Storm Water Sampling for Depleted Uranium at Schofield Barrack, Oahu, Hawaii

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1.0 INTRODUCTION

Depleted Uranium (DU) has been found at a number of Live-Fire Training Ranges across the United States as a result of test firing the Davy Crockett System. This weapons-system fielded from 1961 through 1971 consisted of a portable recoilless rifle capable of launching a small yield nuclear warhead that was intended as a last-ditch effort against masses of invading Soviet troops in the event of war in Germany. It used a spotting round (20mm spotting M101), an inert training warhead that was tested at a number of locations across the country including Hawaii. Only the spotting rounds were used in Hawaii, and the dummy warhead was never fired in Hawaii (Cabrera, 2007a). An Army shipping manifest showed that for the Hawaiian sites 714 spotting rounds, containing about 299 pounds of depleted uranium (DU), were sent to Hawaii between 1962 and 1968. The weapon could be fired up to three miles but would likely have irradiated the soldiers using it, so the weapon system was discontinued.

1.1 PURPOSE

The purpose of this project was to investigate the potential for uranium military constituents to be transported off-site in surface water flow from the Live-Fire training ranges located in the western portions of Schofield Barracks. It has been documented that depleted uranium rounds were fired into the impact area of the Schofield Barracks west range (Figures1 and 2). Surface water flow drains the Waianae Mountain Range flowing past Live-Fire training and impact areas that contain some remnants of the DU spotting rounds. Sampling storm water flow events downstream from the Schofield Barracks impact areas could provide data to indicate the presence or absence of depleted uranium being transported off the live-fire training area.

1.2 BACKGROUND

Uranium is a naturally occurring radioactive element found in both surface water ground water throughout the world. In December 2003, the U.S. Environmental Protection Agency (EPA) began regulating uranium in public water by established a 30 µg/L (30 parts per billion) maximum contaminant level (MCL). As a result of this lower regulatory limit the EPA estimates that approximately 500 public water supply systems (1% of those nationwide) will be impacted (Sherman et al., 2007). Other international regulatory agencies that have recommended limits for uranium in drinking water include Canada (20 micrograms per liter (µg/L)), Australia (20 µg/L) and the World Health Organization (15 µg/L), (Sherman et al., 2007).

It is common for surface water to contain low levels of uranium. For example, Colorado River Water during 2008 contained an average of 3 ug/l of uranium (OCR, 2008). The mobility of uranium, that is its ability to dissolve in water, is highly influenced by the pH and alkalinity of the water, and the concentration of the uranium in the water. The EPA MCL for uranium (30 ug/l) in natural surface or groundwater depends mostly on the ^{238}U isotope, which is more than 99% of uranium by mass. The different isotopes of ^{234}U, ^{235}U, and ^{238}U are forms of uranium that occur in its natural state. ^{235}U which is enriched for nuclear fuel or bomb material, occurs naturally at approximately 0.7%, with ^{234}U only 0.0054% of U by mass (Sherman et al., 2007). However, ^{234}U has a specific activity that is 18,600,000 times higher than ^{238}U, so that the amount of alpha particles (a form of radioactivity) released by the much smaller by mass ^{234}U and ^{235}U isotopes provide a larger portion of the activity from the Uranium metal (Sherman et al., 2007).

A research report of archived records (COE, 2007) provided information that 715 spotting rounds for the Davy Crockett system each containing 6.7 ounces of DU were shipped to Hawaii. This would result in 299 pounds of pure Uranium, or approximately 2.5 cubic feet in all of Hawaii. It is not known conclusively if this shipment represents the only transfer of these Davy Crockett rounds to Hawaii. Therefore, it was recommended that evaluation of the potential for DU at Schofield Barracks be investigated. This included the surface water sampling outlined in this report, as well as soil sampling and a risk assessment for DU conducted as outlined in (Cabrerra, 2007b).

Cabrera (2008b) presents the characterization data collected from the impact area of the Schofield Barracks in Oahu, Hawaii, from August to October 2007. The DU sampling data were collected to serve as exposure point concentrations for the ingestion, inhalation, and dermal exposure pathways in the baseline human health risk assessment (BHHRA), and provide an estimate of human health risk associated with DU identified at the Schofield Barracks Impact Area (SBIA). Data were collected from 428 acres of the SBIA. Since the SBIA includes active firing ranges, unexploded ordnance (UXO) escorts were used as a safety precaution. Three types of data were collected: (1) gamma walkover survey (GWS) data were collected to direct judgmental sampling based on gamma radiation levels; (2) exposure rate measurements were performed to evaluate external radiation exposure; and (3) soil samples were collected from systematic and judgmental locations and analyzed for DU and lead for use in the BHHRA. No surface water was present during field activities; therefore no water samples were collected during the Cabrera Services field activities. The surface water sampling results are the purpose of this report.

Cabrera (2008b) collected a total of 1,226 soil samples at 645 sample locations throughout the Schofield Barracks west range impact area. Based on the soil sample results, concentrations representative of background were determined to be less than 2.57 picocuries per gram (pCi/g) (1.65 ± 0.918 pCi/g at the 95% confidence level) for Uranium-238 (^{238}U). Both systematic and biased soil sample data were found to be similar to reference area data, demonstrating the ^{238}U concentrations in soil are at or near background concentrations with approximately three percent of the samples found to contain DU or exhibit a DU influence (i.e., the reported ^{238}U concentration was above the reference area ^{238}U naturally occurring U concentrations). Concentrations of ^{238}U in soil ranged from 0 to 7,030 pCi/g. One of the purposes of this surface water sampling effort is to verify that that DU associated with these areas is remaining on the impact areas and not flowing off-site within storm flow.

2.0 TECHNICAL APPROACH

As part of this effort, surface water samples were collected in coordination with the Operational Range Assessment Program (ORAP). ORAP monitors for munition constituents (metals, explosives, perchlorate, etc.) in runoff water and identifies potential water quality concerns associated with munitions use on the ranges. This plan was set up based on a watershed monitoring approach to evaluate uranium concentration from the three streams on Schofield Barracks. The three streams in the west range area of Schofield Barracks are Mohiakea Gulch, Waikoloa Gulch, and Hale'au'au Stream.

The basic approach to monitoring DU transport from any live-fire training range begins with identifying the transport pathways in which DU constituents are most likely to be mobilized. These transport pathways may vary from one installation to another as a result of site-specific conditions, range design features, and possibly types of training operations and maintenance procedures. Site-specific conditions include: soil physical and chemical characteristics, climate, vegetative cover, geology, and range topography.

The predominant pathway for metals transport from range areas is typically in storm water runoff/surface water leaving the range areas. Common problems on ranges such as soil erosion and sediment in storm water runoff are potential drivers of metals transport. Other potential pathways for metals to transport to off-ranges areas include: leaching metals to groundwater, airborne dispersion via wind transport, and biological uptake via animals that may result in metals entering the food chain.

Leaching of DU into groundwater is typically not a major concern because if uranium ions are released as a result of the corrosion processes they normally bond to soil particles. This will typically retard vertical movement of the DU and restrict the DU constituents to the shallow soil layer.

As previously stated, the predominant pathway for metals transport is storm water runoff/surface water leaving the range areas. This generally holds true for DU munitions constituents. Therefore, the development of a monitoring plan should be performed on a watershed scale. This is easily done in the for the Schofield Barracks west range since the 3 streams that drain the impact areas flow underneath range roads in accessible areas before leaving the Army's property. The Waianae mountains form a natural boundary, or "backstop" for the impact areas, with rainfall falling in the areas of DU rounds flowing into one of 3 streams monitored as part of this program (Figure 1 and 2). Monitoring on this scale not only ensures that DU is controlled within the range area, but it also provides a means of identifying the general areas in which DU is located if it is detected in the runoff/surface water. The monitoring data would then support further assessment of DU concentration locations and DU management methods that may be implemented to control migration.

The watershed approach is recommended for several reasons. First, the watershed management perspective is consistent with nonpoint source water quality guidance. In addition, a watershed represents a defined area and true boundary from a functional environmental perspective. In general, surface waters, storm water runoff, and shallow groundwater movement are grouped or confined into a well-defined watershed or sub-watershed. Evaluating a range area on the watershed scale will help focus the limited resources available. Areas that need further investigation can be identified and prioritized. Locations can be identified to maximize the benefits of management efforts to control DU transport at minimum cost. Surface water resources represent the pathway where range pollutants can be quickly transported. These resources also have water quality standards that can be compared against sampling results to help evaluate the potential impact of range activities on these water resources.

2.1 SURFACE WATER MONITORING AT SCHOFIELD BARRACKS

All surface water that results from rainfall in the west range of Schofield Barracks watershed flows into one of three intermittent streams: southernmost Mohiakea Gulch, Waikoloa Gulch, or northernmost Hale'au'au Stream (Figure 2). Mohiakea Gulch and Waikoloa Gulch streams are intermittent, in that they only flow during large rainfall events. Hale'au'au stream is intermittent, but it also drains a small amount of flow (2 cubic feet per second or less) from the marsh in the caldera atop Mt. Kaala. This small amount of groundwater discharge occurs from October through April and gives the steam its name: Hale'au'au in Hawaiian means "house of the water" named for this small drainage from atop Mt. Kaala. Potential impact areas of the Davey Crockett rounds are contained within this watershed, so that sampling the storm water for uranium would assist in verifying that these rounds were not used. The DU might be either a suspended solid in the water sample or dissolved within the water.

The monitoring plan included the use of automated storm water sampling equipment. Sub-watershed, down gradient (outlet) storm water samples were collected at the three streams flowing from the west range of Schofield Barracks, including Mohiakea Gulch, Waikoloa Gulch, and Hale'au'au Stream (Figure 1 and 2). The surface water sampler location numbers for these are SW-1 (Mohiakea Gulch), SW-2 (Waikoloa Gulch), and SW-3 (Hale'au'au Stream) as shown in Figure 1 and 2. One up-gradient water sampler (SW-4) was also monitored at a point where the headwaters of Hale'au'au stream flow onto the range. A few samples were collected from the upstream (SW-6) and downstream location (SW-5) along Waikele Stream for additional background information on uranium; however, it was not believed that DU spotting rounds were fired in the Waikele Stream watershed (Figure 1). This provided for a total of six stream-water sampling stations monitored at the Schofield Barracks ranges. Sample collection for uranium water samples began in February 2007 by obtaining bottles and contracting with the analytical laboratory. The first samples were collected in March 2007 with the last samples collected in December 2008. Water samples were collected from 4 small storms and one very large storm in central Oahu during the project sampling period (February 2007 through December 2008) (Table 1). Table 1 provides an explanation of the size of flow and date of the sample collected. Additional samples were collected from the groundwater discharge in Hale'au'au stream as for most of the year this is the only flow from the west range of Schofield Barracks (Table 1). The rainy season defined by State of Hawaii Department of Land and Natural Resources occurs from October 1 through April 1 of each year, with most storms occurring in December, January or February of each year.

2.2 SAMPLING PROTOCOL

Automated storm water sampling equipment, using Durham GeoSlope Indicators model TR-4002 and Teledyne ISCO model 6712, collected most of the samples with some grab samples collected by project personnel. The sampling equipment was maintained for proper operation since there could be a surface water flow event at any time. The samplers are contained in a metal drum with a deep cycle marine battery charged with solar panels (Appendix A). To provide for sampling of surface water at live-fire training ranges it is necessary to use automated sampling equipment. This is especially true for Oahu because experience has shown that during large rains roads to Schofield Barracks are closed due to fallen telephone poles or flooding, preventing access by the sampling crew. It is often impossible to obtain range access to collect stream flow samples by hand for several days due to live-fire training. Automated sampling equipment collect water samples at any time, even if the valley is inaccessible. Also, in Hawaii the runoff in streams from storms is very short lived: often streams stop flowing within 24 hours after a rain event begins. Both the limited access and hydrology of Hawaiian streams make automated sampling equipment necessary.

Steam flow in the intermittent streams in Hawaii generally occurs only in fairly large rainfall events that occur from November through March of each year. First flush flow in the streambeds occurs generally from 4 to 6 hours after the rainstorm begins. Peak flow generally occurs between 8 and 12 hours after the rainstorm begins and the associated stream flow is often finished within 24 hours. The samplers were programmed to sample these events.

The sampling stations at SW-1 (Mohiakea Gulch), SW-2 (Waikoloa Gulch), and SW-3 (Hale'au'au Stream) used an ISCO 6712 automated samplers. The sampling station for upper Hale'au'au stream (SW-4) used a nested pair of Durham samplers during 2007 and until July 2008 when this station was replaced with an ISCO 6712 sampler. The ISCO samplers for Stations SW-1, SW-2, SW-3, and SW-4 are set so that 24 – one liter samples are taken to collect samples throughout the stream flow event, including first flush and peak flow samples. For sampling stations using a nested pair of Durham automated samplers one obtains first flush stream-flow, and the second obtains peak flow as part of a time weighted composite sample over a longer period.

The ISCO 6712 automated 24 bottle samplers are programmed so that the first eight (8) one-liter bottles are taken every ½ hour, with the remaining 16 bottles taken every hour to every 1-½ hours. The automated Durham sampler equipment obtaining the first flush sample is programmed to collect 1 liter of surface water every 10 minutes for a total of 10 samples in the 10 liter bottle. This results in a first flush sample collected over a period of 1 hour and 30 minutes. The second automated Durham sampler collecting peak flow samples is programmed to collect 1 liter samples every 90 minutes, with the last sample (of 10 liters) collected after 13.5 hours. The sampling equipment is set to collect samples whenever there is flow in the intermittent stream above 3-4 inches. The ISCO 6712 samplers also have either a stage meter, or stage and velocity meter to provide flow information within the stream. The sample bottles were also cleaned and decontaminated before they are placed in the field within the sampling equipment.

The sampling crew continually monitored the weather in Hawaii, and was dispatched whenever rainfall was sufficient to result in stream flow. If samples are obtained by the automated equipment, the field sampling crew removed the sample and transferred the water sample to a clean bottle. The automated equipment records the time and date of sample collection. The sample is then placed on ice in a cooler. In addition, field parameters of pH, electrical conductivity, and total dissolved solids (calculated from electrical conductivity) are recorded for the water samples. The water samples are then preserved using nitric acid (HNO_3) without filtration. This results in total uranium being measured by the laboratory with no differentiation between total and dissolved uranium. The samples are then stored in a refrigerator or ice chest until they are shipped to the laboratory. Samples are shipped to the laboratory via Federal Express, Inc. overnight delivery in a cooler packed with ice to allow the samples to be transferred to the laboratory at a temperature of 2 to 6 degrees centigrade. Samples are transferred with the required chain-of-custody forms and chain of custody seals. During the shipping the coolers are opened in Los Angeles, California by the U.S. Department of Agriculture for inspection which can damage the custody seals and result in lost paperwork.

As part of this project a minimum of 10% field split samples were sent to a separate analytical laboratory. The total number of 10% field splits for both the sampling at Schofield Barracks and Makua Military Reservation are included in this total. The total number of samples between the two sites (Makua and Schofield) was 90 original samples and 9 split samples. The primary laboratory is GEL Laboratories in Charleston, South Carolina, with the field split samples sent to GSL Laboratories in Montgomery, Alabama. For most samples the Alpha Spectroscopy Uranium HASL (Health and Safety Laboratory) 300 U-02-RC modified method is used. The split samples use a similar Alpha Spectroscopy Uranium method SM 7500-U C(m). This method measures the activity in picocuries (pCi) and with results reported in pCi/liter of the various naturally occurring isotopes of Uranium (^{234}U, ^{235}U, ^{238}U). The Alpha Spectroscopy uranium test allows for calculation of the uranium isotopes of U^{234}, U^{235}, and U^{238} to provide differentiation of naturally occurring uranium versus depleted uranium.

3.0 RESULTS

The results section includes an explanation of the surface water flow measurements in the streams, and an explanation of the alpha spectroscopy uranium results reported by the analytical laboratory.

3.1 Flow Results Summary

The surface water samples were collected during storm water flow events as listed in Table 1. There were a total of 4 small storms that occurred on 3/14/2007, 11/4/2007, 12/4-12/2007, and 11/22/2008. These represented smaller storms, with small flows of 1 to 40 cubic feet per second (Table 1) in either of the streams. Flow estimations were calculated using manning's equation. Photographs in Appendix A shows a typical flow at Hale'au'au stream at monitoring location SW-3 and SW-4. Additional samples were collected of ponded groundwater from the headwaters of Hale'au'au stream on Mt. Kaala to provide background information on uranium concentrations in a location unlikely to have depleted uranium. The most likely Davey Crocket spotting rounds impact area (COE, 2007) is drained by either Mohiakea Gulch or Hale'au'au Stream.

A large storm occurred on Oahu that began with large rains in the early morning hours of December 11, 2008. All three streams within Schofield Barracks had abundant runoff from this large rain event. Maximum flows in lower Hale'au'au stream during this very large storm were estimated as high as 3,500 cubic feet per second for period of less than an hour. Storm water flows in Mohiakea Gulch and Waikoloa Gulch were not as large, with a peak estimated flow of approximately 1,000 and 600 cubic feet per second for a brief period, respectively. Based on a review of rainfall records, this event was a large flow for the west range of Schofield Barracks.

3.2 DU Sampling Results Data

A total of 75 surface water samples and 6 duplicate samples were collected from the 5 storms as listed in Table 1. Table 2 lists a summary of the total uranium concentrations and the activity ratios (ARs) from the 81 surface water samples collected from streams at Schofield Barracks. For all the samples of storm water results are reported in picocuries per liter (pCi/l), which is a measure of the radiation from the uranium within the sample for the various isotopes (^{234}U, ^{235}U, ^{238}U). A conversion calculation is made from pCi/l to micrograms per liter (ug/l) of uranium to allow for comparison to the EPA drinking water standard of 30 ug/l. Table 2 has 11 pages for the various samples, with the alpha spectroscopy uranium laboratory analysis at the top of the table, and the calculated total uranium value and activity ratios at the right side of the table. For many of the samples it is not possible to calculate the activity ratios because the measured levels of uranium are so low that an accurate calculation cannot be made.

