5.30	ND to 0.15	ND to 1.5
Barium	4.2 to 5.4	3.8 to 123	3.7 to 118	109 to 186	134 to 157
Cadmium	0.038 to 0.057	0.013 to 0.130	0.019 to 0.160	All ND	All ND
Chromium	19.3 to 28.8	15.5 to 176	2.2 to 271	112 to 138	195 to 227
Cobalt	6.9 to 10.8	5.0 to 60.4	1.7 to 74.0	46.7 to 70.9	70.1 to 83.1
Copper	3.4 to 17.6	2.4 to 121	2.5 to 180	50.3 to 56.7	89.9 to 110
Lead	0.3 to 3.4	0.24 to 9.60	0.09 to 26.90	0.32 to 1.70	1.3 to 2.4
Mercury	0.014 to 0.020	0.014 to 0.080	0.008 to 0.082	0.059 to 0.064	0.052 to 0.060
Selenium	0.15 to 0.19	0.3 to 4.0	0.52 to 7.70	All ND	All ND
Silver	All ND	All ND	All ND	All ND	All ND
Vanadium	9.6 to 11.8	7.4 to 185	0.1 to 194	138 to 166	147 to 166
Zinc	11.7 to 16.7	7.6 to 142	0.8 to 188	76.5 to 86.5	103 to 125

3.2.1 Aluminum

Aluminum was found in all of 54 sediment samples. As shown on Table 3-2 and in the Method 6010B table in Appendix C, aluminum concentrations ranged from 35.6 to 67,500 mg/kg. Figure 3-1 shows the distribution frequency of the aluminum concentrations. This figure indicates a bimodal distribution in concentration above 5,000 mg/kg. Nearly half of the samples contained aluminum at concentrations of less than 5,000 mg/kg. A near normal distribution of concentrations ranges from 10,000 to 40,000 mg/kg. Nine samples contained concentrations greater than 45,000 mg/kg. Samples from the north background location fell within the lower range, while samples from the south background location generally fell within the higher range.

Aluminum is a naturally occurring constituent of the igneous rock in Hawai'i, and it (along with several other metals) tends to be concentrated in Hawai'ian and other tropical soils. However, none of the samples collected from any of the areas contained concentrations of aluminum greater than the residential soil PRG of 76,000 mg/kg.

3.2.2 Antimony

Antimony was found in 25 of the 54 sediment samples collected during this program. As shown on Table 3-2 and in the Method 6010B table in Appendix C, the detected antimony concentrations ranged from 0.67 to 3.7 mg/kg, and the other 29 samples did not contain concentrations of antimony greater than the approximate detection limit of 0.26 mg/kg. Figure 3-2 shows the distribution frequency of the antimony data. This figure shows a rapid decrease in the frequencies from 0.0 to 2.0 mg/kg, and three potential high-outlying concentrations greater than 3.0 mg/kg and less than 4.0 mg/kg. All of the background samples contained nondetect concentrations of antimony, and all three of the highest concentrations of antimony were from samples collected at the north muliwai pond.

None of the samples collected from any of the areas contained concentrations of antimony greater than the residential noncancer soil PRG of 31 mg/kg.

3.2.3 Arsenic

Arsenic was found in 35 of the 54 sediment samples collected during this program. As shown on Table 3-2 and in the Method 6010B table in Appendix C, the detected arsenic concentrations ranged from 0.15 to 6.4 mg/kg. Arsenic was not detected above the approximate detection limit of 0.15 mg/kg in the other 19 samples. Figure 3-3 shows the distribution frequency of the arsenic data. This figure shows a nearly normal distribution of detected concentrations between 2.0 and 7.0 mg/kg. All of the sediment samples collected from the background areas were less than 2.0 mg/kg

The 2002 USEPA Region IX PRGs for arsenic distinguish between cancer and non-cancer endpoints, because arsenic presents both a toxic and a carcinogenic risk depending on mode of exposure. None of the samples contained concentrations of arsenic greater than the 2002 residential noncancer soil PRG of 22 mg/kg (US EPA

