

**Integrated Water Quality Reporting Criteria  
for Use Attainment Decisions  
for Hawaii State Surface Waters  
(pursuant to Clean Water Act §303(d) and §305(b))**



**Report from the  
Integrated Water Quality Reporting Workgroup  
To  
Hawaii State Department of Health**

Prepared  
By

Water Quality Consulting, Inc.  
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US Environmental Protection Agency  
US Department of Agriculture  
    Natural Resource Conservation Service  
US Fish and Wildlife Service  
US Geological Survey

## Executive Summary

The Hawaii Department of Health (DOH) has an ongoing obligation to evaluate the quality of our inland and marine waters. In order to comply with the federal Clean Water Act (CWA) and fulfill associated US Environmental Protection Agency (EPA) requirements, DOH submits the *State of Hawaii Water Quality Monitoring and Assessment Report: Integrated Report to Congress Pursuant to Sections 303(d) and 305(b) Clean Water Act (P.L. 97-117)* (the Integrated Report) to the EPA for approval in even numbered years. This report is a critical component of State regulatory and policy responsibilities as it identifies whether surface waters are meeting (or *attaining*) State water quality standards (WQS) and identifies waters that require pollution control actions. These decisions are compiled using a set of criteria to evaluate whether the State surface waters are attaining the designated uses, water quality criteria, and the antidegradation policy contained within the State WQS.

DOH is developing new methods for deciding if the beneficial uses designated by the State WQS (such as “protection of native breeding stock,” “food processing,” “compatible recreation,” “conservation of coral reefs and wilderness areas”), as well as the water quality criteria and antidegradation policy in these standards, are actually attained in particular waters of the state. To seek input on the development of these methods, DOH in the summer of 2008 convened an Integrated Water Quality Reporting Workgroup to bring together the diverse expertise and experience necessary to upgrade our water quality evaluation toolbox. The workgroup objective was to establish meaningful, yet simple methods to determine designated use attainment with limited data.

An introductory public information meeting was held at the DOH office on Oahu, followed by a meeting on Maui, to explain the project to the public and invite participation. Two workgroup meetings were then held at DOH offices on Oahu, with remote conferencing on Maui. This report documents the regulatory background, workgroup process, draft methodology and decision criteria, and recommendations of the workgroup.

The workgroup concluded that there is no “across the board” method of assessing all uses. The workgroup recommended the use of a designated use checklist methodology that is specific to waterbody types and uses and can be utilized with both existing and future regulations, assessment tools and decision rules. The methodology can be put to use in the 2008 assessment with existing tools and decision rules (2006 Rules of Logic and 2004 Priority Ranking and Listing/Delisting Criteria). The methodology provides an assessment framework that is adaptable as regulations and assessment tools change and develop over time.

The full implementation of the methodology requires additional development of data gathering tools, metrics or threshold indicators, and decision rules for each use designated in the regulations. The workgroup identified the need to refine the methodology to identify specific elements of existing tools that can be used as metrics to assess specific uses (Hawaii Stream Visual Protocol (HSVP); Hawaii Stream Bioassessment Protocol (HSBP); Coral Reef Assessment and Monitoring Protocol (CRAMP); Atlas of Hawaiian Watersheds and Their Aquatic Resources; Point Quadrant Method: A rapid Assessment of Hawaiian Streams; and Estuary compendium). Several potential tools for assessing uses were identified, but need but need further development (Ecological Gradient Model for coral reefs (Rodgers 2009); Watershed Health Index (Kido 2008) for inland waters); Algal bioassay using  $\delta^{15}\text{N}$  values (Dailer, Smith, in prep)). These particular tools are not sufficiently developed for use in 2008, but should be considered by DOH for the future cycles.

The workgroup identified the need for consideration of data requirements for using existing and emerging tools in the development of monitoring plans for future assessment cycles. The workgroup identified the need for DOH to develop data quality objectives; guidelines for monitoring program design; a portal and standardized format for data submittal and data sharing; and definition and mapping of water quality decision units (including waterbody inventory and geo-referenced sampling locations). Method development needs include indices, tools and decision rules that are specific to each waterbody type and use.

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# Acronyms

<b>Acronym</b>	<b>Meaning</b>
CALM	Consolidated Assessment and Listing Methodology
CWA	Clean Water Act
CWB	Clean Water Branch
CWRM	Commission on Water Resource Management
DAR	Division of Aquatic Resources
DLNR	US Department of Land and Natural Resources
DOA	Department of Agriculture
DOH	Department of Health
DW	Drinking Water
EHA	Environmental Health Administration
EHSD-DD	Environmental Health Services Division
EPA	US Environmental Protection Agency
EPO	Environmental Planning Office
HAA	Hawaii Aquaculture Association
HAR	Hawaii Administrative Rules
HARC	Hawaii Agriculture Research Center
HCS	Hawaiian Commercial and Sugar Company
HEER	Hazard Evaluation and Emergency Response
HIMB	Hawaii Institute of Marine Biology
HSBP	Hawaii Stream Bioassessment Protocol
HSRC	Hawaii Stream Research Center
HSVP	Hawaii Stream Visual Assessment Protocol
IBI	Index of Biotic Integrity
IR	Integrated Report
IWQR	Integrated Water Quality Reporting
MCC SLIM	Maui Community College, Sustainable Living Institute of Maui
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
QA/QC	Quality Assurance / Quality Control
TMDL	Total Maximum Daily Load
UH	University of Hawaii
USDA	US Department of Agriculture
USFWS	US Fish and Wildlife Service
USGS	US Geological Survey
WQS	Water Quality Standards
WW	Waste Water

# 1. Introduction

The Hawaii Department of Health (DOH) has an ongoing obligation to evaluate the quality of our inland and marine waters. In order to comply with the federal Clean Water Act (CWA) and fulfill associated US Environmental Protection Agency (EPA) requirements, DOH submits the *State of Hawaii Water Quality Monitoring and Assessment Report: Integrated Report to Congress Pursuant to Sections 303(d) and 305(b) Clean Water Act (P.L. 97-117)* (the Integrated Report) to the EPA for approval in even numbered years. This report is a critical component of state regulatory and policy responsibilities as it identifies whether surface waters are meeting (or *attaining*) State water quality standards (WQS) and identifies waters that require pollution control actions. These decisions are compiled using a set of criteria to evaluate whether the State surface waters are attaining the designated uses, water quality criteria, and the antidegradation policy contained within the State WQS.

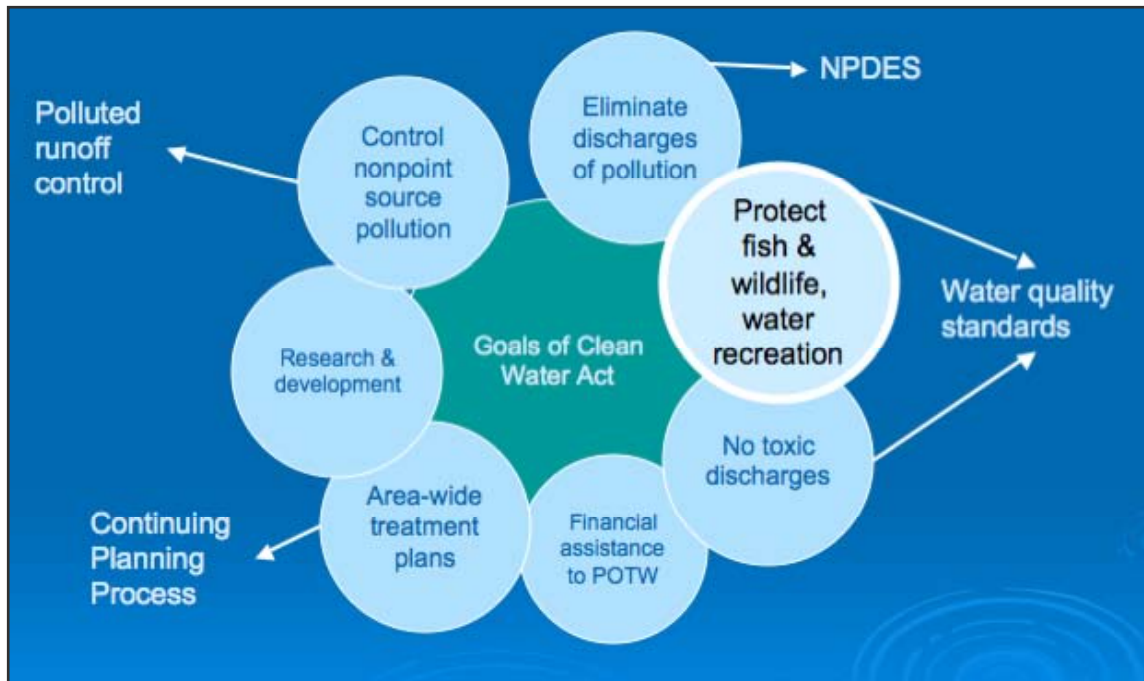
DOH is developing new methods for deciding if the beneficial uses designated by the State WQS (such as “protection of native breeding stock,” “food processing,” “compatible recreation,” “conservation of coral reefs and wilderness areas”), as well as the water quality criteria and antidegradation policy in these standards, are actually attained in particular waters of the state. To seek input on the development of these methods, DOH in the summer of 2008 convened an Integrated Water Quality Reporting Workgroup to bring together the diverse expertise and experience necessary to upgrade our water quality evaluation toolbox. The workgroup objective was to establish meaningful, yet simple methods to determine designated use attainment with limited data. The workgroup's work product is a methodology and draft decision criteria for use attainment decisions that will be proposed for use in the 2008 integrated water quality report. These draft decision criteria will then be subject to public review prior to being established as the official criteria.

An introductory public information meeting was held at the DOH office on Oahu, followed by a meeting on Maui, to explain the project to the public and invite participation. Two workgroup meetings were then held at DOH offices on Oahu, with remote conferencing on Maui. This report documents the regulatory background, workgroup process, draft methodology and decision criteria, and recommendations of the workgroup.

## 2. Clean Water Act Requirements

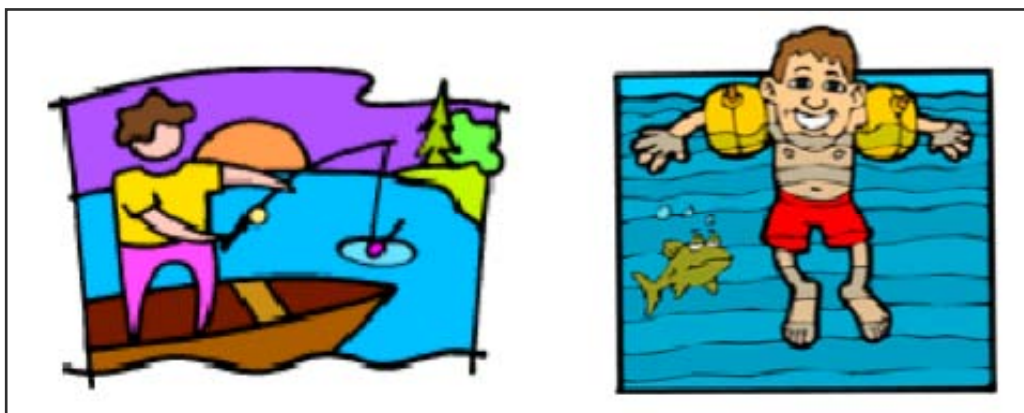
The objective of the Clean Water Act (CWA) is to “restore and maintain the physical, chemical, and biological integrity of the Nation’s waters.” The CWA establishes as a national goal “water quality which provides for the protection and propagation of fish, shellfish, and wildlife, and recreation in and on the water, wherever attainable.” The CWA requires WQS to protect the public health and welfare and enhance the quality of water. To achieve these goals and objectives, states adopt WQS including designated uses, narrative and numeric criteria to protect those uses, and antidegradation policies to prevent deterioration of high-quality waters.