3.2.1 Total Uranium

The activity of the various isotopes activity is measured by the laboratory for ^{234}U, ^{235}U, ^{238}U, and then a conversion from picocuries of activity to milligrams of uranium is calculated (Table 2). The equation use for the conversion from pCi/l to ug/l is the following:

- ug/l of uranium = $(^{234}U/6{,}300)+(^{235}U/2.2)+(^{238}U/0.34)$

where: concentrations of ^{234}U, ^{235}U, ^{238}U are in pCi/l.

All of the surface water sample measurements reported by the analytical laboratory show that uranium concentration are significantly below 30 ug/l, except for a few samples taken during the large rainstorm of December 2008. The maximum concentration is 61 ug/l with the minimum concentration being -0.26 (which is basically zero). This laboratory method reports negative values due to statistical corrections of background radiation, but all negative values can be interpreted as zero. The average total uranium concentration is 3.2 mg/l, with the geometric mean of 0.63 mg/l (positive values greater than zero were used). These surface water samples have uranium concentrations far below drinking water standards except for one sample (RA14-SW-3-2) with a total uranium value of 61 mg/l (Table 2). This sample was collected during the peak flows from a very large storm (Table 1) with total suspended solids (TSS) concentration of 5,420 mg/l, which would have been very muddy water with a large portion of suspended sediment. Sample RA14-SW-3-3 with a total uranium of 13 mg/l also had a very high total suspended solids value of 44,300. The average TSS concentration from all Schofield Range samples was 1,600 mg/l, which is much lower than the TSS values for these two samples. Metals concentrations including uranium would be elevated for samples with such a large portion of total suspended solids. In summary, only 1 of 81 storm water sample from the Schofield Ranges contains uranium at concentration above drinking water standards. Therefore the storm water flow from Schofield Barracks would not represent a health hazard to the public. These values are lower than many surface water uranium concentrations in water throughout the U.S and the world.

3.2.2 Uranium Activity Ratios

A second set of comparisons is calculated to evaluate if the AR (activity ratios) are representative of naturally occurring uranium or depleted uranium. This comparison of ratios is difficult for the Schofield surface water samples, as the total levels of the various uranium isotopes (^{234}U, ^{235}U,^{238}U) are so low that calculations of the different ratios have large statistical uncertainly associated with the measurements (Table 2). Two ratios are calculated: $^{234}U/^{238}U$ and $^{235}U/^{238}U$ (Table 2). The alpha spectroscopy method used by the laboratories in this study evaluates the amount of the 3 isotopes in the water sample in pCi/l. A comparison of the $^{234}U/^{238}U$ and $^{235}U/^{238}U$ activity ratios is also made between the data collected in water at Schofield Barracks, and values published for naturally occurring uranium in natural waters. In natural systems, the ratio of the $^{234}U/^{238}U$ are generally between 1 and 2, through they have been measured to vary from 0.5 to 12 (Gasgoyne 1981) and reported as high as 27.88 (Bonotto 1999). Goldstein (1997) reported that ratios in natural waters range typically from 0.8 to 10 for $^{234}U/^{238}U$, with the $^{235}U/^{238}U$ activity ratio being more uniform at 0.046. Simple weathering of uranium will result in activity ratios (ARs) in the same equilibrium as the host uranium (Sherman et al, 2007). This means that if uranium were moved along in surface water flow, the activity ratio should not change, and therefore AR that were measured as part of this effort would indicate the AR of the uranium in the host soil from the training range.

Hawaiian Volcanic rocks also contain natural uranium varying from 0.12 to 0.20 mg/kg (parts per million) of total uranium with $^{234}U/^{238}U$ ratios of 1.0 (+/- 0.003). Hawaiian coraline rock, that is rock formed from ancient corals beds, contain 2 to 3 mg/kg (ppm) with $^{234}U/^{238}U$ ratios of 1.0 to 1.1 (+/- 0.003). These ranges of values are taken from a number of references including: Muhs and Szabo (1994), Rubin et al. (2000), Sherman (1999), Sims et al. (1995), and Szabo et al. (1994). Weathering of volcanic rocks in Schofield Barracks would provide the uranium to the soil, which would then be transported by storm water flow throughout the valley. Therefore, if concentrations in water samples taken in Schofield Barracks are representative of natural uranium it represents weathered uranium from the silt, clay, sand, boulders, and basalt bedrock in the valley, not depleted uranium.

Additional information on activity ratios is published in Weisman et al. (2007) as summarized in Table 3. This table lists the characteristics of Uranium in various isotopic mixtures, including natural uranium and depleted uranium. In general, the uranium contained in the water samples is weathered from naturally occurring uranium if the $^{234}U/^{238}U$ ratio is greater than or equal to 1, and the $^{235}U/^{238}U$ is greater than or equal to 0.046. For the Uranium contained in the water samples collected as part of this study to be Depleted Uranium, the ratios of $^{234}U/^{238}U$ ratio would be less than 0.04, and the $^{235}U/^{238}U$ would be less than 0.014. Depleted uranium is reduced in the amount of ^{234}U and ^{235}U isotopes and somewhat higher in the amount of ^{238}U (Table 3).

For the water samples collected from Schofield streams, the average $^{234}U/^{238}U$ ratio is 3.85. The range of these values is representative of naturally occurring uranium, as the $^{234}U/^{238}U$ ratio value for natural uranium vary from 0.5 to 28, while values for DU would be lower and less than or equal to 0.4. Figure 3 shows a bar chart of the $^{234}U/^{238}U$ ratios for the Schofield surface water samples and for comparison natural uranium and depleted uranium ratios. Schofield surface water samples are shown in blue, natural uranium is shown in red, and depleted uranium is shown in green. Values for $^{234}U/^{238}U$ ratio greater than 10 are removed from this graph for clarity. The Schofield Barracks water sample's calculated $^{234}U/^{238}U$ ratios are much closer and representative of naturally occurring uranium, rather than DU. The most appropriate way to interpret these data are as large group, with the dataset as a whole indicating that the uranium in these water samples is more representative of naturally occurring uranium than depleted uranium.

A comparison is also made of $^{235}U/^{238}U$ ratios. Values of the $^{234}U/^{238}U$ ratio are generally more accurate than for $^{235}U/^{238}U$, as the uncertainty of the laboratory method for ^{235}U is greater than that for ^{234}U. Figure 4 shows a logarithmic graph of $^{234}U/^{238}U$ ratio on the bottom axis and $^{235}U/^{238}U$ on the horizontal access. The Schofield Barracks water samples calculated ratios for $^{235}U/^{238}U$ average 1.94. These values are much closer to the $^{235}U/^{238}U$ value for naturally occurring uranium of 0.046 than the value for DU of 0.014; however, it should be noted that the $^{235}U/^{238}U$ ratios have greater inaccuracy than either the total uranium calculation or the $^{234}U/^{238}U$ ratio. Values for depleted uranium on this graph plot in the lower left corner as shown in Figure 4. Values for natural uranium from literature of natural water worldwide (Goldstein, 1997 and Gasgoyne, 1981) are plotted towards the middle of the graph. Values for 38 Schofield water samples are plotted in blue towards the top of the graph. Out of 81 water samples 38 contained enough uranium as measured by the laboratory for the calculation of both $^{234}U/^{238}U$ and $^{235}U/^{238}U$ ratios. This plot shows that the water samples coincide with the more accurate $^{234}U/^{238}U$ ratio and represent naturally occurring uranium. The plotted values for the $^{235}U/^{238}U$ ratio are somewhat high at greater than 0.1 and should be considered somewhat more inaccurate than the $^{234}U/^{238}U$, but still are indicative of naturally occurring uranium.

Figure 5 shows a semi-logarithmic plot of total suspended solids and total uranium concentrations. Total suspended solids (TSS) is a measure of the fine particulates transported by surface water, considered to be that portion than can be removed by filtration. As shown in Figure 5, the samples associated with the higher total uranium concentrations in mg/l also contain elevated TSS concentrations. TSS concentrations of greater than 5,000 mg/l are very muddy and turbid samples. It is expected that such a high volume of solids would contain elevated metals concentrations such as natural uranium.

Table 4 lists a summary of the three comparison methods for the water samples collected: the first column is an evaluation (yes or no) if the total uranium values are above drinking water standards, the second column is a evaluation (yes or no) if the $^{234}U/^{238}U$ ratio calculation represents DU, and the third column is a evaluation (yes or no) if the $^{235}U/^{238}U$ ratio calculation represents DU. The most accurate and reliable concentration is the total uranium concentration. All calculated values from the data reported by the analytical laboratories are below drinking water standards except for one muddy sample that contained abundant sediment. The calculated ratios of $^{234}U/^{238}U$ (Table 2) from data reported by the analytical laboratories are all indicative of naturally occurring uranium and not depleted uranium. This is especially true for the one sample with a total uranium concentration above drinking water standards (RA14-SW-3-2) with a $^{234}U/^{238}U$ of 0.95 to 1.19 (for the varying analyses of this sample). Though somewhat less accurate, the calculated ratio of $^{235}U/^{238}U$ (Table 2) from data reported by the analytical laboratories indicate naturally occurring uranium, not depleted uranium.

4.0 CONCLUSIONS

Surface water samples results collected and analyzed by the laboratory from Schofield Barracks show that no depleted uranium is leaving the reservation. Uranium concentrations in surface water reported by the analytical laboratory are indicative of naturally occurring uranium. A review of the results reported by the analytical laboratory indicates the average total uranium concentration is 3.2 mg/l. The maximum concentration is 61 ug/l with the minimum concentration being -0.26 (which is zero). The uranium concentration in these surface water samples have uranium concentrations far below drinking water standards (except for one sample), and therefore storm water from Schofield Barracks does not contain uranium at concentration that would represent a health hazard to the public. These values are lower than many surface waters throughout the U.S and the world, and they are lower than many drinking water supplies in the United States.

An analysis of $^{234}U/^{238}U$ and $^{235}U/^{238}U$ ratios indicates naturally occurring uranium, if these ratios can be calculated. When the levels of the Uranium isotopes are too low or the error for the alpha spectrometry test is too great, then the ratios cannot be calculated. If they can be calculated, the Schofield water sample's calculated $^{234}U/^{238}U$ ratios are much closer and representative of naturally occurring uranium rather than DU. This applies for all samples including the one sample (RA-14-SW-3-2) with total uranium concentrations above drinking water standards. The $^{234}U/^{238}U$ ratios are a somewhat more accurate representation than the $^{234}U/^{238}U$ ratios since ^{235}U measurement is more subject instrument inaccuracies. The somewhat more elevated concentrations of naturally occurring uranium at Schofield Barracks also coincide with elevated concentrations of total suspended solids (TSS). It is expected that such a high volume of solids would contain elevated metals concentrations such as natural uranium.

5.0 References:

Cabrera Services, Inc. (2008a). Final Technical Memorandum, Depleted Uranium Scoping Investigations, Makua Military Reservation, Pohakuloa Training Area, Schofield Barracks Impact Area, Islands of Oahu and Hawaii. Prepared for Department of the Army Headquarters, U.S. Army Sustainment Command. April 2008., 30 p.

Cabrera Services, Inc. (2008b). Final Characterization Report, Schofield Barracks Davy Crockett Impact Area, Oahu, Hawaii. Prepared for Department of the Army Headquarters, U.S. Army Sustainment Command. April 2008., 59 p.

COE (2007) "Archive Search Report On the Use of Cartridge, 20mm Spotting M101 for Davy Crockett Light Weapon M28, Islands of Oahu and Hawaii" (USACE, 2007).

Gascoyne, M. (1991). A simple method of uranium extraction from carbonate groundwater and its application to 234-U/238-U disequilibrium studies. Journal of Geochemical Exploration 14, no. 2-3: 199-207.

Muhs, D. R. & Szabo, B. J. (1994) New uranium-series ages of the Waimanalo Limestone, O'ahu, Hawaii: Implications for sea level during the last interglacial period. Mar. Geol. 118, 315±326.

OCR (2008) Orange County Register Newspaper. "Water Agency Kept Uranium Contamination Secret." Santa Ana, CA, October 10, 2008.

Pietruszka A.J., , K.H. Rubin and M.O. Garcia (2001) 226Ra-230Th-238U disequilibria of historical Kilauea lavas (1790-1982) and the dynamics of mantle melting within the Hawaiian plume. Earth Planet. Sci. Lett., 186, 15-31.

Rubin, C.E., C.H. Fletcher, C.E. Sherman (2000) Fossiliferous Lana'i deposits formed by multiple events rather than a single giant tsunami, Nature, 408, 657-681.

Sherman, C.E., and C.H. Fletcher, and K.H. Rubin, (1999) Marine and meteoric diagenesis of Pleistocene carbonates from a nearshore submarine terrace, Oahu, Hawaii, Journal of Sedimentary Research, 69, 1083-1097.

Sherman, H.M., J. S. Gierke, and C.P. Anderson (2007) Contols on Spatial Variability of Uranium in Sandstone Aquifers. Groundwater Monitoring and Remediation 27, no. 2/ Spring 2007, p. 106-118.

Sims, K.W.W., D.J. DePaolo, M.T. Murrell, W.S. Baldridge, S.J. Goldstein, D.A. Clague (1995) Mechanisms of Magma Generation Beneath Hawaii and Mid-Ocean Ridges: Uranium/Thorium and Samarium/Neodymium Isotopic Evidence, Science, 267, no. 5197, 508-512.

Szabo, B. J., K Ludwig. R.,Muhs, D. R. Simmons (1994) Thorium -230 ages of corals and duration of the last interglacial sea-level high stand on O'ahu, Hawaii. Science 266, 93±96.

Weismann, J. C. Young, S. Masciulli, D. Caputo (2007) Determination of the Origin of Elevated Uranium at a Former Air Force Landfill Using Non-parametric Statistics Analysis and Uranium Isotope Ratio Analysis. Proceedings from the Waste Management 2007 Conference, February 25-March 1, 2007, Tucson, AZ.