Figure 3-1
Aluminum - 54 detects, 0 non-detects
Makua Muliwai Sampling May 2003

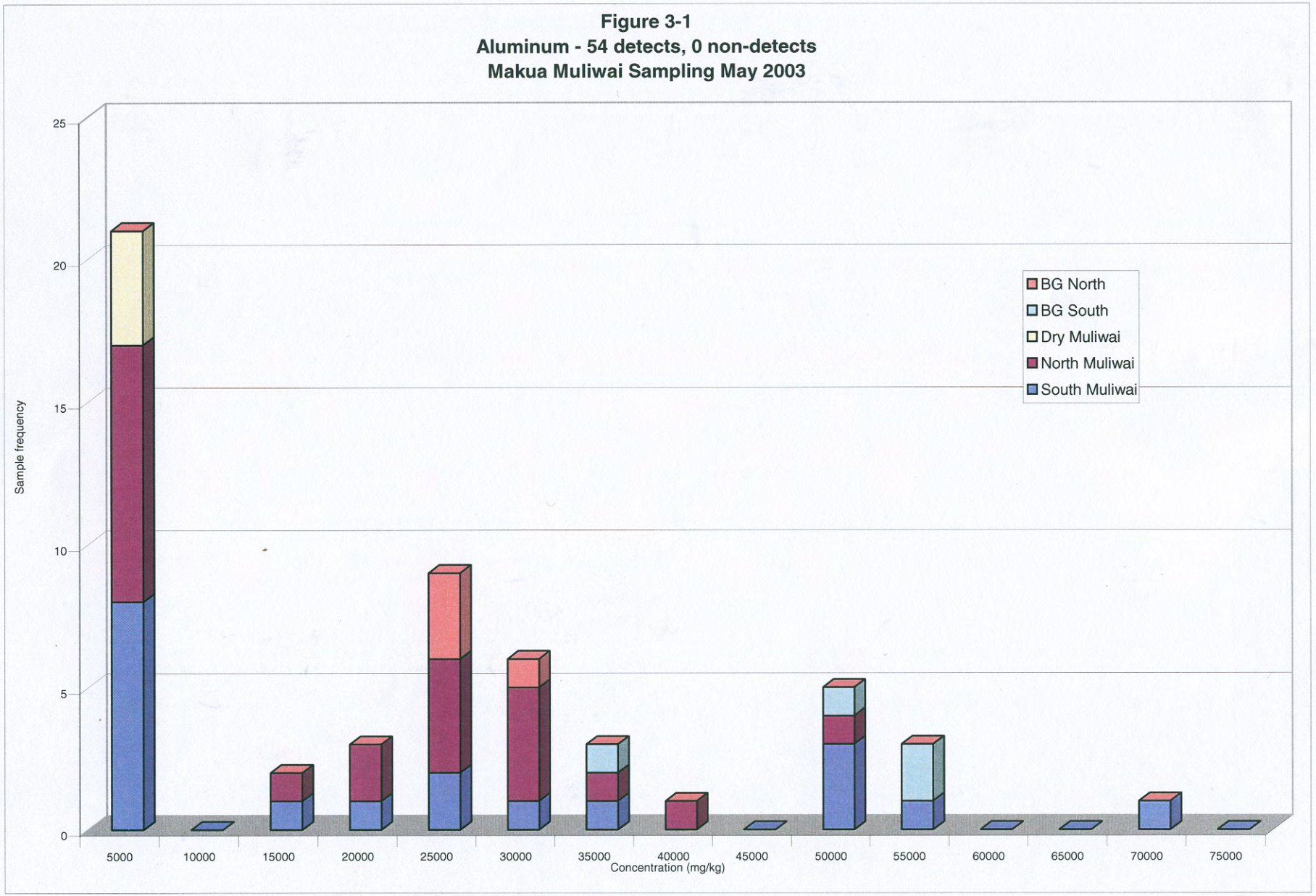


Figure 3-2