**Figure 1. Goals of Clean Water Act**



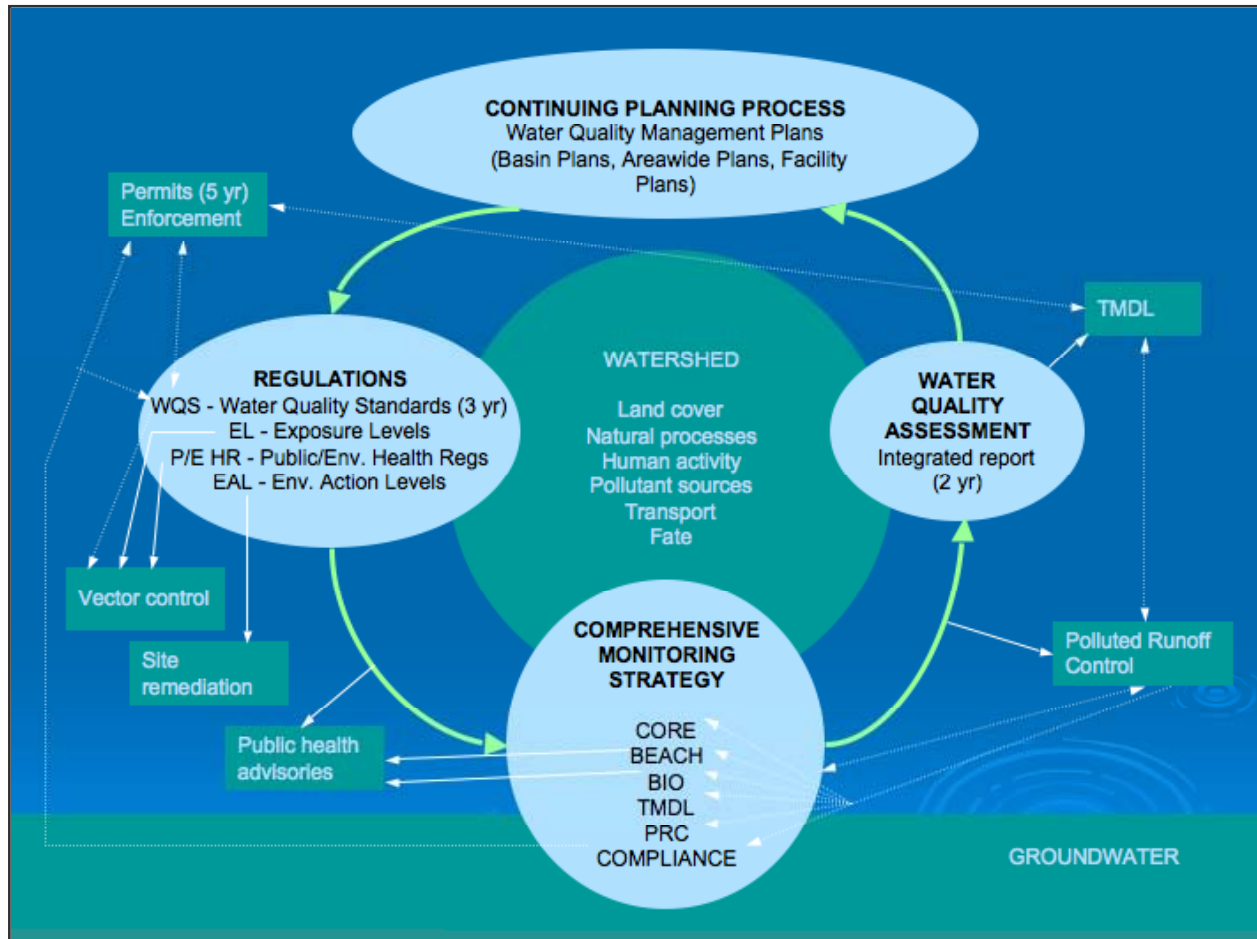
EPA’s regulations require that State WQS provide at a minimum for the “fishable/swimmable” uses unless those uses have been shown to be unattainable. In designating waters, states consider the use and value of water for public water supplies; protection and propagation of fish, shellfish and wildlife; recreation in and on the water; consumption of fish and shellfish by humans; and agricultural, industrial, and other purposes including navigation. In no case may waste transport or assimilation be adopted as a designated use for any waters of the United States.

**Figure 2. Clean Water Act Goals: Fishable / Swimmable**



States implement monitoring programs that allow them to report on attainment of WQS and to identify and prioritize waters not attaining standards. In even numbered years states are required to submit to EPA a water quality inventory report that includes a description of the water quality of all waters of the state (including, rivers/stream, lakes, estuaries/oceans and wetlands). An assessment of status and trends of significant publicly owned lakes is also required. States may also a description of the nature and extent of ground water pollution and recommendations of state plans or programs needed to maintain or improve ground water quality. Figure 3 illustrates the relationship of the water quality planning, assessment, monitoring, and regulatory programs implemented under authority of the CWA by the DOH.

**Figure 3. Continuing Planning Process**



States are also required to report in even numbered years a list of impaired and threatened waters requiring Total Maximum Daily Loads (TMDLs). A TMDL is a budget for pollutants that prescribes pollutant load allocations for point and nonpoint sources. States are required to report the impairing pollutant(s); and priority ranking of these waters, including waters targeted for TMDL development within the next two years. These impairment decisions are compiled using a set of criteria to evaluate whether the State surface waters are attaining their designated uses, water quality criteria, and the antidegradation policy as stated in the Hawaii Administrative Rule (HAR) Chapter 11-54. EPA strongly encourages states to submit a single report (the Integrated Report) that satisfies these reporting requirements of CWA sections 303(d), 305(b) and 314 (See Table 1). (US EPA 2005).

**Table 1. Clean Water Act Requirements and Authority**

<b>Authority</b>	<b>Requirement</b>
Section 303(c)(2)	Adopt WQS including designated uses, narrative and numeric criteria and antidegradation policies
Section 106(e)	Implement monitoring programs, report on attainment of WQS, identify and prioritize waters not attaining standards.
Section 101(a)(2)	Provides for the protection and propagation of fish, shellfish, and wildlife, and recreation in and on the water, wherever attainable
Section 303(c)(2)(A)	Requires WQS to protect the public health and welfare, enhance the quality of water, and serve the purposes of the Act.
Sections 101(a); 303(c)(2)(A); 40 CFR 131	Provide at a minimum for the “fishable/swimmable” uses unless those uses have been shown to be unattainable
Section 303(d); 40 CFR 130.7	<p>By April 1 of all even numbered years states must submit to EPA:</p> <ul style="list-style-type: none"> <li>• A list of water quality-limited (impaired and threatened) waters still requiring TMDLs; identification of the impairing pollutant(s); and priority ranking for TMDL development, including waters targeted for TMDL development within the next two years</li> <li>• A description of the methodology used to develop the list.</li> <li>• A description of the data and information used to identify waters, including a description of the existing and readily available data and information used.</li> <li>• A rationale for any decision to not use any existing and readily available data and information.</li> <li>• Any other reasonable information requested by EPA, such as demonstrating good cause for not including a water or waters on the list CWA section 305(b);</li> </ul>
Section 305(b); 40 CFR 130.8	<p>By April 1 of all even numbered years, states must submit to EPA the following information:</p> <ul style="list-style-type: none"> <li>• A description of the water quality of all waters of the state (including, rivers/stream, lakes, estuaries/oceans and wetlands) and the extent to which the quality of waters provides for the protection and propagation of a balanced population of shellfish, fish, and wildlife and allows recreational activities in and on the water.</li> <li>• A description of the nature and extent of ground water pollution and recommendations of state plans or programs needed to maintain or improve ground water quality (optional reporting).</li> <li>• An estimate of the extent to which CWA control programs have improved water quality or will improve water quality, and recommendations for future actions necessary and identifications of waters needing action.</li> <li>• An estimate of the environmental, economic and social costs and benefits needed to achieve the objectives of the CWA and an estimate of the date of such achievement.</li> <li>• A description of the nature and extent of nonpoint source pollution and recommendations of programs needed to control each category of nonpoint sources, including an estimate of implementation costs.</li> <li>• An assessment of the water quality of all publicly owned lakes, including the status and trends of such water quality as specified in section 314(a)(1) of the CWA.</li> </ul>

## **2.1. Designated Uses and Water Quality Criteria**

States are required to adopt numeric and narrative water quality criteria to protect designated uses (such as protection and propagation of fish, shellfish and wildlife; recreation in and on the water; consumption of fish and shellfish by humans; public water supplies and agricultural, industrial, and other purposes including navigation). Criteria must be based on sound scientific rationale and should contain sufficient parameters or constituents to protect the designated use. Numeric water quality criteria are adopted based on CWA section 304(a) criteria guidance, criteria guidance modified to reflect site-specific conditions, or other scientifically defensible methods. Narrative criteria are adopted to supplement numeric criteria or if numerical criteria cannot be determined. Narrative criteria are descriptions of the conditions necessary for a waterbody to attain its designated use, whereas numeric criteria are values expressed as chemical concentrations, toxicity units, aquatic community index levels, or other numbers deemed necessary to protect designated uses.

A “translator” identifies a process, methodology, or guidance that will be used to quantitatively interpret narrative criteria statements. Translators may consist of biological assessment methods (e.g., field measures of the biological community), biological monitoring methods (e.g., laboratory toxicity tests), models or formulae that use input of site-specific information/data, or other scientifically defensible methods. Translators are particularly useful for addressing water quality conditions that require a greater degree of sophistication to assess than can be typically expressed by numerical criteria that apply broadly to all waters with a given use designation.

For each WQS, the State should describe how it assesses attainment with the standard. The description may be included in the approved WQS or in other implementing regulations or policies and procedures such as the use assessment and listing methodology. This includes defining the water quality indicators it measures and the procedures for analyzing and interpreting data in order to decide whether standards are met or water quality is impaired. This should include collection and analysis of multiple types of readily available data providing information relevant to assessing attainment with approved WQS. This information not only is used for reporting attainment status in the Integrated Report but also supports development of appropriate controls that address the full range of water quality problems.

Most states organize their water quality standards (WQS) according to the designated beneficial uses assigned to waters. Although some states have detailed categories and subcategories of designated uses that apply to specific waters or classes of waters, many have adopted general categories of use that apply broadly to all waters. A report by the National Research Council recommended that states move beyond general categories of “fishable” and “swimmable” and adopt refined or detailed uses that better describe the expectations for the water (NRC 2001). For example, a state may want to distinguish between primary contact recreation and secondary contact recreation. Similarly, the aquatic life use should describe the attributes of aquatic communities expected for the water. The National Research Council report also emphasized selection of criteria that are accurate indicators of the designated use.

### 3. EPA Guidance

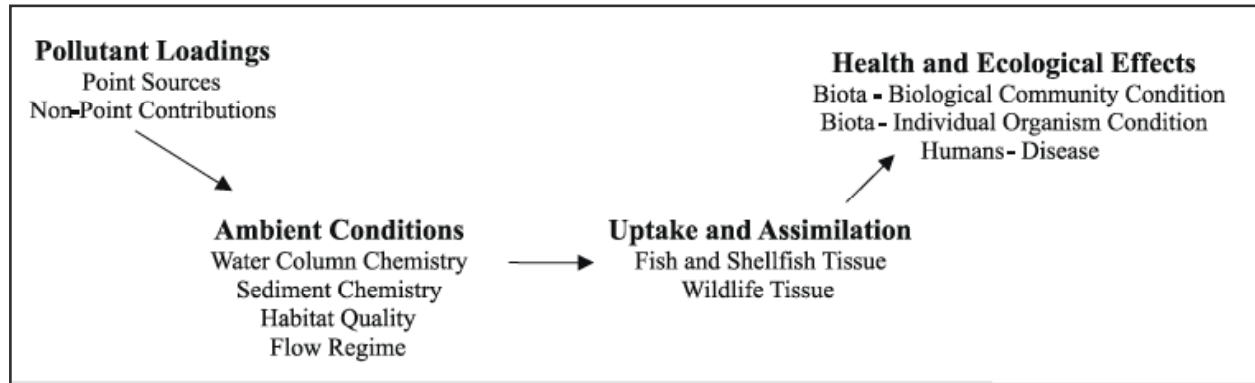
Under section 303(d) (1) of the CWA, states must identify waterbodies for which technology-based controls required by the Act are not sufficient to implement applicable WQS, and prioritize such waterbodies for TMDL establishment. For purposes of determining whether a waterbody is impaired and should be included on section 303(d) lists, states are required by EPA regulations to consider all existing and readily available data and information. This may include physical, chemical, and biological data, including data on pathogens (such as bacteria and phytotoxins), as well as fish and shellfish tissue concentration data, where such data are existing and readily available. The assessment methodology prepared by states should describe how it collects or obtains data and information relevant to applicable WQS, how it evaluates the suitability of the data or information for decision making, and how it analyzes and interprets data to make attainment or nonattainment decisions. As the Clean Water Act requirements for monitoring, assessment and water quality reporting have developed, EPA has issued periodically issued programmatic guidance to state's to facilitate program implementation.

- The Consolidated Assessment and Listing Methodology (CALM) (US EPA 2002) provides a compendium of best practices for Use Attainment Decisions. Guidance is provided for making water quality standards attainment decisions using chemical, biological, toxicological, bacterial, and habitat data as indicators of water quality. The selection of metrics or indicators, design of integrated monitoring for assessment and identification of impaired waters, and interpretation of multiple types of data are discussed.
- Elements of a State Water Monitoring and Assessment Program (US EPA 2003) identifies 10 recommended elements for monitoring programs including strategy, objectives, design, core and supplemental water quality indicators, quality assurance, data management, data analysis and assessment, reporting, programmatic evaluation and general support and infrastructure planning.
- Guidance for 2006 Assessment, Listing and Reporting Requirements (US EPA 2005) provides guidance on preparing one integrated water quality report to meet the reporting requirements of Sections 303(d), 305(b) and 314 of the Clean Water Act. This guidance establishes reporting categories as follows:
  - Category 1: All designated uses are supported, no use is threatened;
  - Category 2: Available data and/or information indicate that some, but not all of the designated uses are supported;
  - Category 3: There is insufficient available data and/or information to make a use support determination;
  - Category 4: Available data and/or information indicate that at least one designated use is not being supported or is threatened, but a TMDL is not needed;
    - 4a = A TMDL to address a specific segment/pollutant combination has been approved or established by EPA.
    - 4b = A use impairment caused by a pollutant is being addressed by the state through other pollution control requirements.
    - 4c = A use is impaired, but the impairment is not caused by a pollutant.
  - Category 5: Available data and/or information indicate that at least one designated use is not being supported or is threatened, and a TMDL is needed.
- Guidance for Information Concerning 2008 Clean Water Act Sections 303(d), 305(b), and 314 Integrated Reporting and Listing Decisions (US EPA 2006) discusses the need for timely reporting compliant with the EPA's assessment decision database.