FIGURES

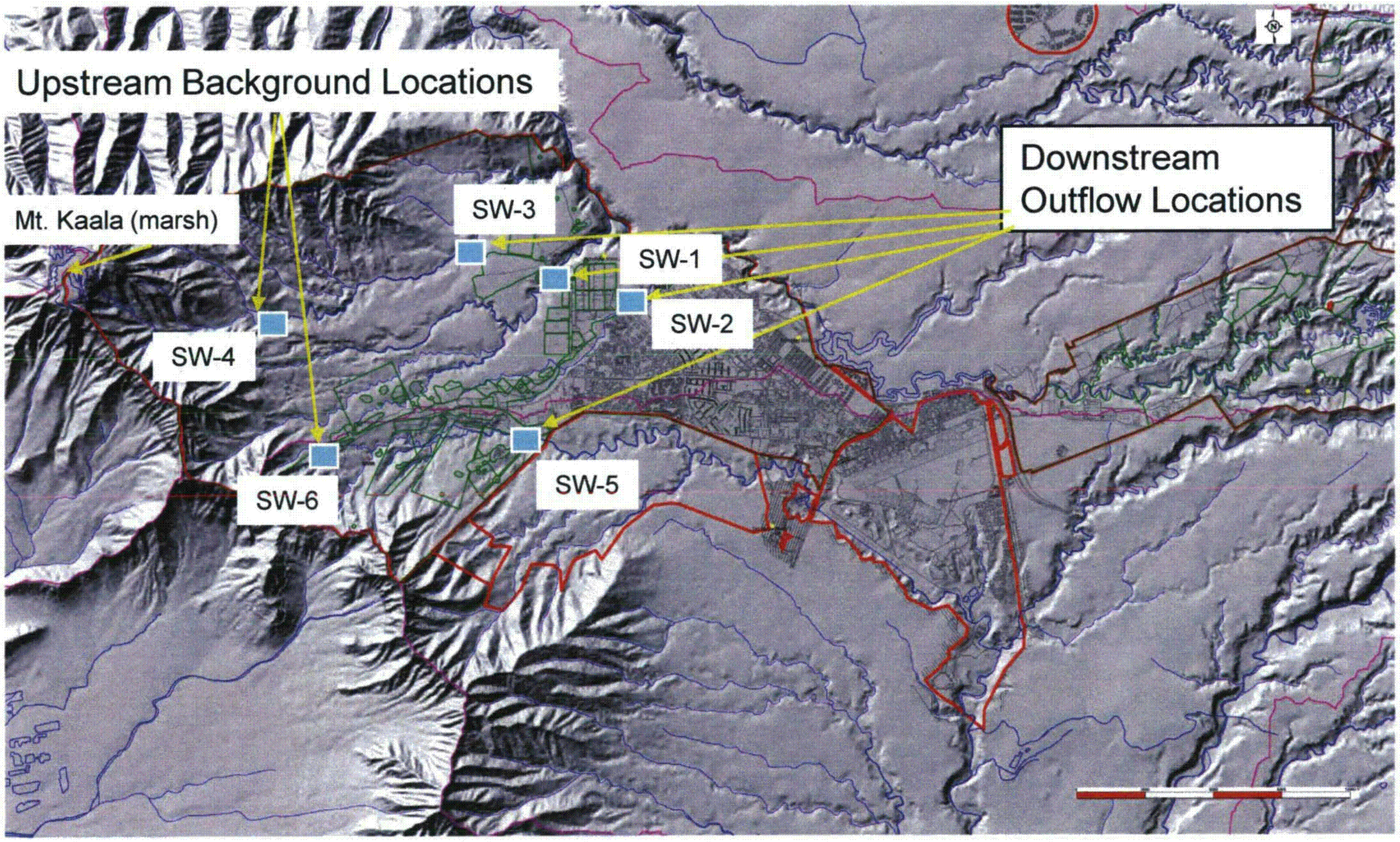

Figure 1. Schofield Barracks Surface Water Sampling Locations

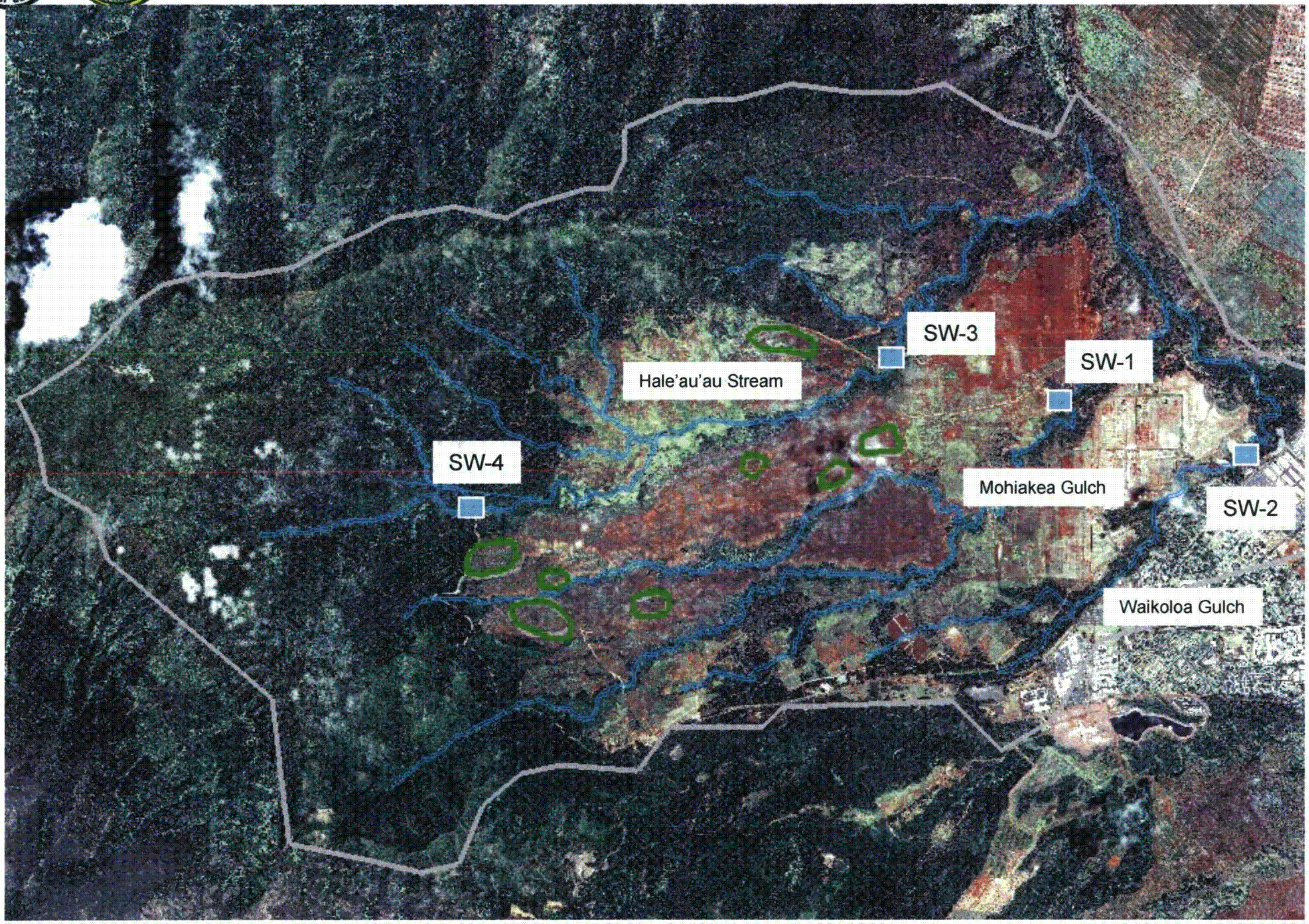

Figure 2. Locations of DU Relative to Water Sampling Locations
(Stream Locations shown in Blue, DU locations in green)

Figure 3. Bar Chart of $^{234}U/^{238}U$ Ratios for Schofield Water Samples, Natural Uranium, and Depleted Uranium

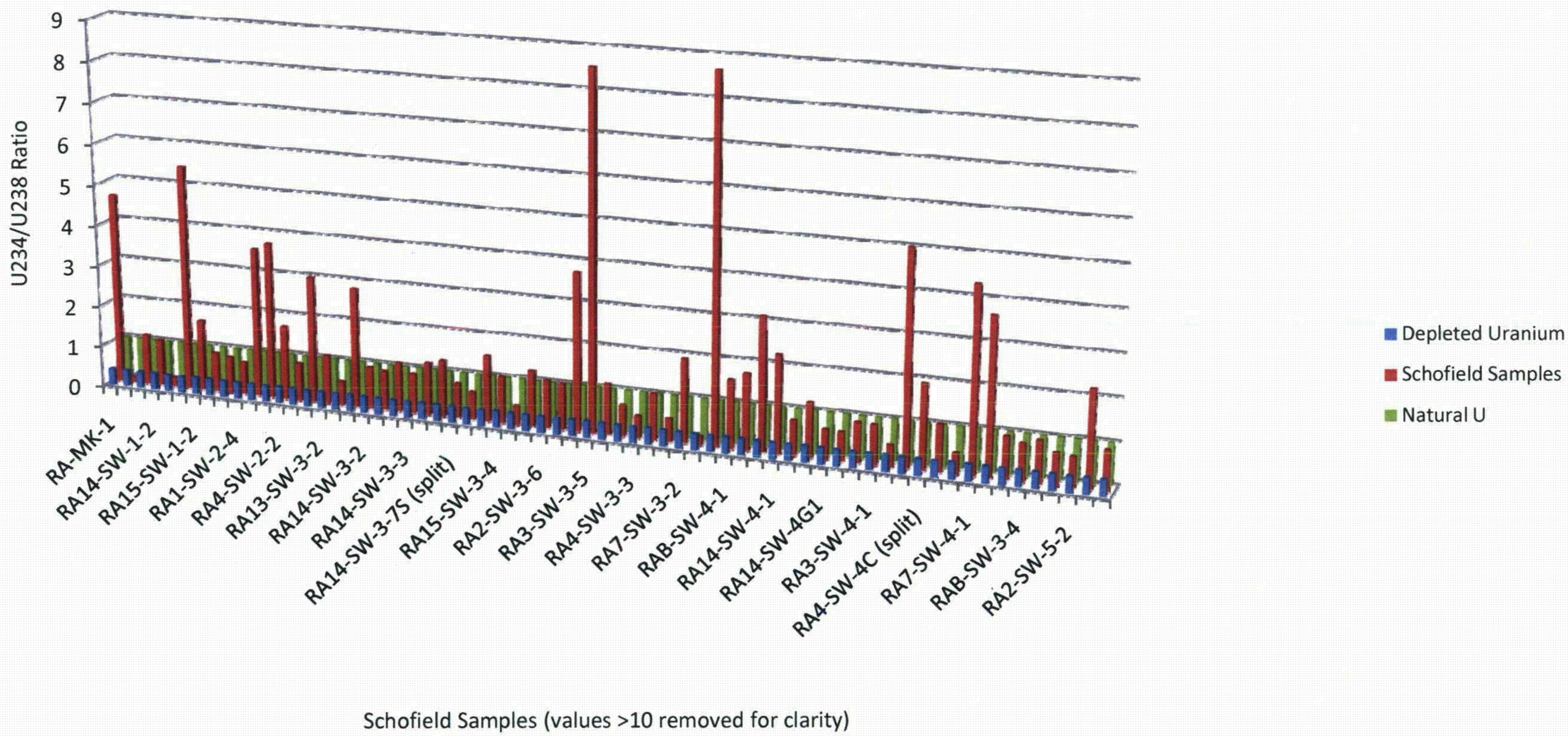

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Figure 4. Logorithmic Graph of U-235/U-238 and U-234/U-238 Ratios for Schofield Water Samples, Depleted Uranium, and Natural Uranium

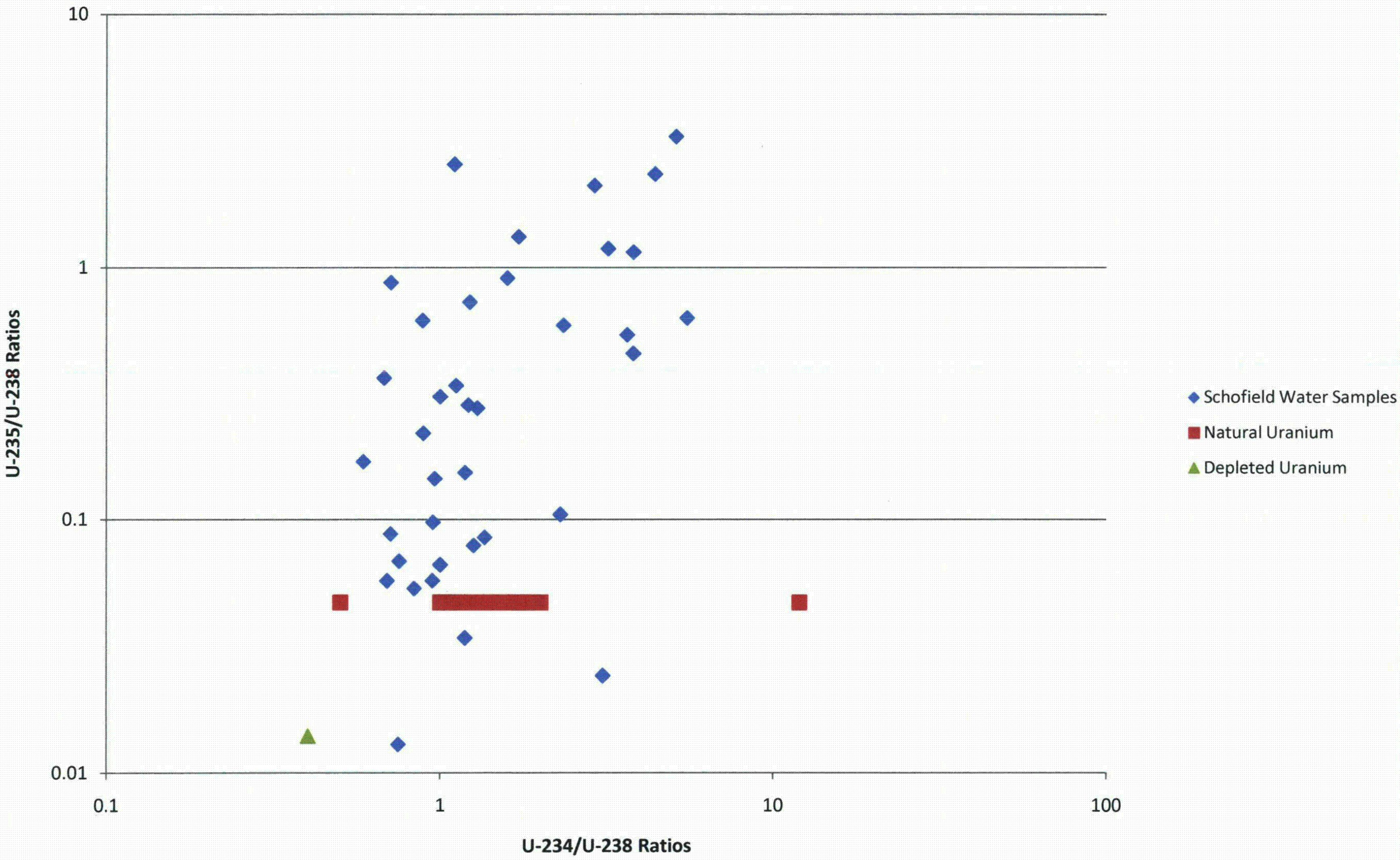

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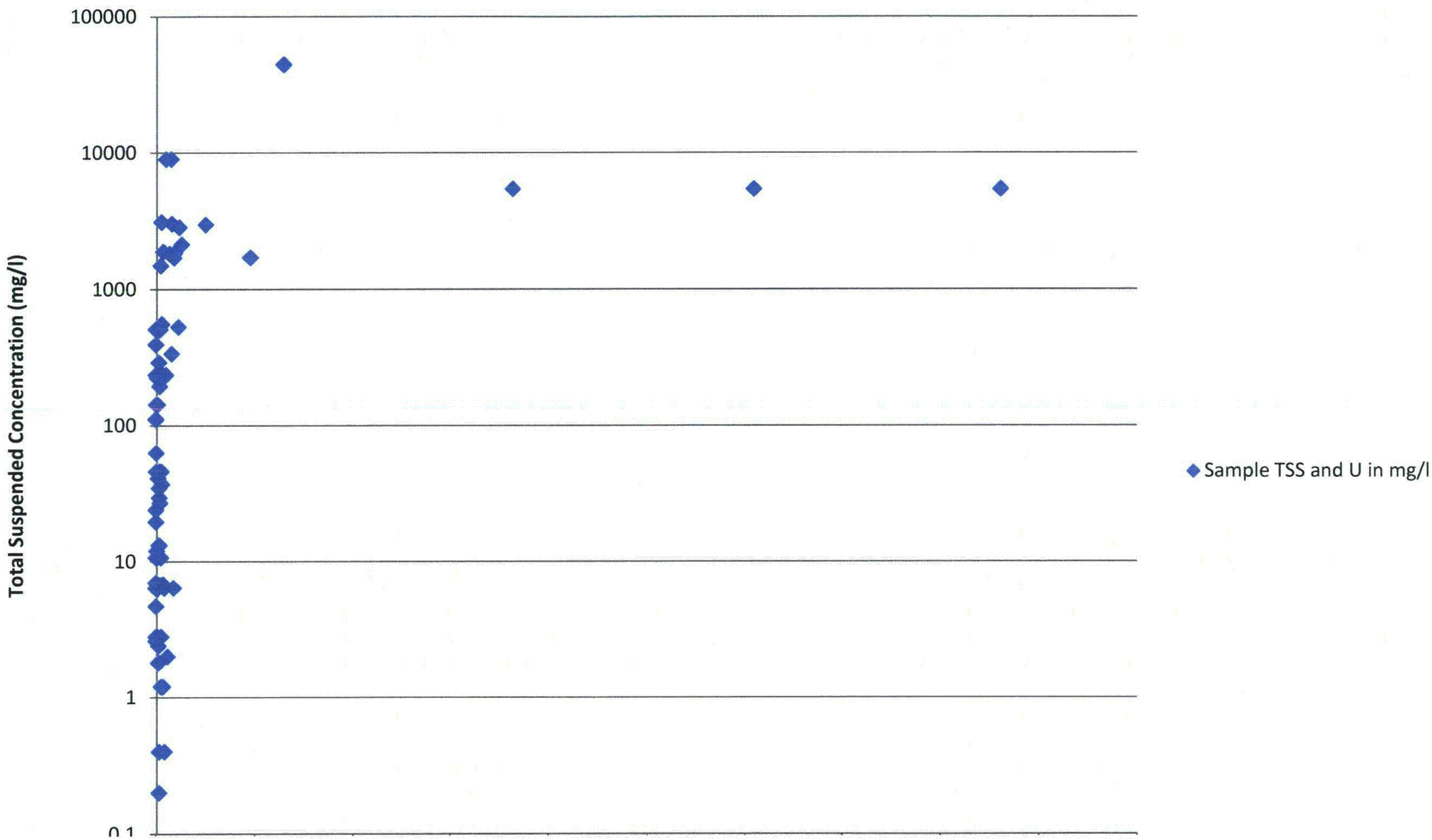
Figure 5. Semi-Logarithmic Plot of Total Suspended Solids and Total Uranium Concentrations



