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Rainfall, Discharge, and Water-Quality Data During Stormwater Monitoring, July 1, 2007, to June 30, 2008: Halawa Stream Drainage Basin and the H-1 Storm Drain, Oahu, Hawaii

By Todd K. Presley, Marcael T.J. Jamison, and Stacie T.M. Young

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Conversion Factors

Inch/Pound to SI

Multiply	By	To obtain
	Length	
inch (in.)	2.54	centimeter (cm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Flow rate	
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:
°F=(1.8×°C)+32
Temperature in degrees Fahrenheit (°F) may be converted to degrees Celsius (°C) as follows:
°C=(°F-32)/1.8
Vertical coordinate information is referenced relative to mean sea level.
Horizontal coordinate information is referenced to Old Hawaiian Datum.
Specific conductance is given in microsiemens per centimeter at 25 degrees Celsius (μS/cm at 25 °C).
Concentrations of chemical constituents in water are given either in milligrams per liter (mg/L) or micrograms per liter (μg/L).

Rainfall, Discharge, and Water-Quality Data During Stormwater Monitoring, July 1, 2007, to June 30, 2008: Halawa Stream Drainage Basin and the H-1 Storm Drain, Oahu, Hawaii

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Abstract

Storm runoff water-quality samples were collected as part of the State of Hawaii Department of Transportation Stormwater Monitoring Program. The program is designed to assess the effects of highway runoff and urban runoff on Halawa Stream and to assess the effects from the H-1 storm drain on Manoa Stream. For this program, rainfall data were collected at three stations, continuous discharge data at four stations, and water-quality data at six stations, which include the four continuous discharge stations. This report summarizes rainfall, discharge, and water-quality data collected between July 1, 2007, and June 30, 2008.

A total of 16 environmental samples were collected over two storms during July 1, 2007, to June 30, 2008, within the Halawa Stream drainage area. Samples were analyzed for total suspended solids, total dissolved solids, nutrients, chemical oxygen demand, and selected trace metals (cadmium, chromium, copper, lead, and zinc). Additionally, grab samples were analyzed for oil and grease, total petroleum hydrocarbons, fecal coliform, and biological oxygen demand. Some samples were analyzed for only a partial list of these analytes because an insufficient volume of sample was collected by the automatic samplers. Three additional quality-assurance/quality-control samples were collected concurrently with the storm samples.

A total of 16 environmental samples were collected over four storms during July 1, 2007, to June 30, 2008 at the H-1 Storm Drain. All samples at this site were collected using an automatic sampler. Samples generally were analyzed for total suspended solids, nutrients, chemical oxygen demand, oil and grease, total petroleum hydrocarbons, and selected trace metals (cadmium, chromium, copper, lead, nickel, and zinc), although some samples were analyzed for only a partial list of these analytes. During the storm of January 29, 2008, 10 discrete samples were collected. Varying constituent concentrations were detected for the samples collected at different times during this storm event. Two quality-assurance/quality-control samples were collected concurrently with the storm samples. Three additional quality-assurance/quality-control samples were collected during routine sampler maintenance to check the effectiveness of equipment-cleaning procedures.

INTRODUCTION

The State of Hawaii Department of Transportation (DOT) Stormwater Monitoring Program Plan (State of Hawaii Department of Transportation Highways Division, 2007) was implemented on January 1, 2001, to monitor the Halawa Stream drainage basin, Oahu, Hawaii. The Stormwater Monitoring Program Plan was designed to fulfill part of the permit requirements for the National Pollutant Discharge Elimination System program and is revised yearly. The Stormwater Monitoring Program Plan includes the collection of rainfall, discharge, and water-quality data at selected stations in the Halawa Stream drainage basin.

In 2005, additional monitoring of a storm drain that collects runoff from the H-1 Freeway was implemented to fulfill requirements, outlined by the United States Environmental Protection Agency (USEPA), regarding Total Maximum Daily Loads (TMDL) for total nitrogen and total phosphoruous (United States Environmental Protection Agency, 2002) for discharges into Manoa Stream. Rainfall, discharge, and stormwater sampling began at this site in 2006.

This report summarizes water-quality data collected by the U.S. Geological Survey (USGS) as part of the Stormwater Monitoring Program Plan. This report also presents rainfall and discharge data collected from July 1, 2007, to June 30, 2008 for stations within the Halawa Stream drainage area and for a storm drain of the H-1 Freeway (hereinafter referred to as the H-1 storm drain) that discharges into Manoa Stream. Descriptions of the sampling techniques are included with the water-quality data. Quality-assurance/quality-control (QA/QC) samples were collected concurrently with storm samples and during routine cleaning of the sampling equipment between storms. Water-quality data for the QA/QC samples are not published in this report, but are available upon request from the USGS Pacific Islands Water Science Center in Honolulu, Hawaii.

Within the Halawa Stream drainage area, 16 samples were collected over two storms during July 1, 2007, to June 30, 2008. Three QA/QC samples were collected concurrently with the storm samples. An additional four artificial blank water samples were collected to check isolated parts of the sampling equipment for possible contamination on August 9, 2007, as part of quality assurance during routine cleaning of the sampling equipment. These samples were not analyzed, because the samples were not fully chilled upon arrival at the laboratory due to shipping delays.

At the H-1 storm drain, 16 samples were collected over four storms during July 1, 2007, to June 30, 2008. Two QA/QC samples were collected concurrently with the storm samples. In addition, three artificial blank water samples were collected to check isolated parts of the sampling equipment for possible contamination.

DATA-COLLECTION NETWORK

Stream-stage, stream-discharge, rainfall, and water-quality data were collected at selected stations in the Halawa Stream drainage basin (fig. 1). Rainfall data were collected at two stations, 212428157511201, North Halawa Valley rain gage at H-3 tunnel portal (abbreviated to Tunnel rain gage), and 212304157542201, North Halawa rain gage near Honolulu (abbreviated to Xeriscape garden rain gage). Rainfall data have been collected at the Tunnel and Xeriscape garden rain gages since July 1998 and May 1983, respectively.

Discharge data were collected at three stations in North Halawa Valley. Since 1998, discharge data have been collected at station 212353157533001, North Halawa Valley Highway Storm Drain C near Aiea (abbreviated Storm drain C). Stream discharge data have been collected at station 16226200, North Halawa Stream near Honolulu (abbreviated to Xeriscape garden), since 1983, and at 16226400, North Halawa Stream at Quarantine Station (abbreviated to Quarantine), since 2001. The gaging stations Storm drain C, Xeriscape garden, and Quarantine are equipped with automatic samplers. The gage at the Quarantine site was destroyed on December 7, 2003 and rebuilt in June 2005.

Discharge data were collected at station 211722157485601 H-1 Storm Drain at Kapiolani Boulevard, Oahu, HI (abbreviated to H-1 storm drain). The H-1 storm drain station was constructed during 2005-2006 and began operation on April 6, 2006 (fig.2). Rainfall data were collected at station 211722157485602, State Key Number 711.7 H-1 Rain Gage at Kapiolani Boulevard, Oahu, HI, (abbreviated to H-1 rain gage). The H-1 rain gage is located on the top of the H-1 storm drain gage house.

Rainfall and discharge data were collected using variable sampling intervals, depending on rainfall or discharge rates. Discharge data from Quarantine and Storm drain C and discharge and rainfall data from the H-1 storm drain are transferred to the USGS National Water Information System (NWIS) database hourly by satellite telemetry. The Xeriscape garden rain gage and stream gage, and the Tunnel rain gage, currently do not have telemetry.

Recent data can be viewed at http://hi.water.usgs.gov/ under “Real-Time Data (from NWISWeb)” by selecting “Streamflow” or “Rainfall” and then selecting the appropriate USGS station numbers. Historical rainfall and streamflow data can be accessed through the website http://hi.water.usgs.gov/ under “Historical Data (from NWISWeb)” by selecting “Streamflow” or “Rainfall” and then selecting “Daily Data” and then entering the appropriate USGS station numbers.

Water-quality data were collected at five stations (fig. 1): 212356157531801, North Halawa Stream at Bridge 8 near Halawa (abbreviated to Bridge 8); Storm drain C; Xeriscape garden; Quarantine; and 16227100, Halawa Stream below H-1 (abbreviated to Stadium). The Bridge 8 station is about 0.75 miles (mi) upstream from the discharge point of Storm drain C on North Halawa Stream. Storm drain C collects runoff from an approximately 4-mi length of freeway starting at the leeward tunnel portal and extending to mid-valley and discharges directly to North Halawa Stream (fig. 1). The Xeriscape garden station is directly upstream from a light-industrial area near North Halawa Stream, and about 0.75 mi downstream of the discharge point of Storm drain C. The Quarantine station is about 1 mi downstream of Xeriscape garden and near the downstream end of the light-industrial area that borders the North Halawa Stream. The Stadium station is about 1.5 mi downstream of the Quarantine station, downstream from the confluence of North and South Halawa Streams, downstream from the crossing of H-1 freeway, and directly upstream from the mouth at Pearl Harbor.

The H-1 storm drain collects runoff from about 1.3 mi of freeway, flowing southeast to northwest (fig 2.). Part of the neighborhood adjacent to the freeway also drains into the drainage system connected to the storm drain. The H-1 storm drain discharges into Manoa Stream near the intersection of King Street and Kapiolani Boulevard, under the viaducts of the freeway and onramp. The discharge point of the storm drain is along a sloping wall about 10 ft higher than the bed of Manoa stream, about 0.1 mi downstream of the confluence of Palolo and Manoa Streams. The H-1 storm drain station, which includes the rain gage, is located directly above the discharge point of the drain.

Water-quality data that have been collected at stations Storm drain C (1998-present), Xeriscape garden (1983-present), and Stadium (1988-present) by the USGS as part of the H-3 freeway construction monitoring study, as well as water-quality data collected for this study and data collected at the H-1 storm drain (2006-present), can be viewed at the website http://hi.water.usgs.gov/ under “Historical Data (from NWISWeb)” by selecting “Water Quality” and then selecting either “Field/lab samples” or “Daily Data” and then entering the appropriate USGS station numbers.

WATER-QUALITY SAMPLING TECHNIQUES

Water-quality samples include: grab samples collected manually, grab samples collected by an automatic sampler, time-composite samples collected by an automatic sampler, and flow-weighted composite samples collected by an automatic sampler. Each grab and composite sample is assigned a median sampling time based on the start and finish time of the grab sampling process, or the times of collection of the samples used for the grab or composite sample from the automatic sampler.

Sampling requirements

The DOT Stormwater Monitoring Program Plan states that water-quality samples will be collected at least once per quarter during periods of storm runoff from each of the five water-quality monitoring stations in the Halawa area (fig. 1) and for the H-1 storm drain (fig. 2). Also, if a storm does not occur during a quarter, no samples will be collected.

Specifically for the H-3 part of the project, the DOT Stormwater Monitoring Program Plan states that efforts must be made to sample all five Halawa-area water-quality monitoring stations during the same storm. A complete set of samples for a storm consists of five grab samples (one from each of the five stations), three flow-weighted composite samples (one each from Storm drain C, Xeriscape garden, and Quarantine stations), and one QA/QC sample. However, some storms are brief and do not produce adequate runoff to sample all five stations and collect all samples. In practice, these storms have been sampled as thoroughly as possible and analyzed for as many constituents as practical.

At the H-1 storm drain, only composite samples are collected. In practice, opportunities to sample at the H-1 storm drain were frequent because of the multitude of discharge peaks associated with each burst of rainfall in the area. Because of time and manpower constraints, however, the H-1 storm drain was not sampled on the same days as the Halawa-area sites.

Storm criteria

The USEPA Storm Water Sampling Guidance Manual (U.S. Environmental Protection Agency, Office of Water, 1993) provides criteria for stormwater sampling. The first criterion requires at least 0.1 in. of accumulated rainfall within a storm. Rainfall accumulations exceeded 0.1 in. at the Tunnel rain gage and Xeriscape garden rain gage when stormwater sampling was conducted. The second criterion requires that samples be collected only for storms preceded by at least 72 hours of dry weather. The second criterion would prevent sampling of most storms on North Halawa Stream because the Halawa Stream drainage basin, as well as many other parts of Oahu, receives tradewind showers almost daily. Many of the samples collected in the past do not meet the second criterion.

In practice, criteria used to initiate sampling of the stream and storm drain were based on the rate of rainfall accumulation and the rise of stage in Storm drain C, Xeriscape garden, Quarantine, and H-1 storm drain stations. Each automatic sampler is triggered at a station-specific, stream-stage threshold determined after investigating the rainfall-to-runoff relation.

Sample collection

In general, grab samples were collected manually using isokinetic, depth-integrating samplers and equal-width increment (EWI) or single vertical sampling techniques (Wilde and others, 1998). The samplers collect water in an isokinetic manner; water enters the sampler at the same velocity as the stream at the sampling point. Samplers are made of high-density polyethylene (HDPE).

The EWI sampling technique utilizes evenly spaced sampling increments along the cross section of the stream, with equal vertical transit rates of the isokinetic sampler for all increments. Since the transit rates are equal for each increment, the volume of each subsample collected at each increment is proportional to the discharge at that increment. Subsamples are combined in a HDPE churn. An EWI sample is practical when depths are greater than 0.5 ft and the stream is wadable, or where bridges or cable ways are available. If it is not practical or safe to collect an EWI sample, an alternative is to sample at the centroid of flow. At such times, a grab sample was collected with the isokinetic sampler at the estimated centroid of flow at a single vertical section. Subsamples from the single-vertical technique also were combined in a HDPE churn. During storms, flow in North Halawa Stream generally is thought to be well mixed, although sampling to determine the extent of mixing has not been done.

Automatic samplers collect water from a fixed point in the stream channel after predetermined stage thresholds are met. The automatic samplers have a capacity of 24 1-liter bottles. When the first threshold has been met, the automatic samplers are programmed to collect water samples about every 2 minutes for the first 5 samples, and then every 15 minutes for the remaining 19 samples. The first stage thresholds for the samplers correspond to discharges of about 5.2, 36, and 55 ft^3/s for Storm drain C, Xeriscape garden, and Quarantine stations, respectively. In order to collect enough water in each sample during storms with quickly rising and falling stream stages, or high overall flow, a second set of stage thresholds, corresponding to higher discharges, is used to trigger the samplers to sample every seven minutes. These higher stage thresholds correspond to discharges of 43.9, 84, and 110 ft^3/s for Storm drain C, Xeriscape garden, and Quarantine stations, respectively. At the H-1 storm drain, the stage thresholds correspond to discharges of 2.4 ft^3/s for the first threshold and 56.2 ft^3/s for the second threshold.

The automatic samplers are set up with “bottles” that are actually bags held in bottlelike frames. The bags are either reusable and made of teflon that can be cleaned, or disposable and made of low-density polyethylene (LDPE). The teflon bags are positioned in the first 3 slots of the sampler, and the LDPE bags are positioned in the remaining 21 slots. The teflon bags are used so that samples collected by the automatic sampler may be used to analyze for oil and grease (O+G) and total petroleum hydrocarbons (TPH). The main limitations of using water collected in the Teflon bags for O+G and TPH analyses are that: (1) analyses for these constituents requires that the samples be chilled prior to analysis and analyzed within a certain time after collection, known as the “holding time,” and (2) these constituents may adhere to tubing lines used to collect the sample. Fecal coliform (FC) and biological oxygen demand (BOD) samples are not collected by this method because the holding times for these constituents would likely be exceeded, and because the teflon bags are not sterilized for fecal coliform analysis and may become contaminated in the field because they are open to the air. Nutrient analyses may also be affected by holding times, but they are not affected by the type of bag.

Time-composite samples and flow-weighted composite samples are created by combining, in a HDPE churn, all or part of the samples collected by the automatic samplers. A time-composite sample is created by combining the entire contents of bottles with no weighting proportional to stream discharge. Time-composite samples are created when there are only a few bottles filled or partially filled, when there are multiple discharge peaks separated by time gaps of an hour or more, or when the combined volume of the sample collected in the bottles is low. A flow-weighted composite sample is created by combining select volumes of water from each sample, the amount being proportional to the volume of stream discharge between sample collection times. Flow-weighted composite samples are collected over time periods that sometimes last several hours, whereas time-composite samples are usually collected over shorter time periods.

Grab, time-composite, or flow-weighted composite samples were created from the samples collected by the automatic sampler depending on (1) the temporal distribution of discharge over the duration of the storm, (2) the discharge at the time the site was visited to collect a grab sample, (3) site analytical requirements, (4) the number of sample bottles filled, and (5) the volume of sample collected in each bottle. Situations in which the storm samples deviate from the sampling requirements, outlined in the sampling plan, occurred when there were multiple peaks in discharge, when stream discharge had decreased too much after a storm to collect a grab sample, or when a small discharge peak was followed by a much larger discharge peak. When discharge was too low to sample at the time of visit, the first five samples from the automatic sampler, which are collected over about two minutes each, may be used to create a grab sample, and would represent a "first flush" type sample because it would be collected during the first peak of discharge for the storm. Because of the variability in discharge, one or a few hours may have separated groups of samples collected by the automatic sampler. In these cases, samples may have been grouped and analyzed separately as flow-weighted composite samples or time-composite samples.

The H-1 storm drain has unique requirements relative to the Halawa composite sample sites; only composite samples (no grab samples) are collected, although samples from the first two bottles are used for O+G and TPH analyses. In practice, because of the short duration and multitude of discharge peaks associated with each burst of rainfall at the H-1 storm drain, the composite samples are most often time-composite samples rather than flow-weighted samples.

In a few cases, individual samples collected by the automatic sampler at the H-1 storm drain were analyzed separately for metals and nutrients only. This type of sample is called a "discrete" sample since it is not combined with samples from other bottles, and it represents the runoff composition at the time at which the sample was taken. Discrete samples allow for the analysis of how constituent concentrations vary with changes in discharge during the storm.

Determination of discharge for samples

At Bridge 8, Storm drain C, Xeriscape garden, and Quarantine stations, discharge associated with each sample was determined using a stage-discharge rating created for the station or by direct measurement using a current meter. Stage-discharge ratings were developed using direct measurements of stage and discharge and the results from hydraulic models that were verified by measurements at each site. USGS practices for making discharge measurements and stage-discharge ratings can be found in Rantz and others (1982).