Antimony - 25 detects, 29 non-detects
Makua Muliwai Sampling May 2003

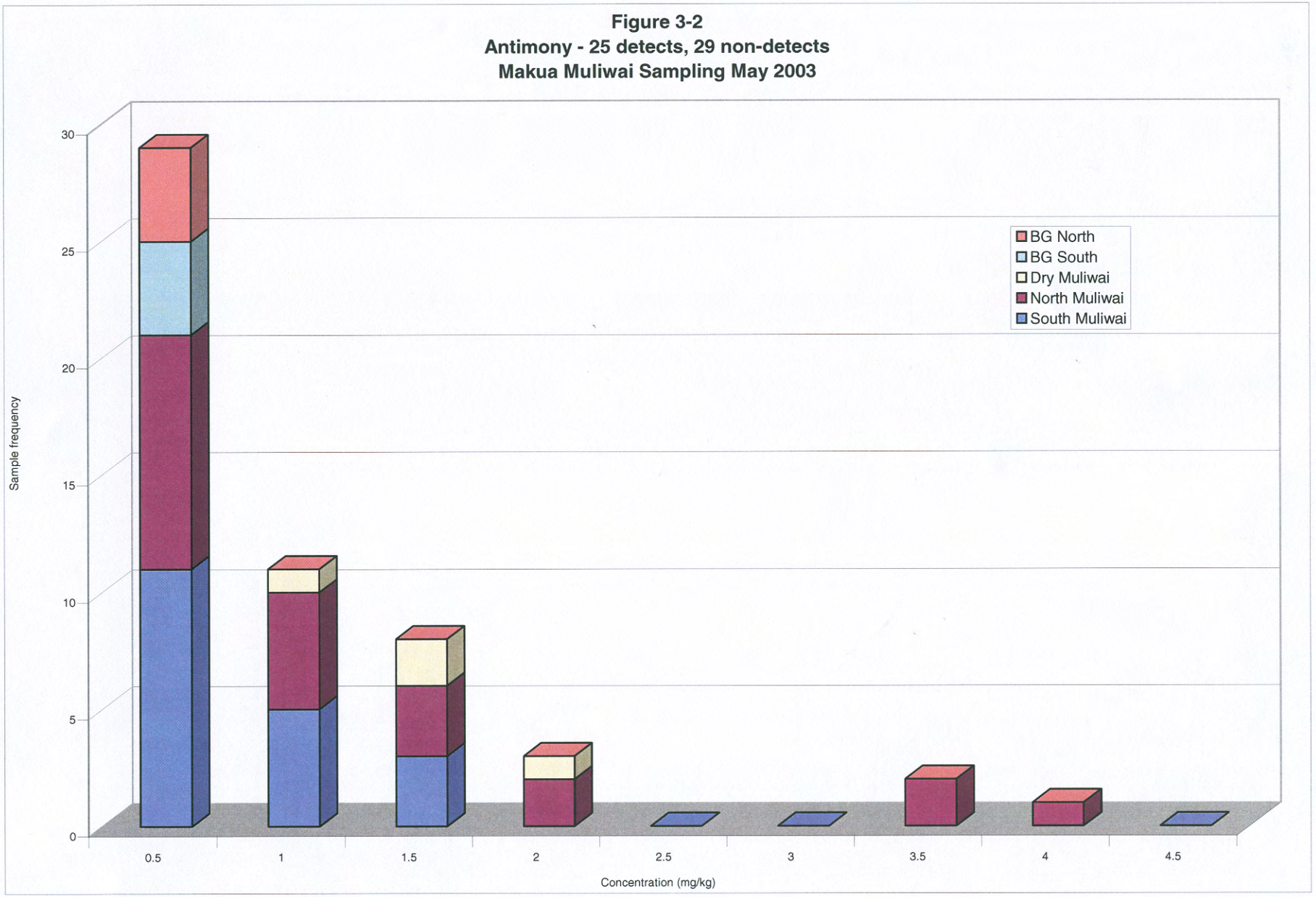
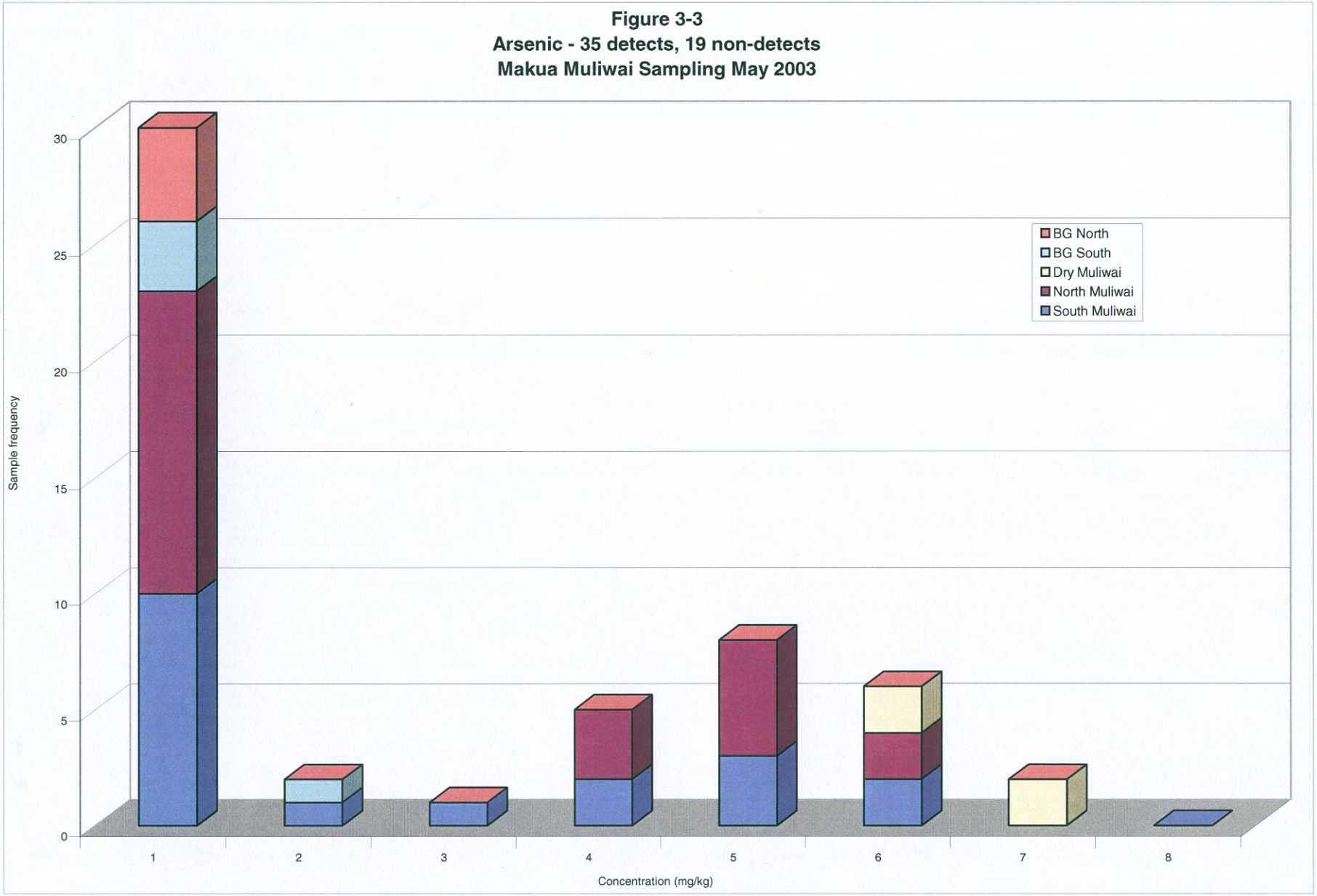