TABLES

Table 1. Sample Information for Schofield Barracks Ranges Uranium Water Samples						
Sample Label Number	Sample Origin	Sample Station Number	Lab Sample Collection Date	Estimated Flow in Stream during Sample Event (cubic feet per second)	Flow Explanation	Total Suspended Solids (mg/l)
RA-MK-1	Mt. Kaala	Mt. Kaala	4/21/08	N/A	perched groundwater grab sample from marsh	37
RA-MK-2B (split for MK-1)	Mt. Kaala	Mt. Kaala	4/21/08	N/A		46
RA14-SW-1-1	Mohiakea Gulch	SW-1	12/11/08	28	Large storm on 12/11/2008, large flows in stream	1,705
RA14-SW-1-2	Mohiakea Gulch	SW-1	12/11/08	28		1,820
RA14-SW-1-3	Mohiakea Gulch	SW-1	12/12/08	4		45
RA14-SW-1-4	Mohiakea Gulch	SW-1	12/12/08	5		27
RA14-SW-1-5	Mohiakea Gulch	SW-1	12/12/08	5		30
RA15-SW-1-2	Mohiakea Gulch	SW-1	12/31/08	2	Small drainage from Dec 11, 2008 storm	6.8*
RA15-SW-1-4	Mohiakea Gulch	SW-1	12/31/08	2		2.8*
RA1-SW-2-4	Waikoloa Gulch	SW-2	3/16/07	2	Small flow in stream, small rainstorm	338
RA3-SW-2-1	Waikoloa Gulch	SW-2	11/4/07	0.1	Small flow in stream, small rainstorm	236
RA4-SW-2-1	Waikoloa Gulch	SW-2	12/11/07	3	Small flow in stream, small rainstorm	236
RA4-SW-2-12	Waikoloa Gulch	SW-2	12/11/07	0.1		236*
RA4-SW-2-2	Waikoloa Gulch	SW-2	12/11/07	9		236*
RA4-SW-2-4	Waikoloa Gulch	SW-2	12/11/07	1		236*
RA4-SW-2-6	Waikoloa Gulch	SW-2	12/11/07	1		236*
RA14-SW-2-1	Waikoloa Gulch	SW-2	12/19/08	307	Large storm on 12/11/2008, large flows in stream	1,490
RA14-SW-2-3	Waikoloa Gulch	SW-2	12/19/08	620		195
RA14-SW-2-6	Waikoloa Gulch	SW-2	12/19/08	307		495
RA1-SW-3-2	Lower Hale'au'au	SW-3	3/10/07	11	Moderate rainstorm, moderate flows in stream	20
RA2-SW-3-4	Lower Hale'au'au	SW-3	3/14/07	23		N/A*
RAB-SW-3-2	Lower Hale'au'au	SW-3	3/14/07	4		3
RA2-SW-3-6	Lower Hale'au'au	SW-3	3/15/07	4		6.4*
RA2-SW-3-17	Lower Hale'au'au	SW-3	3/16/07	4		6.4*
RA2-SW-3-22	Lower Hale'au'au	SW-3	3/17/07	6		6.4*
RAB-SW-3-3	Lower Hale'au'au	SW-3	3/25/07	0.2	Discharge of groundwater from from Mt. Kaala	3
RAB-SW-3-4	Lower Hale'au'au	SW-3	4/16/07	2	Discharge of groundwater from from Mt. Kaala	7
RA3-SW-3-0	Lower Hale'au'au	SW-3	11/4/07	40	Moderate rainstorm, moderate flows in stream	143
RA3-SW-3-0 (split)	Lower Hale'au'au	SW-3	11/4/07	40		143
RA3-SW-3-5	Lower Hale'au'au	SW-3	11/4/07	2		557
RA3-SW-3-12	Lower Hale'au'au	SW-3	11/5/07	2		111
RA3-SW-3-19	Lower Hale'au'au	SW-3	11/5/07	0.2		12*
RA4-SW-3-0	Lower Hale'au'au	SW-3	12/11/07	2	Moderate rainstorm, moderate flows in stream	11
RA4-SW-3-1	Lower Hale'au'au	SW-3	12/11/07	11		10.7*
RA4-SW-3-2	Lower Hale'au'au	SW-3	12/11/07	16		10.7*
RA4-SW-3-3	Lower Hale'au'au	SW-3	12/11/07	4		10.7*
RA5-SW-3-3	Upper Hale'au'au	SW-3	1/18/08	1	Discharge of groundwater from from Mt. Kaala	35
RA5-SW-3-4	Upper Hale'au'au	SW-3	2/5/08	0.4	Discharge of groundwater from from Mt. Kaala	41
RA5-SW-3-5	Upper Hale'au'au	SW-3	2/17/08	1	Discharge of groundwater from from Mt. Kaala	112
RA6-SW-3-1	Upper Hale'au'au	SW-3	3/9/08	1	Discharge of groundwater from from Mt. Kaala	N/A*
RA7-SW-3-2	Upper Hale'au'au	SW-3	4/13/08	1	Discharge of groundwater from from Mt. Kaala	5

Table 1. Sample Information for Schofield Barracks Ranges Uranium Water Samples (con't)						
Sample Label Number	Sample Origin	Sample Station Number	Lab Sample Collection Date	Estimated Flow in Stream during Sample Event (cubic feet per second)	Flow Explanation	Total Suspended Solids (mg/l)
RA7-SW-3-3	Upper Hale'au'au	SW-3	4/18/08	0.1	Discharge of groundwater from from Mt. Kaala	11
RA8-SW-3-1	Upper Hale'au'au	SW-3	5/23/08	1	Discharge of groundwater from from Mt. Kaala	6
RA13-SW-3-2	Lower Hale'au'au	SW-3	11/22/08	11	Small flow in stream, small rainstorm	1710*
RA13-SW-3-5	Lower Hale'au'au	SW-3	11/22/08	11		530*
RA14-SW-3-2	Lower Hale'au'au	SW-3	12/11/08	4	Large storm on 12/11/2008, large flows in stream	5,420
RA14-SW-3-3	Lower Hale'au'au	SW-3	12/11/08	65		44,300
RA14-SW-3-7	Lower Hale'au'au	SW-3	12/11/08	236		8,960
RA14-SW-3-7S (split)	Lower Hale'au'au	SW-3	12/11/08	236		8,960
RA14-SW-3-9	Lower Hale'au'au	SW-3	12/11/08	747		13
RA14-SW-3-14	Lower Hale'au'au	SW-3	12/16/08	23		13.2*
RA15-SW-3-2	Lower Hale'au'au	SW-3	12/31/08	16	Discharge of groundwater from from Mt. Kaala	1.2*
RA15-SW-3-4	Lower Hale'au'au	SW-3	12/31/08	23		1.2*
RAB-SW-4-1	Upper Hale'au'au	SW-4	3/12/07	1	Discharge of groundwater from from Mt. Kaala	2
RA1-SW-4FF-1	Upper Hale'au'au	SW-4	3/14/07	1		3,020
RA1-SW-4C-1	Upper Hale'au'au	SW-4	3/16/07	2		2,970
RAB-SW-4-2	Upper Hale'au'au	SW-4	3/25/07	5		0
RAB-SW-4-3	Upper Hale'au'au	SW-4	4/16/07	0.1	Discharge of groundwater from from Mt. Kaala	0
RA3-SW-4-1	Upper Hale'au'au	SW-4	11/4/07	10	Moderate rainstorm, moderate flows in stream	46
RA3-SW-4-1 (split)	Upper Hale'au'au	SW-4	11/4/07	10		46
RA3-SW-4-FF-1	Upper Hale'au'au	SW-4	11/4/07	7		N/A*
RA3-SW-4-2	Upper Hale'au'au	SW-4	11/8/07	0.3		3
RA4-SW-4FF	Upper Hale'au'au	SW-4	12/11/07	5	Moderate rainstorm, moderate flows in stream	509
RA4-SW-4FF (split)	Upper Hale'au'au	SW-4	12/11/07	5		509
RA4-SW-4C	Upper Hale'au'au	SW-4	12/12/07	1		225
RA4-SW-4C (split)	Upper Hale'au'au	SW-4	12/12/07	1		225
RA5-SW-4-4	Lower Hale'au'au	SW-4	1/18/08	8	Discharge of groundwater from from Mt. Kaala	24
RA5-SW-4-5	Upper Hale'au'au	SW-4	2/17/08	2	Discharge of groundwater from from Mt. Kaala	63
RA7-SW-4-1	Lower Hale'au'au	SW-4	3/30/08	2	Discharge of groundwater from from Mt. Kaala	291
RA7-SW-4-2	Lower Hale'au'au	SW-4	4/13/08	4	Discharge of groundwater from from Mt. Kaala	7
RA8-SW-4-1	Lower Hale'au'au	SW-4	5/21/08	34	Discharge of groundwater from from Mt. Kaala	394
RA8-SW-4-2	Lower Hale'au'au	SW-4	5/23/08	2	Discharge of groundwater from from Mt. Kaala	2
RA11-SW-4-1	Upper Hale'au'au	SW-4	10/29/08	1	Discharge of groundwater from from Mt. Kaala	2
RA13-SW-4-1	Upper Hale'au'au	SW-4	11/26/08	0.1	Discharge of groundwater from from Mt. Kaala	2
RA14-SW-4-1	Upper Hale'au'au	SW-4	12/11/08	40	Large storm, large flows in stream	1885*
RA14-SW-4-15	Upper Hale'au'au	SW-4	12/11/08	120		2130*
RA14-SW-4-9	Upper Hale'au'au	SW-4	12/11/08	50		1840*
RA14-SW-4G1	Upper Hale'au'au	SW-4	12/11/08	12		0.4*
RA2-SW-5-2	Lower Waikele	SW-5	3/10/07	3	Small flow in stream, small rainstorm	N/A*
RA3-SW-5-3	Lower Waikele	SW-5	11/4/07	6	Small flow in stream, small rainstorm	3,105
RA1-SW-6FF-1	Upper Waikele	SW-6	3/9/07	5	Small flow in stream, small rainstorm	2,840
	N/A = Not applicable				Average TSS Concentration =	1,634

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Table 2 - Alpha Spectroscopy Uranium Laboratory Analysis with Calculated Activity Ratios														
			U-234				U-235				U-238			
Water Sample ID	Sample Location (Stream Name)	Date	Result (pCi/L)	±	Uncert.		Result (pCi/L)	±	Uncert.		Result (pCi/L)	±	Uncert.	
RAB-SW-4-1	Upper Hale'au'au	3/12/2007	0.14	±	0.14	U	0.00	±	0.08	U	0.09	±	0.11	U
RAB-SW-3-2	Lower Hale'au'au	3/14/2007	0.02	±	0.11	U	-0.01	±	0.02	U	-0.05	±	0.04	U
RA1-SW-6FF-1	Upper Waikele	3/9/2007	0.76	±	0.27		0.05	±	0.09	U	0.80	±	0.28	
RA2-SW-5-2	Lower Waikele	3/10/2007	0.39	±	0.22	J	0.05	±	0.11	U	0.55	±	0.26	J
RA1-SW-3-2	Lower Hale'au'au	3/10/2007	0.03	±	0.11	U	-0.01	±	0.07	U	-0.01	±	0.06	U

	Calculated Activity Ratios				
Total Uranium					
Water Sample ID	pCi/L		µg/L	EPA Drinking Water Standard (ug/l)	> Drinking Water Standards
RAB-SW-4-1	0.23		0.26	30	No
RAB-SW-3-2	-0.04		-0.16	30	No
RA1-SW-6FF-1	1.61		2.41	30	No
RA2-SW-5-2	0.99		1.67	30	No
RA1-SW-3-2	0.02		-0.02	30	No
U235:U238 Activity Ratios					
Water Sample ID	Value	±	Uncert	Natural U if Ratio >= 0.05	DU if Ratio <= 0.014
RAB-SW-4-1	N/A*	±	N/A*	N/A*	N/A*
RAB-SW-3-2	0.21	±	0.44	Yes	No
RA1-SW-6FF-1	0.06	±	0.11	Yes	No
RA2-SW-5-2	0.09	±	0.20	Yes	No
RA1-SW-3-2	1.48	±	20.65	Yes	No
U234:U238 Activity Ratios					
Water Sample ID	Value	±	Uncert	Natural U of Ratio >= 1	DU if Ratio <= 0.40
RAB-SW-4-1	1.63	±	2.59	Yes	No
RAB-SW-3-2	N/A*	±	N/A*	N/A*	N/A*
RA1-SW-6FF-1	0.95	±	0.47	No	No
RA2-SW-5-2	0.71	±	0.52	No	No
RA1-SW-3-2	N/A*	±	N/A*	N/A*	N/A*

U Result was below method detection limit value

* Isotopic ratios not calculated (negative or zero values)

** Split Samples sent to alternative laboratory

J Estimated Value

Table 2 - Alpha Spectroscopy Uranium Laboratory Analysis with Calculated Activity Ratios (con't)														
			U-234				U-235				U-238			
Water Sample ID	Sample Location (Stream Name)	Date	Result (pCi/L)	±	Uncert.		Result (pCi/L)	±	Uncert.		Result (pCi/L)	±	Uncert.	
RA1-SW-2-4	Waikoloa Gulch	3/16/2007	0.42	±	0.24		0.00	±	0.08	U	0.54	±	0.27	
RA1-SW-4FF-1	Upper Hale'au'au	3/14/2007	0.53	±	0.26		-0.02	±	0.09	U	0.56	±	0.27	
RA1-SW-4C-1	Upper Hale'au'au	3/16/2007	1.18	±	0.43		0.10	±	0.17	U	1.71	±	0.51	
RA2-SW-3-4	Lower Hale'au'au	3/14/2007	0.16	±	0.20	U	-0.23	±	0.10	U	0.12	±	0.16	U
RA2-SW-3-6	Lower Hale'au'au	3/15/2007	0.33	±	0.21		-0.04	±	0.19	U	0.29	±	0.20	
RA2-SW-3-22	Lower Hale'au'au	3/17/2007	0.17	±	0.20	U	-0.03	±	0.08	U	-0.03	±	-0.16	U
RA2-SW-3-17	Lower Hale'au'au	3/16/2007	0.28	±	0.28	U	-0.03	±	0.13	U	0.61	±	0.35	

	Calculated Activity Ratios				
Total Uranium					
Water Sample ID	pCi/L		µg/L	EPA Drinking Water Standard (ug/l)	> Drinking Water Standards
RA1-SW-2-4	0.96		1.60	30	No
RA1-SW-4FF-1	1.07		1.65	30	No
RA1-SW-4C-1	2.99		5.13	30	No
RA2-SW-3-4	0.05		0.25	30	No
RA2-SW-3-6	0.58		0.84	30	No
RA2-SW-3-22	0.11		-0.10	30	No
RA2-SW-3-17	0.85		1.79	30	No
U235:U238 Activity Ratios					
Water Sample ID	Value	±	Uncert	Natural U if Ratio >= 0.05	DU if Ratio <= 0.014
RA1-SW-2-4	N/A*	±	N/A*	N/A*	N/A*
RA1-SW-4FF-1	N/A*	±	N/A*	N/A*	N/A*
RA1-SW-4C-1	0.06	±	0.10	Yes	No
RA2-SW-3-4	N/A*	±	N/A*	N/A*	N/A*
RA2-SW-3-6	N/A*	±	N/A*	N/A*	N/A*
RA2-SW-3-22	1.18	±	N/A*	Yes	No
RA2-SW-3-17	N/A*	±	N/A*	N/A*	N/A*
U234:U238 Activity Ratios					
Water Sample ID	Value	±	Uncert	Natural U of Ratio >= 1	DU if Ratio <= 0.40
RA1-SW-2-4	0.79	±	0.60	No	No
RA1-SW-4FF-1	0.96	±	0.66	No	No
RA1-SW-4C-1	0.69	±	0.32	No	No
RA2-SW-3-4	1.34	±	2.42	Yes	No
RA2-SW-3-6	1.14	±	1.06	Yes	No
RA2-SW-3-22	N/A*	±	N/A*	N/A*	N/A*
RA2-SW-3-17	0.45	±	0.52	No	No

U Result was below method detection limit value
* Isotopic ratios not calculated (negative or zero values)
** Split Samples sent to alternative laboratory

Table 2 - Alpha Spectroscopy Uranium Laboratory Analysis with Calculated Activity Ratios (con't)															
			U-234				U-235				U-238				
Water Sample ID	Sample Location (Stream Name)	Date	Result (pCi/L)	±	Uncert.		Result (pCi/L)	±	Uncert.		Result (pCi/L)	±	Uncert.		
RAB-SW-3-3	Lower Hale'au'au	3/25/2007	0.05	±	0.11	U	0.00	±	0.05	U	0.05	±	0.10	U	
RAB-SW-4-2	Upper Hale'au'au	3/25/2007	0.11	±	0.13	U	0.03	±	0.09	U	0.11	±	0.12	U	
RAB-SW-3-4	Lower Hale'au'au	4/16/2007	0.12	±	0.14	U	0.03	±	0.08	U	0.14	±	0.14	U	
RAB-SW-4-3	Upper Hale'au'au	4/16/2007	0.08	±	0.13	U	0.00	±	0.08	U	0.11	±	0.13	U	

	Calculated Activity Ratios				
Total Uranium					
Water Sample ID	pCi/L		µg/L	EPA Drinking Water Standard (ug/l)	> Drinking Water Standards
RAB-SW-3-3	0.11		0.16	30	No
RAB-SW-4-2	0.24		0.33	30	No
RAB-SW-3-4	0.28		0.42	30	No
RAB-SW-4-3	0.19		0.32	30	No
AVERAGE			0.31		
U235:U238 Activity Ratios					
Water Sample ID	Value	±	Uncert	Natural U if Ratio >= 0.05	DU if Ratio <= 0.014
RAB-SW-3-3	N/A*	±	N/A*	N/A*	N/A*
RAB-SW-4-2	0.31	±	0.96	Yes	No
RAB-SW-3-4	0.22	±	0.63	Yes	No
RAB-SW-4-3	0.01	±	0.71	Yes	No
U234:U238 Activity Ratios					
Water Sample ID	Value	±	Uncert	Natural U of Ratio >= 1	DU if Ratio <= 0.40
RAB-SW-3-3	1.00	±	2.75	Yes	No
RAB-SW-4-2	1.00	±	1.66	Yes	No
RAB-SW-3-4	0.89	±	1.40	No	No
RAB-SW-4-3	0.75	±	1.50	No	No

U Result was below method detection limit value

* Isotopic ratios not calculated (negative or zero values)

** Split Samples sent to alternative laboratory

Table 2 - Alpha Spectroscopy Uranium Laboratory Analysis with Calculated Activity Ratios (con't)														
			U-234				U-235				U-238			
Water Sample ID	Sample Location (Stream Name)	Date	Result (pCi/L)	±	Uncert.		Result (pCi/L)	±	Uncert.		Result (pCi/L)	±	Uncert.	
RA3-SW-3-5	Lower Hale'au'au	11/4/2007	1.77	±	0.49		-0.01	±	0.08	U	0.21	±	0.18	U
RA3-SW-4-1	Upper Hale'au'au	11/4/2007	0.12	±	0.18	U	-0.01	±	0.10	U	0.13	±	0.16	U
RA3-SW-4-1 (split)	Upper Hale'au'au	11/4/2007	0.06	±	0.11		0.05	±	0.09		0.00	±	0.00	
RA3-SW-3-0	Lower Hale'au'au	11/4/2007	0.07	±	0.10	U	-0.03	±	0.08	U	0.06	±	0.10	U
RA3-SW-3-0 (split)	Lower Hale'au'au	11/4/2007	0.16	±	0.19		0.07	±	0.13		0.01	±	0.12	
RA3-SW-3-12	Lower Hale'au'au	11/5/2007	0.15	±	0.15	U	-0.01	±	0.10	U	-0.01	±	0.08	U
RA3-SW-5-3	Lower Waikele	11/4/2007	0.44	±	0.24		0.02	±	0.08	U	0.19	±	0.19	U
RA3-SW-3-19	Lower Hale'au'au	11/5/2007	0.09	±	0.21	U	0.03	±	0.11	U	0.02	±	0.13	U
RA3-SW-4-FF-1	Upper Hale'au'au	11/4/2007	0.18	±	0.19	U	-0.04	±	0.04	U	0.36	±	0.27	U
RA3-SW-4-2	Upper Hale'au'au	11/8/2007	0.00	±	0.06		-0.01	±	0.02	U	-0.01	±	0.02	U
RA3-SW-2-1	Waikoloa Gulch	11/4/2007	0.28	±	0.20		0.04	±	0.08	U	0.08	±	0.12	U