At the Quarantine site, the scouring and depositing bed of the stream and the damaged concrete control resulted in stage-discharge ratings that varied during every storm. The rating for this gage has many adjustments resulting in poor estimates of discharge at any given time.

At the Stadium station, the wide and curving concrete-lined channel and shallow and swift streamflow preclude development of an accurate discharge rating. When possible, discharge at this station was measured using a current meter. At higher flows, discharge was measured either by using float-measurement techniques, a radar gun, or a flow meter suspended by cable. The float-measurement technique involves timing floating objects over a known distance to determine water velocity. The radar gun measures surface velocity at multiple points in the cross section. In both techniques, the area of the cross section was estimated using measured water depths and surveyed dimensions of the channel.

An average-discharge value was calculated for each composite sample. The average-discharge value was equal to the total volume of water that flowed by the gaging station during sample collection, divided by the total elapsed time required to collect the automatic samples. To determine the volume of water that passed the station for each sample, the discharge at the time of sample collection was multiplied by the elapsed time. The elapsed time is computed by taking the difference between the times of the samples taken before and after the sample in question and dividing by two. To compute the elapsed time of the first and last samples, the difference between the time of the sample and next/previous sample is divided by two. These volumes were summed, and the total volume was divided by the total elapsed time.

Measured, stage-discharge rating, and averaged discharge values are reported to appropriate numbers of significant figures. These discharge values and the corresponding values of constituent concentrations are used to compute loads. Reported discharge values and the calculation of loads are discussed in appendix A.

Sample processing, analysis, and quality-assurance/quality-control

USGS water-quality sampling methods (Wilde and others, 1998) were followed to prevent possible contamination during sample processing. Both grab and composite samples were processed using churns to mix and suspend sediment while delivering the sample to specific bottles for the various constituent analyses. The time assigned to each grab and composite sample is the median time of the sample collection.

As required by the DOT Stormwater Monitoring Program Plan, each composite and grab sample was analyzed for temperature, pH, specific conductance, total suspended solids (TSS), nutrients, and selected trace metals (cadmium, chromium, copper, lead, and zinc). In addition, chemical oxygen demand (COD) and total dissolved solids (TDS) analyses are performed only for Halawa samples, and nickel analyses are performed only for H-1 storm drain samples. Grab samples were also analyzed for O+G, TPH, FC, and BOD. Analyses of O+G and TPH are also performed for samples from the H-1 storm drain, and are collected using the automatic sampler and the teflon bags as described in the previous section.

USGS personnel made field measurements of temperature, pH, and specific conductance. The minimum reporting levels for each of the analyzed properties and constituents are listed in table 1 and are based on values published by the USGS National Water Quality Laboratory (NWQL). Calculated values, organic nitrogen and total nitrogen, do not have minimum reporting levels. More information about minimum reporting levels and how they are determined by NWQL can be found in Childress and others (1999).

Table 1. Minimum reporting levels of properties and constituents for all samples collected from Halawa Stream drainage basin and H-1 storm drain from July 1, 2007, to June 30, 2008, Oahu, Hawaii

[std., standard; µS/cm, microsiemens per centimeter at 25°C; mg/L, milligrams per liter; °C, degrees Celsius; µg/L, micrograms per liter; --, no minimum reporting level, computed value; MPN/100mL, most probable number (of colonies) per 100 milliliters]

Property or constituent	Minimum reporting level
pH	0.1 std. units
Specific conductance	2.6 µS/cm
Temperature	0.5°C
Total suspended solids	10 mg/L
Total dissolved solids	10 mg/L
Total nitrogen[a]	--
Organic nitrogen[b]	--
Ammonia dissolved[c]	0.020 mg/L
Nitrogen, total organic + ammonia (Kjeldahl)	0.14 mg/L
Nitrogen, nitrite + nitrate dissolved	0.04 mg/L
Phosphorus dissolved	0.04 mg/L
Total phosphorus	0.04 mg/L
Chemical oxygen demand	10 mg/L
Total cadmium	0.01 µg/L
Total chromium	0.8 µg/L
Total copper	1.2 µg/L
Total lead	0.06 µg/L
Total nickel	0.16 µg/L
Total zinc	2 µg/L
Oil and grease	8 mg/L NWQL, 5.0 mg/L TAL[d]
Total petroleum hydrocarbons	2 mg/L NWQL, 5.0 mg/L TAL[d]
Biological oxygen demand	1 mg/L
Fecal coliform	2 MPN/100mL

[a]Total nitrogen is calculated by adding nitrogen, total organic+ammonia (Kjeldahl) to nitrogen, nitrite+nitrate, dissolved.

[b]Organic nitrogen is calculated by subtracting nitrogen ammonia, dissolved, from nitrogen, total organic+ammonia (Kjeldahl).

[c]Ammonia, dissolved is reported as nitrogen

[d] Oil and grease and total petroleum hydrocarbon analyses were performed at the NWQL laboratory to about January 1, 2008. All subsequent analyses were performed at Test America Laboratories (TAL) in Denver, Colorado

FC and BOD analyses were performed by Aecos Incorporated, a private laboratory on Oahu. QA/QC practices for FC and BOD were performed by Aecos Incorporated, but are not published here. For storm sampling that occurred on a weekend or holiday, no FC or BOD samples were collected because Aecos Incorporated was closed and holding times for these constituents would be exceeded.

O+G and TPH were analyzed either at the NWQL or, as of January of 2008, at the Test America Laboratories facility in Denver, Colorado. All other analyses were performed at the USGS NWQL, in Denver, Colorado. The methods used for analyses of all water-quality constituents and quality-control practices at NWQL are documented in Friedman and Erdmann (1982), Fishman and Friedman (1989), Pritt and Raese (1992), Patton and Truitt (1992), Fishman (1993), Hoffman and others (1996), Garbarino and Struzeski (1998), and Garbarino and others (2006).

A duplicate sample, field or laboratory, is required by the Stormwater Monitoring Program Plan for each storm sample. A field duplicate is a sample that is collected concurrently or split with a grab sample and the analytical results are used to verify the sampling method. A laboratory duplicate is a sample that is split into two equal parts during sample processing and the results are used to verify the precision of the laboratory.

During the period between storms, nondedicated and nondisposable equipment, such as churns, isokinetic samplers, automatic-sampler-intake lines, and teflon automatic-sampler bottle liners, were cleaned following procedures in Wilde and others (1998). Inorganic blank water (IBW), free of inorganic constituents, was passed through the automatic sampler and collected. The IBW field-blank samples were analyzed for the same inorganic constituents as the storm samples.

HALAWA STREAM DRAINAGE BASIN

Rainfall and Discharge Data

Hydrographs of daily rainfall and daily mean discharge for the period of July 1, 2007, through June 30, 2008, are shown in figure 3. During this period, a total of 131.4 in. of rain was recorded at the Tunnel rain gage, and 44.0 in. of rain was recorded at Xeriscape garden rain gage, although 19 days of record were missing at Xeriscape garden. The highest recorded daily rainfall occurred on November 4, 2007, at both sites: 6.8 in. of rain was recorded at Tunnel rain gage, and 6.1 in. was recorded at the Xeriscape garden rain gage.

North Halawa Stream and Storm drain C flow intermittently. Storm drain C had zero flow for 94 days during July 1, 2007, to June 30, 2008, and the longest continuous period of zero flow was 17 days during February 25 to March 12, 2008. The highest daily mean discharge at Storm drain C was 12 ft^3/s on November 4, 2007, and the highest instantaneous discharge was 143 ft^3/s at 01:33 November 4, 2007.

Xeriscape garden station had zero flow for 108 days, and the longest continuous period of zero flow was 16 days from July 1 to July 16, 2007. The highest daily mean discharge was 237 ft^3/s on November 4, 2007, and the highest instantaneous discharge was 1,180 ft^3/s at 02:26 November 4, 2007.

For the Quarantine station, the site had zero flow for 231 days during July 1, 2007, to June 30, 2008. The longest continuous period of zero daily mean discharge at this station was 86 days from February 25 to May 20, 2008. The Quarantine station had 38 days of estimated record, primarily because of gage damage sustained during the November 4, 2007, storm. The highest daily mean discharge was estimated to be 140 ft^3/s, on November 4, 2007. The highest instantaneous discharge was estimated at 1,210 ft^3/s at 02:48 on November 4, 2007.

Stormwater Sampling: Conditions and Results

During the period July 1, 2007, through June 30, 2008, about 12 storms created sufficient runoff to trigger the automatic samplers at the predetermined thresholds at the Xeriscape garden station and the Quarantine station. The number of storms sufficient to trigger the automatic sampler at Storm drain C was much higher, because the storm drain will start to flow at low amounts of rainfall collected on the freeway. Although these storms had sufficient runoff to trigger the samplers, some of the events were either of very short duration and could not be adequately sampled, or there was preceding rainfall that developed small peaks just before larger ones, which is in conflict with USEPA guidelines requiring 72 hours of antecedent dry conditions. Of these storms, two storms were sampled: November 4, 2007, and May 21-22, 2008.

Third Quarter 2007—July 1 to September 30, 2007

Hydrographs of discharge during the third quarter of 2007 for Storm drain C, Xeriscape garden, and Quarantine stations are shown in Figure 4. No storms were sampled during this quarter. The storm on August 15, 2007, had peak discharges that exceeded the sampling thresholds at Storm drain C, Xeriscape garden, and Quarantine stations (fig. 4); however, because of the rapid decrease in stage at Storm drain C and Quarantine stations, an insufficient number of samples from the automatic sampler (hereinafter referred to as “automatic samples”) were collected in order to create composite samples. Thus the storm was not sampled.

Fourth Quarter 2007—October 1 to December 31, 2007

The storm of November 4, 2007, was sampled during the fourth quarter of 2007. A complete set of samples was collected for this storm. Discharge was high during this storm, therefore three of the sites were not wadable and had to be sampled from the side of the stream, and the high discharge damaged mounted equipment at two of the gages.

Two storm periods in early and late December generated peak discharges high enough to sample. No samples were collected during these periods.

Storm of November 4, 2007

About 1 in. of rain was recorded at the Tunnel rain gage on October 31, November 1 and 2, 2007, which resulted in runoff in North Halawa Stream on November 2. Discharge on November 2, 2007, was sufficient to trigger the automatic sampler at Xeriscape garden. On November 4, 2007, 6.8 in. of rain was recorded at the Tunnel rain gage, resulting in runoff that was sufficient for a storm sample to be collected. Hydrographs of discharge at Storm drain C, Xeriscape garden, and Quarantine stations during October 1 to December 31, 2007, are shown in figures 5, 6, and 7.

Composite samples were collected from Storm drain C, Xeriscape garden, and Quarantine stations. Manual grab samples were collected from all stations. Beginning and ending composite sample-collection times are displayed on the hydrographs in figures 5, 6, and 7. The high flow damaged equipment at the Quarantine station, preventing the collection of gage-height data during most of the storm.

Samples were analyzed for all constituents listed in the Stormwater Monitoring Program Plan (State of Hawaii Department of Transportation Highways Division, 2007), except for FC and BOD; the Aecos Incorportated Laboratory was not available on the day of the storm. Discharge, laboratory measurements of pH and specific-conductance values, constituent concentrations, loads for the grab samples, and average loads for the composite samples, are shown on table 4 in appendix B.

***Bridge 8.*—**The grab sample was collected at about 12:53 on November 4, 2007. Because of safety considerations, the sample was not collected using the EWI method across the entire width of stream. Instead, depth-integrated samples were collected at three locations near the middle of the stream with the isokinetic sampler. The stream width was about 27 ft. A discharge of 167 ft^3/s was measured using a current meter about 20 minutes prior to sampling.

***Storm drain C.*—**The grab sample was collected by dipping a clean bottle into the flow and combining the collected water in the churn. The flow was low (about 0.81 ft^3/s) but relatively well mixed at the time of sampling. Discharge measurements were made at the time of sampling, but because of the rapidly changing flow, these measurements were not used to determine discharge. Instead, discharge was calculated using recorded gage heights and the adjusted stage-discharge rating.

The automatic sampler collected 24 samples, but only the first 20 samples were used for the flow-weighted composite sample. Samples in bottles 21 through 24 were collected about an hour after bottle 20 was filled. The composite sample was collected during 00:15 to 03:13 on November 4, 2007 (fig. 5). The time-weighted average flow for the composite sample was estimated at 48 ft^3/s. Peak discharge for this storm at this site was estimated at 143 ft^3/s at 01:33, November 4, 2007.

Xeriscape garden.—The flow was too high to safely wade across the stream and collect an EWI sample at the time of the visit; therefore, a grab sample was collected by dipping a bottle at the right edge of the stream. The grab sample was collected at 12:06 November 4. A discharge of 225 ft^3/s was computed from the gage-height readings and the rating for the station (fig. 6).

The automatic sampler collected a total of 24 samples. However, the first 13 automatic samples were collected on November 2, 2007, and were not used. The sampling lines were not cleaned between November 2 and November 4, 2007. Automatic samples 14-24, collected during 01:16 to 02:41 on November 4, 2007, were used to create a flow-weighted time-composite. The time-weighted average discharge associated with the composite sample was 420 ft^3/s (fig. 6). The peak discharge was 1,180 ft^3/s at 02:26 on November 4, 2007.

Quarantine.—An EWI grab sample was collected at 14:18 on November 4, 2007. The stream width was 27.7 ft, and subsamples were collected every foot across the width. A field duplicate was submitted to the NWQL and analyzed for all grab-sample constituents. A stream discharge of 139 ft^3/s (fig. 6) was measured concurrently with sampling using a current meter at a cross section located about 30 ft downstream from the gage.

As mentioned above, the gage at this station was damaged during the storm. The stage recording equipment, which also controls the triggering of the automatic sampler, was not functioning at the time of peak discharge. The peak discharge, 1,210 ft^3/s, and time of peak discharge, 02:48 on November 4, 2007, were estimated based on a crest gage reading at the Quarantine station, the time of peak discharge at Xeriscape garden, and the time difference between peaks at the Xeriscape and Quarantine sites during previous storms. The automatic sampler was triggered manually during the sampling visit, and seven bottles were filled during 13:50 to 14:28, November 4, 2007. Because of low volumes of the automatic samples, the entire content of each bottle was used to create a time-composite sample rather than a flow-weighted composite sample. The average discharge associated with the composite sample was 133 ft^3/s (fig. 7).

Stadium.—A grab sample was collected at 10:43 on November 4, 2007, from the right edge of water by dipping a clean bottle from the isokinetic sampler. The flow was well mixed. The stage was too high at this site to safely wade. The stream width was 52 ft. Discharge was measured from the bridge using a weighted current meter suspended from a winch. The measured discharge was 1,280 ft^3/s.

First Quarter 2008—January 1 to March 31, 2008

Hydrographs showing discharge during the first quarter 2008 for Storm drain C, Xeriscape garden, and Quarantine stations are shown in figure 8. Rainfall during the last 6 days of the fourth quarter 2007 through January 6, 2008, and during February 2 through 9, 2008 (fig. 3), produced discharge peaks that exceeded the sampling thresholds at the three sites. During these two periods, the discharge peaks that were large enough to sample were preceded by smaller peaks in discharge insufficient to sample. These two rainy periods were not sampled, and no other storms were sampled during this quarter.

Second Quarter 2008—April 1 to June 30, 2008

Only two storms during second quarter 2008 had sufficient rainfall and discharge to trigger the automatic samplers, one on May 21-22, 2008, and a second on June 12, 2008. The storm of May 21-22 had discharge only slightly above thresholds for the sampler. The June 12 storm had higher discharges but was short in duration; the flow lasted only about 3 hours at Xeriscape garden. Only the May 21-22, 2008, storm was sampled.

Storm of May 21-22, 2008

The tunnel rain gage collected about 3.2 in. of rainfall on May 21, and the Xeriscape rain gage collected about 1.8 in. of rainfall. This rainfall produced enough runoff to trigger the automatic samplers (figs. 9, 10, and 11). Only a partial set of samples was collected because of insufficient flow at the time of sampling at some sites. Grab samples were collected at Bridge 8, Xeriscape garden, and Quarantine sites. Flow was low and decreasing at the time of sampling; thus the sampling team decided not to sample at the Stadium site. Automatic samples were collected at Storm drain C, Xeriscape garden, and Quarantine stations; however, only a few bottles at Quarantine and Storm drain C were filled. Beginning and ending composite sample-collection times are displayed on the hydrographs in figures 9, 10, and 11. Discharge, laboratory measurements of pH and specific-conductance values, constituent concentrations, loads for the grab samples, and average loads for the composite samples are shown on table 4 in appendix B.

Bridge 8.—The grab sample was collected using the EWI method at 13:23 on May 22, 2008. The sampling cross section was about 13 ft wide, and was sampled at 1-ft intervals. About 45 minutes prior to sampling, a discharge of 11.8 ft^3/s was measured using a current meter. This site was chosen for a field duplicate for selected analyses; thus, a second set of FC, BOD, O+G, and TPH bottles were filled at the site.

Storm drain C.—Discharge was nearly zero at the time the site was visited on May 22, 2008; thus a grab sample was not collected.

The automatic sampler at Storm drain C malfunctioned and only filled four bottles starting about 2 hours after the first peak. Samples were collected from 20:06 to 21:21 on May 21, 2008. About 5 hours later, at 02:25 and 02:41, two more bottles were filled, and about 2 hours later, at 04:03 and 04:21(fig. 9), two additional bottles filled. The samples were taken during three distinct time periods; therefore the three groups of bottles were processed separately. The first four samples were used to create a flow-weighted composite sample, and the next two pairs of samples were each combined to create two time-composite samples. The volume of water collected was insufficient for filling all of the analyte bottles; thus only metals, TSS, and total nutrient bottles were filled and submitted for analysis from the flow-weighted sample, and only metal bottles from the two time-composite samples. Average discharge associated with the first group was 22 ft^3/s, with the second group was 24 ft^3/s, and with the third group was 7.8 ft^3/s. The instantaneous peak discharges at the storm drain during the storm were: 44 ft^3/s at 18:27, 34 ft^3/s at 19:49, and 26 ft^3/s at 20:51 on May 21, 2008; and 44 ft^3/s at 02:31 and 15 ft^3/s at 04:22 on May 22, 2008.

Xeriscape garden.—An EWI grab sample was collected about 40 to 50 ft upstream of the gage at 12:20, May 22, 2008. The sampling cross section was 18.7 ft wide and was sampled at 1-ft intervals. The discharge measured was 16.6 ft^3/s (fig. 10) using a current meter.