Figure 3-3
Arsenic - 35 detects, 19 non-detects
Makua Muliwai Sampling May 2003



2002). However, of the 35 samples with detectable arsenic, 29 samples contained concentrations greater than the residential cancer soil PRG of 0.39 mg/kg, and 23 of these samples contained concentrations greater than the industrial cancer soil PRG of 1.6 mg/kg. Two of the samples that contained concentrations of arsenic greater than the residential cancer soil PRG were collected from the south background area.

3.2.4 Barium

Barium was found in all of 54 sediment samples collected during this program. As shown on Table 3-2 and in the Method 6010B table in Appendix C, these barium concentrations ranged from 3.7 to 186 mg/kg. Figure 3-4 shows the distribution frequency of the barium data. Nearly half of the samples contained barium at concentrations of less than 25 mg/kg with the remaining sample frequencies distributed to a maximum of less than 200 mg/kg. The six samples with the greatest barium concentrations were collected from the north and south background areas.

None of the samples collected from any of the areas contained concentrations of barium greater than the residential soil PRG of 5,400 mg/kg.

3.2.5 Cadmium

Cadmium was found in 33 of the samples. As shown on Table 3-2 and in the Method 6010B table in Appendix C, the detected cadmium concentrations ranged from 0.013 to 0.16 mg/kg. Twenty one samples did not contain concentrations of cadmium greater than the approximate detection limit of 0.016 mg/kg. Figure 3-5 shows the distribution frequency of the cadmium data. Nearly half of the muliwai samples contained cadmium at concentrations of less than 0.025 mg/kg, with the remaining sample frequencies distributed to a maximum of less than 0.175 mg/kg. None of the samples from the background areas contained detectable concentrations of cadmium.

None of the samples collected from any of the areas contained concentrations of cadmium greater than the residential soil PRG of 37 mg/kg. The Hawaii Tier I soil Action Level is 38 mg/kg. The U.S. EPA Region 5 ESL for cadmium in sediments is 0.99 mg/kg. None of the sample results exceeded this level.

3.2.6 Chromium

Chromium was found in all samples collected during this program. As shown on Table 3-2 and in the Method 6010B table in Appendix C, the chromium concentrations ranged from 2.2 to 271 mg/kg. Figure 3-6 shows the distribution of the chromium data. Nearly half of the samples contained chromium at concentrations of less than 50 mg/kg with the remaining concentrations distributed to a maximum of less than 300 mg/kg. Three of the five samples with the greatest chromium concentrations were collected from the south background area, and all of the samples collected from the background areas contained chromium at concentrations greater than 100 mg/kg.