	Calculated Activity Ratios				
Total Uranium					
Water Sample ID	pCi/L		µg/L	EPA Drinking Water Standard (ug/l)	> Drinking Water Standards
RA3-SW-3-5	1.97		0.61	30	No
RA3-SW-4-1	0.23		0.37	30	No
RA3-SW-4-1 (split)	0.11		0.02	30	No
RA3-SW-3-0	0.10		0.16	30	No
RA3-SW-3-0 (split)	0.23		0.06	30	No
RA3-SW-3-12	0.12		-0.03	30	No
RA3-SW-5-3	0.65		0.58	30	No
RA3-SW-3-19	0.15		0.09	30	No
RA3-SW-4-FF-1	0.50		1.05	30	No
RA3-SW-4-2	-0.02		-0.05	30	No
RA3-SW-2-1	0.40		0.25	30	No
U235:U238 Activity Ratios					
Water Sample ID	Value	±	Uncert	Natural U if Ratio >= 0.05	DU if Ratio <= 0.014
RA3-SW-3-5	N/A*	±	N/A*	N/A*	N/A*
RA3-SW-4-1	N/A*	±	N/A*	N/A*	N/A*
RA3-SW-4-1 (split)	N/A***	±	N/A***	Yes	No
RA3-SW-3-0	N/A*	±	N/A*	N/A*	N/A*
RA3-SW-3-0 (split)	6.50	±	79.09	Yes	No
RA3-SW-3-12	1.24	±	14.70	Yes	No
RA3-SW-5-3	0.10	±	0.43	Yes	No
RA3-SW-3-19	1.15	±	7.69	Yes	No
RA3-SW-4-FF-1	N/A*	±	N/A*	N/A*	N/A*
RA3-SW-4-2	0.62	±	1.48	Yes	No
RA3-SW-2-1	0.54	±	1.35	Yes	No
U234:U238 Activity Ratios					
Water Sample ID	Value	±	Uncert	Natural U of Ratio >= 1	DU if Ratio <= 0.40
RA3-SW-3-5	8.59	±	7.83	Yes	No
RA3-SW-4-1	0.94	±	1.86	No	No
RA3-SW-4-1 (split)	N/A***	±	N/A***	Yes	No
RA3-SW-3-0	1.12	±	2.57	Yes	No
RA3-SW-3-0 (split)	15.70	±	189.31	Yes	No
RA3-SW-3-12	N/A*	±	N/A*	N/A*	N/A*
RA3-SW-5-3	2.29	±	2.59	Yes	No
RA3-SW-3-19	3.79	±	22.01	Yes	No
RA3-SW-4-FF-1	0.50	±	0.66	No	No
RA3-SW-4-2	N/A*	±	N/A*	N/A*	N/A*
RA3-SW-2-1	3.63	±	6.16	Yes	No

U	Result was below method detection limit value
*	Isotopic ratios not calculated (negative or zero values)
**	Split Samples sent to alternative laboratory
***	U values to small to calculate this ratio

Table 2 - Alpha Spectroscopy Uranium Laboratory Analysis with Calculated Activity Ratios (con't)														
			U-234				U-235				U-238			
Water Sample ID	Sample Location (Stream Name)	Date	Result (pCi/L)	±	Uncert.		Result (pCi/L)	±	Uncert.		Result (pCi/L)	±	Uncert.	
RA4-SW-4C	Upper Hale'au'au	12/12/2007	0.16	±	0.15	U	0.10	±	0.13	U	0.03	±	0.03	U
RA4-SW-4C (split)	*Upper Hale'au'au*	*12/12/2007*	*0.20*	±	*0.16*		*0.00*	±	*0.00*		*0.10*	±	*0.12*	
RA4-SW-4FF	Upper Hale'au'au	12/11/2007	0.00	±	0.08	U	0.03	±	0.09	U	-0.01	±	0.02	U
RA4-SW-4FF (split)	Upper Hale'au'au	12/11/2007	0.16	±	0.15		0.00	±	0.00		0.15	±	0.13	
RA4-SW-3-0	Lower Hale'au'au	12/11/2007	0.03	±	0.12	U	0.02	±	0.08	U	0.03	±	0.14	U
RA4-SW-2-1	Waikoloa Gulch	12/11/2007	0.45	±	0.24	U	0.05	±	0.10	U	0.12	±	0.26	U
RA4-SW-2-2	Waikoloa Gulch	12/11/2007	0.40	±	0.29		-0.03	±	0.13	U	0.22	±	0.22	U
RA4-SW-2-4	Waikoloa Gulch	12/11/2007	0.32	±	0.20		-0.02	±	0.08	U	0.35	±	0.21	
RA4-SW-2-6	Waikoloa Gulch	12/11/2007	0.19	±	0.16		0.00	±	0.08	U	0.06	±	0.11	U
RA4-SW-2-12	Waikoloa Gulch	12/11/2007	0.18	±	0.16	U	0.04	±	0.10	U	-0.03	±	0.06	U
RA4-SW-3-1	Lower Hale'au'au	12/11/2007	0.12	±	0.15	U	0.01	±	0.09	U	0.17	±	0.16	U
RA4-SW-3-2	*Lower Hale'au'au*	*12/11/2007*	*0.12*	±	*0.13*	U	*-0.01*	±	0.08	U	0.00	±	*0.07*	U
RA4-SW-3-3	Lower Hale'au'au	12/11/2007	0.01	±	0.06	U	-0.01	±	0.08	U	0.02	±	0.06	U

	Calculated Activity Ratios				
Total Uranium					
Water Sample ID	**pCi/L**		**µg/L**	**EPA Drinking Water Standard (ug/l)**	**> Drinking Water Standards**
RA4-SW-4C	0.29		0.14	30	No
RA4-SW-4C (split)	*0.30*		*0.29*	*30*	*No*
RA4-SW-4FF	0.03		-0.01	30	No
RA4-SW-4FF (split)	0.31		0.43	30	No
RA4-SW-3-0	0.08		0.09	30	No
RA4-SW-2-1	0.62		0.38	30	No
RA4-SW-2-2	0.59		0.65	30	No
RA4-SW-2-4	0.65		1.03	30	No
RA4-SW-2-6	0.25		0.18	30	No
RA4-SW-2-12	0.20		-0.06	30	No
RA4-SW-3-1	0.30		0.50	30	No
RA4-SW-3-2	0.11		0.00	30	No
RA4-SW-3-3	0.02		0.04	30	No
U235:U238 Activity Ratios					
Water Sample ID	**Value**	±	**Uncert**	**Natural U if Ratio >= 0.05**	**DU if Ratio <= 0.014**
RA4-SW-4C	3.29	±	5.22	Yes	No
RA4-SW-4C (split)	N/A*	±	N/A*	N/A*	N/A*
RA4-SW-4FF	N/A*	±	N/A*	N/A*	N/A*
RA4-SW-4FF (split)	N/A*	±	N/A*	N/A*	N/A*
RA4-SW-3-0	0.73	±	4.57	Yes	No
RA4-SW-2-1	0.46	±	1.33	Yes	No
RA4-SW-2-2	N/A*	±	N/A*	N/A*	N/A*
RA4-SW-2-4	N/A*	±	N/A*	N/A*	N/A*
RA4-SW-2-6	0.02	±	1.32	Yes	No
RA4-SW-2-12	N/A*	±	N/A*	N/A*	N/A*
RA4-SW-3-1	0.07	±	0.52	Yes	No
RA4-SW-3-2	N/A*	±	N/A*	N/A*	N/A*
RA4-SW-3-3	N/A*	±	N/A*	N/A*	N/A*
U234:U238 Activity Ratios					
Water Sample ID	**Value**	±	**Uncert**	**Natural U of Ratio >= 1**	**DU if Ratio <= 0.40**
RA4-SW-4C	5.08	±	6.90	Yes	No
RA4-SW-4C (split)	2.02	±	2.87	Yes	No
RA4-SW-4FF	N/A*	±	N/A*	N/A*	N/A*
RA4-SW-4FF (split)	1.12	±	1.42	Yes	No
RA4-SW-3-0	1.22	±	7.23	Yes	No
RA4-SW-2-1	3.79	±	8.72	Yes	No
RA4-SW-2-2	1.78	±	2.19	Yes	No
RA4-SW-2-4	0.91	±	0.80	No	No
RA4-SW-2-6	3.07	±	5.91	Yes	No
RA4-SW-2-12	N/A*	±	N/A*	N/A*	N/A*
RA4-SW-3-1	0.75	±	1.15	No	No
RA4-SW-3-2	N/A*	±	N/A*	Yes	No
RA4-SW-3-3	0.54	±	4.61	Yes	No

U Result was below method detection limit value
* Isotopic ratios not calculated (negative or zero values)
** Split Samples sent to alternative laboratory

Table 2 - Alpha Spectroscopy Uranium Laboratory Analysis with Calculated Activity Ratios (con't)															
			U-234				U-235				U-238				
Water Sample ID	Sample Location (Stream Name)	Date	Result (pCi/L)	±	Uncert.		Result (pCi/L)	±	Uncert.		Result (pCi/L)	±	Uncert.		
RA5-SW-3-3	Lower Hale'au'au	1/18/2008	0.09	±	0.14	U	0.20	±	0.20	U	0.08	±	0.14	U	
RA5-SW-4-4	Upper Hale'au'au	1/18/2008	-0.04	±	0.09	U	0.02	±	0.10	U	-0.09	±	0.10	U	
RA5-SW-3-4	Lower Hale'au'au	2/5/2008	0.04	±	0.10	U	-0.02	±	0.09	U	0.08	±	0.14	U	
RA5-SW-4-3	Upper Hale'au'au	1/18/2008	-0.44	±	0.09	U	0.02	±	0.10	U	-0.09	±	0.10	U	
RA5-SW-3-5	Lower Hale'au'au	2/17/2008	0.00	±	0.07	U	0.04	±	0.08	U	-0.01	±	0.08	U	
RA5-SW-4-5	Upper Hale'au'au	2/17/2008	0.06	±	0.11	U	0.07	±	0.11	U	0.00	±	0.07	U	

	Calculated Activity Ratios				
Total Uranium					
Water Sample ID	**pCi/L**		**µg/L**	**EPA Drinking Water Standard (ug/l)**	**> Drinking Water Standards**
RA5-SW-3-3	0.36		0.32	30	No
RA5-SW-4-4	-0.11		-0.26	30	No
RA5-SW-3-4	0.10		0.22	30	No
RA5-SW-4-3	-0.51		-0.26	30	No
RA5-SW-3-5	0.03		-0.02	30	No
RA5-SW-4-5	0.13		0.04	30	No
U235:U238 Activity Ratios					
Water Sample ID	**Value**	±	**Uncert**	**Natural U if Ratio >= 0.05**	**DU if Ratio <= 0.014**
RA5-SW-3-3	2.56	±	5.24	Yes	No
RA5-SW-4-4	N/A*	±	N/A*	N/A*	N/A*
RA5-SW-3-4	N/A*	±	N/A*	N/A*	N/A*
RA5-SW-4-3	N/A*	±	N/A*	N/A*	N/A*
RA5-SW-3-5	N/A*	±	N/A*	N/A*	N/A*
RA5-SW-4-5	N/A*	±	N/A*	Yes	No
U234:U238 Activity Ratios					
Water Sample ID	**Value**	±	**Uncert**	**Natural U of Ratio >= 1**	**DU if Ratio <= 0.40**
RA5-SW-3-3	1.10	±	2.63	Yes	No
RA5-SW-4-4	0.49	±	1.16	No	No
RA5-SW-3-4	0.55	±	1.58	No	No
RA5-SW-4-3	N/A*	±	N/A*	Yes	No
RA5-SW-3-5	N/A*	±	N/A*	N/A*	N/A*
RA5-SW-4-5	N/A*	±	N/A*	Yes	No

U Result was below method detection limit value
* Isotopic ratios not calculated (negative or zero values)
** Split Samples sent to alternative laboratory

Table 2 - Alpha Spectroscopy Uranium Laboratory Analysis with Calculated Activity Ratios (con't)														
			U-234				U-235				U-238			
Water Sample ID	Sample Location (Stream Name)	Date	Result (pCi/L)	±	Uncert.		Result (pCi/L)	±	Uncert.		Result (pCi/L)	±	Uncert.	
RA6-SW-3-1	Upper Hale'au'au	3/9/2008	0.41	±	0.36	U	0.00	±	0.18	U	-0.05	±	0.16	U
RA7-SW-3-2	Upper Hale'au'au	4/13/2008	-0.07	±	0.17	U	0.00	±	0.19	U	-0.04	±	0.16	U
RA7-SW-3-3	Upper Hale'au'au	4/18/2008	0.02	±	0.15	U	-0.06	±	0.18	U	0.09	±	0.20	U
RA7-SW-4-1	Lower Hale'au'au	3/30/2008	0.33	±	0.37	U	0.18	±	0.33	U	0.08	±	0.28	U
RA7-SW-4-2	Lower Hale'au'au	4/13/2008	0.09	±	0.20	U	-0.02	±	0.17	U	-0.01	±	0.16	U
RA-MK-1	Mt. Kaala	4/21/2008	0.95	±	0.67	U	0.00	±	0.25	U	0.20	±	0.28	U
RA-MK-2B (split for MK-1)	Mt. Kaala	4/21/2008	0.02	±	0.08		0.00	±	0.00		0.18	±	0.17	
RA8-SW-4-1	Lower Hale'au'au	5/21/2008	0.24	±	0.29	U	-0.04	±	0.18	U	-0.03	±	0.15	U
RA8-SW-4-2	Lower Hale'au'au	5/23/2008	0.34	±	0.37	U	-0.07	±	0.18	U	0.09	±	0.17	U
RA8-SW-3-1	Upper Hale'au'au	5/23/2008	0.34	±	0.34	U	-0.02	±	0.19	U	0.04	±	0.16	U

	Calculated Activity Ratios				
Total Uranium					
Water Sample ID	**pCi/L**		**µg/L**	**EPA Drinking Water Standard (ug/l)**	**> Drinking Water Standards**
RA6-SW-3-1	0.36		-0.16	30	No
RA7-SW-3-2	-0.11		-0.11	30	No
RA7-SW-3-3	0.05		0.23	30	No
RA7-SW-4-1	0.58		0.30	30	No
RA7-SW-4-2	0.05		-0.05	30	No
RA-MK-1	1.15		0.61	30	No
RA-MK-2B (split for MK-1)	0.21		0.54	30	No
RA8-SW-4-1	0.16		-0.12	30	No
RA8-SW-4-2	0.37		0.24	30	No
RA8-SW-3-1	0.36		0.11	30	No
U235:U238 Activity Ratios					
Water Sample ID	**Value**	±	**Uncert**	**Natural U if Ratio >= 0.05**	**DU if Ratio <= 0.014**
RA6-SW-3-1	N/A*	±	N/A*	N/A*	N/A*
RA7-SW-3-2	N/A*	±	N/A*	N/A*	N/A*
RA7-SW-3-3	N/A*	±	N/A*	N/A*	N/A*
RA7-SW-4-1	2.34	±	9.73	Yes	No
RA7-SW-4-2	1.49	±	20.70	Yes	No
RA-MK-1	N/A*	±	N/A*	N/A*	N/A*
RA-MK-2B (split for MK-1)	N/A*	±	N/A*	N/A*	N/A*
RA8-SW-4-1	1.24	±	7.58	Yes	No
RA8-SW-4-2	N/A*	±	N/A*	N/A*	N/A*
RA8-SW-3-1	N/A*	±	N/A*	N/A*	N/A*
U234:U238 Activity Ratios					
Water Sample ID	**Value**	±	**Uncert**	**Natural U of Ratio >= 1**	**DU if Ratio <= 0.40**
RA6-SW-3-1	N/A*	±	N/A*	N/A*	N/A*
RA7-SW-3-2	2.00	±	9.77	Yes	No
RA7-SW-3-3	0.22	±	1.73	No	No***
RA7-SW-4-1	4.39	±	17.01	Yes	No
RA7-SW-4-2	N/A*	±	N/A*	N/A*	N/A*
RA-MK-1	4.65	±	7.23	Yes	No
RA-MK-2B (split for MK-1)	0.12	±	0.45	Yes	No ***
RA8-SW-4-1	N/A*	±	N/A*	N/A*	N/A*
RA8-SW-4-2	3.71	±	8.06	Yes	No
RA8-SW-3-1	8.71	±	35.65	Yes	No

U	Result was below method detection limit value
*	Isotopic ratios not calculated (negative or zero values)
**	Split Samples sent to alternative laboratory
***	While ratio is <0.40, uncertainty is +/- 1.73 so result unreliable