The composite sample was collected from 23:38 on May 21 to 00:44 on May 22, 2008. The flow-weighted composite sample was made from nine samples, with the first five samples collected over about 7 minutes. The average discharge associated with the composite sample was 51 ft^3/s. Peak flow was 69 ft^3/s at 23:41 on May 21, 2007. A smaller peak of 38 ft^3/s preceded the larger peak at 20:11.

***Quarantine.*—**A grab sample was collected near the gage at 14:20 on May 22, 2008 (fig.11). Stream width was 14 ft at the cross-section, and the EWI method was used, collecting subsamples every 1 ft. A discharge of 10.6 ft^3/s was measured just prior to sampling. A QA/QC duplicate analysis of the sample was analyzed at NWQL.

The time-composite sample was created by combining only two samples collected within a few minutes of each other at 20:31 and 20:33 on May 21, 2008. Five samples were triggered, based on the record from the logger and sampler; however, the last three samples were found empty. Since only two samples were processed, there was not enough water to perform all composite analyses. The volume was sufficient only for total metals, TSS, and whole-water nutrient analyses. The peak flow for the storm was 63 ft^3/s at 20:31 on May 21, 2008, followed by two smaller peaks at 53 ft^3/s at 00:15 and 40 ft^3/s at 03:48 on May 22, 2008. Average discharge associated with the composite sample was 62 ft^3/s.

Quality Assurance

Field and laboratory quality-assurance procedures were implemented as described in the DOT Storm Water Monitoring Program Plan (State of Hawaii Department of Transportation Highways Division, 2007). Three QA/QC samples were analyzed: two field-duplicate samples collected during the two storms, and one laboratory-duplicate sample. Four inorganic-blank-water (IBW) samples were collected at Storm drain C on August 9, 2007; however, the samples arrived at the NWQL too warm for analysis, and these samples were discarded. Results for the duplicate samples are not published in this report but are available from the USGS Pacific Islands Water Science Center upon request.

All grab-sample-collection equipment was cleaned prior to use. Automatic sampler intake lines were cleaned six times during the year at Storm drain C, three times at Xeriscape garden, and once at the Quarantine site. Possible contamination of the sampling lines may have occurred at the Quarantine site prior to the November 4, 2007 sample, since the sampling lines were not cleaned prior to sampling. The potential for contamination is reduced because the automatic sampler conducts a rinse cycle before collecting every sample. The rinse cycle routine is as follows: (1) sample line is first purged by air, (2) water is pumped up the line to a sensor located before the pump, (3) water is purged out, and (4) the sample is then collected. Thus, the rinse cycle conditions the intake lines with sample water prior to sample collection, reducing possible contamination from water pumped during earlier storms and from previously pumped samples during the same storm.

H-1 STORM DRAIN

Rainfall and Discharge Data

Hydrographs of daily rainfall and daily mean discharge for the period of July 1, 2007, through June 30, 2008, are shown in figure 12 for the H-1 rain gage and the H-1 storm drain station. Total rainfall at the H-1 rain gage was 27.11 in. during July 1, 2007, through June 30, 2008. The highest recorded daily rainfall was 4.18 in. on November 4, 2007. The highest daily mean discharge at the H-1 storm drain was 6.1 ft^3/s, also on November 4, 2007, and the highest instantaneous discharge was 65 ft^3/s at 11:30 December 7, 2007. Fifty-eight days had zero flow, and the longest period of zero flow was 11 days, from July 4 through July 14, 2007.

Stormwater Sampling: Conditions and Results

During the period July 1, 2007, through June 30, 2008, the flashy nature of the H-1 storm drain created many discharge peaks high enough to sample. Over the year, 18 samples were collected over 4 distinct storms. Two of these 18 samples were QA/QC field duplicates processed concurrently with the environmental samples.

Third Quarter 2007—July 1 to September 30, 2007

The hydrographs of discharge (fig. 13) show at least three peak discharges that were high enough to trigger the sampler: August 2, August 11, and September 1, 2007. Samples were collected during the storm of August 11, 2007.

Storm of August 11, 2007

The H-1 rain gage collected about 0.12 in. of rain on August 11, 2007. Seven samples were collected by the automatic sampler on August 11, 2007, from 21:06 to 21:24. The H-1 storm drain had little or no flow for 8 days prior to the storm, and the sampler lines were cleaned on August 10, 2007. Water samples collected in bottles one and two were used for O+G and TPH analysis. The entire contents of bottles three through seven were combined in a HDPE churn for a time-composite sample. A field duplicate was split from the sample; however, the composite-sample volume was not large enough to make a complete field duplicate for all analyses and only nutrient analyses were done. Average discharge during the sampling was 3.4 ft^3/s. Peak discharge during the storm was 4.1 ft^3/s at 21:11 on August 11, 2007. Discharge, laboratory measurements of pH and specific-conductance values, constituent concentrations, and average loads for the composite samples, are shown on table 5 in appendix B.

Fourth Quarter 200—October 1 to December 31, 2007

Hydrographs of discharge and sampled storms during October 1 to December 31, 2007, are shown in figure 14. More than 10 storms during the fourth quarter 2007 produced sufficient flow to trigger the sampler. Of these storms, samples were collected during those of October 30 and November 1, 2007.

Storm of October 30, 2007

The H-1 rain gage collected 0.17 in. of rainfall on October 30, 2007. Two bottles were filled by the automatic sampler on October 30, 2007 at 21:45 and 21:56 (fig.14). There was very little discharge in the drain from October 7 to 30. The sampler lines were cleaned on October 3, 2007. Because insufficient water was collected to make a composite sample, each automatic sample was processed separately to create “discrete” samples by pouring the water directly from the automatic sampler bottles into the analysis bottles. Only metals analyses were performed. Discharge was 2.7 ft^3/s for the 21:45 sample and 1.6 ft^3/s for the 21:56 sample. The peak discharge was 9.2 ft^3/s at 21:30 on October 30, 2007. Discharge, laboratory measurements of pH and specific-conductance values, constituent concentrations, and loads for the discrete samples, are shown on table 5 in appendix B.

Storm of November 1, 2007

The H-1 rain gage collected 0.25 in. of rainfall on October 31, 2007, and 0.52 in. of rainfall on November 1, 2007. Eight samples were collected by the automatic sampler and the last six were used to make a composite sample during 06:25 to 06:40 on November 1, 2007 (fig. 14). The sampler lines were not cleaned between sample collections on October 30 and November 1, 2007. The entire contents of bottles three through eight were combined to make a time-composite sample. The composite sample was analyzed for all constituents except for O+G and TPH. Average discharge during the sampling duration was 9.7 ft^3/s. Peak discharge during the storm was 12 ft^3/s at 06:26 on November 1, 2007. Discharge, laboratory measurements of pH and specific-conductance values, constituent concentrations, and average loads for the composite samples, are shown on table 5 in appendix B.

First Quarter 2008—January 1 to March 31, 2008

Hydrographs showing discharge and the storms sampled during January 1 to March 31, 2008, are shown in figure 15. Storms during January 28-29 and February 7 had sufficient discharge to trigger the automatic samplers. Only the storm of January 28-29 was sampled.

Storm of January 28 and 29, 2008

The H-1 rain gage collected 0.27 in. and 1.45 in. of rainfall on January 28 and 29, 2008, respectively. Fifteen bottles, associated with multiple peak discharges, were filled by the automatic sampler during 17:24 January 28 to 09:34 January 29, 2008. The period prior to the rainfall of January 28 was relatively dry; a small amount of discharge was measured in the H-1 storm drain on January 25, 2008. Sampler lines were cleaned on January 11, 2008. More than nine discharge peaks occurred during January 28-30, 2008, and only peaks during the first half of the storm were sampled. Five automatic samples were collected on January 28, 2008, and the first two samples, collected at 17:21 and 17:24, were used for O+G and TPH analyses. The entire contents of bottles three through five, collected at 22:34, 22:37, and 22:40, were combined to make a time-composite sample. The sample was assigned a mean time of 20:00. The time-composite sample was processed and analyzed for all constituents. A field duplicate of the composite sample was processed for nutrient analysis. Average discharge associated with the composite sample was 3.8 ft^3/s. Discharge, laboratory measurements of pH and specific-conductance values, constituent concentrations, and average loads for the time-composite samples, are shown on table 5 in appendix B.

The remaining 10 samples, collected on January 29, 2008, during 04:25 to 09:34, were processed separately as discrete samples for nutrient and total metals analyses only. Discharge associated with these 10 automatic samples ranged from 2.4 ft^3/s to 13 ft^3/s (fig. 15). Discharge, laboratory measurements of pH and specific-conductance values, constituent concentrations, and loads for the discrete samples, are shown on table 5 in appendix B.

Second Quarter 2008—April 1 to June 30, 2008

Two storms caused enough runoff to trigger the automatic sampler at the H-1 storm drain during second quarter 2008; they were on April 6 and June 7, 2008. The April 6, 2008, storm was sampled. Hydrographs of discharge during April 1 to June 30, 2008 and details for the sampled storm during April 6, 2008 are shown in figure 16.

Storm of April 6, 2008

Rainfall on April 2, 3, 5, and 6 caused discharge in the storm drain. The H-1 rain gage collected 0.11 in. and 0.36 in. of rainfall on April 5 and 6, 2008, respectively. Discharge peaks were less than 1.1 ft^3/s on April 2, 3 and 5. Seven bottles were filled by the automatic sampler during 09:06 to 09:24 on April 6, 2008. Sampler lines were cleaned on April 4, 2008. Samples collected in bottles one and two were used for O+G and TPH analysis. The entire contents of bottles three through seven were used to make a time-composite sample. The composite sample was processed for all constituents required for the H-1 storm drain sampling. Average discharge associated with the time-composite sample was 5.5 ft^3/s. Peak discharge was 7.7 ft^3/s at 09:08 on April 6, 2008. Discharge, laboratory measurements of pH and specific-conductance values, constituent concentrations, and average loads for the time-composite samples, are shown on table 5 in appendix B.

Quality Assurance

Field and laboratory quality-assurance procedures were implemented as described in the DOT Storm Water Monitoring Program Plan (State of Hawaii Department of Transportation Highways Division, 2007). Two QA/QC samples were collected concurrently with the composite samples, one on August 11, 2007, and the other on January 28, 2008. Two field duplicate samples were collected and analyzed for nutrients. For the storm of August 11, 2007, the relative percent difference between the duplicate sample and the environmental sample ranged from 0 to 16 percent for the six nutrient determinations. For the storm of January 28, 2008, the relative percent difference between the duplicate sample and the environmental sample ranged from 0 to 50 percent, with 3 constituents at 0 percent and one each at 11, 20, and 50 percent difference. The total Kjeldahl (ammonia plus organic) nitrogen values differed by 50 percent (4.5 and 9.1 mg/L). The total phosphorus values differed by 20 percent (1.75 and 2.2 mg/L). Data were not reviewed in time to order a reanalysis of these constituents. Results for other analytes for the duplicate sample are not published in this report, but are available from the USGS Pacific Islands Water Science Center upon request.

Contamination of the sampling lines may have occurred at the H-1 storm drain prior to the collection of some of the samples. Maintaining a clean sampling line is challenging; discharge in the storm drain is flashy and triggers the sampler during most storms. The potential for contamination is reduced, however, because the automatic sampler conducts a rinse cycle before collecting every sample.

IBW field-blank samples from the automatic sampler were collected at the H-1 storm drain on August 10, 2007. Intake lines were cleaned prior to the collection of IBW field-blank samples. Three different types of field-blank samples were collected: (1) a source-solution trip sample (a blank-water sample is transported to the sampling site and back), (2) an equipment blank sample exposed to the sampling lines, and (3) an equipment blank sample exposed to the LDPE bags that line the bottles in the automatic sampler. The only element detected was lead at 0.1 μg/L in the equipment blank for the LDPE sample bag. Lead was not detected in the source solution trip sample or the equipment blank sample exposed to the sampling lines.

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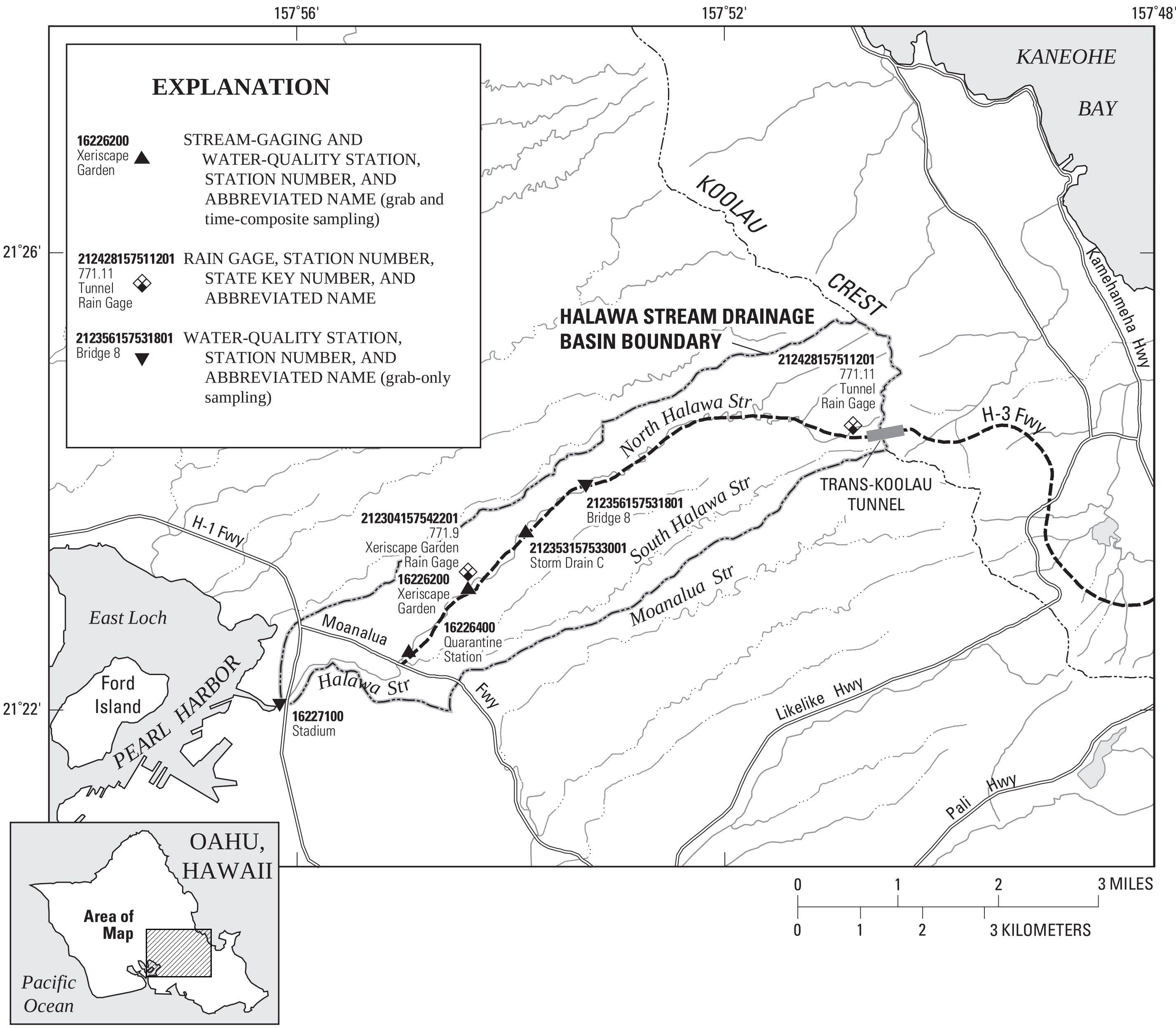

Figure 1. Stream-gaging stations, rain gages, and water-quality sampling stations in the Halawa drainage basin, Oahu, Hawaii.

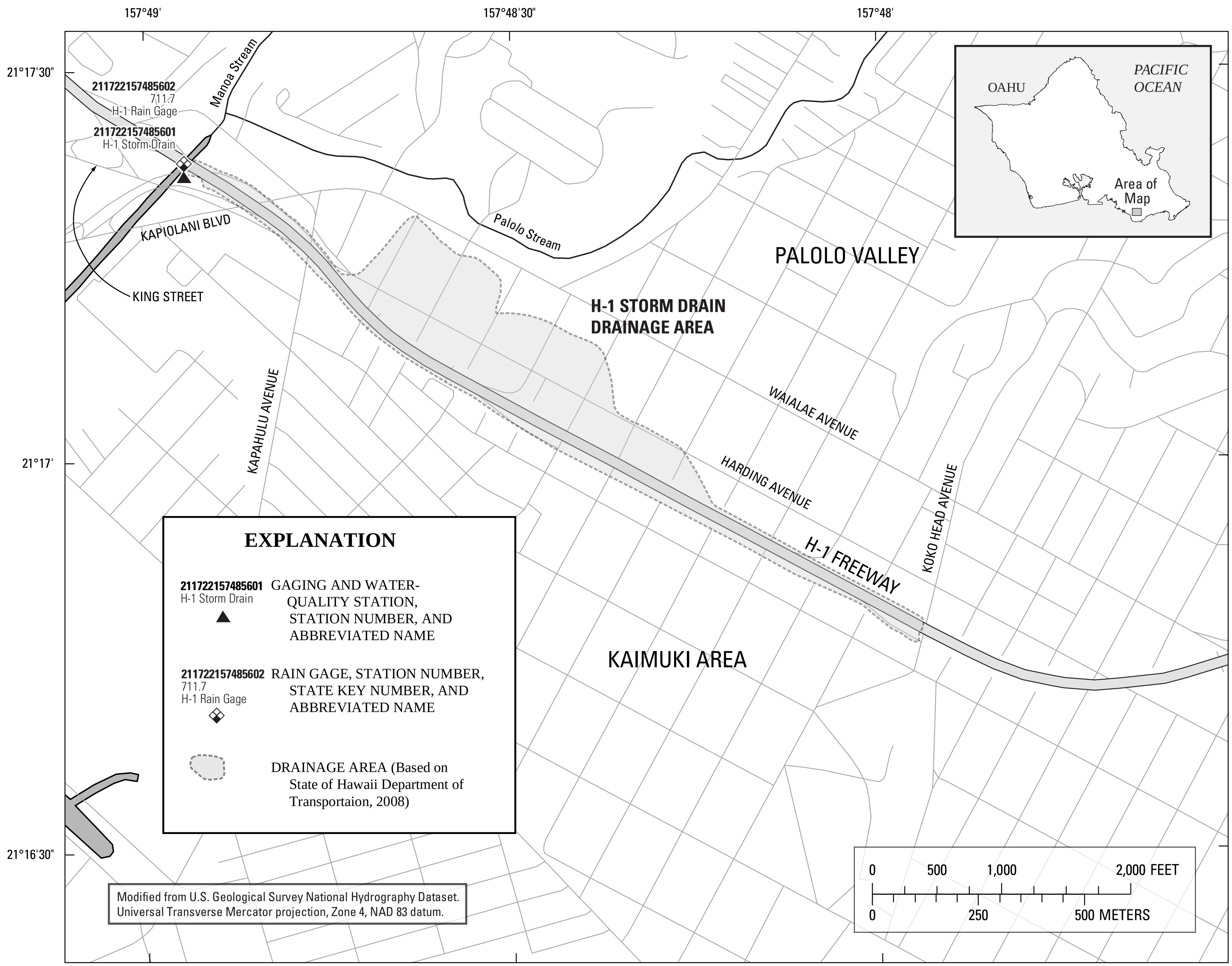

Figure 2. Drainage area of the H-1 storm drain and location of the H-1 rain gage, H-1 storm drain gage and sampling site, Oahu, Hawaii.