Figure 3-4
Barium - 54 detects, 0 non-detects
Makua Muliwai Sampling May 2003

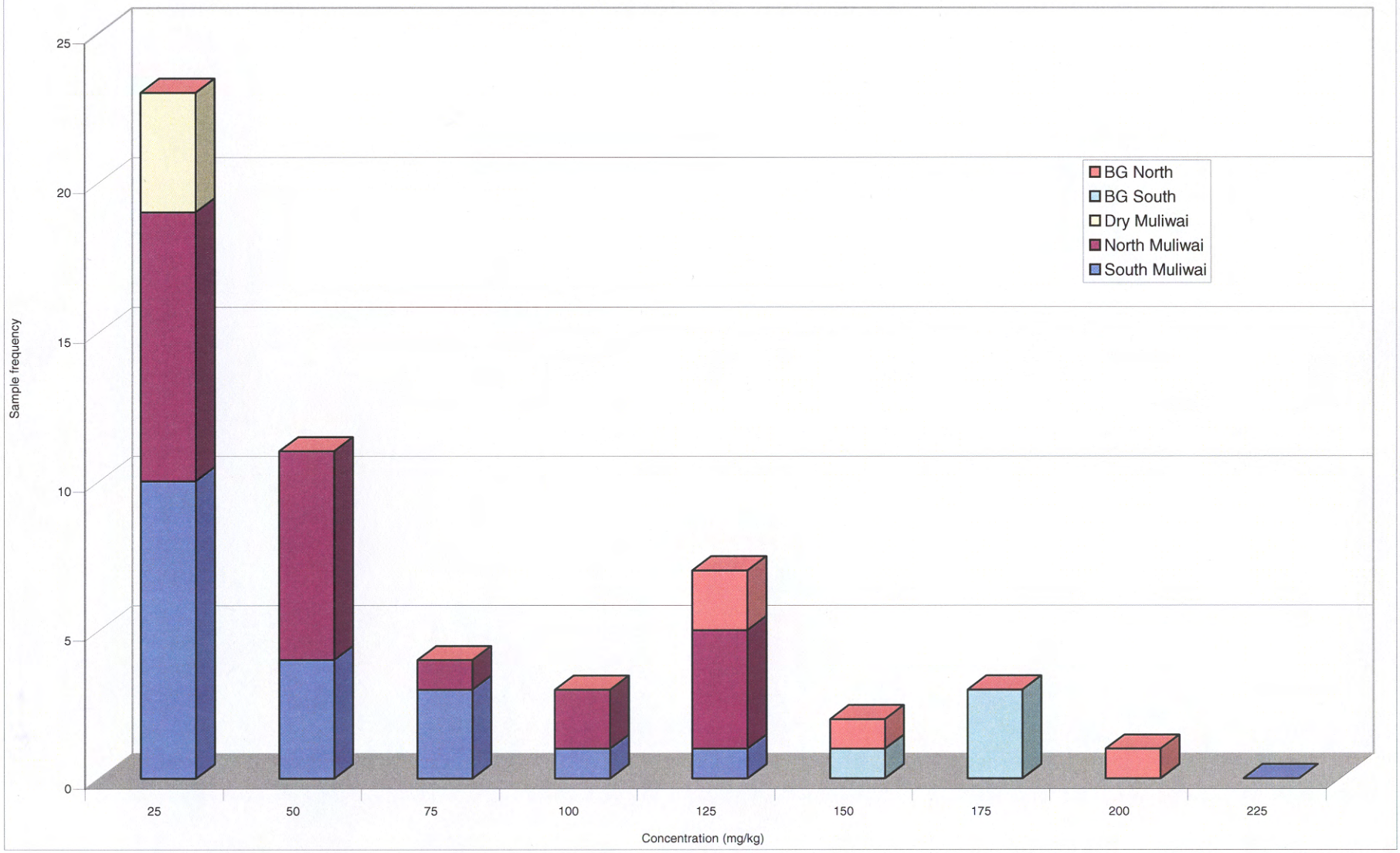


Figure 3-5