Table 2 - Alpha Spectroscopy Uranium Laboratory Analysis with Calculated Activity Ratios (con't)															
			U-234				U-235				U-238				
Water Sample ID	Sample Location (Stream Name)	Date	Result (pCi/L)	±	Uncert.		Result (pCi/L)	±	Uncert.		Result (pCi/L)	±	Uncert.		
RA11-SW-4-1	Upper Hale'au'au	10/29/2008	0.73	±	0.42		-0.02	±	0.15	U	0.40	±	0.31		
RA13-SW-3-2***	Lower Hale'au'au	11/22/2008	3.79	±	1.32		0.11	±	0.29	U	3.20	±	1.23		
RA13-SW-3-5	Lower Hale'au'au	11/22/2008	0.44	±	0.36		0.13	±	0.24	U	0.76	±	0.47		
RA13-SW-4-1	Upper Hale'au'au	11/26/2008	0.24	±	0.33	U	0.09	±	0.17	U	0.07	±	0.21	U	

Calculated Activity Ratios					
Total Uranium					
Water Sample ID	pCi/L		µg/L	EPA Drinking Water Standard (ug/l)	> Drinking Water Standards
RA11-SW-4-1	1.11		1.18	30	No
RA13-SW-3-2***	7.10		9.57	30	No
RA13-SW-3-5	1.33		2.31	30	No
RA13-SW-4-1	0.40		0.26	30	No
U235:U238 Activity Ratios					
Water Sample ID	Value	±	Uncert	Natural U if Ratio >= 0.05	DU if Ratio <= 0.014
RA11-SW-4-1	N/A*	±	N/A*	N/A*	N/A*
RA13-SW-3-2***	0.03	±	0.09	No	No
RA13-SW-3-5	0.17	±	0.34	Yes	No
RA13-SW-4-1	1.19	±	4.07	Yes	No
U234:U238 Activity Ratios					
Water Sample ID	Value	±	Uncert	Natural U of Ratio >= 1	DU if Ratio <= 0.40
RA11-SW-4-1	1.82	±	1.75	Yes	No
RA13-SW-3-2***	1.18	±	0.61	Yes	No
RA13-SW-3-5	0.59	±	0.60	No	No
RA13-SW-4-1	3.19	±	9.96	Yes	No

U Result was below method detection limit value

* Isotopic ratios not calculated (negative or zero values)

** Split Samples sent to alternative laboratory

*** Sample did not meet requirements for pH, so results may be approximate.

Table 2 - Alpha Spectroscopy Uranium Laboratory Analysis with Calculated Activity Ratios (con't)

			U-234				U-235				U-238			
Water Sample ID	Sample Location (Stream Name)	Date	Result (pCi/L)	±	Uncert.		Result (pCi/L)	±	Uncert.		Result (pCi/L)	±	Uncert.	
RA14-SW-1-1	Mohiakea Gulch	12/12/2008	0.72	±	0.37		0.17	±	0.21	U	0.60	±	0.34	
RA14-SW-1-2	Mohiakea Gulch	12/12/2008	0.55	±	0.37		-0.04	±	0.14	U	0.48	±	0.31	
RA14-SW-1-3	Mohiakea Gulch	12/12/2008	0.21	±	0.35	U	0.17	±	0.27	U	-0.04	±	-0.21	U
RA14-SW-1-4	Mohiakea Gulch	12/12/2008	0.03	±	0.13	U	0.00	±	0.12	U	0.14	±	0.17	U
RA14-SW-1-5	Mohiakea Gulch	12/12/2008	0.58	±	0.36		0.07	±	0.19	U	0.11	±	0.18	U
RA14-SW-2-1	Waikoloa Gulch	12/19/2008	0.14	±	0.16	U	0.10	±	0.15	U	0.16	±	0.18	U
RA14-SW-2-3	Waikoloa Gulch	12/19/2008	-0.08	±	0.16	U	0.00	±	0.13	U	0.13	±	0.18	U

Calculated Activity Ratios

Total Uranium

Water Sample ID	pCi/L		µg/L	EPA Drinking Water Standard (ug/l)	> Drinking Water Standards
RA14-SW-1-1	1.49		1.86	30	No
RA14-SW-1-2	0.99		1.42	30	No
RA14-SW-1-3	N/A*		N/A*	N/A*	N/A*
RA14-SW-1-4	0.17		0.41	30	No
RA14-SW-1-5	0.75		0.34	30	No
RA14-SW-2-1	0.39		0.51	30	No
RA14-SW-2-3	0.05		0.39	30	No

U235:U238 Activity Ratios

Water Sample ID	Value	±	Uncert	Natural U if Ratio >= 0.05	DU if Ratio <= 0.014
RA14-SW-1-1	0.28	±	0.39	Yes	No
RA14-SW-1-2	N/A*	±	N/A*	N/A*	N/A*
RA14-SW-1-3	N/A*	±	N/A*	N/A*	N/A*
RA14-SW-1-4	N/A*	±	N/A*	N/A*	N/A*
RA14-SW-1-5	0.63	±	2.09	Yes	No
RA14-SW-2-1	0.62	±	1.21	Yes	No
RA14-SW-2-3	N/A*	±	N/A*	N/A*	N/A*

U234:U238 Activity Ratios

Water Sample ID	Value	±	Uncert	Natural U of Ratio >= 1	DU if Ratio <= 0.40
RA14-SW-1-1	1.21	±	0.93	Yes	No
RA14-SW-1-2	1.13	±	1.06	Yes	No
RA14-SW-1-3	N/A*	±	N/A*	N/A*	N/A*
RA14-SW-1-4	0.21	±	0.99	Yes	No***
RA14-SW-1-5	5.49	±	10.12	Yes	No
RA14-SW-2-1	0.88	±	1.43	Yes	No
RA14-SW-2-3	N/A*	±	N/A*	N/A*	N/A*

U Result was below method detection limit value

* Isotopic ratios not calculated (negative or zero values)

** Split Samples sent to alternative laboratory

*** While ratio is <0.40, uncertainty is +/- 0.99, making result unreliable

Table 2 - Alpha Spectroscopy Uranium Laboratory Analysis with Calculated Activity Ratios (con't)														
			U-234				U-235				U-238			
Water Sample ID	Sample Location (Stream Name)	Date	Result (pCi/L)	±	Uncert.		Result (pCi/L)	±	Uncert.		Result (pCi/L)	±	Uncert.	
RA14-SW-2-6	Waikoloa Gulch	12/19/2008	-0.05	±	0.17	U	0.03	±	0.12	U	0.06	±	0.13	U
RA14-SW-3-2	Lower Hale'au'au	12/12/2008	12.10	±	3.19		0.80	±	0.91		12.10	±	3.17	
RA14-SW-3-2 (reanalysis)	Lower Hale'au'au	12/12/2008	23.70	±	3.41		3.07	±	1.39		20.00	±	3.13	
RA14-SW-3-2 (2nd -reanalysis)	Lower Hale'au'au	12/12/2008	27.10	±	5.60		2.78	±	0.16		28.50	±	1.40	
RA14-SW-3-3	Lower Hale'au'au	12/12/2008	4.09	±	0.90		0.62	±	0.39		4.25	±	0.92	
RA14-SW-3-3 (reanalysis)	Lower Hale'au'au	12/12/2008	5.37	±	1.80		0.34	±	0.54		4.27		1.61	
RA14-SW-3-7	Lower Hale'au'au	12/12/2008	0.71	±	0.36		0.04	±	0.12	U	0.52	±	0.32	
RA14-SW-3-7S (split)	Lower Hale'au'au	12/12/2008	0.30	±	0.18		-0.01	±	0.02		0.35	±	0.19	
RA14-SW-3-9	Lower Hale'au'au	12/12/2008	0.06	±	0.18	U	0.03	±	0.13	U	0.09	±	0.15	U
RA14-SW-3-14	Lower Hale'au'au	12/16/2008	0.26	±	0.24	U	0.19	±	0.21		0.09	±	0.14	U

	Calculated Activity Ratios				
Total Uranium					
Water Sample ID	pCi/L		µg/L	EPA Drinking Water Standard (ug/l)	> Drinking Water Standards
RA14-SW-2-6	0.04		0.19	30	No
RA14-SW-3-2	25.00		36.38	30	Yes
RA14-SW-3-2 (2nd run)	46.77		60.93	30	Yes
RA14-SW-3-2 (3rd run)	58.38		86.09	30	Yes
RA14-SW-3-3	8.96		12.93	30	No
RA14-SW-3-3	9.98		12.86	30	No
RA14-SW-3-7	1.27		1.57	30	No
RA14-SW-3-7S	0.64		1.04	30	No
RA14-SW-3-9	0.19		0.29	30	No
RA14-SW-3-14	0.54		0.35	30	No

U235:U238 Activity Ratios					
Water Sample ID	Value	±	Uncert	Natural U if Ratio >= 0.05	DU if Ratio <= 0.014
RA14-SW-2-6	0.50	±	2.29	Yes	No
RA14-SW-3-2	0.07	±	0.08	Yes	No
RA14-SW-3-2 (2nd run)	0.15	±	0.07	Yes	No
RA14-SW-3-2 (3rd run)	0.10	±	0.01	Yes	No
RA14-SW-3-3	0.15	±	0.10	Yes	No
RA14-SW-3-3	0.08	±	0.13	Yes	No
RA14-SW-3-7	0.09	±	0.23	Yes	No
RA14-SW-3-7S	N/A*	±	N/A*	Yes	No
RA14-SW-3-9	0.37	±	1.57	Yes	No
RA14-SW-3-14	2.11	±	4.13	Yes	No

U234:U238 Activity Ratios					
Water Sample ID	Value	±	Uncert	Natural U of Ratio >= 1	DU if Ratio <= 0.40
RA14-SW-2-6	N/A*	±	N/A*	N/A*	N/A*
RA14-SW-3-2	1.00	±	0.37	Yes	No
RA14-SW-3-2 (2nd run)	1.19	±	0.25	Yes	No
RA14-SW-3-2 (3rd run)	0.95	±	0.20	Yes	No
RA14-SW-3-3	0.96	±	0.30	No	No
RA14-SW-3-3	1.26	±	0.63	Yes	No
RA14-SW-3-7	1.36	±	1.10	Yes	No
RA14-SW-3-7S	0.85	±	0.67	No	No
RA14-SW-3-9	0.68	±	2.20	No	No
RA14-SW-3-14	2.90	±	5.33	Yes	No

U Result was below method detection limit value
* Isotopic ratios not calculated (negative or zero values)
** Split Samples sent to alternative laboratory
\# Sample analyzed 3 times, 2nd run had highest recovery and is most accurate
Bold values are those above drinking water standards

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Table 2 - Alpha Spectroscopy Uranium Laboratory Analysis with Calculated Activity Ratios (con't)

			U-234				U-235				U-238			
Water Sample ID	Sample Location (Stream Name)	Date	Result (pCi/L)	±	Uncert.		Result (pCi/L)	±	Uncert.		Result (pCi/L)	±	Uncert.	
RA14-SW-4-1	Upper Hale'au'au	12/19/2008	0.54	±	0.36		0.14	±	0.21	U	0.23	±	0.22	U
RA14-SW-4-9	Upper Hale'au'au	12/19/2008	0.80	±	0.41		0.17	±	0.21	U	0.62	±	0.36	
RA14-SW-4-15	Upper Hale'au'au	12/19/2008	0.74	±	0.48		0.05	±	0.19	U	0.88	±	0.52	
RA14-SW-4G1	Upper Hale'au'au	12/19/2008	0.18	±	0.25	U	0.23	±	0.31	U	0.26	±	0.33	U
RA15-SW-1-2	Mohiakea Gulch	12/31/2008	0.35	±	0.30	U	0.27	±	0.28	U	0.20	±	0.23	U
RA15-SW-1-4	Mohiakea Gulch	12/31/2008	0.18	±	0.28	U	-0.05	±	0.15	U	0.19	±	0.23	U
RA15-SW-3-2	Lower Hale'au'au	12/31/2008	0.33	±	0.29	U	0.19	±	0.24	U	0.21	±	0.22	U
RA15-SW-3-4	Lower Hale'au'au	12/31/2008	0.19	±	0.24	U	0.06	±	0.15	U	0.17	±	0.21	U

Calculated Activity Ratios

Total Uranium					
Water Sample ID	pCi/L		µg/L	EPA Drinking Water Standard (ug/l)	> Drinking Water Standards
RA14-SW-4-1	0.91		0.75	30	No
RA14-SW-4-9	1.60		1.93	30	No
RA14-SW-4-15	1.67		2.65	30	No
RA14-SW-4G1	0.67		0.87	30	No
RA15-SW-1-2	0.83		0.73	30	No
RA15-SW-1-4	0.31		0.53	30	No
RA15-SW-3-2	0.73		0.71	30	No
RA15-SW-3-4	0.41		0.52	30	No

U235:U238 Activity Ratios					
Water Sample ID	Value	±	Uncert	Natural U if Ratio >= 0.05	DU if Ratio <= 0.014
RA14-SW-4-1	0.59	±	1.06	Yes	No
RA14-SW-4-9	0.28	±	0.38	Yes	No
RA14-SW-4-15	0.05	±	0.22	Yes	No
RA14-SW-4G1	0.87	±	1.63	Yes	No
RA15-SW-1-2	1.32	±	2.04	Yes	No
RA15-SW-1-4	N/A*	±	N/A*	N/A*	N/A*
RA15-SW-3-2	0.91	±	1.48	Yes	No
RA15-SW-3-4	0.34	±	1.00	Yes	No

U234:U238 Activity Ratios					
Water Sample ID	Value	±	Uncert	Natural U of Ratio >= 1	DU if Ratio <= 0.40
RA14-SW-4-1	2.34	±	2.66	Yes	No
RA14-SW-4-9	1.29	±	0.99	Yes	No
RA14-SW-4-15	0.83	±	0.74	No	No
RA14-SW-4G1	0.71	±	1.33	No	No
RA15-SW-1-2	1.72	±	2.44	Yes	No
RA15-SW-1-4	0.94	±	1.89	No	No
RA15-SW-3-2	1.59	±	2.16	Yes	No
RA15-SW-3-4	1.11	±	1.98	Yes	No

U Result was below method detection limit value

* Isotopic ratios not calculated (negative or zero values)

** Split Samples sent to alternative laboratory

Table 3. Characteristics of Naturally Occuring Uranium and Depleted Uranium.

	Natural Uranium (in equilibrium)		Depleted Uranium	
Isotope	Weight %	Activity % (approximate)	Weight %	Activity % (approximate)
^{234}U	0.006	48.8	0.0007	28
^{235}U	0.72	2.3	0.2	0.2
^{238}U	99.2	48.8	99.8	71
$^{234}U/^{238}U$		***1***		***0.4***
$^{235}U/^{238}U$		***0.047***		***0.014***

Taken from Weismann, et al., (2007)

Table 4. Summary of Total Uranium and Activity Ratios for Schofield Range Water Samples								
Sample Label Number	Sample Origin	Sample Station Number	Lab Sample Collection Date	Total Uranium (mg/l)	Total Suspended Solids (mg/l)	> EPA Drinking Water Standard (30 ug/l)	U234:U238 Activity Ratios Indicate DU?	U235:U238 Activity Ratios Indicate DU?
RA-MK-1	Mt. Kaala	Mt. Kaala	4/21/2008	0.61	37	No	N/A*	No
RA-MK-2B (split for MK-1)	Mt. Kaala	Mt. Kaala	4/21/2008	0.54	46	No	N/A*	No
RA14-SW-1-1	Mohiakea Gulch	SW-1	12/12/2008	1.86	1,705	No	No	No
RA14-SW-1-2	Mohiakea Gulch	SW-1	12/12/2008	1.42	1,820	No	N/A*	No
RA14-SW-1-3	Mohiakea Gulch	SW-1	12/12/2008	N/A*	45	N/A*	N/A*	N/A*
RA14-SW-1-4	Mohiakea Gulch	SW-1	12/12/2008	0.41	27	No	N/A*	No***
RA14-SW-1-5	Mohiakea Gulch	SW-1	12/12/2008	0.34	30	No	No	No
RA15-SW-1-2	Mohiakea Gulch	SW-1	12/31/2008	0.73	7**	No	No	No
RA15-SW-1-4	Mohiakea Gulch	SW-1	12/31/2008	0.53	3**	No	N/A*	No
RA1-SW-2-4	Waikoloa Gulch	SW-2	3/16/2007	1.60	338	No	N/A*	No
RA3-SW-2-1	Waikoloa Gulch	SW-2	11/4/2007	0.25	236	No	No	No
RA4-SW-2-1	Waikoloa Gulch	SW-2	12/11/2007	0.38	236	No	No	No
RA4-SW-2-12	Waikoloa Gulch	SW-2	12/11/2007	-0.06	236**	No	N/A*	N/A*
RA4-SW-2-2	Waikoloa Gulch	SW-2	12/11/2007	0.65	236**	No	N/A*	No
RA4-SW-2-4	Waikoloa Gulch	SW-2	12/11/2007	1.03	236**	No	N/A*	No
RA4-SW-2-6	Waikoloa Gulch	SW-2	12/11/2007	0.18	236**	No	No	No
RA14-SW-2-1	Waikoloa Gulch	SW-2	12/19/2008	0.51	1,490	No	No	No
RA14-SW-2-3	Waikoloa Gulch	SW-2	12/19/2008	0.39	195	No	N/A*	N/A*
RA14-SW-2-6	Waikoloa Gulch	SW-2	12/19/2008	0.19	495	No	No	N/A*
RA1-SW-3-2	Lower Hale'au'au	SW-3	3/10/2007	-0.02	20	No	No	N/A*
RA2-SW-3-4	Lower Hale'au'au	SW-3	3/14/2007	0.25	N/A	No	N/A*	No
RAB-SW-3-2	Lower Hale'au'au	SW-3	3/14/2007	-0.16	3	No	No	N/A*
RA2-SW-3-6	Lower Hale'au'au	SW-3	3/15/2007	0.84	6**	No	N/A*	No
RA2-SW-3-17	Lower Hale'au'au	SW-3	3/16/2007	1.79	6**	No	N/A*	No
RA2-SW-3-22	Lower Hale'au'au	SW-3	3/17/2007	-0.10	6**	No	No	N/A*
RAB-SW-3-3	Lower Hale'au'au	SW-3	3/25/2007	0.16	3	No	N/A*	No
RAB-SW-3-4	Lower Hale'au'au	SW-3	4/16/2007	0.42	7	No	No	No
RA3-SW-3-0	Lower Hale'au'au	SW-3	11/4/2007	0.16	143	No	N/A*	No
RA3-SW-3-0 (split)	Lower Hale'au'au	SW-3	11/4/2007	0.06	143	No	No	No
RA3-SW-3-5	Lower Hale'au'au	SW-3	11/4/2007	0.61	557	No	N/A*	No
RA3-SW-3-12	Lower Hale'au'au	SW-3	11/5/2007	-0.03	111	No	No	N/A*
RA3-SW-3-19	Lower Hale'au'au	SW-3	11/5/2007	0.09	12**	No	No	No
RA4-SW-3-0	Lower Hale'au'au	SW-3	12/11/2007	0.09	11	No	No	No
RA4-SW-3-1	Lower Hale'au'au	SW-3	12/11/2007	0.50	11**	No	No	No
RA4-SW-3-2	Lower Hale'au'au	SW-3	12/11/2007	0.00	11**	No	N/A*	No
RA4-SW-3-3	Lower Hale'au'au	SW-3	12/11/2007	0.04	11**	No	N/A*	No
RA5-SW-3-3	Upper Hale'au'au	SW-3	1/18/2008	0.32	35	No	No	No
RA5-SW-3-4	Upper Hale'au'au	SW-3	2/5/2008	0.22	41	No	N/A*	No
RA5-SW-3-5	Upper Hale'au'au	SW-3	2/17/2008	-0.02	112	No	N/A*	N/A*
RA6-SW-3-1	Upper Hale'au'au	SW-3	3/9/2008	-0.16	N/A	No	N/A*	N/A*
RA7-SW-3-2	Upper Hale'au'au	SW-3	4/13/2008	-0.11	5	No	N/A*	No
RA7-SW-3-3	Upper Hale'au'au	SW-3	4/18/2008	0.23	11	No	N/A*	No***
RA8-SW-3-1	Upper Hale'au'au	SW-3	5/23/2008	0.11	6	No	N/A*	No
RA13-SW-3-2	Lower Hale'au'au	SW-3	11/22/2008	9.57	1710**	No	No	No
RA13-SW-3-5	Lower Hale'au'au	SW-3	11/22/2008	2.31	530**	No	No	No