### 3.1. Monitoring To Assess Attainment with WQS and Identify Impaired Waters

Monitoring to determine attainment of applicable WQS should include a multi-indicator approach that may include biological, toxicological, physical, and chemical indicators of the WQS and its components. Each type of data provides unique insights into the integrity and health of an aquatic system, as well as the ability of the public to safely recreate in such waters. These indicators are frequently organized on a continuum from loadings entering the system, to stressors present in the system, to response of the system. (See Figure 4)

Figure 4. Continuum of water quality indicators (from US EPA 2002)



Each type of data offers different strengths and limitations. For example, biological assessments measure the response of aquatic life to the cumulative effects of past or current impacts from multiple physical and chemical stressors. However, these assessments may be limited in their ability to predict future impacts, or identify new stresses that have not begun to be reflected in the biological community. Chemical-specific assessments evaluate and predict impacts from single pollutants, but do not capture the combined interactions of pollutants or their cumulative impacts over time. Assessment of the physical, chemical, and biological integrity of the waters should be based on an appropriate combination of indicators selected to characterize WQS attainment status, including physical, chemical, and toxic characteristics of water and sediment; chemical accumulations in fish tissue; a biological assessment of the aquatic community; and physical condition of habitats.

#### 3.1.1. Assessing Whether Aquatic Life-Based WQS Are Attained

State water quality standards are comprised of three distinct elements: (1) designated use, (2) numeric and narrative criteria that protect the use, and (3) antidegradation policy. For each state standard, the state should describe how it assesses attainment with the standard, and each component element. This description should be included in the state's water quality standards or it may be defined in other implementing regulations or policies and procedures documents (such as the state's continuous planning process or consolidated assessment and listing methodology).

The State should describe the indicators and thresholds that are used to assess attainment status for each WQS. The term "indicators" is used to refer to a wide range of measures (or metrics) of water quality (e.g., physical, chemical, biological, habitat, toxicity, tissue data). "Thresholds" refers to the numeric value or narrative description that distinguishes attainment from impairment. These thresholds may be adopted into the state WQS or defined in other implementing regulations or policy and procedure documents as a translator or implementation procedure for interpreting the WQS.

Following are brief descriptions of the various indicators or types of data a state may use to interpret its aquatic life-based WQS.

*Biological data*—Biological data measure actual effects of pollutants on an aquatic community. Biological assessments measure biological attributes (e.g., the structure, function, and condition) of the aquatic community in a particular type or class of waterbody. EPA recommends that states include biological indicators among the core indicators used to assess attainment with aquatic life-based WQS.

*Habitat data*—Habitat assessments are often conducted in conjunction with biological assessments. A general habitat assessment incorporates physical attributes from microhabitat features such as substrate, velocity, and depth, with waterbody morphology features such as width, sinuosity, flow, or volume, and macrohabitat features such as vegetation and land use. All of these features can be incorporated into an index or summary of overall habitat conditions. Typically, states integrate habitat assessments with biological assessments when assessing applicable WQS attainment, but they may be used independently when assessing uses.

*Toxicity data from water column and sediment*—Ambient water column and sediment toxicity tests are useful for examining the effects of unknown mixtures of chemicals in surface waters. They may also be used to confirm that an observed impairment is not due to chemical or toxicity-related sources. Toxicity levels are determined by exposing aquatic organisms to water samples. To sensitive aquatic organisms, toxicity testing integrates the biological effects of most chemical stressors present, potentially giving a more accurate estimate of the actual water or sediment quality compared with chemical concentration measurements. Even unknown toxicants are addressed during testing.

*Chemical and physical data*—Chemical and physical data address toxicants (e.g., priority pollutants and nonpriority pollutants) and physical characteristics (e.g., dissolved oxygen, suspended solids, pH, and temperature) in water and sediments. Chemical and physical data provide direct information about whether specific pollutants are present in amounts that are causing or likely to cause adverse impacts to aquatic organisms EPA recommends the use of physical and chemical indicators as core and supplemental indicators of aquatic life-based WQS.

An important element of a state's assessment and listing methodology is a description of how it assesses attainment with its WQS. In the most comprehensive circumstance, the state may measure indicators of the use and all applicable numeric and narrative criteria in addition to ensuring that the antidegradation policy is met. A state following this approach would identify a water as attaining a particular WQS only when the state has demonstrated that all of these indicators are in attainment. States are often more selective in the water quality indicators used to assess attainment with water quality standards. States may describe a subset or hierarchy of indicators that serve to characterize whether a WQS (and its components) are attained. Under this approach, a state may identify core indicators that represent the most direct measures of the WQS as the first tier of data used to support WQS attainment decisions and identify impaired waters. If measurements of these core indicators show attainment, the state may list the water as attaining the WQS.

Regardless of the approach, the state should clearly document how attainment decisions are made. If not documented elsewhere, the assessment and listing method is the appropriate place. Supplemental indicators are added to the monitoring and data collection strategy as appropriate. For example, supplemental indicators may be added for waters where there is a reasonable potential for specific pollutants to cause or contribute to water quality impairments based on evaluation of watershed conditions, including land use and source assessments. Additionally, a state may add supplemental indicators to explore the presence of pollutants widely distributed by atmospheric deposition or to establish a baseline for emerging pollutants of concern. It is important to note that even though the use of core and supplemental indicators should make the state, territory or authorized tribe's monitoring, information collection, and decision making activities more efficient, it cannot preclude the consideration of other relevant data and information. The state is obliged to consider any other data that are relevant to

its WQS (and each component) when making attainment decisions. Therefore, the assessment methodology should also address how each component of the WQS will be assessed in the event the state collects or receives additional data.

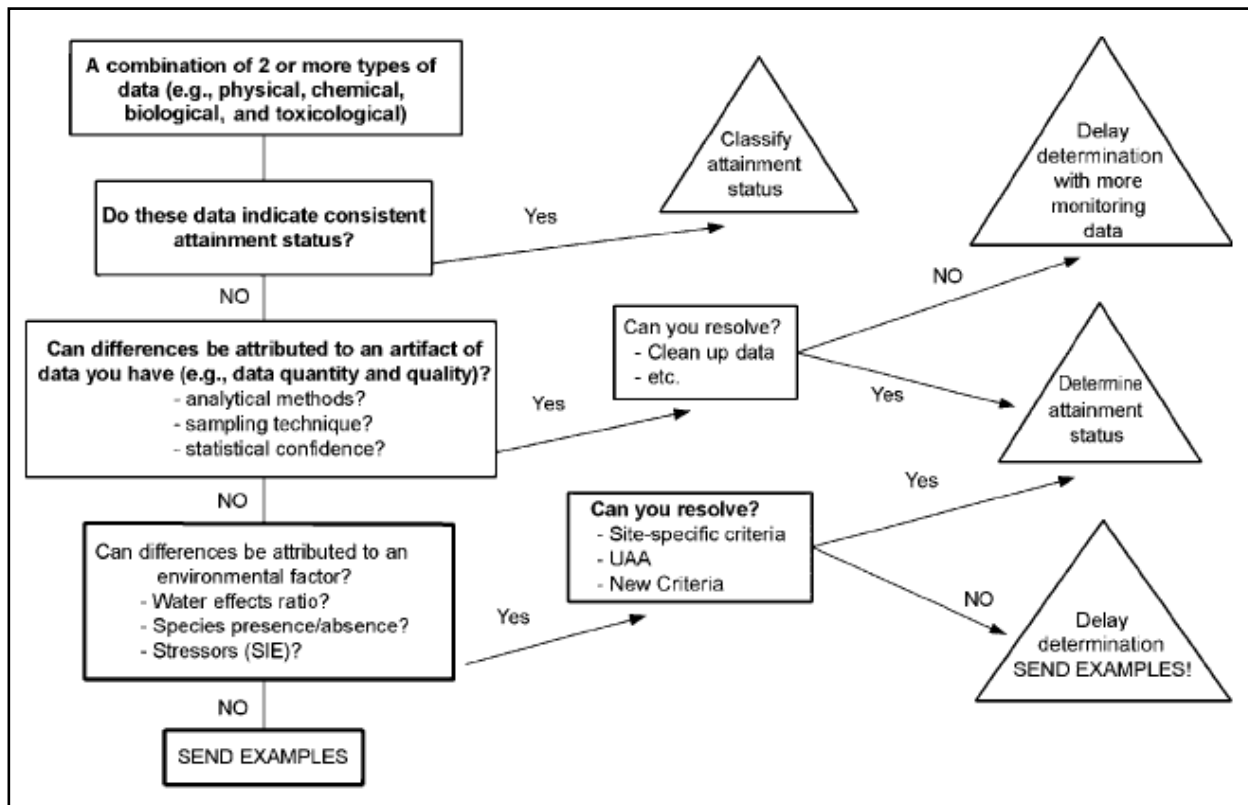
### 3.1.2. Interpreting Multiple Data Sources in WQS Impairment Decisions

The first step involves evaluation of the monitoring results for each indicator or type of data independently. This step includes seeking data, evaluating their quality, and interpreting the results against the applicable component of the WQS. The second step involves looking across the multiple types of data that serve as indicators of aquatic life-based WQS and making an attainment decision for the standard. In most cases, the WQS will be attained only when all of the indicators that the state evaluates show attainment. If one or more indicators show nonattainment, the state will typically categorize the water as not attaining the aquatic life-based WQS. There are, however, exceptions to this general policy of independent applicability, as described below.

To address the possibility of conflicting results among different types of data used to assess attainment with WQS, EPA recommends that states apply the policy on independent applicability as appropriate for making WQS attainment decisions. This policy was initially crafted to address development of NPDES permit discharge limits. Its use is slightly different in the context of WQS attainment decisions. The intent of this policy is to protect against dismissing valuable information when evaluating aquatic life use attainment, particularly in detecting impairment. EPA's policy on independent application is based on the premise that **any valid, representative dataset indicating actual or projected water quality impairment should not be ignored when one is determining the appropriate action to be taken (emphasis added).**

However, EPA recognizes that there are circumstances when conflicting results should be investigated further before the attainment or nonattainment decision is made. For example, states may obtain multiple datasets of varying quality, which may influence the reliability of the assessment results. When a state has two or more types of data that do not indicate consistent attainment status, it should determine whether differences in assessment results can be attributed to differences in the quality of the datasets. For example, this may involve consideration of analytical methods, review of sampling techniques, and detailed assessment of datasets. When the differences are due to data quality issues, the independent application policy allows for resolving the differences by cleaning the data or weighing the higher quality dataset more favorably in the attainment decision. (See Figure 5)

Figure 5. Using multiple types of data to assess attainment (US EPA 2002 Fig. 3-2)



For purposes of WQS Attainment/Nonattainment Determinations, the Policy of independent applicability says:

- When evaluating multiple types of data (e.g., biological, chemical) and any one type of data indicates an element of a WQS is not attained, the water should most likely be identified as impaired.
- If there is reason to doubt the nonattainment finding, re-evaluate all of the data sets to resolve discrepancies. In some cases this may lead to modification of applicable WQS to account for site-specific information.

The Policy of independent applicability *does not say*:

- Always assume that a single sample result showing impairment outweighs all other data showing attainment.
- Accept all differences in data findings at face value.
- Ignore data quality and site-specific environmental factors.

When detailed data analysis fails to identify data quality issues that explain the discrepancies, site-specific environmental conditions should be considered (e.g., effects of water chemistry or the ability of species to adapt over time). Three procedures may be explored to assess whether site-specific environmental conditions explain the discrepancies: application of the water effects ratio, development of site-specific criteria, revisions to State criteria, or conducting a use attainability analysis (UAA). These are examples of techniques that examine whether the WQS and its component elements are appropriate for the water being assessed.

### 3.2. Data Quality

Data quality assessment is the scientific and statistical evaluation of data to determine if the data are appropriate to support attainment or impairment decisions. EPA encourages states to use the data quality objectives process (DQO) to define minimum data quality requirements. This includes information on

sample size and monitoring design, analytical methods and detection limits, quality control procedures, and data management. Data quality requirements can be documented in a quality assurance plan or standard operating procedure. Some data quality requirements maybe defined in applicable water quality standards or implementation policy. For instance, regulation or policy may define critical conditions such as flow or temperature under which the criteria apply.

All data may not be of equal value for assessing WQS attainment or impairment. Chemical or any other types of data may be of limited value unless they are accompanied by documentation about sample collection, analytical methods and quality control protocols. A state may establish data quality tiers to provide guidance on appropriate use of data with varying levels of quality control. Poorly documented data may not provide an adequate basis for an attainment or impairment decision, but may be used as an indicator of potential problems, corroboration of other data, or to trigger additional monitoring (US EPA 2002).

It is important to balance data quality requirements with common sense. States are required to consider all readily available data; therefore data requirements must be objective and inclusive. States should make data quality requirements readily available to organizations such as state, federal, academic, and volunteer citizen group who do water quality monitoring. Data should not be excluded solely because of source or age without a reasonable explanation as to why they do not represent water quality conditions. Data collected using methods different from those used by the state should also be considered where appropriate.

### **3.2.1. Sample Size**

Sample size is an important aspect of data quality. In general, statistical tests have good power for detecting exceedances if they are based on data with a sample size of 30 or more. “Smaller sample sizes are prone to yield erroneous attainment decisions because they have a low probability of detecting WQS exceedances unless they are large and pervasive” “Larger data sets have a greater probability of detecting less frequent exceedances. If a small data set detects an exceedance, the waterbody is likely experiencing a higher frequency of exceedances. However, if a small data set does not detect an exceedance, it is difficult to say with statistical confidence that the water is attaining WQS. Larger data sets are more powerful in terms of supporting decisions that a water is attaining WQS” (US EPA 2002). EPA indicates that if a state is not comfortable with the level of uncertainty associated with attainment decisions made on the basis of small data sets, the state should commit to collecting adequate data to meet its data quality objectives.

An assessment methodology should take into account the balance between desired data requirements and the practical realities affecting the availability of information and the strength of the available evidence. Generally, decisions should be made based on very small data sets only when there is overwhelming evidence for impairment. EPA does not recommend making decisions based on very small data sets of water column chemistry. Probability approaches that define acceptable probability of decision error are preferred for WQS assessment.