Cadmium - 33 detects, 21 non-detects
Makua Muliwia Sampling May 2003

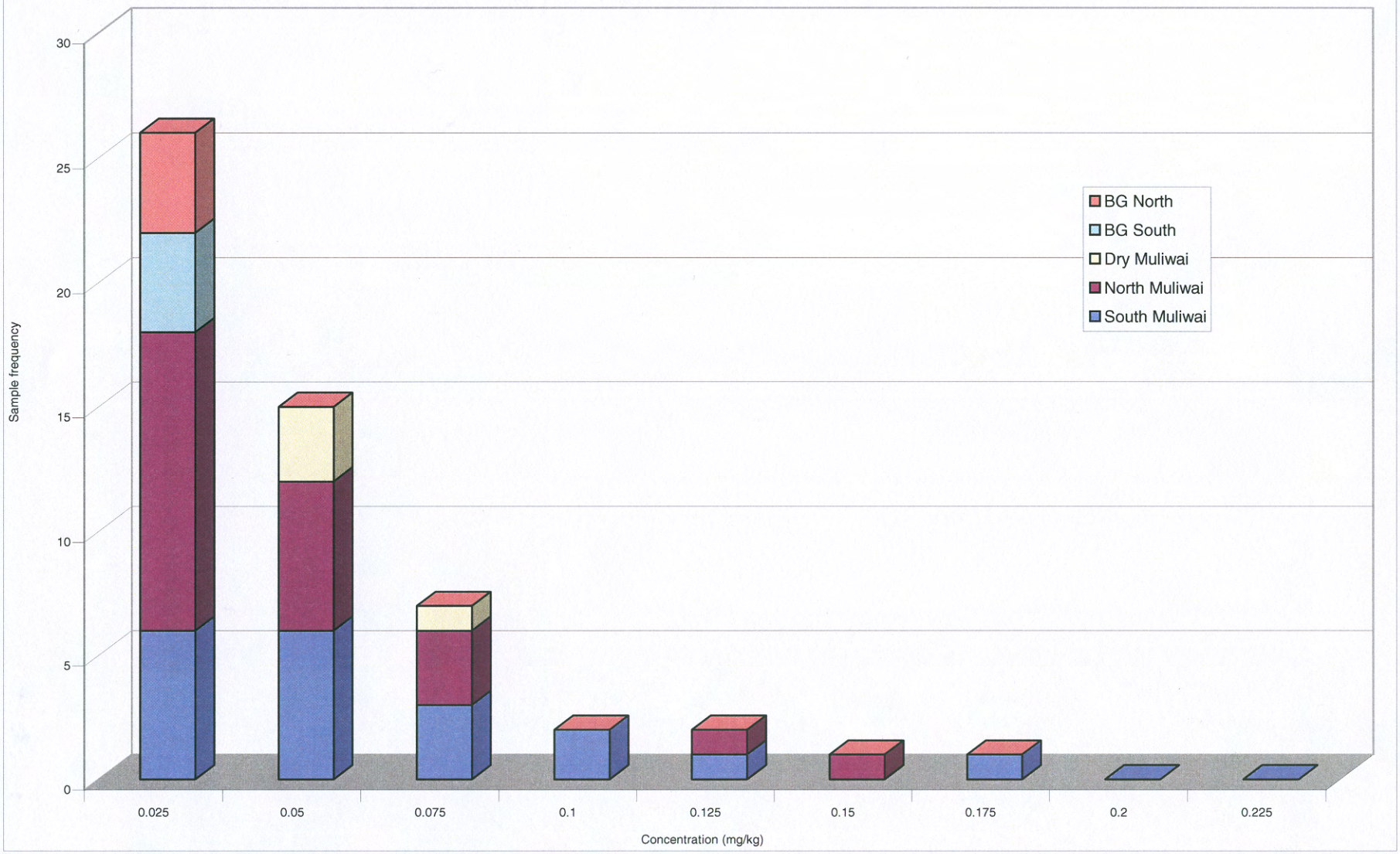
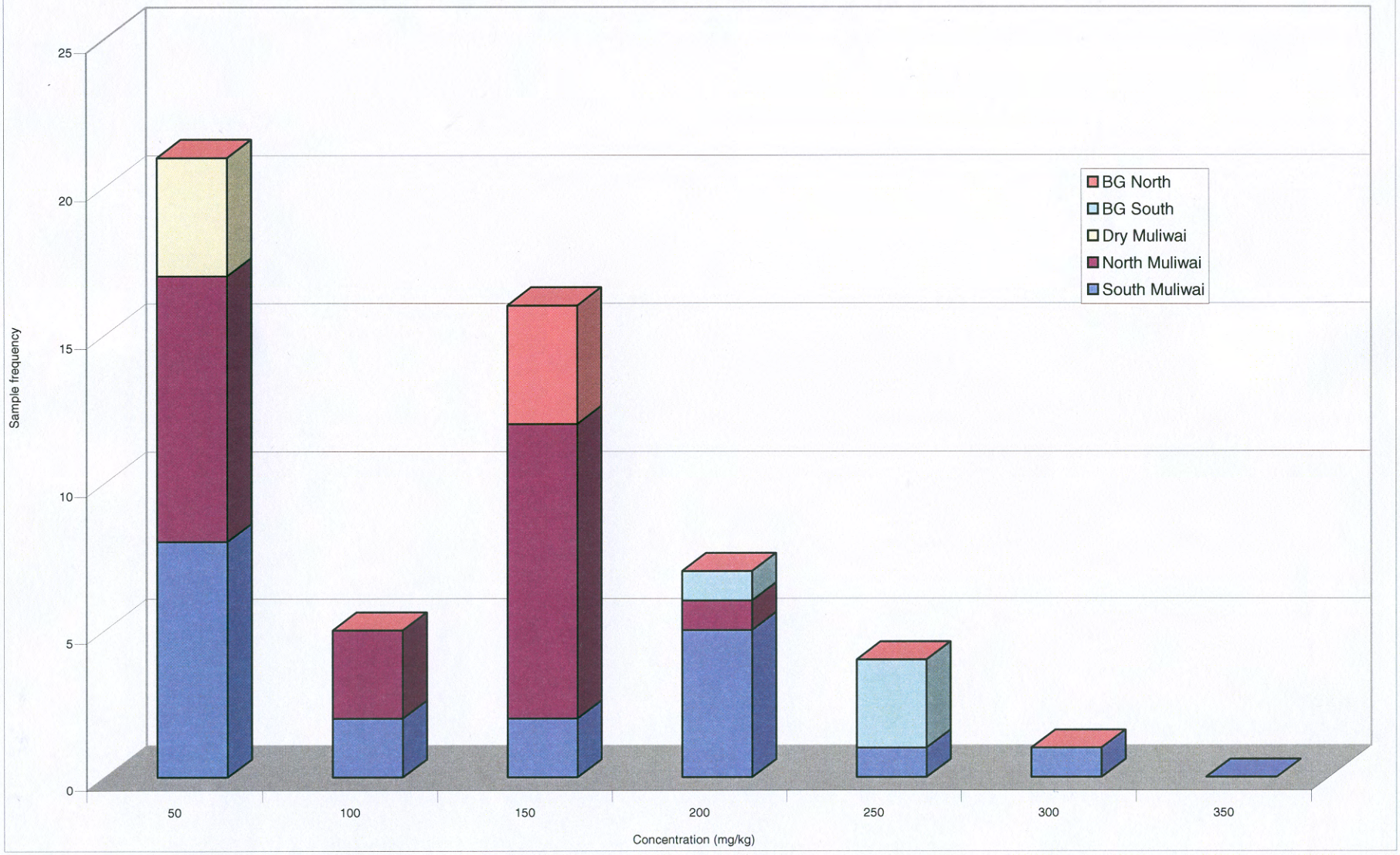