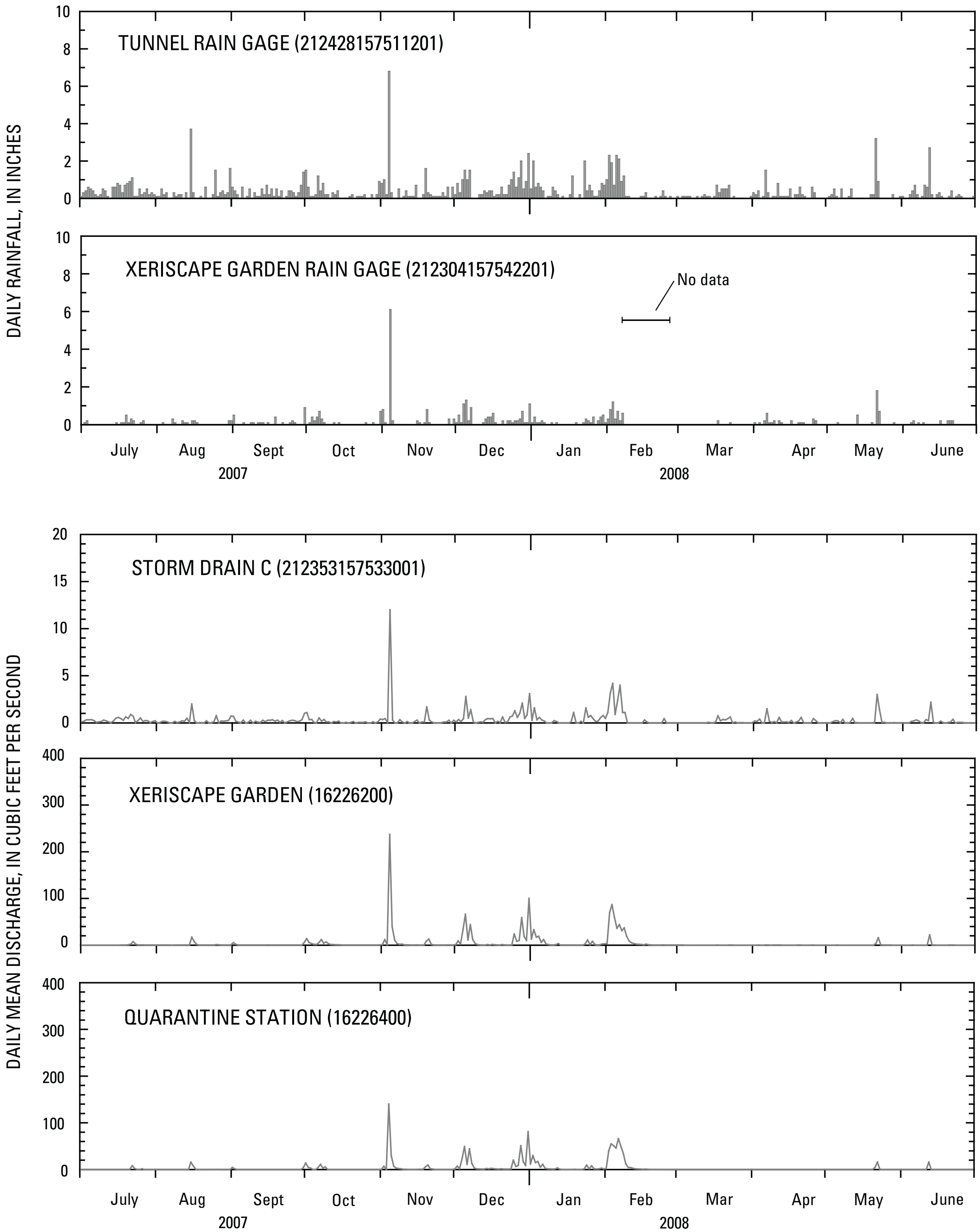

Figure 3. Rainfall and discharge for stations within the Halawa Stream drainage basin, Oahu, Hawaii, for July 1, 2007, to June 30, 2008.

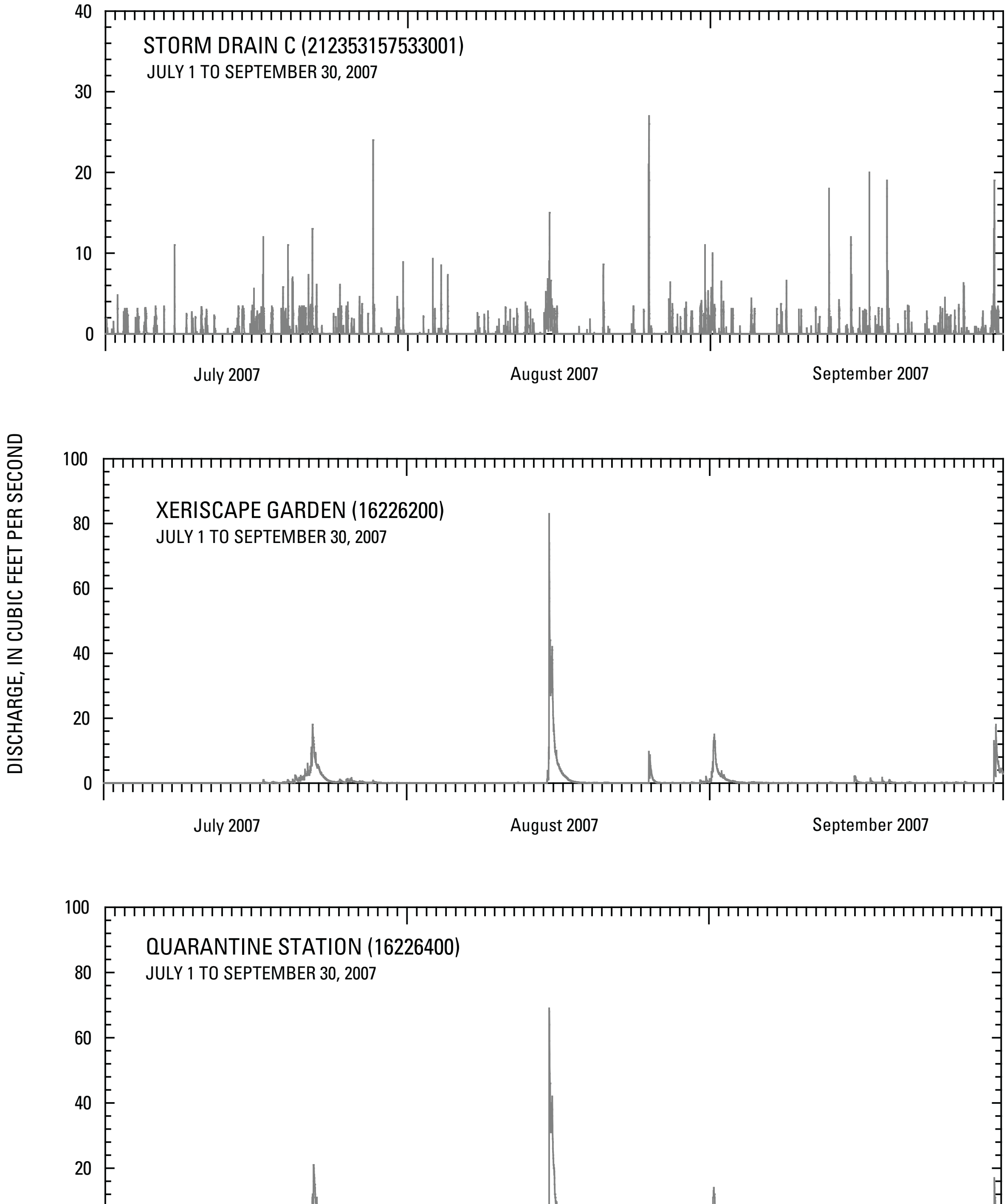

Figure 4. Discharge at Storm Drain C (212353157533001), and stream discharge at Xeriscape garden (16226200) and Quarantine station (16226400), for July 1 to September 30, 2007, Oahu, Hawaii.

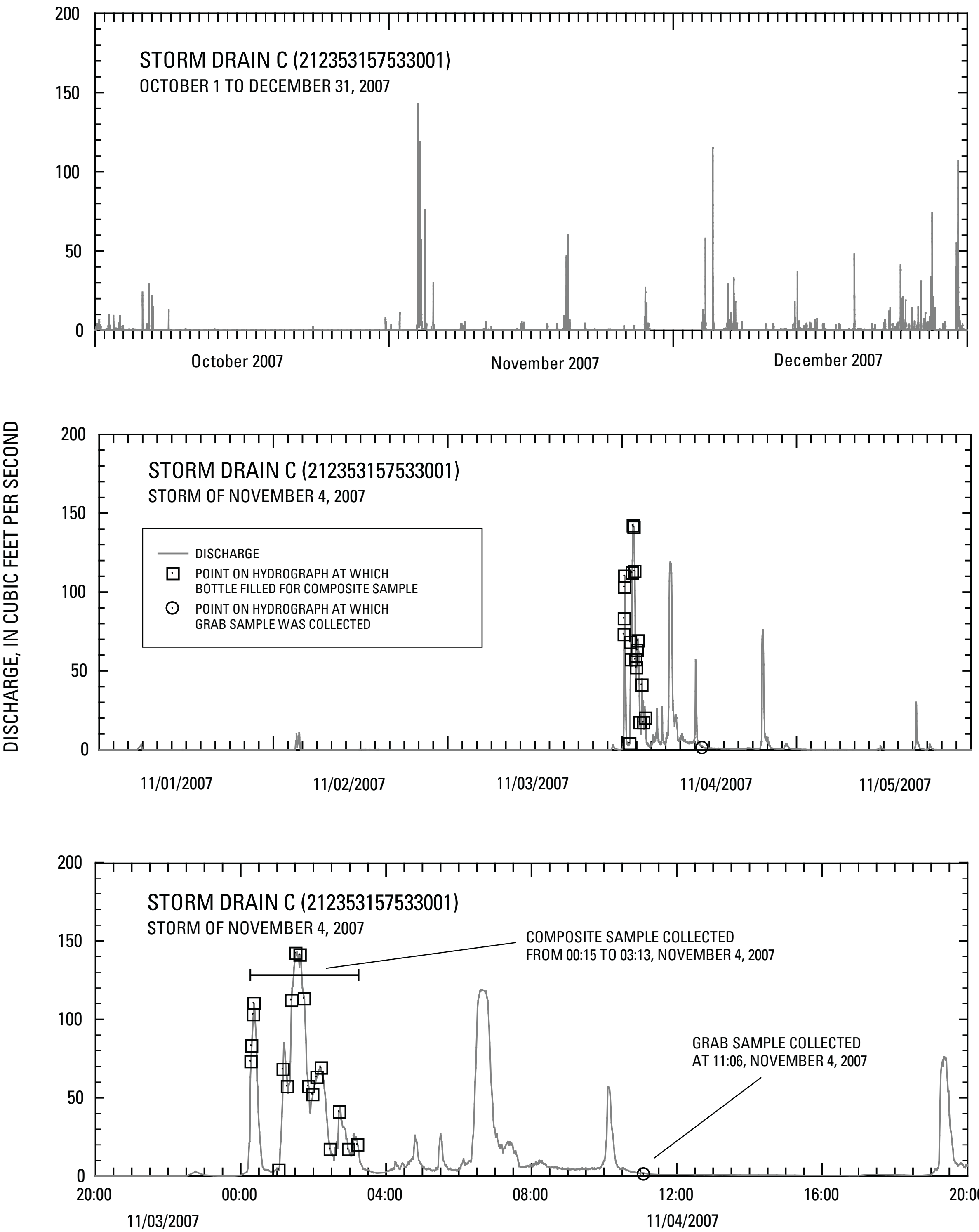

Figure 5. Discharge at Storm drain C (212353157533001) for October 1 to December 31, 2007; detail of 5-day period from November 1 to 5, 2007; and detail of 24-hour period from 20:00 November 3 to 20:00 November 4, 2007, Oahu, Hawaii.

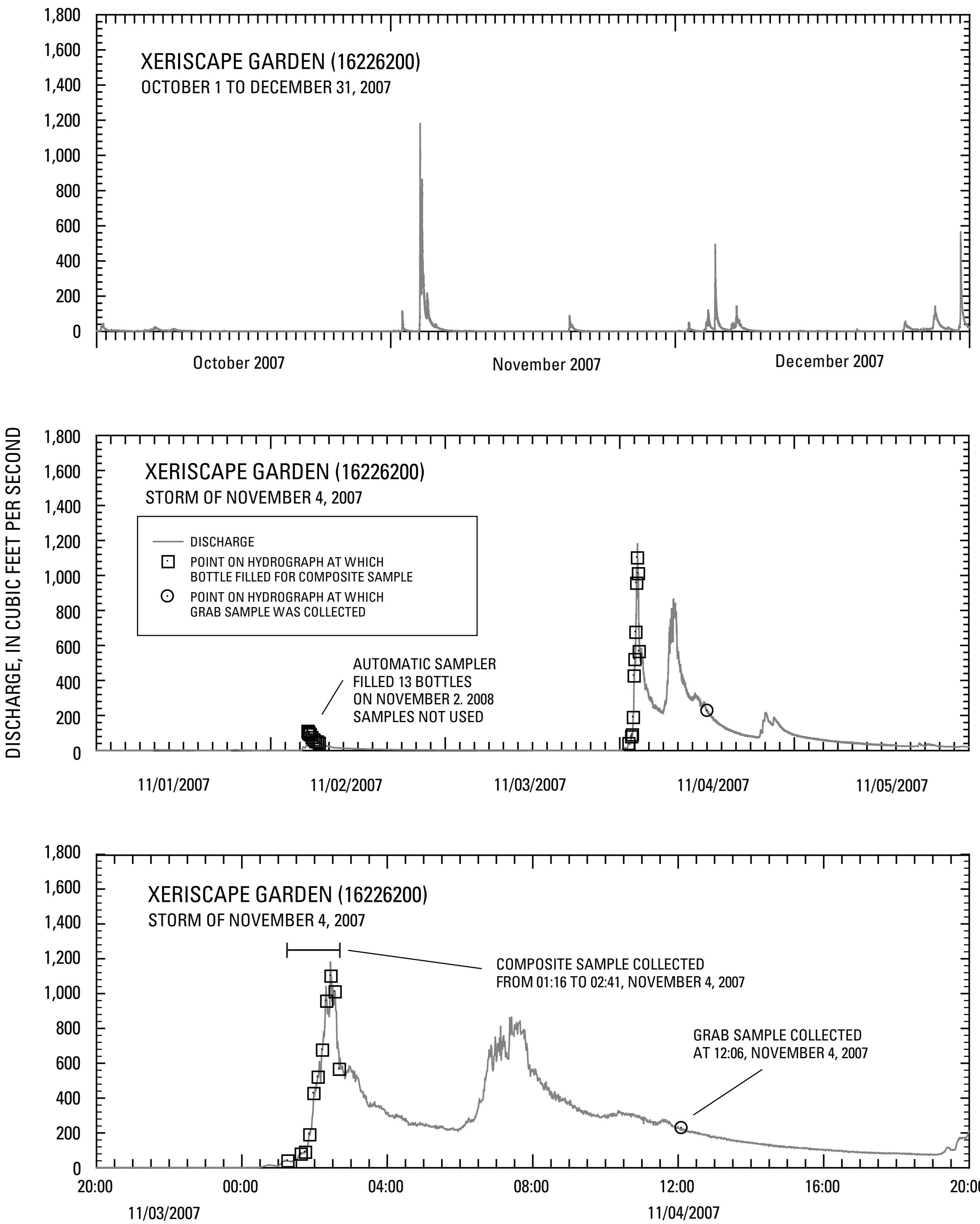

Figure 6. Stream discharge at Xeriscape garden station (16226200) for October 1 to December 31, 2007; detail of 5-day period from November 1 to 5, 2007; and detail of 24-hour period from 20:00 November 3 to 20:00 November 4, 2007, Oahu, Hawaii.