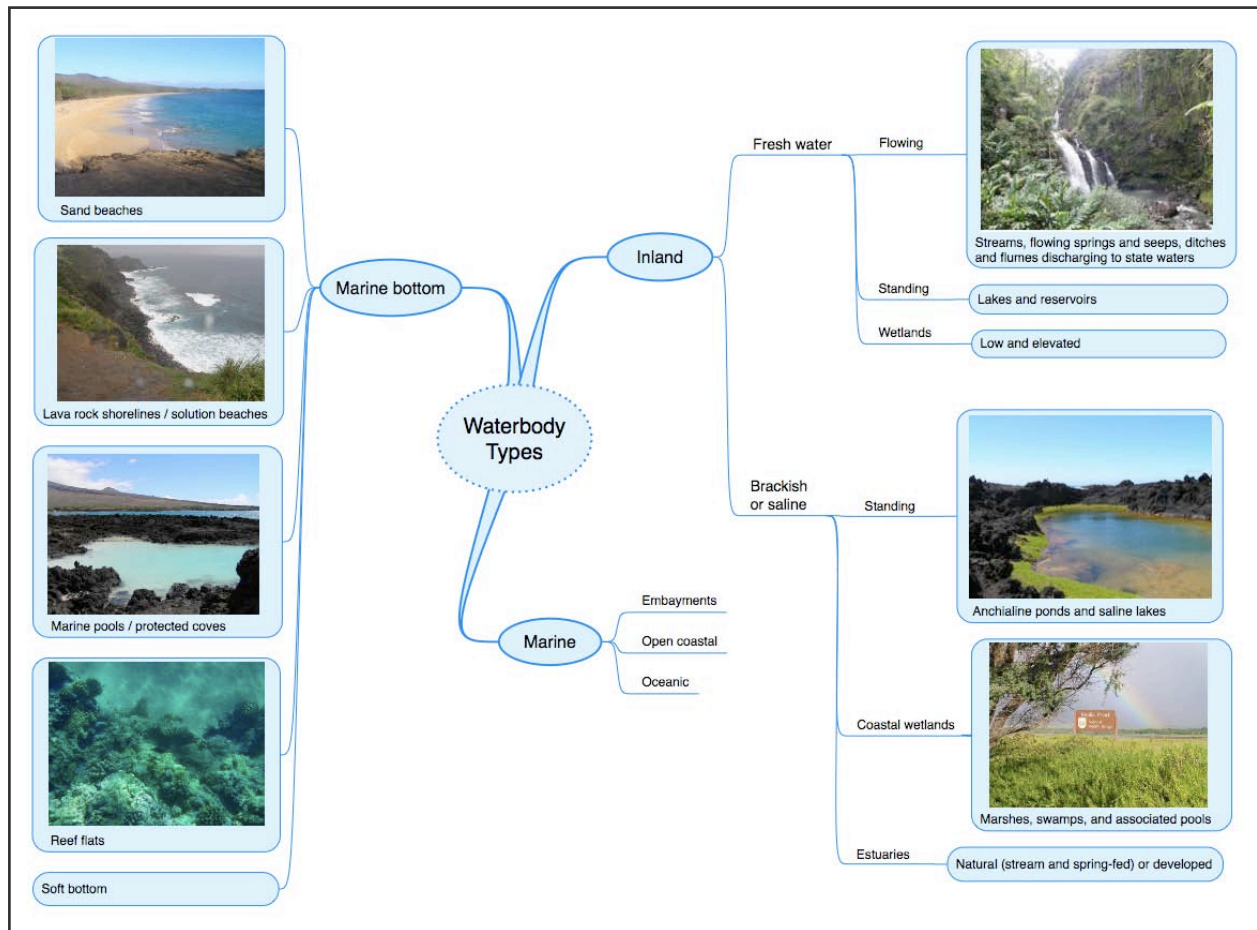
## 4. Overview of Hawaii Water Quality Standards

WQS for the State of Hawaii including designated uses, water quality criteria, and the antidegradation policy are found in the Hawaii Administrative Rule (HAR) Chapter 11-54. In the Hawaii regulations, waters are first classified by waterbody type as inland waters, marine waters or marine bottom ecosystem, and then are further categorized into classes based on ecological characteristics and other natural criteria.

### 4.1. Waterbody Types

The three main waterbody types are inland waters, marine waters, and marine bottom ecosystems. Inland waters can be fresh, brackish or saline. Inland freshwaters are further classified as flowing, standing or wetlands (low and elevated). Brackish or saline waters are classified as standing waters (such as anchialine ponds), coastal wetlands, or estuaries (natural and developed). Marine waters can be classified as embayment, open coastal (shoreline to 600 foot depth contour), and oceanic (beyond 600 foot depth contour). Marine bottom ecosystems are classified as sand beaches, lava rock shorelines, marine pools and protected coves, reef flats, and soft bottoms. These waterbody types encompass diverse types of ecosystems, which will vary in uses of the waters, including the type of aquatic organisms each supports. (See Figure 6) These waterbody types are grouped into classes and beneficial uses are designated for each waterbody class.

Figure 6. Waterbody types

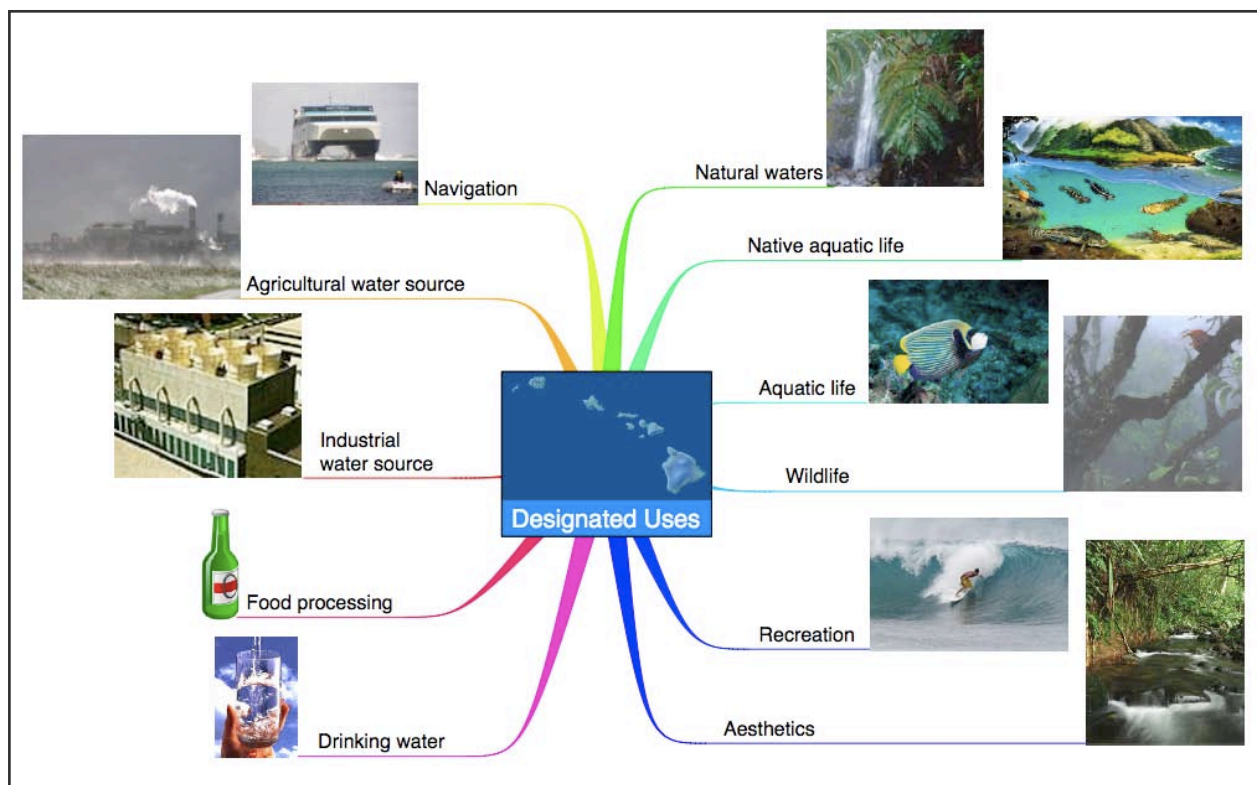


## 4.2. Designation of Beneficial Uses in Hawaii

There are a variety of beneficial uses designated in the Hawaii WQS regulations. Designated uses are assigned to classes of waterbody types. Figure 7 provides an overview of Hawaii's designated uses. Each water body type does not necessarily require a unique set of uses. Instead, the characteristics necessary to support a use can be identified so that water bodies having those characteristics in common can be grouped together as a waterbody class supporting particular uses. In Hawaii, for purposes of designating beneficial uses, 13 waterbody types are organized into 7 classes. Uses are then assigned to waterbody classes. A generalized overview of Waterbody Classes and Designated Uses is provided in Table 2. (It should be noted that uses descriptions are generalized here for ease of discussion. A more precise description of beneficial uses designated for each waterbody class is found in Appendix A, Tables 1-7.)

Specific waterbodies are assigned to classes based on both waterbody characteristics (e.g. marine or saline, standing or flowing) and other considerations described in the anti-degradation policy such as outstanding natural resource, or important economic or social development.

Figure 7. Designated uses



**Table 2. Waterbody Classes and Designated Uses**

Designated Uses	Inland Waters			Marine Waters		Marine Bottom Ecosystem	
	Class 1a	Class 1b	Class 2	Class AA	Class A	Class I	Class II
Natural Waters <sup>1</sup>							
Native Aquatic Life							
Aquatic Life							
Recreation							
Aesthetics							
Wildlife							
Drinking Water							
Food Processing							
Agricultural Water Source							
Industrial Water Source							
Shipping							

<b>Legend:</b>	
Use is designated for class	
Use is not designated for class	

<sup>1</sup> Hawaii Water Quality Standards at Hawaii Administrative Rules (HAR) §11-54-03(1) state, “It is the objective of Class 1 waters that these waters remain in their natural state as nearly as possible with an absolute minimum of pollution from any human-caused source.” The basic conditions to be maintained in Class AA Marine Waters and Class I Marine Bottoms use the phrase “natural pristine state”.

### 4.3. Water Quality Criteria

Basic criteria are applied to all classes of waters, and specific criteria are assigned to some but not all classes. Within a class the criteria may not apply to all waterbody types. The regulations do not provide specific criteria for uses or all waterbody types. Therefore, the regulations provide a nexus between waterbody class and use but not between use and criteria. An exception is that recreational waters are defined and recreational uses are tied to bacterial criteria in the water quality standards.

The basic narrative criteria apply to all waters (HAR §11-54-4). These criteria include narrative statements for controlling substances including materials that settle or float, or that can have toxic or other undesirable effects. The narrative criteria include that all waters should be free of “deleterious substances sufficient to be toxic or harmful to human, animal, plant, or aquatic life, or in amounts to interfere with any beneficial use of the water.” A translator for these narrative criteria is contained within the regulation in the requirement that waters be free from pollutants in concentrations exceeding acute and chronic toxicity and human health standards (expressed as average criteria concentrations at specified durations). There are also provisions translating the narrative criteria in terms of toxicity testing (bioassay) results.

For some waterbody types, there are specific narrative or numeric criteria. There are specific criteria for inland waters (HAR §11-54-5), marine waters (HAR §11-54-6), marine bottom types (HAR §11-54-7), and recreational areas (HAR §11-54-8). Numeric criteria for water column chemistry are expressed for wet and dry conditions and as values not to be exceeded by the geometric mean, more than ten percent of the time and more than two percent of the time. Numerical criteria are provided for water column concentration of enterococcus bacteria for waters classified for recreational use.

The anti-degradation policy (HAR §11-54-1.1) specifies that existing uses shall be protected and maintained. Existing uses are defined as those uses actually attained in the waterbody on or after November 28, 1975 whether or not they are included in the water quality standards (HAR §11-54-1). Where the quality of water exceeds that required to support propagation of fish, shellfish, and wildlife and support recreation in and on the water, the policy requires that high quality to be maintained unless allowing lower water quality is necessary to accommodate important economic or social development. Where high quality waters constitute an outstanding natural resource (e.g. state or national parks, or waters of exceptional recreational or ecological significance), that water quality must be maintained.

## **5. Hawaii's Designated Use Attainment and Water Quality Standards**

In general, the water quality criteria and antidegradation requirements of the Hawaii State Water Quality Standards (WQS), Chapter §11-54, are not explicitly associated with the support of particular designated uses (DOH 2006). Numeric water quality criteria are assigned by waterbody type, not by designated use. There are no direct links tying the pollutant parameters of the WQS to the designated uses. In limited cases, DOH can link certain parameters directly to the uses. Refining the WQS to add biological criteria and methods to evaluate attainment of designated uses within waterbodies may be proposed in future revisions of the WQS and 303(d) listing criteria. The WQS will need significant adjustments to ascertain attainment of designated uses through sampling of conventional and toxic pollutants. Hawaii's WQS revisions are scheduled for evaluation and review on a 3-year cycle are subject to public review and comment.

### **5.1. 2006 State of Hawaii Integrated Water Quality Report**

In the 2006 Integrated Report, assessment results for each waterbody were assigned one of five categories based on water quality standards attainment decisions made in accordance with Hawaii's 2004 Priority Ranking and Listing/Delisting Criteria and 2006 Rules of Logic (See Section 5.5 for more details):

- Category 1 - all designated uses attained
- Category 2 - one or more designated use attainments
- Category 3 - insufficient data for determining designated use attainment and water quality impairment
- Category 4 - one or more designated use non-attainments or water quality impairments (describe the exceptions)
  - 4a = A TMDL to address a specific segment/pollutant combination has been approved or established by EPA.
  - 4b = A use impairment caused by a pollutant is being addressed by the state through other pollution control requirements.
  - 4c = A use is impaired, but the impairment is not caused by a pollutant.
- Category 5 - one or more designated use non-attainments or water quality impairments.