Figure 3-6
Chromium - 54 detects, 0 non-detects
Makua Muliwai Sampling May 2003



USEPA Region IX identifies PRGs for both non-cancer and cancer endpoints for chromium. The cancer endpoint is associated with hexavalent chromium (chromium VI), which is a soluble form of chromium that is favored by conditions of high pH (basic rather than acidic). The cancer PRGs for total chromium assume a mixture of chromium "VI" and the more common from, chromium "III" in a ratio of one-to-six. None of the samples collected from any of the areas contained concentrations of chromium greater than the total chromium industrial cancer soil PRG of 450 mg/kg, but four samples contained concentrations greater than the residential cancer soil PRG of 210 mg/kg. Two of these four samples exceeding the residential cancer soil PRG were collected from the south background area and all of the samples from the north background area contained concentrations of chromium between 110 and 140 mg/kg. Thus, the chromium concentrations in the muliwai samples do not appear to be significantly different from the background concentrations.

3.2.7 Cobalt

Cobalt was found in all of the 54 sediment samples collected during this program. As shown on Table 3-2 and in the Method 6010B table in Appendix C, the concentrations ranged from 1.7 to 83.1 mg/kg. Figure 3-7 shows the distribution of the cobalt data. Nearly one-third of the samples contained cobalt at concentrations of less than 10 mg/kg, with the remaining sample frequencies distributed to a maximum of less than 90 mg/kg. Five of the six samples with the highest cobalt concentrations were collected from the north and south background areas, and all of the samples collected from the background areas contained cobalt at concentrations greater than 40 mg/kg. Thus, cobalt concentrations in the muliwai samples do not appear to be higher than background concentrations.

None of the samples collected from any of the areas contained concentrations of cobalt greater than the residential soil PRG of 900 mg/kg. The U.S. EPA Region 5 ESL for cobalt in sediment is 50 mg/kg. This level was exceeded in 12 of the samples. Most of the background muliwai samples contained concentrations above the Region 5 ESL. Cobalt is a trace constituent of igneous rocks. The background range of cobalt in Hawaiian soils is above 50 mg/kg (Halbig et al 1985), and the 95 percent upper confidence limit for the concentration in surface soil samples on the Makua installation is 71 mg/kg (WES 2004). Therefore, the concentrations observed in the muliwai sediments likely are due to natural, rather than man-made sources.