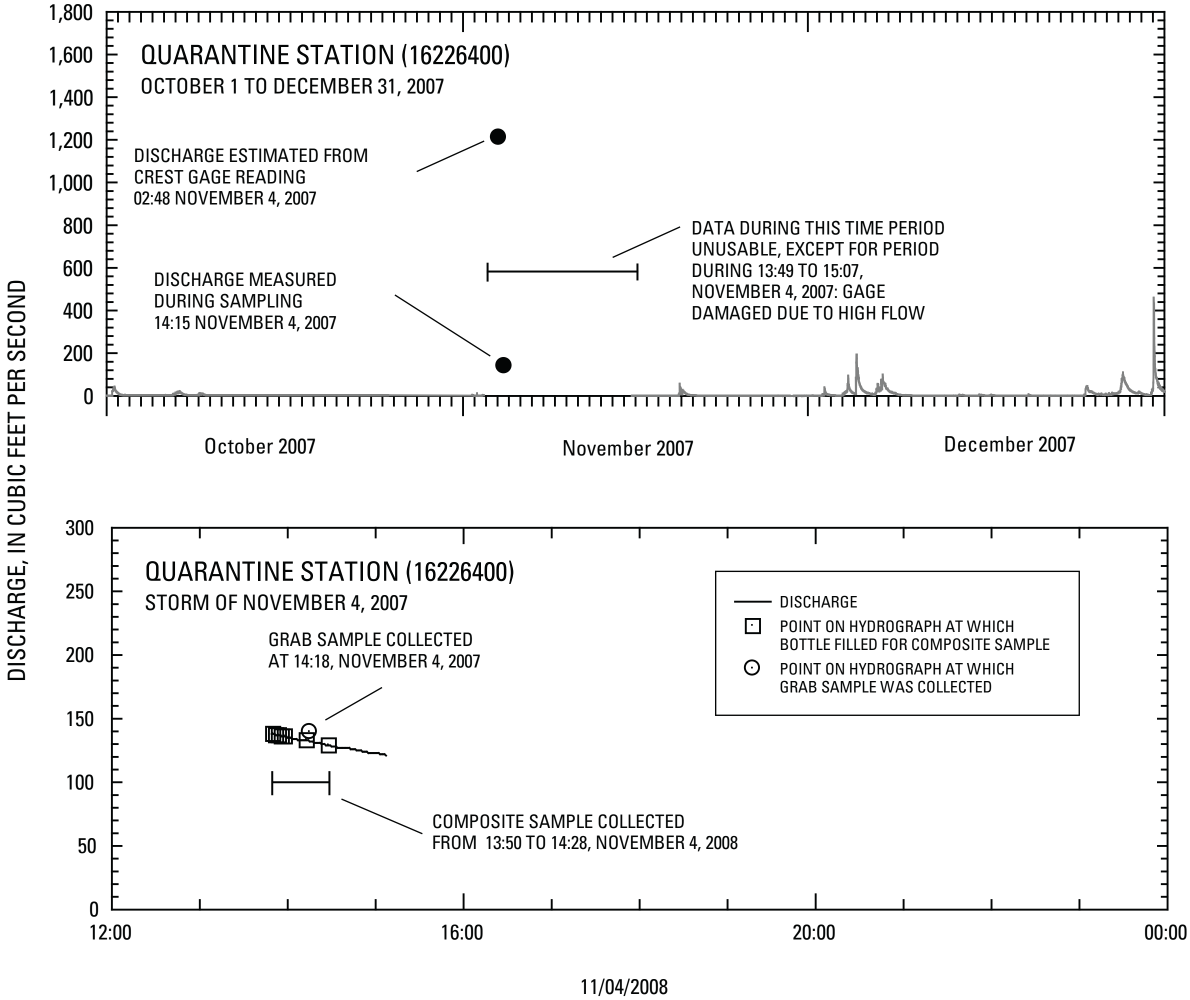

Figure 7. Stream discharge at Quarantine station (16226400) for October 1 to December 31, 2007; and detail of 12-hour period from 12:00 November 4 to 00:00 November 5, 2007, Oahu, Hawaii.

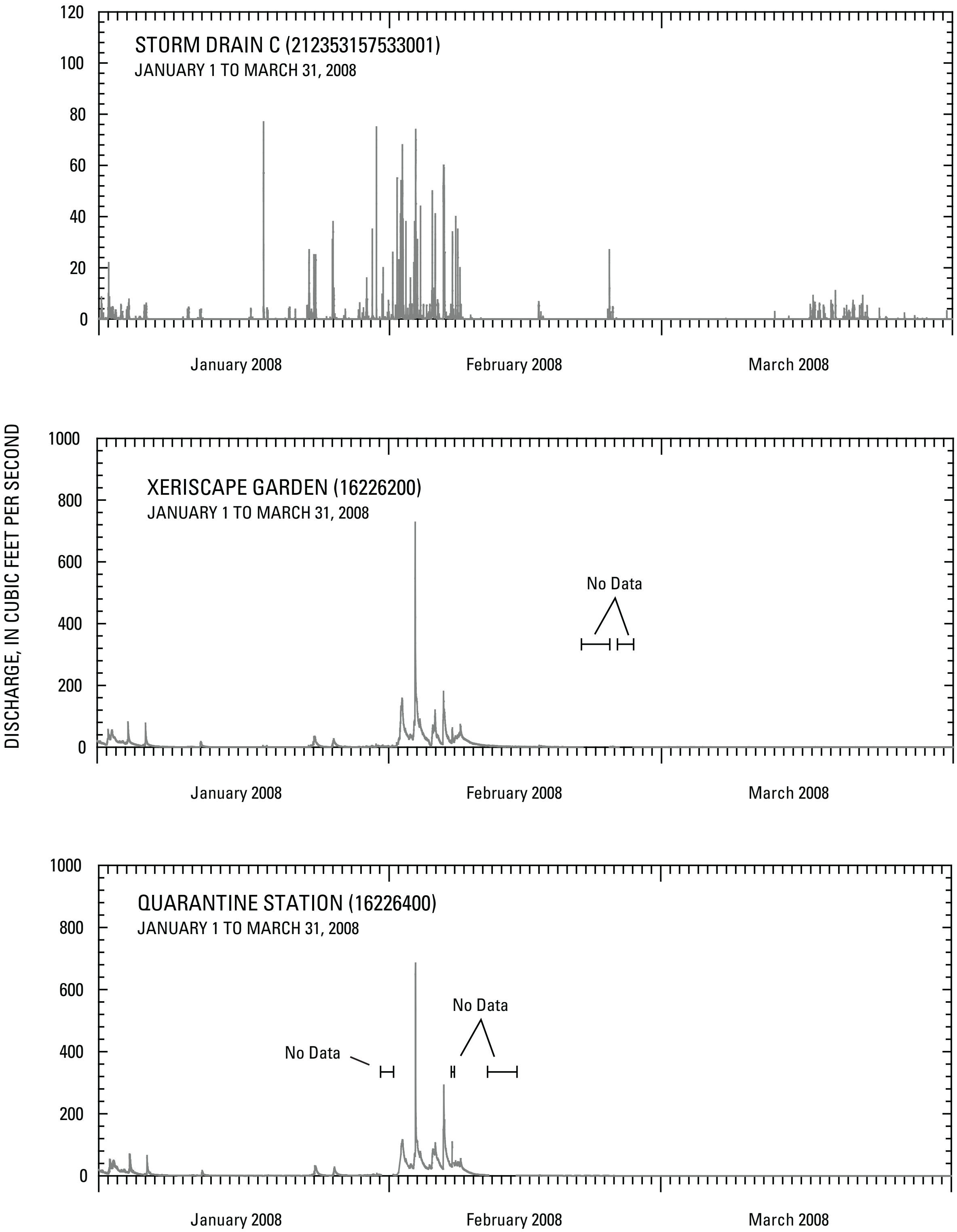

Figure 8. Discharge at Storm Drain C (212353157533001), and stream discharge at Xeriscape garden (16226200) and Quarantine station (16226400), for January 1 to March 31, 2008, Oahu, Hawaii.

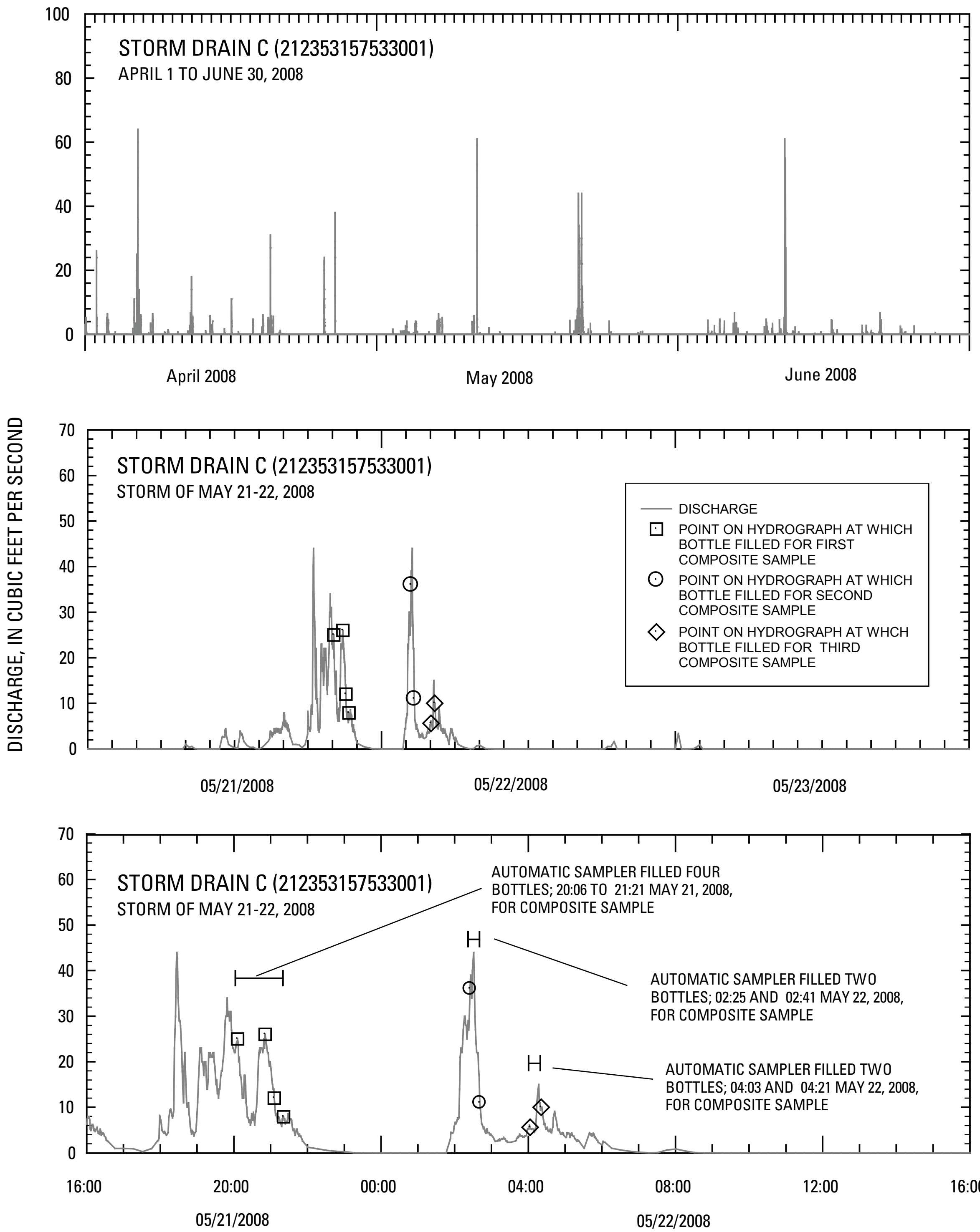

Figure 9. Discharge at Storm drain C (212353157533001) for April 1 to June 30, 2008; detail of 3-day period from May 21 to 23, 2008; and detail of 24-hour period from 16:00 May 21 to 16:00 May 22, 2008, Oahu, Hawaii.

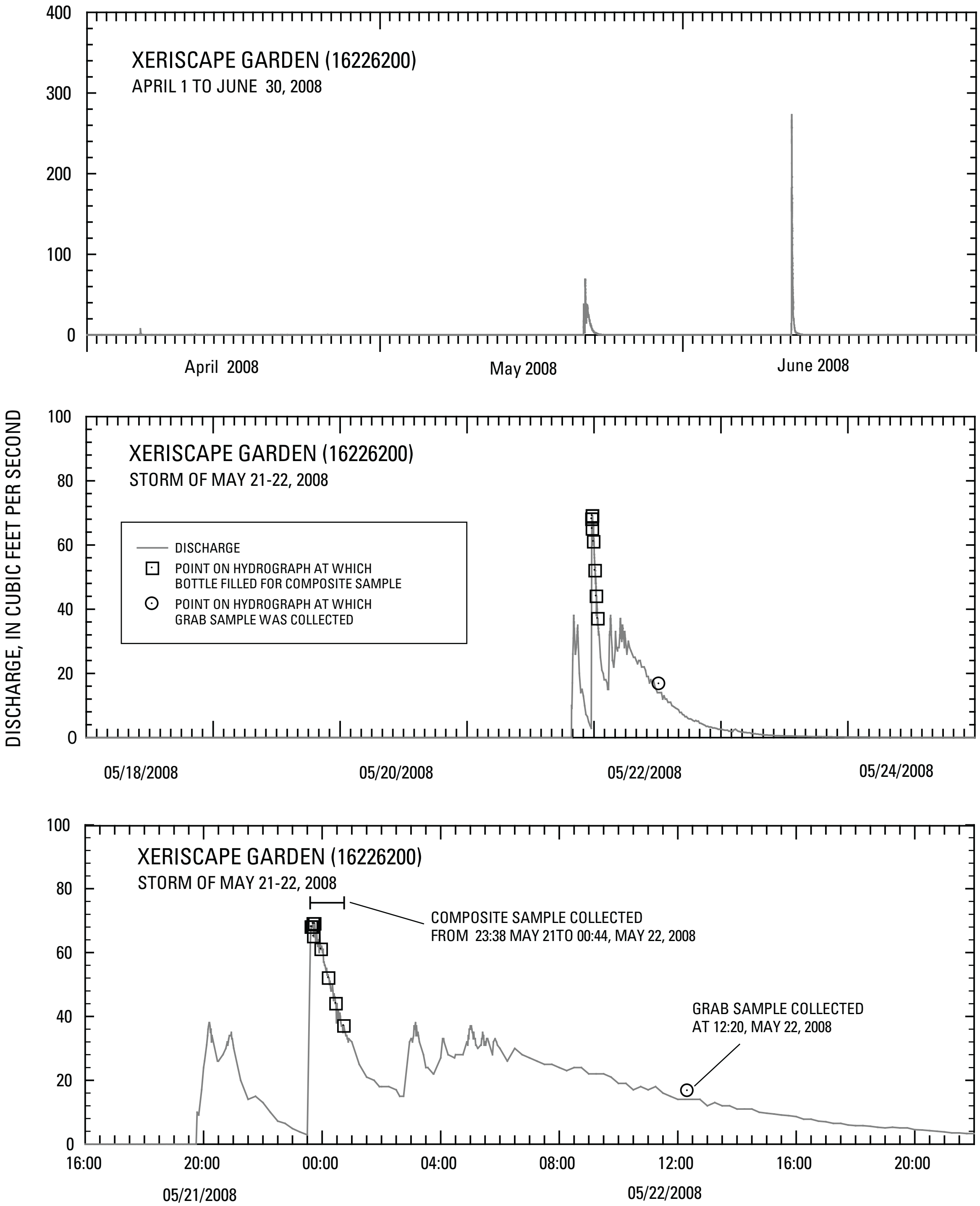

Figure 10. Stream discharge at Xeriscape garden station (16226200) for April 1 to June 30, 2008; detail of 7-day period from May 18 to 24, 2008; and detail of 30-hour period from 16:00 May 21 to 22:00 May 22, 2008, Oahu, Hawaii.

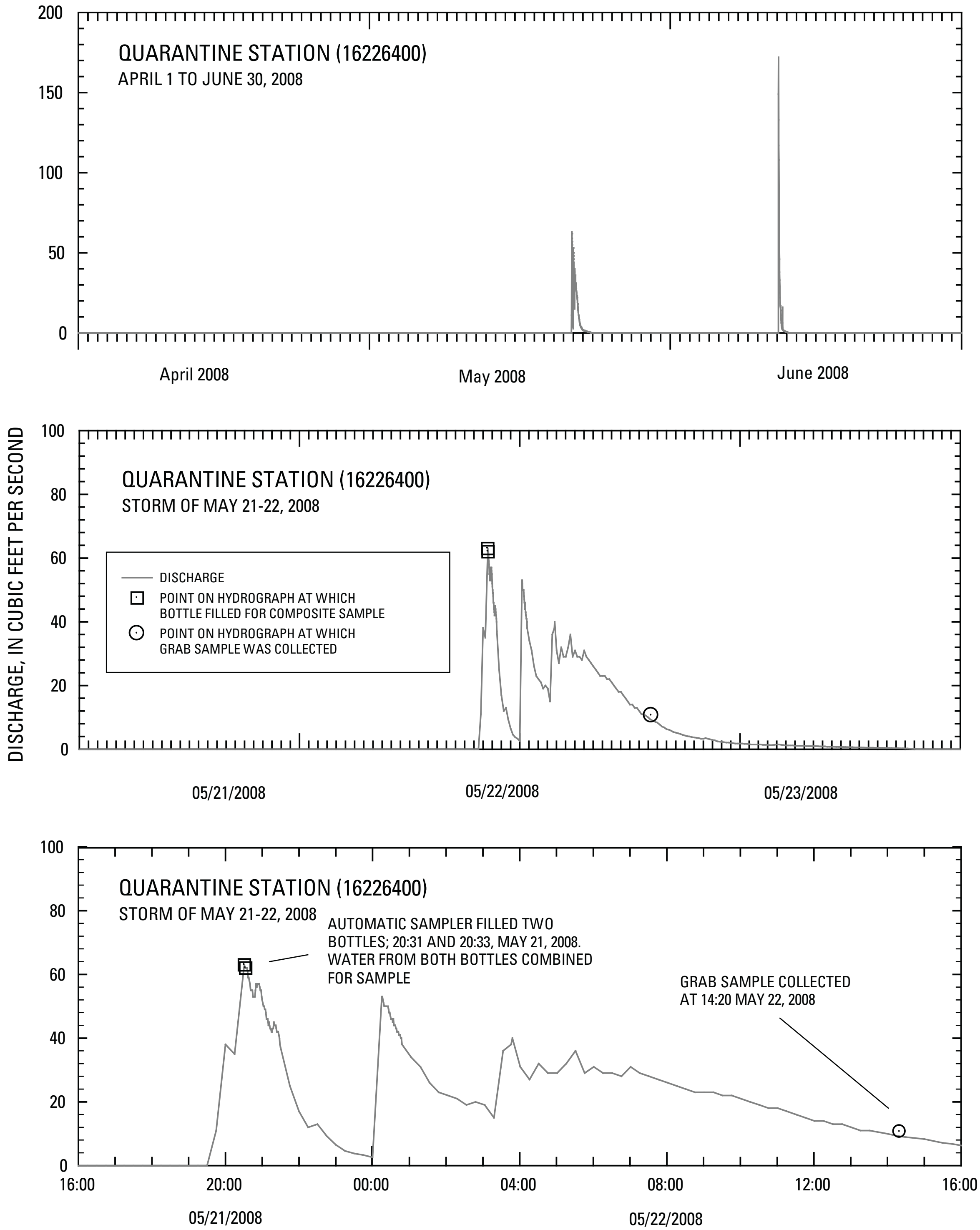

Figure 11. Stream discharge at Quarantine station (16226400) for April 1 to June 30, 2008; detail of 3-day period from May 21 to 23, 2008; and detail of 24-hour period from 16:00 May 21 to 16:00 May 22, 2008, Oahu, Hawaii.