Chapter IV of the report includes the Water Body Assessment Decisions table that contains the assessment results for all waters, inland and marine. Waterbodies entered in the table are not necessarily reflective of all waters of the state; rather they indicate areas where sampling has taken place, and areas of higher incidence of human contact. Areas not shown in the table do not have any sampling data available, and are considered to be in category "3," more information needed to make a decision. Future reporting cycles may add waterbodies as necessary. Tools utilized for the assessment in the 2006 reporting cycle included chemical analyses, bacteriological analyses, and Hawaii Stream Bioassessment Protocol scores (for native aquatic life - Class 1 streams).

### **5.2. Data Sources**

Data from the following sources may be used for making listing or delisting decisions in addition to or instead of routine DOH Clean Water Branch sampling, provided that an acceptable written Quality Assurance/Quality Control (QA/QC) Plan or other documented data quality assurance process was utilized during sample collection and analysis and is available for review, if requested:

- 1) United States Geological Survey (USGS)
- 2) National Oceanic & Atmospheric Administration (NOAA)
- 3) Universities
- 4) Community groups, individuals & respondents to a published, statewide "Call for Data"
- 5) HDOH Hazard Evaluation and Emergency Response Office (HEER)

- 6) Military
- 7) United States Fish and Wildlife (USFWS)
- 8) Superfund investigation and remediation projects
- 9) United States Department of Agriculture (USDA)
- 10) Special projects by HDOH Clean Water Branch
- 11) Other government agencies
- 12) Environmental Assessments and Environmental Impact Statements
- 13) Consulting Firms
- 14) Private & public entities operating under water pollution control permits

### **5.3. Data Quality Requirements**

Basic data quality requirements for all listing priorities include acceptable written QA/QC document appropriate for the project which contains a description of procedures used during sample collection and analysis. This QA document must be available for review, if requested. Listing Priority 1 has the following additional data quality requirements:

- Photographs and written descriptions of the sampling sites.
- A general visual assessment of the water body that contains sufficient information to place the water body in the context of surrounding land uses and overall condition of the habitat.

### **5.4. Attainment Decision Units**

A use attainment decision applies to a water quality management unit referred to as an Attainment Decision Unit (ADU) or decision unit. The decision unit defines the geographic area to which an attainment decision applies. Decision units, in general, are intended to represent a combination of hydrologic and regulatory truth and are constrained by water quality monitoring logistics, resources and data.

The basic (Tier I) decision unit for fresh inland Hawaii waters is the entire network of hydrologically connected freshwater segments (salinity <0.5 ppt) associated with a single listed stream, stream segment, or stream tributary. These freshwater segments, and thus the basic ADU, can include one or more waterbody types [as defined by Hawaii Administrative Rules Title 11 Chapter 54 (HAR §11-54; see Tables 2. and 3.), including but not limited to intermittent streams, reservoirs, and wetlands. Tier II decision units encompass segments and partial segments that can be more narrowly defined and assessed based on existing monitoring locations, data, and boundaries between waterbody types, and are used for attainment decisions on a case-by-case basis. Tier III decision units are those established for TMDL development and other intensive monitoring and analysis purposes. Tier IV decision units are parts of Tier III decision units that can be defined based on the most detailed assessment information. For Marine waters, decision units are less clearly defined, being primarily bounded by waterbody type and standards applicability.

Use attainment decisions were made primarily on the basis of comparison of DOH CORE water quality monitoring data to water quality criteria for chemical constituents and bacteria. For inland streams, the Hawaii Stream Bioassessment Protocol (HSBP) and Hawaii Stream Visual Assessment Protocols (HSVP) were also used. The 2006 Integrated report Attainment Designations were derived from application of the Rules of Logic and 2004 Priority Ranking and Listing/Delisting Criteria for Hawaii State Surface Waters.

### **5.5 2006 Rules of Logic and 2004 Priority Ranking and Listing/Delisting Criteria**

1. Neither the State Water Quality Standards nor existing state policy explains the relationship between water quality criteria attainment and designated use attainment.
2. Attainment of one or more water quality criterion (including all narrative and numeric criterion) does not establish attainment of one or more designated uses (with the exception of recreational uses that are associated with numerical bacterial criteria).

3. Non-attainment of a single water quality impairment criterion (including all narrative and numeric criterion) establishes water quality impairment.
4. Categorization designations (waterbody attainment decisions) have the following meanings, and are applied to all waterbodies according to these Rules of Logic (1-4) and the 2004 Priority Ranking and Listing/Delisting Criteria for Hawaii State Surface Waters:
  - a. Category 5 - one or more designated use non-attainments or water quality impairments.
  - b. Category 4 - one or more designated use non-attainments or water quality impairments
    - o 4a = A TMDL to address a specific segment/pollutant combination has been approved or established by EPA.
    - o 4b = A use impairment caused by a pollutant is being addressed by the state through other pollution control requirements.
    - o 4c = A use is impaired, but the impairment is not caused by a pollutant.
  - c. Category 3 - insufficient data for determining designated use attainment and water quality impairment.
  - d. Category 2 - one or more designated use attainments
  - e. Category 1 - all designated uses attained

5. Limited Designated use attainment is considered established as follows:

If the calculated level was found to be above the state standard, the parameter was entered as “Not Attaining” (N). If the calculated value was below the stated value, the parameter was entered as “Attaining” (A).

TMDL Priority rankings columns for marine water bodies were provided by the TMDL coordinator. TMDL priorities for inland waters were assigned in accordance with the decision rules. The decision rules for determining whether or not a standard was attained differ for marine and inland waters, and for different water quality parameters. The 2004 Priority Ranking and Listing/Delisting Criteria were used in the 2006 reporting cycle. The detailed decision criteria are illustrated in figures 8-11.