Table 4. Summary of Total Uranium and Activity Ratios for Schofield Range Water Samples (Con't)								
Sample Label Number	Sample Origin	Sample Station Number	Lab Sample Collection Date	Total Uranium (mg/l)	Total Suspended Solids (mg/l)	> EPA Drinking Water Standard (30 ug/l)	U234:U238 Activity Ratios Indicate DU?	U235:U238 Activity Ratios Indicate DU?
RA14-SW-3-2	Lower Hale'au'au	SW-3	12/12/2008	36.38	5,420	Yes	No	No
RA14-SW-3-2 (reanalysis)	Lower Hale'au'au	SW-3	12/12/2008	60.93	5,420	Yes	No	No
RA14-SW-3-3	Lower Hale'au'au	SW-3	12/12/2008	12.93	44,300	No	No	No
RA14-SW-3-3 (reanalysis)	Lower Hale'au'au	SW-3	12/12/2008	12.86	44,300	No	No	No
RA14-SW-3-7	Lower Hale'au'au	SW-3	12/12/2008	1.57	8,960	No	No	No
RA14-SW-3-7S (split)	Lower Hale'au'au	SW-3	12/12/2008	1.04	8,960	No	No	No
RA14-SW-3-9	Lower Hale'au'au	SW-3	12/12/2008	0.29	13	No	No	No
RA14-SW-3-14	Lower Hale'au'au	SW-3	12/16/2008	0.35	13**	No	No	No
RA15-SW-3-2	Lower Hale'au'au	SW-3	12/31/2008	0.71	1**	No	No	No
RA15-SW-3-4	Lower Hale'au'au	SW-3	12/31/2008	0.52	1**	No	No	No
RAB-SW-4-1	Upper Hale'au'au	SW-4	3/12/2007	0.26	2	No	N/A*	No
RA1-SW-4FF-1	Upper Hale'au'au	SW-4	3/14/2007	1.65	3,020	No	N/A*	No
RA1-SW-4C-1	Upper Hale'au'au	SW-4	3/16/2007	5.13	2,970	No	No	No
RAB-SW-4-2	Upper Hale'au'au	SW-4	3/25/2007	0.33	0	No	No	No
RAB-SW-4-3	Upper Hale'au'au	SW-4	4/16/2007	0.32	0	No	No	No
RA3-SW-4-1	Upper Hale'au'au	SW-4	11/4/2007	0.37	46	No	N/A*	No
RA3-SW-4-1 (split)	Upper Hale'au'au	SW-4	11/4/2007	0.02	46	No	No	No
RA3-SW-4-FF-1	Upper Hale'au'au	SW-4	11/4/2007	1.05	N/A	No	N/A*	No
RA3-SW-4-2	Upper Hale'au'au	SW-4	11/8/2007	-0.05	3	No	No	N/A*
RA4-SW-4FF	Upper Hale'au'au	SW-4	12/11/2007	-0.01	509	No	N/A*	N/A*
RA4-SW-4FF (split)	Upper Hale'au'au	SW-4	12/11/2007	0.43	509	No	N/A*	No
RA4-SW-4C	Upper Hale'au'au	SW-4	12/12/2007	0.14	225	No	No	No
RA4-SW-4C (split)	Upper Hale'au'au	SW-4	12/12/2007	0.29	225	No	N/A*	No
RA5-SW-4-4	Lower Hale'au'au	SW-4	1/18/2008	-0.26	24	No	N/A*	No
RA5-SW-4-5	Upper Hale'au'au	SW-4	2/17/2008	0.04	63	No	No	No
RA7-SW-4-1	Lower Hale'au'au	SW-4	3/30/2008	0.30	291	No	No	No
RA7-SW-4-2	Lower Hale'au'au	SW-4	4/13/2008	-0.05	7	No	No	N/A*
RA8-SW-4-1	Lower Hale'au'au	SW-4	5/21/2008	-0.12	394	No	No	N/A*
RA8-SW-4-2	Lower Hale'au'au	SW-4	5/23/2008	0.24	2	No	N/A*	No
RA11-SW-4-1	Upper Hale'au'au	SW-4	10/29/2008	1.18	2	No	N/A*	No
RA13-SW-4-1	Upper Hale'au'au	SW-4	11/26/2008	0.26	2	No	No	No
RA14-SW-4-1	Upper Hale'au'au	SW-4	12/19/2008	0.75	1885**	No	No	No
RA14-SW-4-15	Upper Hale'au'au	SW-4	12/19/2008	2.65	2130**	No	No	No
RA14-SW-4-9	Upper Hale'au'au	SW-4	12/19/2008	1.93	1840**	No	No	No
RA14-SW-4G1	Upper Hale'au'au	SW-4	12/19/2008	0.87	0.4**	No	No	No
RA2-SW-5-2	Lower Waikele	SW-5	3/10/2007	1.67	N/A	No	No	No
RA3-SW-5-3	Lower Waikele	SW-5	11/4/2007	0.58	3,105	No	No	No
RA1-SW-6FF-1	Upper Waikele	SW-6	3/9/2007	2.41	2,840	No	No	No

* Isotopic ratios not calculated due to zero or negative values

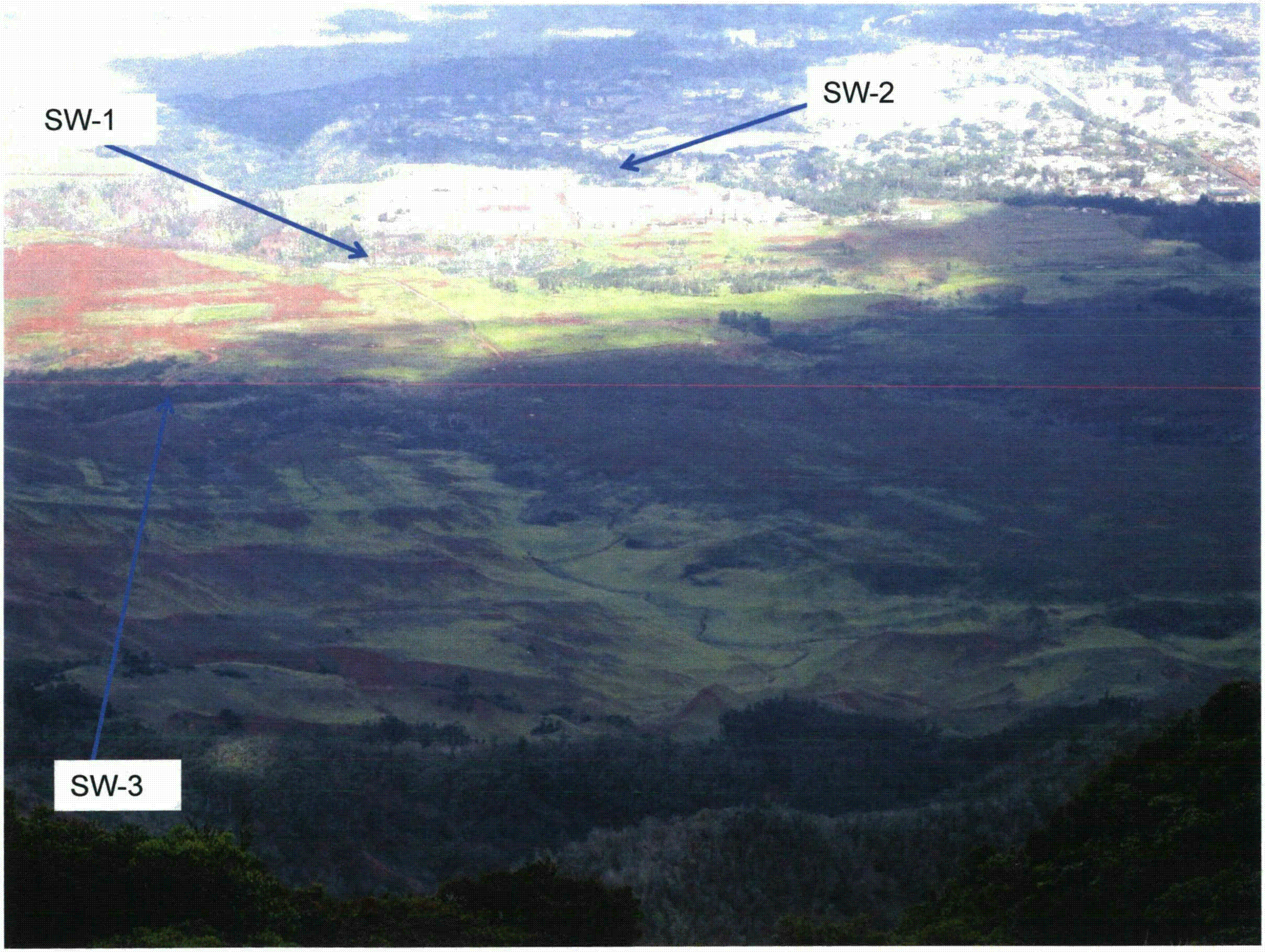
** TSS values estimated from water samples taken just before or after this sample

APPENDIX A

PHOTOGRAPHS

Appendix A

Schofield Barracks Ranges (center of picture) – Taken from Mt. Kaala



Surface Water Sampling Location SW-1 and SW-2

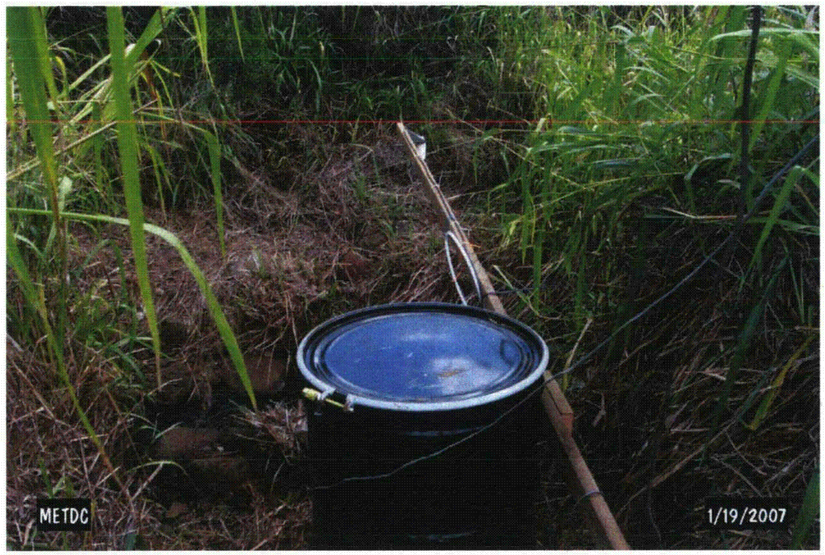
Monitoring Station SW-1 (Mohiakea Gulch) – Taken after August 2007 fire

Monitoring Station SW-2 (Waikoloa Gulch)

Surface Water Sampling Location SW-3 (Hale'au'au Stream)

Typical flow (2 cubic feet per second) in Hale'au'au stream from discharge atop Mt. Kaala crater

Sampling equipment is in drum



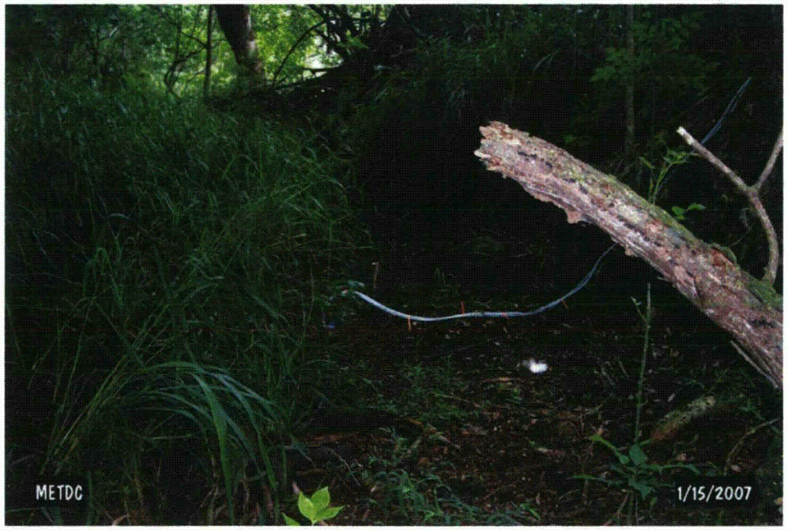
Surface Water Sampling Location SW-4 (upper Hale'au'au Stream)

SW-4 sampler location (equipment in drum)

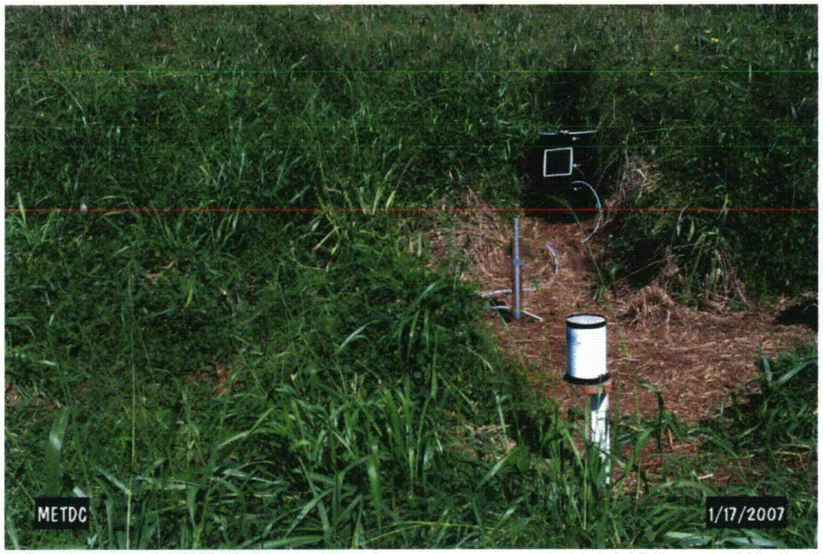
- Typical flow (<1 cubic feet per second) in Hale'au'au stream from discharge atop Mt. Kaala crater

Surface Water Sampling Location SW-5 and SW-6 (Upper Waikele Stream)

SW-6 equipment and location



SW-5 equipment and location



APPENDIX B

Quality Assurance (Q/A) and Quality Control (Q/C)

APPENDIX B. Quality Assurance (Q/A) and Quality Control (Q/C).

Measurement performance criteria have been evaluated for the laboratory uranium water sample result. These criteria are for precision, accuracy/bias, representativeness, comparability, and completeness of the data. These parameters indicate the qualitative and quantitative degrees of quality associated with measurement data and, hence, are also referred to as data quality indicators (DQIs). The following paragraphs describe the DQI parameters.