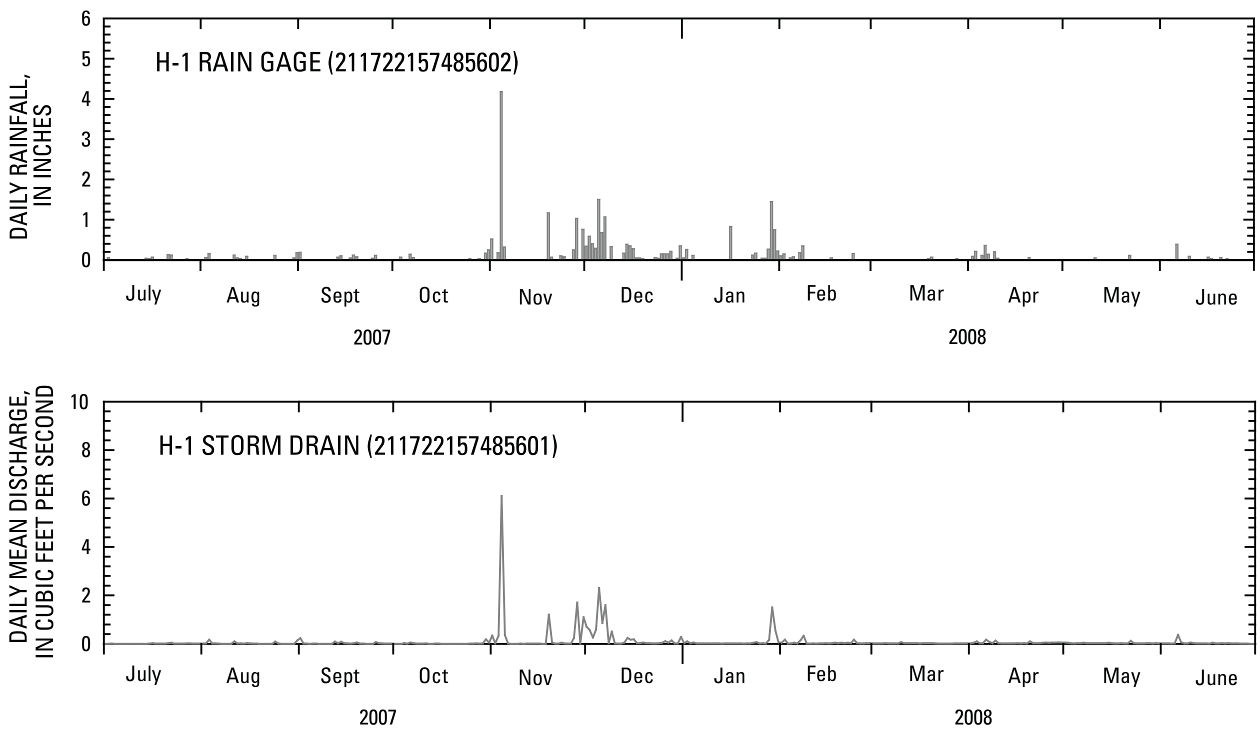

Figure 12. Rainfall for H-1 rain gage and discharge for H-1 storm drain, Oahu, Hawaii, for July 1, 2007, to June 30, 2008.

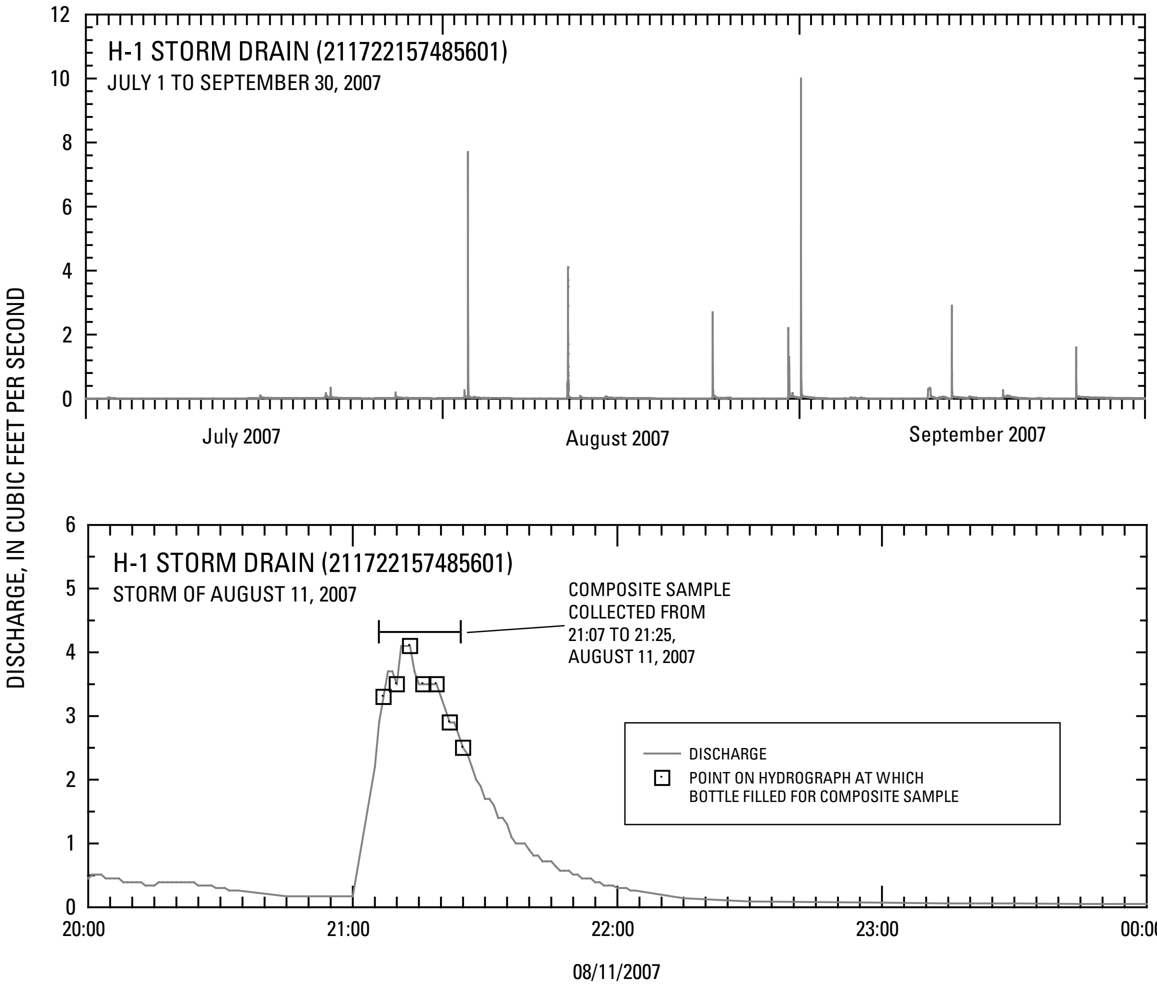

Figure 13. Discharge at H-1 storm drain (211722157485601) for July 1 to September 30, 2007; and detail of 4-hour period from 20:00 August 11 to 00:00 August 12, 2007, Oahu, Hawaii.

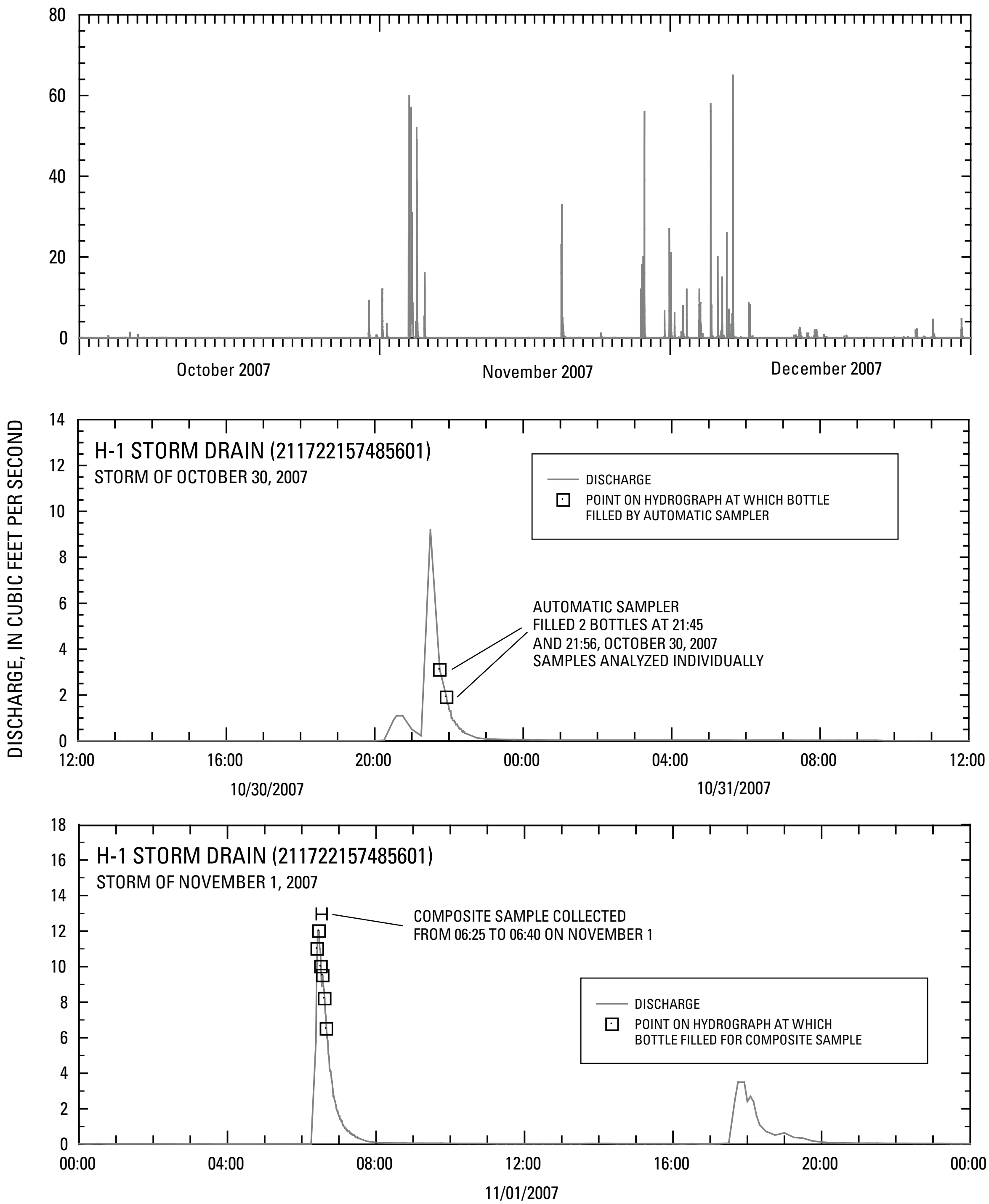

Figure 14. Discharge at H-1 storm drain (211722157485601) for October 1 to December 31, 2007; detail of 24-hour period from 12:00 October 30 to 12:00 October 31, 2007; and detail of 24-hour period from 00:00 November 1 to 00:00 November 2, 2007, Oahu, Hawaii.

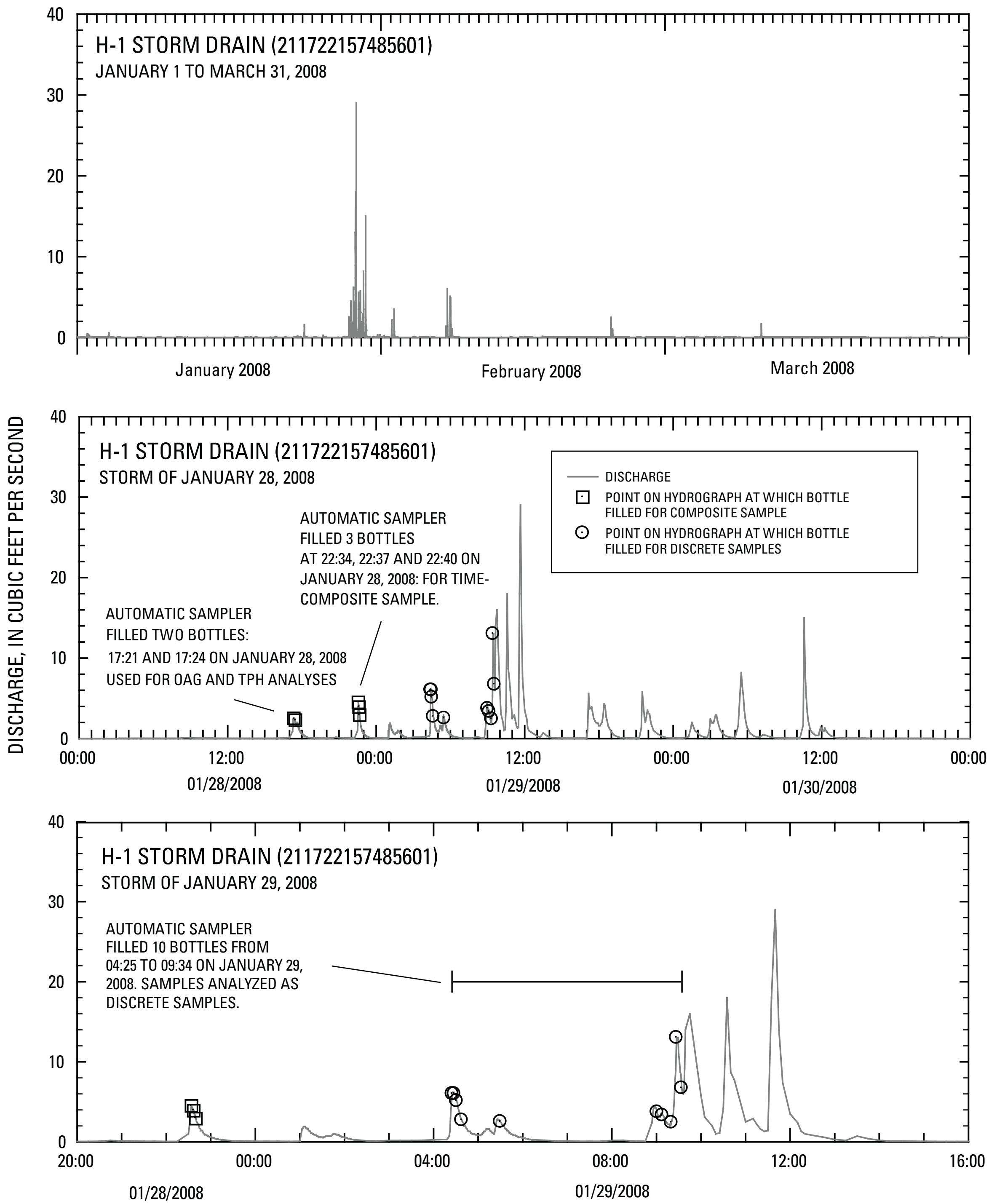

Figure 15. Discharge at H-1 storm drain (211722157485601) for January 1 to March 31, 2008; detail of 3-day period from January 28 to 30, 2008; and detail of 20-hour period from 20:00 January 28 to 16:00 January 29, 2008, Oahu, Hawaii.

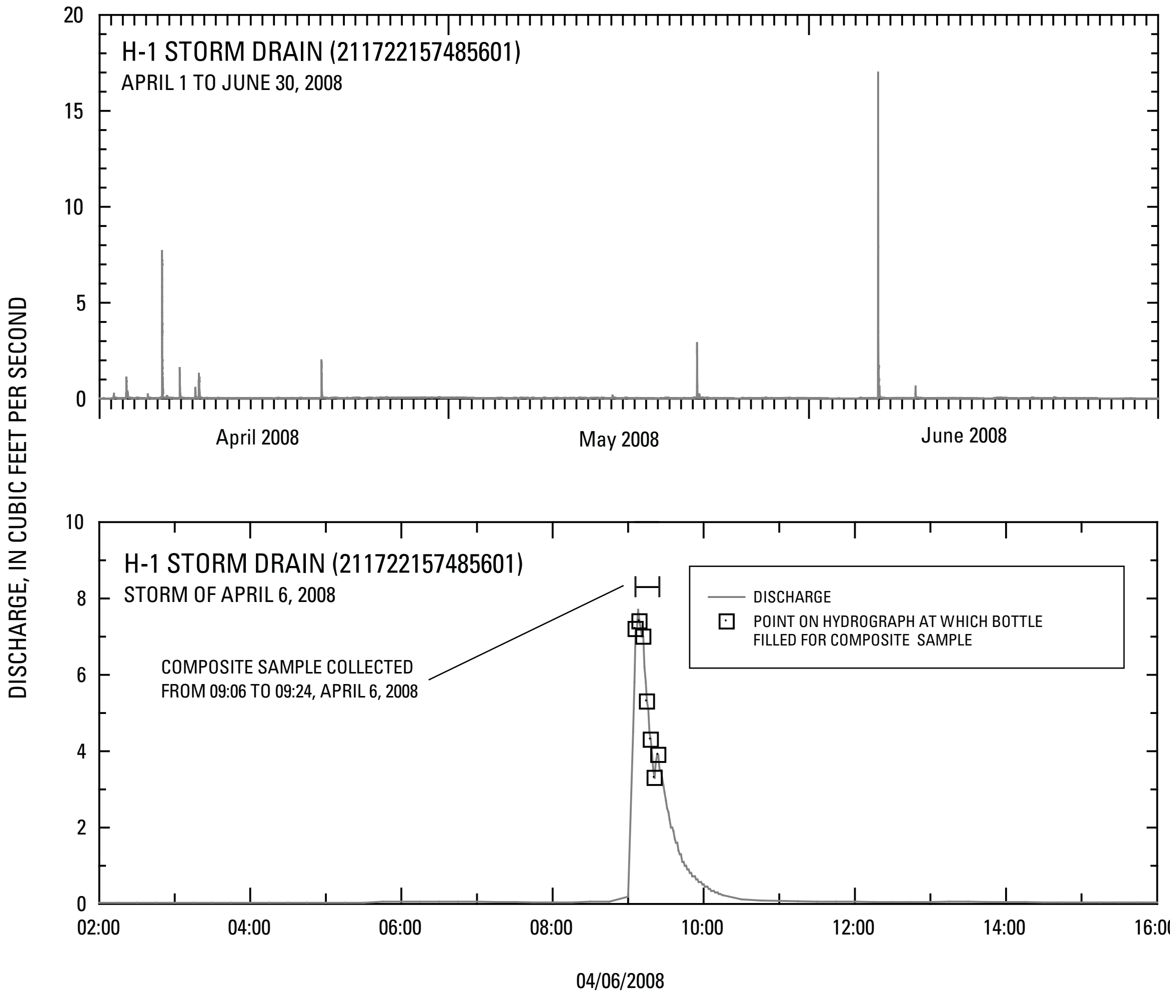

Figure 16. Discharge at H-1 storm drain (211722157485601) for April 1 to June 30, 2008; and detail of 14-hour period from 02:00 to 16:00, April 6, 2008, Oahu, Hawaii.