Figure 8. Listing/delisting logic – conventional pollutants, marine waters

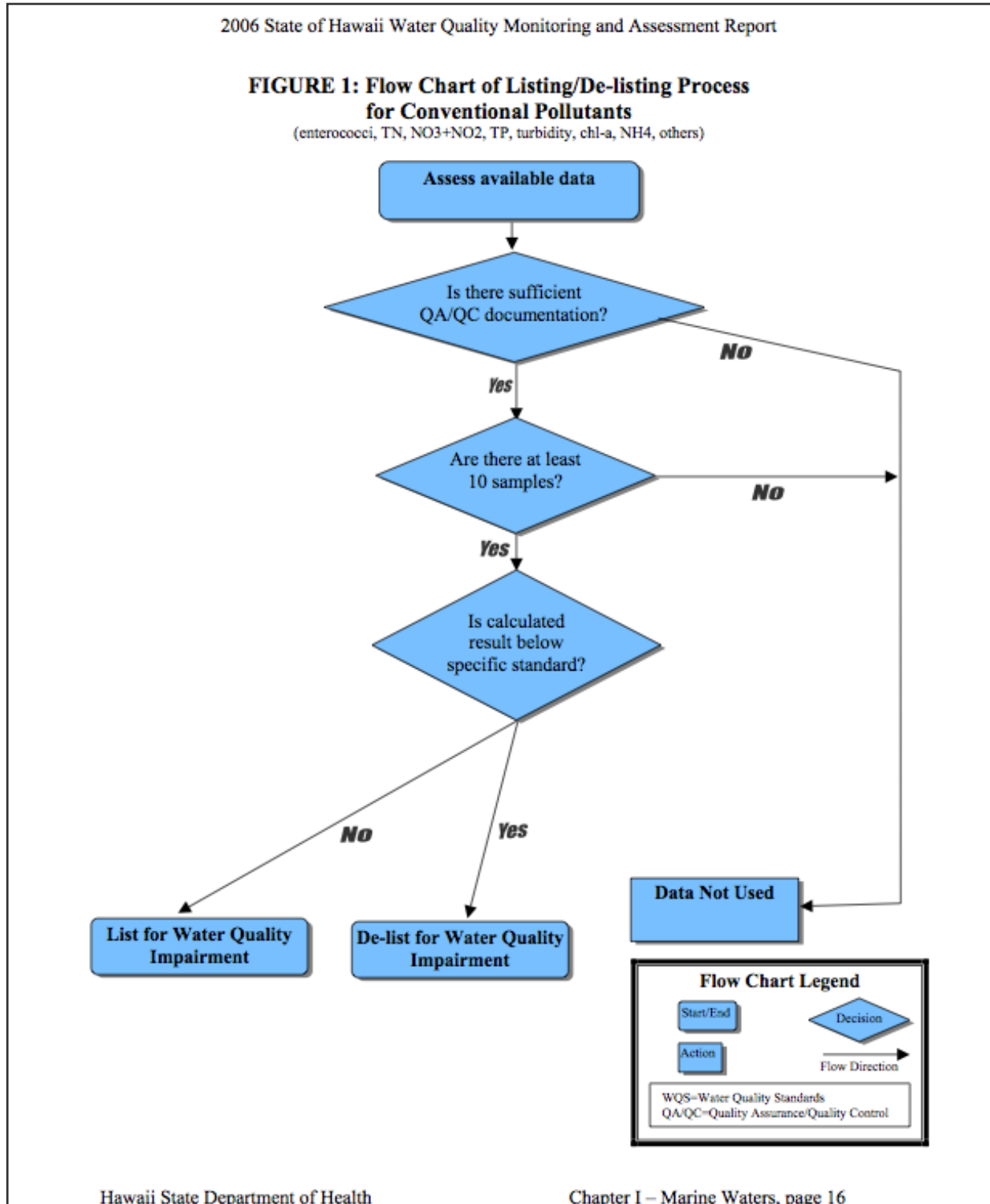


Figure 9. Listing/delisting logic – conventional pollutants, inland freshwaters

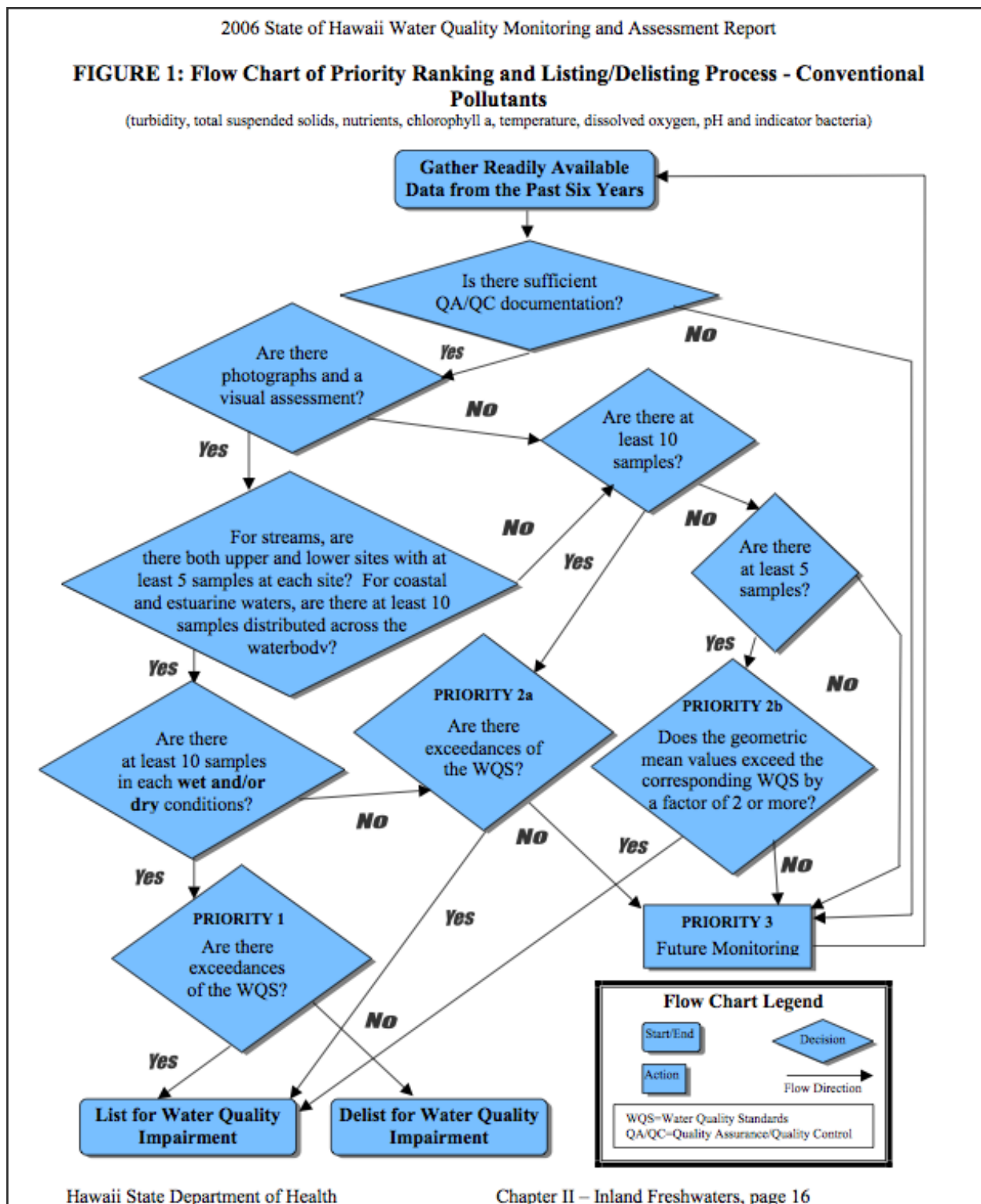


Figure 10. Listing/delisting logic – toxic pollutants

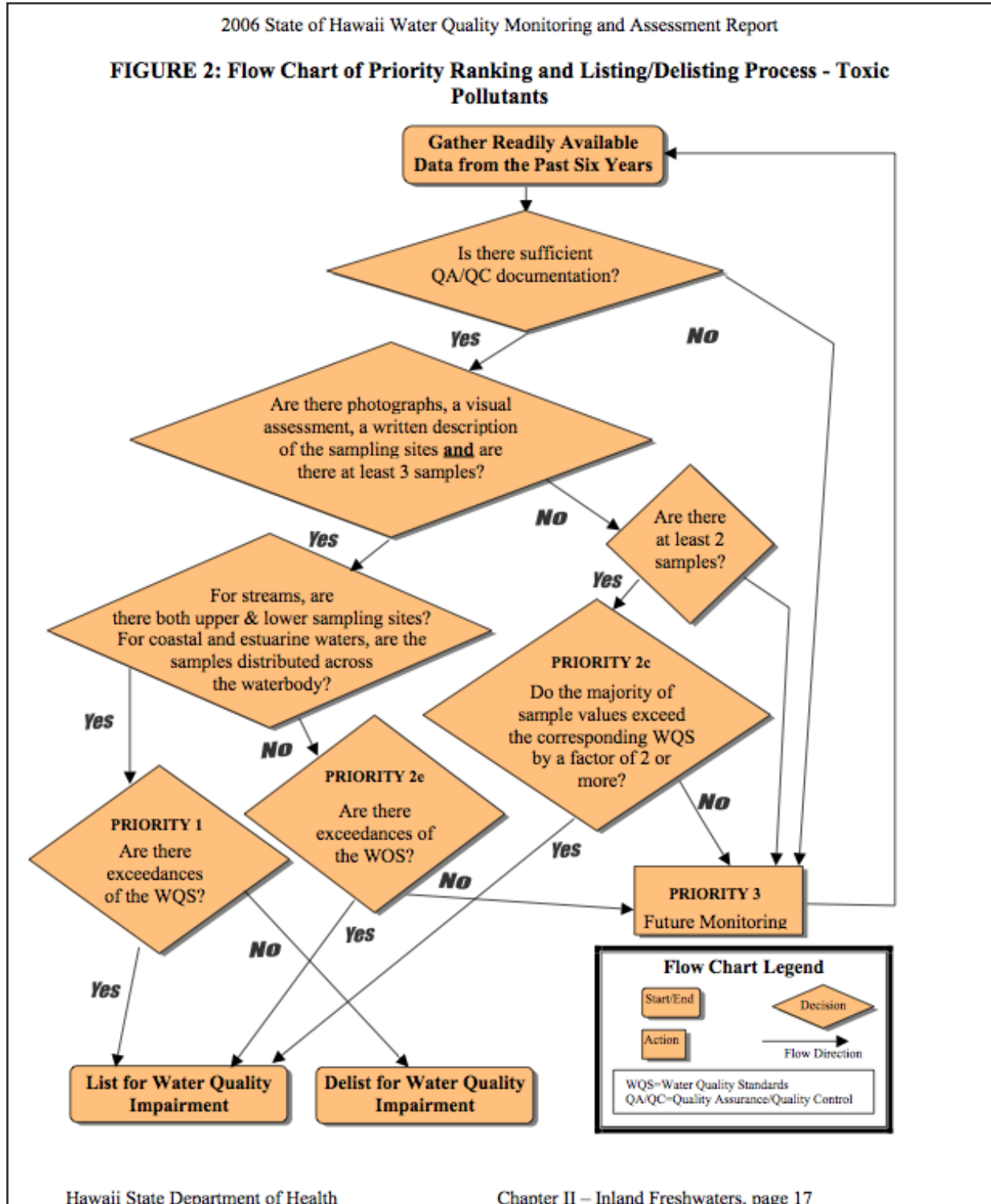
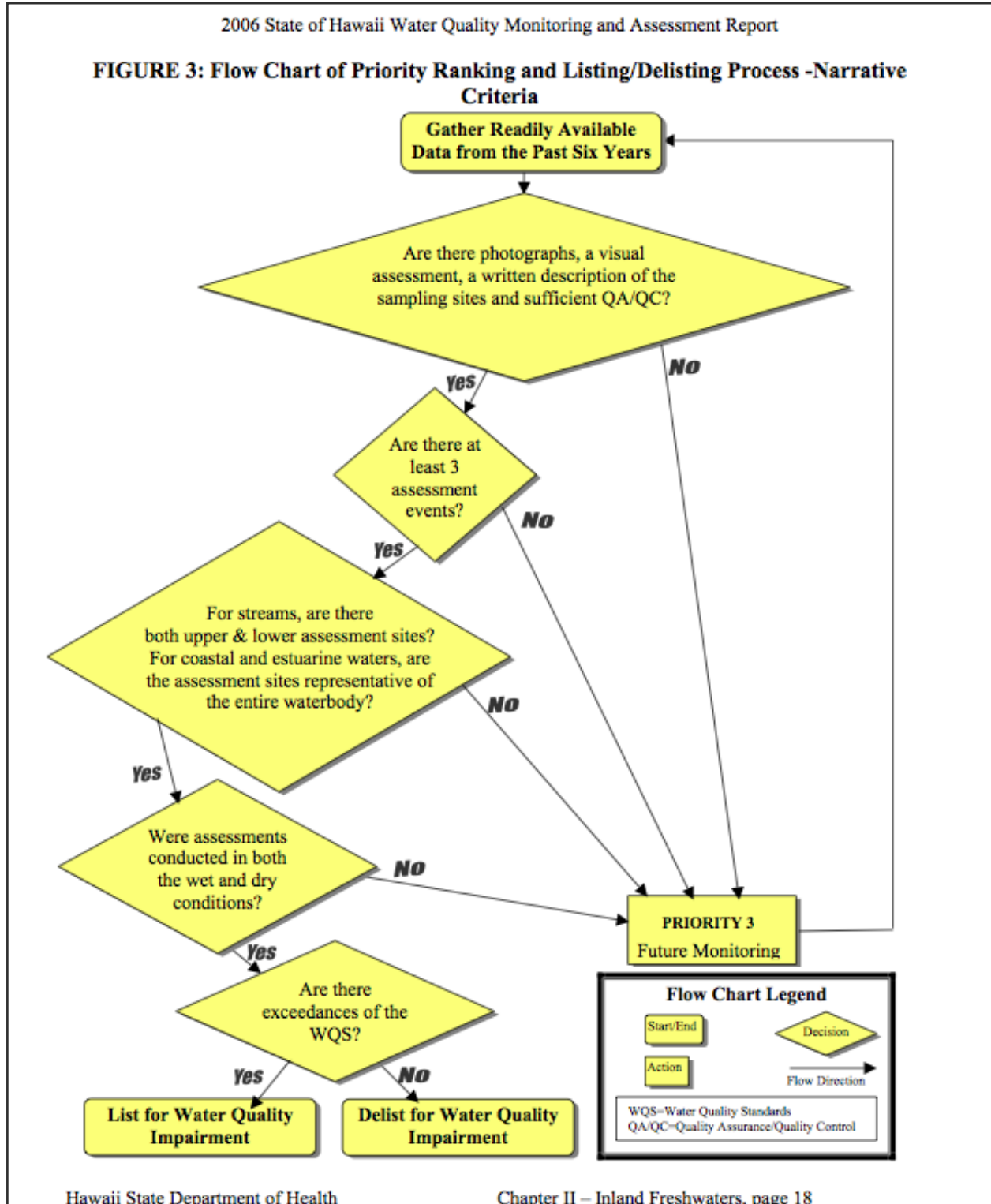


Figure 11. Listing/delisting logic – narrative criteria



## 6. Workgroup Process

DOH sought diverse expertise to develop a use attainment methodology for the 2008 integrated report.

Robin Knox and Karen Bennett were selected as meeting facilitators. A workgroup was invited to participate in two working meetings on Oahu and to collaborate by telephone and electronic correspondence outside of meetings. The facilitator collated available materials from existing state and federal documentation, and submissions by workgroup members, to develop the proposed methodology described later in this document.

Workgroup objectives were to determine the tools necessary to evaluate the waters and to establish a meaningful, yet simple method for determining use attainment with a limited data set.

The workgroup objectives did not include changing the existing standards (uses and criteria), but rather focused on:

- Identifying tools for determining use attainment
- Defining data quality and availability requirements
- Determining decision rules and logic for attainment decisions

### 6.1. *May 7 Public Meeting*

An introductory public meeting was held on May 7, 2008 at the Department of Health office on Oahu to explain the project to the public and invite their participation. Fifty-five people attended. The facilitator presented background information on water quality monitoring and assessment programs; relation to Clean Water Act and other DOH programs; water use classification in Hawaii; current use attainment tools and decision rules; the Integrated Water Quality Reporting (IWQR) workgroup goals; and how to participate.



DOH encouraged participation by individuals representing diverse user interests. Participants were given a chance to comment and ask questions, and told how to indicate their interest in “diligently and enthusiastically sharing their expertise” as part of the workgroup. The same material was presented on May 22 to 20 people on Maui.

The workgroup facilitators and DOH collaborated to decide a list of 50 people with diverse and appropriate expertise, representing county, state and federal agencies; UH; the private sector; and individuals, to invite to participate in the workgroup. All workgroup members were expected to participate in two meetings (in person or via teleconference) and work within a subgroup on completing assigned tasks. Interested parties who are not chosen for the workgroup were encouraged to coordinate their input through workgroup members, and to participate in the public review of the proposed decision criteria.

### 6.2. *June 23 First Workgroup Meeting*

The first workgroup meeting was held on June 23, 2008 at the DOH office on Oahu. Thirty people attended, representing Hawaii state agencies DOH (EPO, CWB) and DAR/DLNR, federal agencies (EPA, USGS, USFWS, and USDA/NRCS), University of Hawaii, and various organizations. The goal was to identify potential methods for determining use attainment, and questions or issues that



would need to be resolved for those methods to be used. An overview of objectives, goals, and regulations was presented. Then participants were divided into four subgroups:

1. Aquatic Life (includes native aquatic life);
2. Recreation, Aesthetics, Wildlife (includes natural waters);
3. Water Uses (includes navigation, agricultural water source, industrial water source, drinking water supply); and
4. Monitoring Data (includes data quality, data management; data sources (readily available; data format)). The subgroups identified action items to obtain data and resolve questions prior to the next meeting.

Notes from the meeting, including participant list, the presentation, handouts, instructions, and materials created during workgroup exercises, were sent to participants with a request to provide corrections and changes. An attachment identified action items and due dates for submissions by individuals and subgroups. Following the first workgroup meeting, participants provided the information shown in Table 3 to be considered in development of use attainment methodology.

**Table 3. Workgroup submittals – First meeting**

Submitted by	Item	What is it?	How is it used in proposed methodology?
Meaghan Dailer	Dailer and Smith (2008) unpublished  <i>Acclimated Hypnea musciformis</i> Sewage Effluent Addition Experiment	Papers on use of $\delta^{15}\text{N}$ values of invasive macroalgae to identify locations and potential sources of nutrient enrichment	Potential future tool for assessment with ability to discern when blooms are fueled by nitrogen; and to distinguish between sewage and fertilizer sources of nitrogen
June Harrigan-Lum	a) Designated Use Checklist  b) Report to Water Quality Working Group (July 2, 2008)  c) Report# 2 to Water Quality Working Group (August 10,2008	a) Checklist relating all the designated uses within each waterbody class to one of more metrics  b) Analyzes question of how many samples needed to cover variability at a site  c) Demonstrates how to make best use of limited data by clustering data sets in conjunction with waterbody indices	a) Used to provide nexus between designated uses in the water quality standards and use attainment decisions reported under Section 303(d)  b) Provides rationale for number of samples required using analysis of coefficient of variation  c) Allows combining data or using surrogate data from similar sites; example uses watershed index that might be a future tool/ for assessing uses.

Glenn Higashi	<p>a) Atlas of Hawaiian Watersheds and Their Aquatic Resources</p> <p>b) Point Quadrant Method: A rapid Assessment of Hawaiian Streams</p> <p>c) Estuary compendium</p>	<p>a) DAR stream Atlas HawaiiWatershedAtlas.com</p> <p>b) Survey methodology used in DAR assessments</p> <p>c) Survey methodology used in DAR assessments</p>	<p>a) Provided to workgroup for consideration as a tool</p> <p>b) Provided to workgroup for consideration as a tool</p> <p>c) Provided to workgroup for consideration as a tool</p>
Mike Kido	Hawaii Gradient Study and Watershed Health Index	Tool for assessment of watersheds; comments on how it might be employed in assessment with clustering data	Potential future use as a metric
Linda Koch	2006 IR Freshwater data set	The data that was the basis of the 2006 attainment decisions for Inland Waters	Used by Data and Monitoring Task Group for analysis of methodology
Elise Leroux	List of Surface Waters used as Drinking water Sources	Initial draft of list of waters used as drinking water sources (known to be incomplete at this time)	Tool for assessment of metric “used as a drinking water source”
Dale Mikami	2006 IR Marine Water Data set	The data that was the basis of the 2006 attainment decisions	Provided for the Data and Monitoring Task Group to analyze
Watson Okubo	Report to Recreational Aesthetics and Wildlife Group	Information on National heritage Rivers designation and ciguatera reporting	Considered as potential metrics for use assessment
Dana Okano	Comments by email	Regarding need for monitoring data requirements and coordinated statewide effort to facilitate gathering and sharing of monitoring data among agencies to achieve common programmatic goals	Included in discussion and recommendations
Ku’ulei Rodgers	<p>“Modeling Hawaiian Coral Reef Condition”</p> <p>Ecological Gradient Model  <a href="http://cramp.wcc.hawaii.edu/EG%20Model.htm">http://cramp.wcc.hawaii.edu/EG%20Model.htm</a></p>	Describes modeling reef condition within habitat class (geomorphology and hydrodynamics); Models continuum of conditions along a gradient of degradation from severely impacted to unimpacted.	Not available for this round of reporting; but may be available as an index of biotic integrity by the 2010 reporting period.