3.2.8 Copper

Copper was found in 53 of the 54 sediment samples collected during this program. As shown on Table 3-2 and in the Method 6010B table in Appendix C, the detected copper concentrations ranged from 2.4 to 121 mg/kg. The one remaining sample did not contain copper at a concentration greater than the detection limit of 0.12 mg/kg. Figure 3-8 shows the distribution of the cadmium concentration. Nearly half of the samples contained copper at concentrations of less than 25 mg/kg with the remaining sample frequencies distributed to a maximum of less than 125 mg/kg. Two of the five samples with concentrations of copper greater than 100 mg/kg were collected from the south

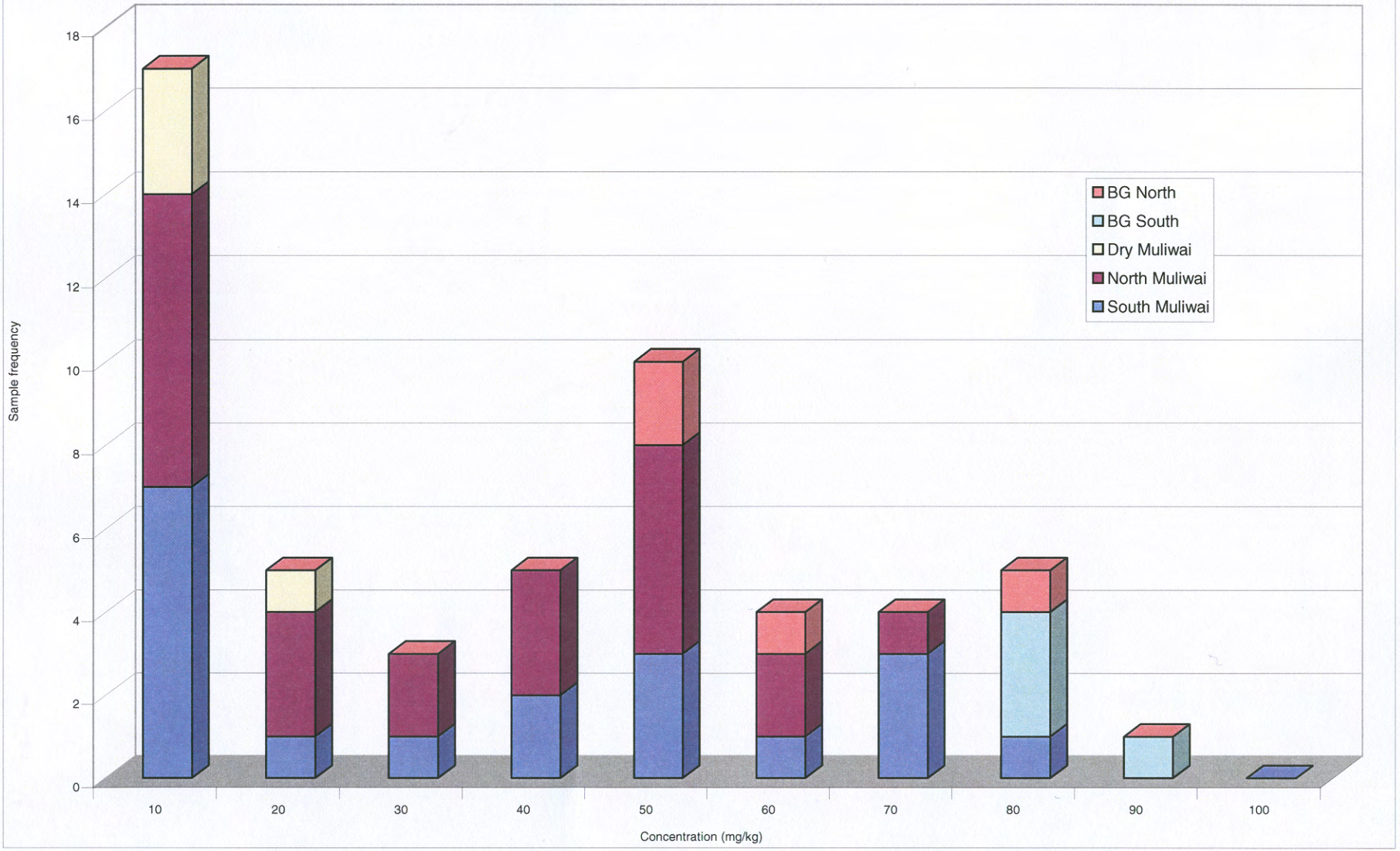



Figure 3-7
Cobalt - 54 detects, 0 non-detects
Makua Muliwai Sampling May 2003