Appendix A: Discharge-Reporting and Load-Calculation Methods

This appendix further defines the methods used for reporting discharge data and constituent-concentration data and the methods for calculating constituent loads. Discharge and water-quality-data values are rounded off to the number of significant figures that best describe the precision of the measurement.

Discharge data.—Table 2 shows the number of significant figures and rounding limits for the range of discharges used in this study. Discharges measured by current meter or float-measurement techniques follow guidelines for measured discharges. Discharges determined by discharge rating or by averaging follow guidelines for daily mean discharges (Sauer, 2002). Measured discharges may have more significant figures because they are considered more precise than averaged discharges.

Table 2. Significant figures and rounding limits for measured, discharge-rating, and averaged discharges

[ft^3/s, cubic feet per second; <, actual value is less than shown; ≥ , actual value is greater than or equal to value shown]

Range of discharge (ft^3/s)	Measured discharge		Discharge-rating and averaged discharges	
	Significant figures	Rounding limit	Significant figures	Rounding limit
<0.10	2	thousandths	1	hundredths
≥ 0.10 and <1.0	2	hundredths	2	hundredths
≥ 1.0 and < 10	3	hundredths	2	tenths
≥ 10 and < 100	3	tenths	2	units
≥ 100	3	variable	3	variable

Calculation of loads.—Table 3 shows the conversion factors used for determining constituent loads. Constituent loads for all analyses are reported as pounds per day (lbs/day), except for fecal coliform, which is reported as billion colonies per day. All loads are the product of constituent concentration multiplied by associated discharge and the appropriate conversion factor (equation 1). Concentrations are reported in milligrams per liter (mg/L) or micrograms per liter (μg/L), except for fecal coliform, which is reported in most probable number (of colonies) per 100 milliliters (MPN/100 ml).

$$Q(C)K = L, \qquad (1)$$

where Q = discharge ($^{ft^3}/_{s}$),
C = constituent concentration ($^{mg}/_{L}$, $^{\mu g}/_{L}$ or $^{MPN}/_{100\,ml}$),
K = conversion factor, and
L = constituent load ($^{lbs}/_{day}$ or billion colonies per day).

Because the values of concentrations are multiplied by the discharge, a significant-figure rule applies for cases where the number of significant figures for each value is different by at least two figures. In these cases, the value with the greater number of significant figures is rounded off to contain one more significant figure than the value with the lesser number of significant figures, prior to multiplying the values. The load value is reported with the number of significant figures of the value (concentration or discharge) with the least number of significant figures. This significant-figure rule is not applied to the conversion factor, which has four significant figures.

Table 3. Conversion factors for computing daily loads from constituent concentration and discharge

[mg/L, milligrams per liter; µg/L, micrograms per liter; MPN/100mL, most probable number (of colonies) per 100 milliliters; lbs/day, pounds per day]

Unit of concentration	Conversion factor[a]	Load unit
mg/L	5.394	lbs/day
µg/L	0.005394	lbs/day
MPN/100mL	0.02447	billion colonies per day

[a]All conversion factors are based on discharge in cubic feet per second.

Appendix B: Physical Properties, Concentrations, and Loads for All Samples Collected from Halawa Stream Drainage Basin and H-1 Storm Drain During the Period from July 1, 2006, to June 30, 2007, Oahu, Hawaii

Table 4. Physical properties, concentrations, and loads for all samples collected from Halawa Stream drainage basin during the period from July 1, 2007 to June 30, 2008, Oahu, Hawaii

[hh:mm, hours and minutes; Instant., value of instantaneous discharge; Avg., value of average discharge for flow-weighted time-composite samples; Conc., concentration; Load, computed from concentration value and discharge value for each sample, loads associated with grab samples are instantaneous loads, loads associated with composite samples are average loads; <, actual value is less than the value shown; ≤, actual value is less than or equal to the value shown; #, discharge value from streamflow rating, all others are measured; e, value is estimated; --, not analyzed or measured; composite, flow-weighted time-composite sample; M, presence of material verified but not quantified; N, nitrogen; µS/cm, microsiemens per centimeter; ºC, degrees Celsius; ft^3/s, cubic feet per second; mg/L, milligrams per liter; lbs/day, pounds per day; µg/L, micrograms per liter; MPN/100 mL, most probable number (of colonies) per 100 milliliters]

Station name	Date	Median time (hh:mm)	Sample type	Discharge (ft^3/s)		pH, lab reported to nearest 0.1	Specific conductance (µS/cm at 25ºC) reported to nearest whole number	Temperature (ºC) reported to nearest 0.1 ºC	Total suspended solids		Total dissolved solids	
				Instant.	Avg.				Conc. (mg/L)	Load (lbs/day)	Conc. (mg/L)	Load (lbs/day)
Storm of November 4, 2007												
Bridge 8	November 4, 2007	12:53	Grab	167		7.7	120	21.3	96	86,000	88	79,000
Storm drain	November 4, 2007	01:44	Composite		#48	7.5	32		<10.	<2,600	16	4,100
Storm drain	November 4, 2007	11:06	Grab	#0.81		7.2	179	23.1	<10.	<44	117	510
Xeriscape	November 4, 2007	01:58	Composite		#420.	7.2	80		3670	8,310,000	47	110,000
Xeriscape	November 4, 2007	12:06	Grab	#225		7.4	131	21.2	197	239,000	86	100,000
Quarantine	November 4, 2007	14:09	Composite		#133	7.7	162		59	42,000	104	74,600
Quarantine	November 4, 2007	14:18	Grab	139		7.6	163	22.6	92	69,000	99	74,000
Stadium	November 4, 2007	10:43	Grab	1280		7.5	145	21.6	240.	1,660,000	96	660,000
Storm of May 21-22, 2008												
Bridge 8	May 22, 2008	13:23	Grab	11.8		7.8	129	21.5	<10.	<640	108	6,870
Storm drain	May 21, 2008	20:44	Composite		#22	7.7	46		<10.	<1,200	--	--
Storm drain	May 22, 2008	02:33	Composite		#24	7.7	42		--	--	--	--
Storm drain	May 22, 2008	04:12	Composite		#7.8	7.7	62		--	--	--	--
Xeriscape	May 22, 2008	00:11	Composite		#51	7.6	93		94	26,000	79	22,000
Xeriscape	May 22, 2008	12:20	Grab	16.6		7.8	131	21.7	<10.	<900	109	9,760
Quarantine	May 21, 2008	20:32	Composite		#62	7.1	139		454	150,000	--	--
Quarantine	May 22, 2008	14:20	Grab	10.6		8.3	151	22.1	<10.	<570	125	7,150

Table 4. Physical properties, concentrations, and loads for all samples collected from Halawa Stream drainage basin during the period from July 1, 2007 to June 30, 2008, Oahu, Hawaii--Continued

[hh:mm, hours and minutes; Instant., value of instantaneous discharge; Avg., value of average discharge for flow-weighted time-composite samples; Conc., concentration; Load, computed from concentration value and discharge value for each sample, loads associated with grab samples are instantaneous loads, loads associated with composite samples are average loads; <, actual value is less than the value shown; ≤, actual value is less than or equal to the value shown; #, discharge value from streamflow rating, all others are measured; e, value is estimated; --, not analyzed or measured; composite, flow-weighted time-composite sample; M, presence of material verified but not quantified; N, nitrogen; µS/cm, microsiemens per centimeter; ºC, degrees Celsius; ft³/s, cubic feet per second; mg/L, milligrams per liter; lbs/day, pounds per day; µg/L, micrograms per liter; MPN/100 mL, most probable number (of colonies) per 100 milliliters]

Station name	Date	Median time (hh:mm)	Sample type	Total nitrogen[a]		Organic nitrogen[b]		Ammonia dissolved		Nitrogen, total organic + ammonia	
				Conc. (mg/L as N)	Load (lbs/day)	Conc. (mg/L as N)	Load (lbs/day)	Conc. (mg/L as N)	Load (lbs/day)	Conc. (mg/L as N)	Load (lbs/day)
Storm of November 4, 2007											
Bridge 8	November 4, 2007	12:53	Grab	e0.57	e510	≤0.44	≤400	<0.020	<18	0.44	400
Storm drain	November 4, 2007	01:44	Composite	<0.24	<62	<0.11	<28	0.029	7.5	<0.14	<36
Storm drain	November 4, 2007	11:06	Grab	e1.16	e5.1	e0.15	e0.66	e0.013	e0.057	0.16	0.70
Xeriscape	November 4, 2007	01:58	Composite	e24	e54,000	≤24	≤54,000	<0.020	<45	24	54,000
Xeriscape	November 4, 2007	12:06	Grab	e1.38	e1,670	e0.87	e1,100	e0.020	e24	0.89	1,100
Quarantine	November 4, 2007	14:09	Composite	e1.14	e818	e0.48	e340	e0.019	e14	0.50	360
Quarantine	November 4, 2007	14:18	Grab	e1.17	e877	≤0.55	≤410	<0.020	<15	0.55	410
Stadium	November 4, 2007	10:43	Grab	e2.2	e15,000	e1.1	e7,600	e0.015	e100	1.1	7,600
Storm of May 21-22, 2008											
Bridge 8	May 22, 2008	13:23	Grab	0.45	29	≤0.19	≤12	<0.020	<1.3	0.19	12
Storm drain	May 21, 2008	20:44	Composite	≥0.16	≥19	≤0.16	≤19	--	--	0.16	19
Storm drain	May 22, 2008	02:33	Composite	--	--	--	--	--	--	--	--
Storm drain	May 22, 2008	04:12	Composite	--	--	--	--	--	--	--	--
Xeriscape	May 22, 2008	00:11	Composite	1.8	500	≤1.4	≤390	<0.020	<5.5	1.4	390
Xeriscape	May 22, 2008	12:20	Grab	0.49	44	≤0.26	≤23	<0.020	<1.8	0.26	23
Quarantine	May 21, 2008	20:32	Composite	≥3.4	≥1,100	<3.4	<1,100	--	--	3.4	1,100
Quarantine	May 22, 2008	14:20	Grab	0.53	30.	≤0.24	≤14	<0.020	<1.1	0.24	14

Table 4. Physical properties, concentrations, and loads for all samples collected from Halawa Stream drainage basin during the period from July 1, 2007 to June 30, 2008, Oahu, Hawaii--Continued

[hh:mm, hours and minutes; Instant., value of instantaneous discharge; Avg., value of average discharge for flow-weighted time-composite samples; Conc., concentration; Load, computed from concentration value and discharge value for each sample, loads associated with grab samples are instantaneous loads, loads associated with composite samples are average loads; <, actual value is less than the value shown; ≤, actual value is less than or equal to the value shown; #, discharge value from streamflow rating, all others are measured; e, value is estimated; --, not analyzed or measured; composite, flow-weighted time-composite sample; M, presence of material verified but not quantified; N, nitrogen; µS/cm, microsiemens per centimeter; ºC, degrees Celsius; ft^3/s, cubic feet per second; mg/L, milligrams per liter; lbs/day, pounds per day; µg/L, micrograms per liter; MPN/100 mL, most probable number (of colonies) per 100 milliliters]

Station name	Date	Median time (hh:mm)	Sample type	Nitrogen, nitrite + nitrate dissolved		Phosphorus dissolved		Total phosphorus		Chemical oxygen demand	
				Conc. (mg/L as N)	Load (lbs/day)	Conc. (mg/L)	Load (lbs/day)	Conc. (mg/L)	Load (lbs/day)	Conc (mg/L)	Load (lbs/day)
Storm of November 4, 2007											
Bridge 8	November 4, 2007	12:53	Grab	e0.13	e120	<0.04	<40	0.15	140	20	20,000
Storm drain	November 4, 2007	01:45	Composite	e0.10	e26	<0.04	<10.	e0.03	e8	<10	<3,000
Storm drain	November 4, 2007	11:06	Grab	e1.00	e4.4	e0.03	e0.1	0.05	0.2	<10	<40
Xeriscape	November 4, 2007	01:58	Composite	e0.39	e880	<0.04	<90	5.45	12,300	--	--
Xeriscape	November 4, 2007	12:06	Grab	e0.49	e590	<0.04	<50	0.32	390	30	40,000
Quarantine	November 4, 2007	14:16	Composite	e0.64	e460	e0.03	e20	0.11	79	20	10,000
Quarantine	November 4, 2007	14:18	Grab	e0.62	e460	<0.04	<30	0.14	100	20	20,000
Stadium	November 4, 2007	10:43	Grab	e1.10	e7,590	0.05	400	0.42	2,900	40	300,000
Storm of May 21-22, 2008											
Bridge 8	May 22, 2008	13:23	Grab	0.26	17	<0.04	<3	e0.03	e2	<10	<600
Storm drain	May 21, 2008	20:44	Composite	--	--	--	--	e0.03	e4	--	--
Storm drain	May 22, 2008	02:33	Composite	--	--	--	--	--	--	--	--
Storm drain	May 22, 2008	04:12	Composite	--	--	--	--	--	--	--	--
Xeriscape	May 22, 2008	00:11	Composite	0.35	96	<0.04	<10	0.21	58	50	10,000
Xeriscape	May 22, 2008	12:20	Grab	0.23	21	<0.04	<4	e0.03	e3	<10	<900
Quarantine	May 21, 2008	20:32	Composite	--	--	--	--	1.24	410	--	--
Quarantine	May 22, 2008	14:20	Grab	0.29	17	<0.04	<2	e0.03	e2	<10	<600

Table 4. Physical properties, concentrations, and loads for all samples collected from Halawa Stream drainage basin during the period from July 1, 2007 to June 30, 2008, Oahu, Hawaii--Continued

[hh:mm, hours and minutes; Instant., value of instantaneous discharge; Avg., value of average discharge for flow-weighted time-composite samples; Conc., concentration; Load, computed from concentration value and discharge value for each sample, loads associated with grab samples are instantaneous loads, loads associated with composite samples are average loads; <, actual value is less than the value shown; ≤, actual value is less than or equal to the value shown; #, discharge value from streamflow rating, all others are measured; e, value is estimated; --, not analyzed or measured; composite, flow-weighted time-composite sample; M, presence of material verified but not quantified; N, nitrogen; µS/cm, microsiemens per centimeter; ºC, degrees Celsius; ft³/s, cubic feet per second; mg/L, milligrams per liter; lbs/day, pounds per day; µg/L, micrograms per liter; MPN/100 mL, most probable number (of colonies) per 100 milliliters]

Station name	Date	Median time (hh:mm)	Sample type	Total cadmium		Total chromium		Total copper		Total lead	
				Conc. (µg/L)	Load (lbs/day)	Conc. (µg/L)	Load (lbs/day)	Conc. (µg/L)	Load (lbs/day)	Conc. (µg/L)	Load (lbs/day)
Storm of November 4, 2007											
Bridge 8	November 4, 2007	12:53	Grab	0.02	0.02	14	13	7.4	6.7	0.41	0.37
Storm drain	November 4, 2007	01:44	Composite	0.02	0.01	M	--	2.6	0.67	0.38	0.098
Storm drain	November 4, 2007	11:06	Grab	0.03	0.0001	4	0.02	3.9	0.017	0.54	0.0024
Xeriscape	November 4, 2007	01:58	Composite	0.84	1.9	289	655	168	381	22.5	51.0
Xeriscape	November 4, 2007	12:06	Grab	0.04	0.05	29	35	15.8	19.2	1.24	1.50
Quarantine	November 4, 2007	14:09	Composite	0.02	0.01	8	6	5.9	4.2	0.41	0.29
Quarantine	November 4, 2007	14:18	Grab	0.03	0.02	13	9.7	7.8	5.8	0.69	0.52
Stadium	November 4, 2007	10:43	Grab	0.06	0.4	29	200	19.5	135	3.30	22.8
Storm of May 21-22, 2008											
Bridge 8	May 22, 2008	13:23	Grab	0.03	0.002	1	0.06	1.8	0.11	0.09	0.006
Storm drain	May 21, 2008	20:44	Composite	0.03	0.004	2	0.2	4.0	0.47	0.52	0.062
Storm drain	May 22, 2008	02:33	Composite	0.03	0.004	1	0.1	3.8	0.49	0.99	0.13
Storm drain	May 22, 2008	04:12	Composite	0.09	0.004	2	0.08	3.9	0.16	0.44	0.019
Xeriscape	May 22, 2008	00:11	Composite	0.10	0.028	8	2	18.2	5.0	3.19	0.88
Xeriscape	May 22, 2008	12:20	Grab	e0.01	e0.0009	1	0.09	2.4	0.21	0.10	0.0090
Quarantine	May 21, 2008	20:32	Composite	0.35	0.12	37	12	50.3	17	12.7	4.2
Quarantine	May 22, 2008	14:20	Grab	e0.01	e0.0006	2	0.1	2.2	0.13	0.12	0.0069