Gordon Smith	Maciolek 1978; Maciolek 1977	Papers discussing regulatory background information on Hawaii Water Quality Standards	Material presented at workgroup meeting # 1, and in regulatory background section
Terry Teruya	Comments by email and “Memo 1977-03-10 to the WQS Committee (Krock) and DOH Parnell WQS Coastal Waters (1980)”	Background information on the development of the Hawaiian regulations	Provided to the workgroup for consideration
Tom Young	Water Quality Discussion: Wet and Dry Seasons	Discussion of issues surrounding wet and dry season, water quality standards on ephemeral streams	See Discussion
Wendy Wiltse	Templates for Coral Reef Biocriteria	Examples biocriteria for protection of reef /coastal fisheries uses	Provided to the workgroup for consideration

A draft IWQR criteria document was sent out to the workgroup for review on August 22 with an invitation to comment.

### **6.3. Sept. 4 Second Workgroup Meeting**

The second workgroup meeting was held on September 4, 2008 at the DOH office on Oahu. Seventeen people attended, representing Hawaii County (Big Island), Hawaii state agency DOH, United States agency USDA, and various organizations. The goal was to review and refine the proposed methodology. First an overview of the methodology sent on August 22 was presented. Then, in subgroups according to waterbody classes, participants reviewed the metrics proposed for each use for that waterbody class. Following that, participants were asked to identify tools and rules for determining use attainment for one particular use in each waterbody class. Notes from the meeting were sent to participants, with a request to provide comments, corrections or clarifications.



In coordination with the DOH, the facilitator refined the methodology for clarity, consistency and simplicity. Comments received from workgroup members subsequent to the September 4, 2008 meeting were considered and incorporated in the refinements. These workgroup submittals are listed in Table 4.

**Table 4. Workgroup submittals – Second meeting**

Submitted by	Item	What is it?	How is it used in proposed methodology?
Anne Gasc	DOH Water Quality Workshop 2008 General Concerns	Discussion of factors such as decision unit, representative sampling, data QA/QC, data access and data analysis.	See Discussion; some aspects addressed in decision logic
Linda Koch; Bob Nishimoto, Sean O’Keefe	HSBP Discussion via emails	Comments, information and references regarding the HSBP	See Discussion

**Table 5. Workgroup participants**

May 7 public meeting (Oahu)	May 22 public meeting (Maui)	June 23 WG1	Sept 4 WG2	Last	First	Agency or affiliation
Y		Y		Arizumi	Thomas	DOH EHA Division Chief
Y		Y	Y	Ashman	Janet	HARC
Y		Y	Y	Bennett	Karen	Picture it Solved
Y		Y		Bienfang	Paul	UH HAA
				Brooks	Barbara	DOH HEER
			Y	Chong	Robert	DLNR CWRM
				Collier	Lawana	DOH CWB
	Y			Dailer	Meaghan	UH Botany
Y				Decarlo	Eric	UH Oceanography
Y		Y		Dollar	Steve	UH School of Earth Science
				Eversull	Dolan	Sea Grant
			Y	Fielding	Emily	The Nature Conservancy
Y			Y	Gasc	Anne	EnCoRe
				Grange	Fenix	DOH HEER
Y		Y	Y	Harrigan-Lum	June	self
		Y		Higashi	Glenn	DLNR DAR
			Y	Howerton	Robert	
Y		Y		Hunter	Brian	DOH CWB
Y		Y		Jokiel	Paul	UH - Corals - HIMB
Y		Y		Kido	Mike	UH HSRC
Y	Y	Y	Y	Koch	Linda	DOH EPO
Y	Y	Y	Y	Knox	Robin	WQC, Inc., UH Botany
				Koob	Greg	USDA NRCS
Y				Lau	Larry	DOH EHSD-DD
Y		Y		Leroux	Elise	DLNR CWRM
		Y	Y	Lum	Darryl	DOH CWB
Y		Y	Y	Minshew	Hudson	USDA NRCS
		Y		Miyashiro	Scott	DOH CWB
		Y		Murakawa	Scott	DOH
				Nishimoto	Bob	DLNR DAR

<b>May 7 public meeting (Oahu)</b>	<b>May 22 public meeting (Maui)</b>	<b>June 23 WG1</b>	<b>Sept 4 WG2</b>	<b>Last</b>	<b>First</b>	<b>Agency or affiliation</b>
Y			Y	Okano	Dana	County of Hawaii
Y		Y	Y	O'Keefe	Sean	HCS
		Y	Y	Okubo	Watson	DOH CWB
	Y			Paman	JoyLynn	Ao'Ao' O Na Loka I'a O Maui
		Y		Pelleteri	Sara	DLNR DAR
Y				Penn	Dave	DOH EPO
	Y	Y		Porter	Brooke	Pacific Whale Foundation
		Y		Pruder	Sina	DOH
				Randall	Leonard	USDA NRCS
Y		Y	Y	Remnek	Alexandre	DOH EPO
		Y		Robinson	Phyllis	Maui Board of Water Supply
Y		Y		Rodgers	Ku'u lei	UH Marine Biology
Y	Y	Y	Y	Sakamoto	Maile	DOH EPO
				See	Tom	DOH WW
		Y	Y	Slay	Hudson	DOH CWB
		Y		Smith	Gordon	USFWS
	Y			Sparks	Russell	DLNR DAR
		Y		Sunada	Kelvin	DOH EPO Manager
		Y		Teruya	Randy	DOA
		Y		Teruya	Terence	DOH
Y				Uyeno	Dean	DLNR CWRM
Y				Weiant	Pamela	The Nature Conservancy
		Y		Wiltse	Wendy	EPA
		Y		Wolff	Reuben	USGS
Y				Wood	Shannon	Windward Ahupua'a Alliance
		Y		Yamada	Stuart	DOH DW
		Y		Yamamoto	Earl	DOA
Y				Yan	Tao	UH Civil Engineering

Y indicates attendance at the meeting.

## 7. Evaluation of Existing Methodology

The desirable attributes for use attainment methodology were identified based on review of EPA guidance and discussion of workgroup objectives with Department of Health. The Use Attainment Methodology should describe how data is collected or obtained, information relevant to applicable WQS, how it evaluates the suitability of the data or information for decision making, and how it analyzes and interprets data to make attainment or non-attainment decisions.

Desirable attributes are:

- Meaningful yet simple
- Includes biological, toxicological, physical, chemical indicators
- Flexibility to accommodate current standards and future standards revisions.
- Considers all readily available data and information
- Facilitates data sharing with other agencies
- Provides nexus of decision criteria with standards and monitoring program
- Provides conformity with EPA Assessment Decision Database integrated reporting
- Focuses on use attainment

The methodology used in the 2006 Integrated Report was evaluated to identify areas where continued method development would result in an improved ability to address trends in EPA monitoring, assessment, and reporting requirements (such as probabilistic sampling design, use of multiple lines of evidence and automated reporting). A number of challenges with the existing methodology and opportunities for improvement were identified. The existing methodology relies heavily upon comparison of quantitative water column concentration data to numerical criteria for water chemistry and bacteria as the primary tool for use assessment. It is, therefore, criteria-focused rather than use attainment-focused. Because it does not use multiple lines of evidence, the existing methodology is potentially under-protective when there is no numerical criterion for a particular use or there is limited water column chemical and bacteriological data. The statistical design of the comparison of limited quantitative data sets (less than or equal to 10 observations) to numerical criteria is more likely to miss an impairment that exists than to report an impairment that does not exist. Under the existing methodology, the less numerical water column data that exists for a particular waterbody, the more likely that an existing impairment will be missed. In some cases, if limited data sets are not representative of the full range of variability, impairment maybe reported where none exists.”

The existing methodology does not use all readily available data. It has limited integration of biological, habitat, and other types of readily available data and it is unclear how these types of data are to be used. Although the stated policy is to use multiple lines of evidence, rigid requirements for data quality components sometime sideline otherwise useful data. Using multiple lines of evidence, data sets with tiered quality assurance requirements can be used. For instance data of lesser quality can be used to support another line of evidence, but if the lines of evidence disagree, then monitoring priorities can be focused to collect data of sufficient quality and quantity to resolve the discrepancy.

The existing methodology did not allow for easy translation to EPA reporting formats, to adapt to the use of emerging methods (probabilistic approaches), or to meet EPA Assessment Database requirements. The existing decision process documentation was not readily accessible to the public.

## 8. Proposed Methodology

The proposed methodology addresses these challenges by allowing use of a multiple lines of evidence approach that looks at all readily available data. Looking at a broader range of metrics allows integration of different types of data with differing spatial and temporal attributes. The bias of an individual metric is less likely to bias overall outcome of the attainment decision. The proposed methodology allows data requirements and decision rules to be set for each metric. It does not require data for all metrics, but rather makes best use of all readily available data. The proposed methodology uses programmable logic, lending itself to automation of reporting requirements as the tools are developed. The proposed methodology is flexible, allowing continued use of current tools and rules, while allowing incorporation of future tools and rules as the method is developed and refined. The most important benefits of the proposed methodology include:

- more versatile (less likely to miss impairment based solely on limited laboratory analyzed chemical or microbiological water column data);
- more effective use of all readily available existing data;
- provides a clearly documented, flexible decision process that works with existing rules and tool; and;
- can incorporate both regulatory change and development of management tools in each reporting cycle.

The proposed designated use assessment method is generally described in Methodology Overview. The method employs a Designated Use Checklist to assess support of uses based on metrics. The designated use checklist, tools and rules identified by the workgroup are provided in Appendix A – Tables 1-7. Each table presents the uses and metrics specific to one of seven waterbody classes. Each metric has its own data requirements and decision rules.

## 8.1. Methodology Overview

This overview is a generalized discussion of the proposed designated use attainment methodology. The four-step process is depicted below. A detailed explanation of each step follows.

### 1. Evaluate metrics for each use

### 2. Apply decision rules to determine use support

Designated Uses for Inland Waters Class 1a	Metrics	Metric Evaluation Tools	Is metric met? Yes No Don't Know	Decision Rules	Use is: Supported + Not supported X TMDL exempt (4a 4b 4c) Insufficient data?
Science & education	1. Access to State waters available 2. Minimally polluted runoff 3. Trash absent	Water body evaluation, visual assessment	1. 2. 3.		
Baseline references from which human-caused changes can be measured	1. Access to State waters available 2. Basic Criteria for all waters met (HAR §11-54-4) 3. Specific Inland Water Criteria met where applicable (HAR §11-54-5.2)				
Protection of native breeding stock	1. Basic Criteria for all waters met (HAR §11-54-4) 2. Specific Inland Water Criteria met where applicable (HAR §11-54-5.2) 3. HSBP score $\geq$ 60% reference for streams				
Compatible recreation, defined as swimming, wading, paddling, trail walking, viewing aquatic life, fishing	1. Compatible recreation present 2. Trash absent 3. Specific Criteria for inland recreational waters are met (HAR §11-54-8(a)) 4. Absence of hazardous levels of leptospirosis				

### 3. Tabulate use support

### 4. Assign segment use categories

Seg.	DU1	DU2	DU3	DU4	Description	C1	C2	C3	C4	C5	Category summary
A											
B											
C											
D											
etc.											

## 8.2. Methodology Details

### 1. Evaluate metrics for each use

For each segment, assemble and consider all existing and readily available data and/or information to determine the support status for each individual designated use. Use the indicated metrics, tools, and logic or guidance for each use.

#### 1. Evaluate this waterbody for each use in turn, using the specified metrics, tools, or metrics evaluation worksheet.

Class 1a, Segment B

Designated Uses	Metrics	Metric Evaluation Tools	Is metric met? Yes No Don't Know	Decision Rules	Use is: + x 4a 4b 4c ?
DU 1	Metric 1 Metric 2 Metric 3				
DU 2					
DU 3					
DU 4					

Designated Uses	Metrics	Metric Evaluation Tools	Is metric met? Yes No Don't Know	Decision Rules	Use is: + x 4a 4b 4c ?
DU 1	Metric 1 Metric 2 Metric 3				
DU 2					
DU 3					
DU 4					

**1.3 Do the same for remaining uses**

Designated Uses	Metrics	Metric Evaluation Tools	Is metric met? Yes No Don't Know	Decision Rules	Use is: + x 4a 4b 4c ?
DU 1	Metric 1 Metric 2 Metric 3				
DU 2					
DU 3					
DU 4					

**1.1 Evaluate each metric for this use, ideally at least one each of physical, chemical, biological, and visual**

**Metric 1: Physical**

	Yes	No	Don't know
Condition 1 met?			
Condition 2 met?			
Condition 3 met?			

**Metric 2: Chemical**

	Yes	No	Don't know
Condition 1 met?			
Condition 2 met?			
Condition 3 met?			

**Metric 3: Biological**

	Yes	No	Don't know
Condition 1 met?			
Condition 2 met?			
Condition 3 met?			

**1.2 Summarize metrics for this use & transfer to checklist**

	Yes	No	Don't know
Metric 1 met?			
Metric 2 met?			
Metric 3 met?			