Precision

Precision reflects the reproducibility of a measurement system and is measured as the relative percent difference (RPD) between two (theoretically identical) samples. This RPD calculation is made for samples when the resulting value reported by the analytical laboratory is greater than 5 times the reporting limit. For this study, there were 8 duplicate samples taken and sent to different laboratories (Table B-1). Of these 8 samples, there were 2 original with 2 duplicates samples with enough uranium concentrations that meet the conditions for Relative Percent Difference (RPD) calculations to be made which were samples RA14-SW-3-2 and RA14-SW-3-3 (Table B-1). For the other 6 original and 6 split samples the uranium activity values were not greater than 5 times the reporting limit of 1 pCi/l (Table B-1). Under this scenario a different criteria is used: that the original and duplicate (or split sample) uranium activity differ by less than the reporting limit (Table B-1). As shown in Table B-1 all but one set of samples meet these criteria for either the RPD calculation or the percent difference calculation. The exception is samples RA14-SW-3-2 (original and reanalysis) for ^{238}U which had a 35% difference. Since only one of 3 isotopes did not meet the requirement, this sample was not removed from the data set. For this study the precision requirements are considered to be acceptable for all samples.

Accuracy/Bias

Accuracy/bias is a measure of the bias that exists in a measurement system and is also the degree of agreement between a sample's theoretical and observed concentrations. When the measurement is applied to a particular set of observed values, it will be a combination of two components: a random component and common systematic error (or bias) component. The accuracy of a particular measurement system may be estimated by calculating the percent recovery (%R). These calculations are reported by the laboratory as percent recovery, and are shown for each of the water samples in Table B-2. The criteria for this project are laboratory percent recoveries of 15% to 125%. As shown in Table B-2, all the samples meet this requirement.

Completeness

Completeness is a measure of the amount of usable data collected using a measurement system. It is expressed as a percentage of the number of valid measurements that should have been collected. Completeness is a comparison of the amount of valid data received versus the amount that is specified. It may be calculated as follows, where relative percent completeness = the number of valid measurements completed (or samples collected) divided by the number of measurements specified that are required to achieve a specified level of confidence. For this project it is considered that 81 samples are enough to meet the project objectives. One of the samples is disregarded from the dataset (RA13-SW-3-2) since the pH of the sample was not <2 (it was 4). Therefore, 1 sample was rejected for not meeting QA/QC requirements with 80 samples considered acceptable; therefore, completeness for this project is 99%:

Completeness (99%) = ((80/81)*100

Representativeness and Comparability

Representativeness is the degree to which data accurately represents a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental condition. The degree of representativeness is dependant on the thoroughness and proper design of the sampling plan and adherence to its prescribed procedures.

Comparability is an expression of the confidence with which one data set can be compared with another. Comparability of field data will be dependent upon the proper design of the sampling design and testing protocols, and ensuring that the field procedures are followed. Comparability of analytical laboratory data is based largely on the use of identical or nearly identical methods and procedures.

A review of the laboratory reports indicates that the laboratory used laboratory methods and procedures that meet comparability requirements. None of the analysis of the 81 samples showed analytical deficiencies or matrix interference that would disqualify the results. None of the samples required dilutions or deviations from laboratory protocols. One sample (RA14-SW-3-2) was reanalyzed twice by the laboratory to confirm the results. The analytical results of the quality control samples met the acceptance criteria specified by the laboratory's quality assurance plans.

A review of the sample preparation and transfer of the samples from the field to the laboratory indicates that quality assurance control procedures were followed. All samples were sent to the laboratory within required holding times of 180 days. In addition all but one sample (RA13-SW-3-2) had proper pH of <2. None of the sample bottles were broken and transit and all samples arrived at the laboratory at the required temperature of 2-6 degrees centigrade. A few samples required some clarification with the laboratory technicians to confirm labeling, but none of these were significant enough to disqualify the samples. The chain of custody forms had the required signatures, and the samples were properly transferred via Federal Express, Inc. to the laboratory except for one cooler. One cooler had the chain of custody lost most likely during inspection by the U.S. Department of Agriculture in Los Angeles (all coolers from Hawaii are inspected in Los Angeles, and sometimes paperwork is lost during inspection). A copy of the chain was sent to the laboratory via facsimile to validate the shipment. None of these discrepancies were considered sufficient to disqualify the samples for representativeness or comparability.

Table B-1. Relative Percent Difference and Percent Difference Calculations

Relative Percent Difference Calculations (applies for samples with Result > 5 times laboratory reporting limit)

				U-234			*U-235*			*U-238*					
Sample label	**Automated Sampler Designation**	**Stream or Location**	**Date**	**Result (pCi/L)**	**RPD**	**Criteria meet ? (RPD < 30%)#**	**Result (pCi/L)**	**RPD**	**Criteria meet ? (RPD < 30%)#**	**Result (pCi/L)**	**RPD**	**Criteria meet ? (RPD < 30%)#**	**Result pCi/L**	**RPD**	**Criteria meet ? (RPD < 30%)#**
RA14-SW-3-2 (reanalysis)	SW-3	Lower Hale'au'au	12/12/2008	23.70	13	Yes	see below for calculations*			20.00	35	No	46.77	22	Yes
RA14-SW-3-2 (2nd redo)	SW-3	Lower Hale'au'au	12/12/2008	27.10						28.50			58.38		
RA14-SW-3-3	SW-3	Lower Hale'au'au	12/12/2008	4.09	27	Yes				see below for calculations*			8.957	11	Yes
RA14-SW-3-3 (reanalysis)	SW-3	Lower Hale'au'au	12/12/2008	5.37									9.977		

Percent Difference Calculations (applies for samples with Result < 5 times laboratory reporting limit)

Sample label	**Automated Sampler Designation**	**Stream or Location**	**Date**	**Result (pCi/L)**	**Difference**	**Criteria meet? (< RL)#**	**Result (pCi/L)**	**Difference**	**Criteria meet? (< RL)#**	**Result (pCi/L)**	**Difference**	**Criteria meet? (< RL)#**
RA-MK-1	Mt. Kaala	Mt. Kaala	4/21/2008	0.95	0.93	Yes	0.00	0.00	Yes	0.20	0.02	
RA-MK-2B (split for MK-1)	Mt. Kaala	Mt. Kaala	4/21/2008	0.02			0.00			0.18		
RA3-SW-3-0	SW-3	Lower Hale'au'au	11/4/2007	0.07	0.09	Yes	-0.03	0.09	Yes	0.06	0.05	Yes
RA3-SW-3-0 (split)	SW-3	Lower Hale'au'au	11/4/2007	0.16			0.07			0.01		
RA14-SW-3-2 (reanalysis)	SW-3	Lower Hale'au'au	12/12/2008	see calculations above**			3.07	0.29	Yes	see above**		
RA14-SW-3-2 (2nd redo)	SW-3	Lower Hale'au'au	12/12/2008				2.78					
RA14-SW-3-3	SW-3	Lower Hale'au'au	12/12/2008				0.62	0.28	Yes	4.25	0.02	Yes
RA14-SW-3-3 (reanalysis)	SW-3	Lower Hale'au'au	12/12/2008				0.34			4.27		
RA14-SW-3-7	SW-3	Lower Hale'au'au	12/12/2008	0.71	0.41	Yes	0.04	0.06	Yes	0.52	0.17	Yes
RA14-SW-3-7S (split)	SW-3	Lower Hale'au'au	12/12/2008	0.30			-0.01			0.35		
RA3-SW-4-1	SW-4	Upper Hale'au'au	11/4/2007	0.12	0.06	Yes	-0.01	0.05	Yes	0.13	0.12	Yes
RA3-SW-4-1 (split)	SW-4	Upper Hale'au'au	11/4/2007	0.06			0.05			0.00		
RA4-SW-4FF	SW-4	Upper Hale'au'au	12/11/2007	0.00	0.16	Yes	0.03	0.03	Yes	-0.01	0.15	Yes
RA4-SW-4FF (split)	SW-4	Upper Hale'au'au	12/11/2007	0.16			0.00			0.15		
RA4-SW-4C	SW-4	Upper Hale'au'au	12/12/2007	0.16	0.04	Yes	0.10	0.10	Yes	0.03	0.07	Yes
RA4-SW-4C (split)	SW-4	Upper Hale'au'au	12/12/2007	0.20			0.00			0.10		

* Results do not meet criteria for relative percent difference calculations. See percent difference calculations

** Results meet criteria for relative percent difference calculations. See relative percent difference calculations

***N/A - Not applicable - calculations made for these 4 samples as U isotopes meet both criteria

RPD = Relative Percent Difference

Percent difference calculations use primary laboratory reporting limit of 1 pCi/L

Table B-2. Quality Assurance and Quality Control Review of Water Samples					
Sample Label Number	Sample Origin	Sample Station Number	Lab Sample Collection Date*	Lab Report Number	Laboratory Percent Recovery (Acceptable Range 15 to 125%)
RA-MK-1	Mt. Kaala	Mt. Kaala	4/21/2008	GEL-208940	58
RA-MK-2B (split)	Mt. Kaala	Mt. Kaala	4/21/2008	GPL-8515	108 to 110
RA14-SW-1-1	Mohiakea Gulch	SW-1	12/12/2008	GEL-222302	96
RA14-SW-1-2	Mohiakea Gulch	SW-1	12/12/2008	GEL-222302	100
RA14-SW-1-3	Mohiakea Gulch	SW-1	12/12/2008	GEL-222302	91
RA14-SW-1-4	Mohiakea Gulch	SW-1	12/12/2008	GEL-222302	98
RA14-SW-1-5	Mohiakea Gulch	SW-1	12/12/2008	GEL-222302	100
RA15-SW-1-2	Mohiakea Gulch	SW-1	12/31/2008	GEL-222302	83
RA15-SW-1-4	Mohiakea Gulch	SW-1	12/31/2008	GEL-222302	88
RA1-SW-2-4	Waikoloa Gulch	SW-2	3/16/2007	GEL-182920	88
RA3-SW-2-1	Waikoloa Gulch	SW-2	11/4/2007	GEL-197454	86
RA4-SW-2-1	Waikoloa Gulch	SW-2	12/11/2007	GEL-199895	103
RA4-SW-2-12	Waikoloa Gulch	SW-2	12/11/2007	GEL-199895	102
RA4-SW-2-2	Waikoloa Gulch	SW-2	12/11/2007	GEL-199895	56
RA4-SW-2-4	Waikoloa Gulch	SW-2	12/11/2007	GEL-199895	95
RA4-SW-2-6	Waikoloa Gulch	SW-2	12/11/2007	GEL-199895	100
RA14-SW-2-1	Waikoloa Gulch	SW-2	12/19/2008	GEL-222302	111
RA14-SW-2-3	Waikoloa Gulch	SW-2	12/19/2008	GEL-222302	96
RA14-SW-2-6	Waikoloa Gulch	SW-2	12/19/2008	GEL-222302	108
RA1-SW-3-2	Lower Hale'au'au	SW-3	3/10/2007	GEL-182633	94
RA2-SW-3-4	Lower Hale'au'au	SW-3	3/14/2007	GEL-182633	77
RAB-SW-3-2	Lower Hale'au'au	SW-3	3/14/2007	GEL-182920	79
RA2-SW-3-6	Lower Hale'au'au	SW-3	3/15/2007	GEL-182920	81
RA2-SW-3-17	Lower Hale'au'au	SW-3	3/16/2007	GEL-182920	46
RA2-SW-3-22	Lower Hale'au'au	SW-3	3/17/2007	GEL-182920	82
RAB-SW-3-3	Lower Hale'au'au	SW-3	3/25/2007	GEL-183468	87
RAB-SW-3-4	Lower Hale'au'au	SW-3	4/16/2007	GEL-184656	94
RA3-SW-3-0	Lower Hale'au'au	SW-3	11/4/2007	GEL-197454	95
RA3-SW-3-0 (split)	Lower Hale'au'au	SW-3	11/4/2007	GPL-8095	97.1 to 103
RA3-SW-3-5	Lower Hale'au'au	SW-3	11/4/2007	GEL-197454	94
RA3-SW-3-12	Lower Hale'au'au	SW-3	11/5/2007	GEL-197454	81
RA3-SW-3-19	Lower Hale'au'au	SW-3	11/5/2007	GEL-197454	70
RA4-SW-3-0	Lower Hale'au'au	SW-3	12/11/2007	GEL-199895	97
RA4-SW-3-1	Lower Hale'au'au	SW-3	12/11/2007	GEL-199895	100
RA4-SW-3-2	Lower Hale'au'au	SW-3	12/11/2007	GEL-199895	103
RA4-SW-3-3	Lower Hale'au'au	SW-3	12/11/2007	GEL-199895	91
RA5-SW-3-3	Lower Hale'au'au	SW-3	1/18/2008	GEL-204277	92
RA5-SW-3-4	Lower Hale'au'au	SW-3	2/5/2008	GEL-204277	92
RA5-SW-3-5	Lower Hale'au'au	SW-3	2/17/2008	GEL-204277	87
RA6-SW-3-1	Lower Hale'au'au	SW-3	3/9/2008	GEL-208940	77
RA7-SW-3-2	Lower Hale'au'au	SW-3	4/13/2008	GEL-208940	78

Table B-2. Quality Assurance and Quality Control Review of Water Samples (con't)					
Sample Label Number	**Sample Origin**	**Sample Station Number**	**Lab Sample Collection Date***	**Lab Report Number**	**Laboratory Percent Recovery (Acceptable Range 15 to 125%)**
RA7-SW-3-3	Lower Hale'au'au	SW-3	4/18/2008	GEL-208940	79
RA8-SW-3-1	Lower Hale'au'au	SW-3	5/23/2008	GEL-210565	78
RA13-SW-3-2	Lower Hale'au'au	SW-3	11/22/2008	GEL-222302	50
RA13-SW-3-5	Lower Hale'au'au	SW-3	11/22/2008	GEL-222302	83
RA14-SW-3-2	Lower Hale'au'au	SW-3	12/12/2008	GEL-222302	23
RA14-SW-3-2 (reanalysis)	Lower Hale'au'au	SW-3	12/12/2008	GEL-223760	46
RA14-SW-3-2 (3rd analysis)	Lower Hale'au'au	SW-3	12/12/2008	GEL-223760	19
RA14-SW-3-3	Lower Hale'au'au	SW-3	12/12/2008	GEL-222302	94
RA14-SW-3-3 (reanalysis)	Lower Hale'au'au	SW-3	12/12/2008	GEL-223760	81
RA14-SW-3-7	Lower Hale'au'au	SW-3	12/12/2008	GEL-222302	104
RA14-SW-3-7S (split)	Lower Hale'au'au	SW-3	12/12/2008	GPL-8916	102 to 104
RA14-SW-3-9	Lower Hale'au'au	SW-3	12/12/2008	GEL-222302	97
RA14-SW-3-14	Lower Hale'au'au	SW-3	12/16/2008	GEL-222302	95
RA15-SW-3-2	Lower Hale'au'au	SW-3	12/31/2008	GEL-222302	89
RA15-SW-3-4	Lower Hale'au'au	SW-3	12/31/2008	GEL-222302	80
RAB-SW-4-1	Upper Hale'au'au	SW-4	3/12/2007	GEL-182633	77
RA1-SW-4FF-1	Upper Hale'au'au	SW-4	3/14/2007	GEL-182920	84
RA1-SW-4C-1	Upper Hale'au'au	SW-4	3/16/2007	GEL-182920	77
RAB-SW-4-2	Upper Hale'au'au	SW-4	3/25/2007	GEL-183468	89
RAB-SW-4-3	Upper Hale'au'au	SW-4	4/16/2007	GEL-184656	102
RA3-SW-4-1	Upper Hale'au'au	SW-4	11/4/2007	GEL-197454	95
RA3-SW-4-1 (split)	Upper Hale'au'au	SW-4	11/4/2007	GPL-8095	97.1 to 103
RA3-SW-4-FF-1	Upper Hale'au'au	SW-4	11/4/2007	GEL-197454	93
RA3-SW-4-2	Upper Hale'au'au	SW-4	11/8/2007	GEL-197454	96
RA4-SW-4FF	Upper Hale'au'au	SW-4	12/11/2007	GEL-199895	91
RA4-SW-4FF (split)	Upper Hale'au'au	SW-4	12/11/2007	GPL-8178	95.5 to 96.6
RA4-SW-4C	Upper Hale'au'au	SW-4	12/12/2007	GEL-199895	90
RA4-SW-4C (split)	Upper Hale'au'au	SW-4	12/12/2007	GPL-8178	95.5 to 96.6
RA5-SW-4-3	Upper Hale'au'au	SW-4	1/18/2008	GEL-204277	82
RA5-SW-4-4	Upper Hale'au'au	SW-4	1/18/2008	GEL-204277	97
RA5-SW-4-5	Upper Hale'au'au	SW-4	2/17/2008	GEL-204277	91
RA7-SW-4-1	Upper Hale'au'au	SW-4	3/30/2008	GEL-208940	64
RA7-SW-4-2	Upper Hale'au'au	SW-4	4/13/2008	GEL-208940	85
RA8-SW-4-1	Upper Hale'au'au	SW-4	5/21/2008	GEL-210565	79
RA8-SW-4-2	Upper Hale'au'au	SW-4	5/23/2008	GEL-210565	82
RA11-SW-4-1	Upper Hale'au'au	SW-4	10/29/2008	GEL-222302	86
RA13-SW-4-1	Upper Hale'au'au	SW-4	11/26/2008	GEL-222302	87
RA14-SW-4-1	Upper Hale'au'au	SW-4	12/19/2008	GEL-222302	101
RA14-SW-4-15	Upper Hale'au'au	SW-4	12/19/2008	GEL-222302	87
RA14-SW-4-9	Upper Hale'au'au	SW-4	12/19/2008	GEL-222302	94
RA14-SW-4G1	Upper Hale'au'au	SW-4	12/19/2008	GEL-222302	76
RA2-SW-5-2	Lower Waikele	SW-5	3/10/2007	GEL-182633	88
RA3-SW-5-3	Lower Waikele	SW-5	11/4/2007	GEL-197454	94
RA1-SW-6FF-1	Upper Waikele	SW-6	3/9/2007	GEL-182633	99

* Date when sample retreived from automated sampler