Table 4. Physical properties, concentrations, and loads for all samples collected from Halawa Stream drainage basin during the period from July 1, 2007 to June 30, 2008, Oahu, Hawaii--Continued

[hh:mm, hours and minutes; Instant., value of instantaneous discharge; Avg., value of average discharge for flow-weighted time-composite samples; Conc., concentration; Load, computed from concentration value and discharge value for each sample, loads associated with grab samples are instantaneous loads, loads associated with composite samples are average loads; <, actual value is less than the value shown; ≤, actual value is less than or equal to the value shown; #, discharge value from streamflow rating, all others are measured; e, value is estimated; --, not analyzed or measured; composite, flow-weighted time-composite sample; M, presence of material verified but not quantified; N, nitrogen; µS/cm, microsiemens per centimeter; °C, degrees Celsius; ft^3/s, cubic feet per second; mg/L,milligrams per liter; lbs/day, pounds per day; µg/L,micrograms per liter; MPN/100 mL, most probable number (of colonies) per 100 milliliters]

Station name	Date	Median time (hh:mm)	Sample type	Total zinc		Oil and grease		Total petroleum hydrocarbons		Biological oxygen demand		Fecal coliform	
				Conc. (µg/L)	Load (lbs/day)	Conc. (mg/L)	Load (lbs/day)	Conc. (mg/L)	Load (lbs/day)	Conc. (mg/L)	Load (lbs/day)	Conc. (MPN/100 mL)	Load (billion colonies per day)
Storm of November 4, 2007													
Bridge 8	November 4, 2007	12:53	Grab	8.2	7.4	e5	e5,000	<2	<2,000	--	--	--	--
Storm drain	November 4, 2007	01:44	Composite	10.5	2.7	--	--	--	--	--	--	--	--
Storm drain	November 4, 2007	11:06	Grab	17.9	0.078	<8	<30	<2	<9	--	--	--	--
Xeriscape	November 4, 2007	01:58	Composite	217	492	--	--	--	--	--	--	--	--
Xeriscape	November 4, 2007	12:06	Grab	19.0	23.1	<8	<9,000	<2	<2,000	--	--	--	--
Quarantine	November 4, 2007	14:09	Composite	8.8	6.3	--	--	--	--	--	--	--	--
Quarantine	November 4, 2007	14:18	Grab	9.8	7.3	<8	<6,000	2	2,000	--	--	--	--
Stadium	November 4, 2007	10:43	Grab	57.6	398	<8	<60,000	2	10,000	--	--	--	--
Storm of May 21-22, 2008													
Bridge 8	May 22, 2008	13:23	Grab	e1.1	e0.070	e4.6	e290	<5.0	<320	<1.0	<64	500	100
Storm drain	May 21, 2008	20:44	Composite	32.7	3.9	--	--	--	--	--	--	--	--
Storm drain	May 22, 2008	02:33	Composite	23.2	3.0	--	--	--	--	--	--	--	--
Storm drain	May 22, 2008	04:12	Composite	112	4.7	--	--	--	--	--	--	--	--
Xeriscape	May 22, 2008	00:11	Composite	60.8	17	--	--	--	--	--	--	--	--
Xeriscape	May 22, 2008	12:20	Grab	2.5	0.22	e3.5	e310	<5.0	<450	1.0	90.	2300	930
Quarantine	May 21, 2008	20:32	Composite	146	49	--	--	--	--	--	--	--	--
Quarantine	May 22, 2008	14:20	Grab	10.5	0.600	<5.0	<290	<5.0	<290	1.0	57	5000	1,300

[a] Total nitrogen is calculated by adding nitrogen, total organic + ammonia (Kjeldahl), to nitrogen, nitrite + nitrate, dissolved. If the concentration value of nitrogen, nitrite + nitrate dissolved, is estimated and below the minimum reporting level, the concentration value of total nitrogen is reported as the sum of the values shown for nitrogen, total organic + ammonia (Kjeldahl) and nitrogen, nitrite + nitrate dissolved, and noted as estimated. If the concentration value of nitrogen, nitrite + nitrate, dissolved is below the minimum reporting level, the concentration value of total nitrogen is reported as less than the sum of the values shown for nitrogen, total organic + ammonia (Kjeldahl) and nitrogen, nitrite + nitrate dissolved, which represents the maximum possible value for total nitrogen. If the concentration value of nitrogen, nitrite + nitrate dissolved, is not analyzed or measured, the concentration value for total nitrogen is reported as greater than or equal to the value shown for nitrogen, total organic + ammonia (Kjeldahl).

[b] Organic nitrogen is calculated by subtracting nitrogen ammonia, dissolved, from total organic + ammonia (Kjeldahl). If the concentration value of nitrogen ammonia, dissolved is below the minimum reporting level, or not analyzed or measured, the concentration value for organic nitrogen is reported as less than or equal to the value of total organic + ammonia (Kjeldahl), which represents the maximum possible value for organic nitrogen. If the concentration value of nitrogen ammonia, dissolved is estimated and below the minimum reporting level, the concentration value of organic nitrogen is reported as the difference between the values shown for nitrogen, total organic + ammonia (Kjeldahl), and nitrogen ammonia, dissolved, and noted as estimated. If the concentration value of total organic + ammonia (Kjeldahl) is reported as less than the minimum reporting level, the concentration value of organic nitrogen is reported as less than the difference between the values shown for nitrogen, total organic + ammonia (Kjeldahl), and nitrogen ammonia.

Table 5. Physical properties, concentrations, and loads for all samples collected from H-1 Storm Drain during the period from July 1, 2007 to June 30, 2008, Oahu, Hawaii

[hh:mm, hours and minutes; Avg., value of average discharge for time-composite samples; Conc., concentration; Load, computed from concentration value and discharge value for each sample, loads associated with grab samples are instantaneous loads, loads associated with composite samples are average loads; <, actual value is less than the value shown; ≤, actual value is less than or equal to the value shown; N, nitrogen; #, discharge value from streamflow rating, all others are measured; e, value is estimated; --, not analyzed or measured; composite, flow-weighted time-composite sample; µS/cm, microsiemens per centimeter; ºC, degrees Celsius; ft^3/s, cubic feet per second; mg/L,milligrams per liter; lbs/day, pounds per day; µg/L,micrograms per liter; MPN/100 mL, most probable number (of colonies) per 100 milliliters]

Date	Time	Sample type	Discharge	pH, lab reported to nearest 0.1	Specific conductance (µS/cm at 25ºC) reported to nearest whole number	Total suspended solids		Total nitrogen[a]		Organic nitrogen[b]	
			Avg. (ft3/s)			Conc. (mg/L)	Load (lbs/day)	Conc. (mg/L as N)	Load (lbs/day)	Conc. (mg/L as N)	Load (lbs/day)
August 11, 2007	21:16	Composite	# 3.4	7.0	160	222	4,100	4.0	73	e3.7	e68
October 30, 2007	21:45	Grab	# 2.7	7.4	172	--	--	--	--	--	--
October 30, 2007	21:56	Grab	# 1.6	7.2	154	--	--	--	--	--	--
November 1, 2007	06:32	Composite	# 9.7	7.7	127	360	19,000	e5.0	e260	4.6	240
January 28, 2008	20:00	Composite	# 3.8	7.2	157	540	11,000	9.3	190	≤9.1	≤190
January 29, 2008	04:25	Grab	# 6.0	7.2	150	--	--	4.1	130	≤4.0	≤130
January 29, 2008	04:28	Grab	# 6.0	7.2	111	--	--	3.2	100	3.1	100
January 29, 2008	04:31	Grab	# 5.1	7.1	97	--	--	2.1	58	e2.0	e55
January 29, 2008	04:38	Grab	# 2.7	7.1	102	--	--	1.3	19	e2.1	e17
January 29, 2008	05:30	Grab	# 2.6	7.5	140	--	--	1.1	15	0.95	13
January 29, 2008	09:01	Grab	# 3.7	7.4	146	--	--	2.4	48	2.3	46
January 29, 2008	09:08	Grab	# 3.3	7.3	138	--	--	2.9	52	2.8	50
January 29, 2008	09:20	Grab	# 2.4	7.3	142	--	--	2.2	28	2.0	26
January 29, 2008	09:27	Grab	# 13	6.8	119	--	--	4.0	280	3.9	270
January 29, 2008	09:34	Grab	# 6.7	7.1	107	--	--	2.9	100	2.8	100
April 6, 2008	09:15	Composite	# 5.5	7.6	140	288	8,500	4.3	130	e4.1	e120

Table 5. Physical properties, concentrations, and loads for all samples collected from H-1 Storm Drain during the period from July 1, 2007 to June 30, 2008, Oahu, Hawaii--Continued

[hh:mm, hours and minutes; Avg., value of average discharge for time-composite samples; Conc., concentration; Load, computed from concentration value and discharge value for each sample, loads associated with grab samples are instantaneous loads, loads associated with composite samples are average loads; <, actual value is less than the value shown; ≤, actual value is less than or equal to the value shown; N, nitrogen; #, discharge value from streamflow rating, all others are measured; e, value is estimated; --, not analyzed or measured; composite, flow-weighted time-composite sample; µS/cm, microsiemens per centimeter; ºC, degrees Celsius; ft^3/s, cubic feet per second; mg/L, milligrams per liter; lbs/day, pounds per day; µg/L, micrograms per liter; MPN/100 mL, most probable number (of colonies) per 100 milliliters]

Date	Time	Sample type	Ammonia dissolved		Nitrogen, total organic + ammonia		Nitrogen, nitrite + nitrate dissolved		Phosphorus dissolved		Total phosphorus	
			Conc. (mg/L as N)	Load (lbs/day)	Conc. (mg/L as N)	Load (lbs/day)	Conc. (mg/L as N)	Load (lbs/day)	Conc. (mg/L)	Load (lbs/day)	Conc. (mg/L)	Load (lbs/day)
August 11, 2007	21:16	Composite	e0.018	e0.33	3.7	68	0.25	4.6	0.15	2.8	1.05	19
October 30, 2007	21:45	Grab	--	--	--	--	--	--	--	--	--	--
October 30, 2007	21:56	Grab	--	--	--	--	--	--	--	--	--	--
November 1, 2007	06:32	Composite	0.08	4	4.7	250	e0.35	e18	0.14	7.3	1.74	91
January 28, 2008	20:00	Composite	<0.020	<0.41	9.1	190	0.17	3.5	0.09	2	2.20	45
January 29, 2008	04:25	Grab	<0.020	<0.65	4.0	130	0.14	4.5	0.09	3	1.42	46
January 29, 2008	04:28	Grab	0.021	0.68	3.1	100	0.09	3	0.09	3	1.04	34
January 29, 2008	04:31	Grab	e0.018	e0.50	2.0	55	0.09	2	0.07	2	0.72	20
January 29, 2008	04:38	Grab	e0.012	e0.17	1.2	17	0.11	1.6	0.09	1	0.43	6.3
January 29, 2008	05:30	Grab	0.027	0.38	0.98	14	0.12	1.7	0.10	1.4	0.33	4.6
January 29, 2008	09:01	Grab	0.034	0.68	2.3	46	0.12	2.4	0.08	2	0.80	16
January 29, 2008	09:08	Grab	0.037	0.66	2.8	50	0.12	2.1	0.09	2	0.86	15
January 29, 2008	09:20	Grab	0.034	0.44	2.0	26	0.17	2.2	0.09	1	0.67	8.7
January 29, 2008	09:27	Grab	0.046	3.2	3.9	270	0.1	7	0.07	5	1.51	110
January 29, 2008	09:34	Grab	0.044	1.6	2.8	100	0.1	4	0.10	3.6	0.94	34
April 6, 2008	09:15	Composite	e0.017	e0.50	4.1	120	0.16	4.7	0.11	3.3	1.15	34

Table 5. Physical properties, concentrations, and loads for all samples collected from H-1 Storm Drain during the period from July 1, 2007 to June 30, 2008, Oahu, Hawaii--Continued

[hh:mm, hours and minutes; Avg., value of average discharge for time-composite samples; Conc., concentration; Load, computed from concentration value and discharge value for each sample, loads associated with grab samples are instantaneous loads, loads associated with composite samples are average loads; <, actual value is less than the value shown; ≤, actual value is less than or equal to the value shown; N, nitrogen; #, discharge value from streamflow rating, all others are measured; e, value is estimated; --, not analyzed or measured; composite, flow-weighted time-composite sample; µS/cm, microsiemens per centimeter; ºC, degrees Celsius; ft^3/s, cubic feet per second; mg/L, milligrams per liter; lbs/day, pounds per day; µg/L, micrograms per liter; MPN/100 mL, most probable number (of colonies) per 100 milliliters]

Date	Time	Sample type	Total cadmium		Total chromium		Total copper		Total lead		Total nickel	
			Conc. (µg/L)	Load (lbs/day)	Conc. (µg/L)	Load (lbs/day)	Conc. (µg/L)	Load (lbs/day)	Conc. (µg/L)	Load (lbs/day)	Conc. (µg/L)	Load (lbs/day)
August 11, 2007	21:16	Composite	0.99	0.018	30	0.55	188	3.5	112	2.1	33.3	0.61
October 30, 2007	21:45	Grab	2.16	0.031	72	1.0	374	5.4	243	3.5	78.9	1.1
October 30, 2007	21:56	Grab	0.98	0.0085	40	0.35	211	1.8	172	1.5	34.2	0.30
November 1, 2007	06:32	Composite	3.01	0.16	71	3.7	370	19	250	13	84.5	4.4
January 28, 2008	20:00	Composite	1.78	0.036	64	1.3	371	7.6	189	3.9	87.6	1.8
January 29, 2008	04:25	Grab	1.38	0.045	51	1.7	322	10.	173	5.6	72.7	2.4
January 29, 2008	04:28	Grab	0.95	0.031	38	1.2	228	7.4	116	3.8	52.4	1.7
January 29, 2008	04:31	Grab	0.58	0.016	23	0.63	138	3.8	73.5	2.0	34.6	0.95
January 29, 2008	04:38	Grab	0.38	0.0055	16	0.23	90.2	1.3	41.3	0.60	18.8	0.27
January 29, 2008	05:30	Grab	0.27	0.0038	10	0.14	73.3	1.0	30.6	0.43	12.1	0.17
January 29, 2008	09:01	Grab	0.72	0.014	31	0.62	181	3.6	78.0	1.6	36.5	0.73
January 29, 2008	09:08	Grab	0.87	0.015	36	0.64	216	3.8	106	1.9	36.3	0.65
January 29, 2008	09:20	Grab	0.54	0.0070	34	0.44	139	1.8	79.8	1.0	30.4	0.39
January 29, 2008	09:27	Grab	1.60	0.11	73	5.1	363	25	203	14	98.2	6.9
January 29, 2008	09:34	Grab	0.87	0.031	46	1.7	187	6.8	110	4.0	47.5	1.7
April 6, 2008	09:15	Composite	1.00	0.030	39	1.2	199	5.9	120	3.6	41.1	1.2

Table 5. Physical properties, concentrations, and loads for all samples collected from H-1 Storm Drain during the period from July 1, 2007 to June 30, 2008, Oahu, Hawaii--Continued

[hh:mm, hours and minutes; Avg., value of average discharge for time-composite samples; Conc., concentration; Load, computed from concentration value and discharge value for each sample, loads associated with grab samples are instantaneous loads, loads associated with composite samples are average loads; <, actual value is less than the value shown; ≤, actual value is less than or equal to the value shown; N, nitrogen; #, discharge value from streamflow rating, all others are measured; e, value is estimated; --, not analyzed or measured; composite, flow-weighted time-composite sample; µS/cm, microsiemens per centimeter; ºC, degrees Celsius; ft3/s, cubic feet per second; mg/L,milligrams per liter; lbs/day, pounds per day; µg/L, micrograms per liter; MPN/100 mL, most probable number (of colonies) per 100 milliliters]

Date	Time	Sample type	Total zinc		Oil and grease		Total petroleum hydrocarbons	
			Conc. (µg/L)	Load (lbs/day)	Conc. (mg/L)	Load (lbs/day)	Conc. (mg/L)	Load (lbs/day)
August 11, 2007	21:16	Composite	653	12	17	310	--	--
October 30, 2007	21:45	Grab	1250	18	--	--	--	--
October 30, 2007	21:56	Grab	640	5.5	--	--	--	--
November 1, 2007	06:32	Composite	1200	63	--	--	--	--
January 28, 2008	20:00	Composite	1170	24	9.60	200	6.1	130
January 29, 2008	04:25	Grab	962	31	--	--	--	--
January 29, 2008	04:28	Grab	637	21	--	--	--	--
January 29, 2008	04:31	Grab	395	11	--	--	--	--
January 29, 2008	04:38	Grab	236	3.4	--	--	--	--
January 29, 2008	05:30	Grab	208	2.9	--	--	--	--
January 29, 2008	09:01	Grab	583	12	--	--	--	--
January 29, 2008	09:08	Grab	610	11	--	--	--	--
January 29, 2008	09:20	Grab	444	5.7	--	--	--	--
January 29, 2008	09:27	Grab	1050	74	--	--	--	--
January 29, 2008	09:34	Grab	525	19	--	--	--	--
April 6, 2008	09:15	Composite	726	22	12.0	360	12	360

[a] Total nitrogen is calculated by adding nitrogen, total organic + ammonia (Kjeldahl), to nitrogen, nitrite + nitrate, dissolved. If the concentration value of nitrogen, nitrite + nitrate dissolved, is estimated and below the minimum reporting level, the concentration value of total nitrogen is reported as the sum of the values shown for nitrogen, total organic + ammonia and nitrogen, nitrite + nitrate dissolved, and noted as estimated.

[b] Organic nitrogen is calculated by subtracting nitrogen ammonia, dissolved, from total organic + ammonia (Kjeldahl). If the concentration value of nitrogen ammonia, dissolved is below the minimum reporting level, the concentration value for organic nitrogen is reported as less than or equal to the value of total organic + ammonia (Kjeldahl), which represents the maximum possible value for organic nitrogen. If the concentration value of nitrogen ammonia, dissolved is estimated and below the minimum reporting level, the concentration value of organic nitrogen is reported as the difference between the values shown for nitrogen, total organic + ammonia (Kjeldahl), and nitrogen ammonia, dissolved, and noted as estimated.