## 2. Apply decision logic to determine use support

Based on the data and information available, make support decisions for each designated use in the segment and assign the appropriate symbol (+, 0, ?, T, 4a, 4b, 4c – See *Symbols and Definitions*, below).

### 2. Apply decision logic to determine use support

Class 1a, Segment B

Designated Uses	Metrics	Metric Evaluation Tools	Is metric met? Yes No Don't Know	Decision Rules	Use is: + x 4a 4b 4c ?
DU 1	Metric 1 Metric 2 Metric 3				
DU 2					
DU 3					
DU 4					

Designated Uses	Metrics	Metric Evaluation Tools	Is metric met? Yes No Don't Know	Decision Rules	Use is: + x 4a 4b 4c ?
DU 1	Metric 1 Metric 2 Metric 3				+
DU 2					
DU 3					
DU 4					

### 2.3 Do the same for remaining uses

Designated Uses	Metrics	Metric Evaluation Tools	Is metric met? Yes No Don't Know	Decision Rules	Use is: + x 4a 4b 4c ?
DU 1	Metric 1 Metric 2 Metric 3				+
DU 2					+
DU 3					?
DU 4					x

**2.1 Apply use attainment decision rules for this use**  
 If all metrics met, +  
 If no metrics met, x  
 If some metrics met [more logic here]

**2.2 Place corresponding symbol in the table for this use**

**Symbols and Definitions:**

**+** = The existing data and information shows that a use *is supported*.

**x** = The existing data and information shows that a use *is not supported*.

**?** = There is insufficient existing data and information to make a use support determination, consistent with the state's assessment and listing methodology.

**T** = A use in this segment is currently being supported, but is **THREATENED** and it is projected not to be supporting by the next scheduled list submission date.

**4a** = A TMDL to address a specific segment/pollutant combination has been approved or established by EPA.

**4b** = A use impairment caused by a pollutant is being addressed by the state through other pollution control requirements.

**4c** = A use is impaired, but the impairment is not caused by a pollutant.

### 3. Tabulate use support

Transfer the symbols to that segment's row in the waterbody class listing. Summarize the findings in the Description field.

Seg.	DU1	DU2	DU3	DU4	Description	Cat 1	Cat 2	Cat 3	Cat 4	Cat 5	Category summary
A											
B	+	+	?	X	2 uses supported, 1 not, 1 insuff. data						
C											
D											
etc.											

### 4. Assign segment use categories

Using the results of Step 3, place the segment into the appropriate category or categories.

Category 1: All designated uses are supported, no use is threatened;

Category 2: Available data and/or information indicate that some, but not all of the designated uses are supported;

Category 3: There is insufficient available data and/or information to make a use support determination;

Category 4: Available data and/or information indicate that at least one designated use is not being supported or is threatened, but a TMDL is not needed;

4a = A TMDL to address a specific segment/pollutant combination has been approved or established by EPA.

4b = A use impairment caused by a pollutant is being addressed by the state through other pollution control requirements.

4c = A use is impaired, but the impairment is not caused by a pollutant.

Category 5: Available data and/or information indicate that at least one designated use is not being supported or is threatened, and a TMDL is needed.

Seg.	DU1	DU2	DU3	DU4	Description	Cat 1	Cat 2	Cat 3	Cat 4	Cat 5	Category summary
A											
B	+	+	?	X	2 uses supported, 1 not, 1 insuff. data		C2	C3		C5	C2, C3, C5
C											
D											
etc.											

## Metric Evaluation Tool Example: Protection of native breeding stock, 1a

**Class 1a, Inland waters not degraded**

**Use: Protection of native breeding stock**

Metric 1: Basic Criteria met for all waters (HAR Section 11-54-4)

If answer is YES to any condition below, then Metric 1 is NOT MET

Condition Present?	Yes	No	Don't know
a. Settable materials, objectionable sludge or bottom deposits			
b. Floating debris, oil, scum			
c. Substances causing taste, odor, color, turbidity			
d. Temp (higher or lower than desired range)			
d. Other deleterious substances biocides, pathogens, toxins, radioactivity i. acute or chronic toxicity ii. exceedance of acute, chronic or human health (fish consumption) criteria			
f. substances or conditions or combinations thereof in concentrations which produce undesirable aquatic life			
g. Soil particles from erosion(except where present in compliance with HAR 11-54-4(c))			

Metric 2: Specific Inland Water Criteria (HAR 11-54-5.2) met where applicable

If answer is YES to all conditions below, then Metric 2 is NOT MET.

If answer to any question is NO, then mark DON'T KNOW for metric 2

Condition Present?	Yes	No
Are water chemistry data available?		
Is there adequate QA/QC documentation?		
Are there at least five data points and the data geomean > 2X criteria geomean?		
Are there at least 10 data points or statistical summary showing sufficient data points and data geomean > criteria geomean?		

Metric 3: HSBP total score  $\geq$  60% reference for streams

Is the HSBP score  $\geq$  60% reference for streams?

If YES, then HSBP Criteria metric is MET

Summary of Metrics for this use

	Yes	No	Don't know
Metric 1 met?			
Metric 2 met?			
Metric 3 met?			

## 9. Discussion

According to EPA guidance, the state's overall assessment methodology should describe how it assesses attainment with three distinct elements of the water quality standards: (1) designated use, (2) numeric and narrative criteria that protect the use, and (3) antidegradation policy. A waterbody segment is considered impaired when the water quality standards are not being attained and designated uses are not met. The segment is considered threatened when data suggests that the segment will not meet the water quality standards in the next reporting cycle. If any component of the standards is not attained, the water is considered impaired. The focus of the workgroup was to provide the designated use attainment portion of the state's overall assessment methodology utilizing the current Hawaii State Water Quality Standards (HAR 11-54). The overall objective of the workgroup was to determine the tools necessary to evaluate the waters and establish a meaningful yet simple method to determine designated use attainment with a limited data set.

Specific objectives were:

- Identifying tools for determining use attainment
- Defining data quality and availability requirements
- Determining decision rules and logic for attainment decisions

The workgroup developed and provided comment on a method to assess designated use attainment, a designated uses checklist for each waterbody type, a list of metrics for each use, a list of tools for assessment, and decision rules. The checklist, tools and decision rules provided in Appendix A, Tables 1-7 are the result of compiling workgroup comments on the draft materials.

Overall, there was workgroup consensus that there is no single “across the board” method of assessing uses for all waterbody types. There was general agreement that a designated use checklist organized by waterbody class (i.e. common characteristics and uses) is an appropriate methodology. There was agreement that the methodology needs further development to complete the array of metrics, rules and tools for each designated use. The workgroup did not propose any change from the 2004 rules of logic and 2006 decision rules that are currently in use for assessing criteria attainment.

There were areas of disagreement regarding specific metrics. Issues beyond the scope of the workgroup were raised, including standards applicability and how uses are defined and assigned to specific waterbodies. Much of the workgroup discussion focused on the quality of data required for determining criteria attainment. These issues will be forwarded to DOH as future topics of discussion for WQS revision.

The workgroup identified the use descriptions as an area where greater definition is needed in order to further develop the assessment methodology. Uses are identified but not specifically defined in the water quality standards. The details of what a particular use includes would determine appropriate metrics for use attainment assessment. For instance, recreational use is described in the standards as “compatible recreation” for waters not degraded by consumptive use (Inland Class 1, Marine Class AA) and as “recreation” for lower quality waters where consumptive use is acceptable (Inland Class 2, Marine Class). In the designated use checklist, the workgroup defined these uses identically as “swimming, wading, paddling, trail walking, viewing aquatic life, and fishing.” With this definition both bacterial criteria for recreational uses and fish tissue contaminant levels would be appropriate metrics for recreational use. These uses could be further defined as separate uses of primary contact recreation and fish consumption.

“Other uses” are listed in the standards, but are not defined. Cultural uses are not specifically named as a protected use. Are cultural uses considered under the designation for “Other uses”? Suggestions from workgroup for defining cultural uses include limu harvest, traditional fishing, surfing, and processing plant fibers. It was noted that cultural uses should not be limited to Native Hawaiian cultural uses, and that many of these uses would be protected under existing categories of use such as recreational and aquatic life support uses.

## **9.1. Tools for Use Attainment Determination**

The proposed designated use attainment methodology includes narrative and numeric water quality criteria as metrics for certain uses (See Appendix A). Available tools for numerical criteria assessment include chemical and microbiological analyses. For narrative criteria, an example Metric Evaluation Tool for assessing attainment with the Basic Criteria (applicable to all waters) was developed and reviewed by the workgroup. This tool is available for use in the 2008 assessment. For assessment of narrative criteria and aquatic life uses several tools were identified that are available and supported by existing and readily available data.

- Hawaii Stream Visual Protocol;
- Hawaii Stream Bioassessment Protocol;
- Coral Reef Assessment and Monitoring Protocol (CRAMP);
- Atlas of Hawaiian Watersheds and Their Aquatic Resources;
- Point Quadrant Method: A rapid Assessment of Hawaiian Streams; and
- Estuary compendium

These tools are available for use in the 2008 assessment; however specific questions remain about how to use these tools in the context of use attainment decisions. (See 9.1.1 Discussion of Metrics).

A statistical summary tool was submitted (Appendix B) that could be used to determine if sample size is adequate to capture variability. This tool needs to be tested with additional data sets prior to employing as a use assessment tool.

Several indices were discussed that have potential as tools for assessing uses. These include the Ecological Gradient Model for coral reefs (Rodgers 2009) and Watershed Health Index (Kido 2008) for inland waters. These indices allow correlation of multiple metrics directly to the use. An algal bioassay approach was identified using  $\delta^{15}\text{N}$  values of invasive macroalgae to identify locations and potential sources of nutrient enrichment. (Dailer, Smith, in prep). These particular tools are not sufficiently developed for use in 2008, but should be considered by DOH for the 2010 cycle. The data requirements for implementing these approaches should be considered in the development of monitoring plans for 2009 and 2010.

### **9.1.1. Discussion of Metrics**

There was focused discussion on several of the metrics proposed. Access was proposed as a metric for evaluating the attainment of uses such as recreation, science and education, and baseline reference. Concerns were expressed about private lands and liability for providing access. It was noted that access can refer not only to landowner allowing people to cross their lands, but also to physical or hydrologic features such as slope, flow, or presence of infrastructure that may impede access and keep use from being attained.

Workgroup members noted that with biological metrics it is important that protocol be appropriate with respect to expectations of species present. For instance in Hawaiian streams, species distribution may be influenced by factors such as elevation range. With regard to the Hawaii Stream Bioassessment Protocol (HSBP) concerns were expressed regarding the index of

biotic integrity. Specifically there was objection to the species presence or absence as a metric for biological integrity. It was noted that native species in Hawaii spend part of the life cycle in ocean and part in freshwater.

Issues raised regarding the index of biotic integrity include:

- Where species are subject to open recruitment does absence necessarily indicate impairment?
- If the habitat is there, but no fish are present, how can an aquatic life use attainment decision be supported?
- If only one size class of species is present, and the standard says to protect brood stock, would the presence/absence method alone be sufficient?

Questions were raised regarding how to use existing DAR protocols (or data elements of protocols) as metrics for use attainment decisions. CRAMP data is suggested as a metric for the conservation of coral reef uses, but it is not clear what the criteria or threshold for this metric should be. Does the waterbody fail if there is any significant decline in coral cover? What time period should be looked at when determining if there is decline?

Another proposed metric, the Atlas of Hawaiian Watersheds presents a useful compendium of historic watershed data, but the ratings contained within the atlas do not discern current from past conditions, and are therefore of limited usefulness in making decisions about the present-day use attainment. However specific data used to develop the ratings that are also representative of current conditions might be of use in attainment decisions if the data were readily available and had sufficient data quality documentation.

The workgroup identified the need for a metric for to address physical aspects of systems such as hydrologic modification and hardening. These needs include assessment of the volume and velocity of water movement; the impact of hydrologic changes to receiving water assimilative capacity and the impact of hydrology on fate and transport of pollutants. The need for a metric relating land use changes such as increasing impervious surfaces to changes in pollutant loading was discussed; Water body continuity and frequency, deviation and magnitude of flow patterns are important to attainment of aquatic life uses. The metrics should take into account effects of makai stream segment modification on mauka segments. If there is no water in the channel, or if the channel is concrete-lined and temperature is elevated as a result, fish cannot get to the upstream segment. There was a recommendation to include this as a component in future evaluations tools. The identification of irreversible anthropogenic changes to hydrology may lead to the need for use attainability analysis and development of tiered aquatic life uses. These approaches may also be applied to assign appropriate uses to naturally occurring ephemeral and intermittent streams.

Some metrics may require detailed instructions for evaluation. An example of metric evaluation worksheet was provided to the workgroup. The following questions were identified by the workgroup when reviewing the example metric evaluation worksheet:

- How are the basic criteria conditions in Metric 1 measured? Are there specific HSBP or HSVAP elements? By visual assessment? Where are these measurements taken? How much of the habitat needs to be assessed for a
- For pH, what is the desired range? Standards say ambient, what does that mean?
- What is no data, does that mean it is not assessed?
- What defines “undesirable aquatic life? Is it invasive species? Do we need to further define the term?

- What is acceptable severity of impact due to residual soil entering a receiving body of water (relates to discharges from lands meeting basic criteria compliance requirements for management and technology §HAR 11-54-4(c))? Do we need a metric for soil erosion that is separate from this narrative criterion?
- Does Metric 3 (HSBP > 60%) mean that both the habitat component and the biological integrity component be above 60%?

Comments received from the workgroup highlight the limitations of using the basic criteria as metrics. For instance the metrics could be further developed to define “undesirable aquatic life” for use attainment purposes by establishing metrics that are specific to the aquatic life, substances, and other conditions of concern for given uses and waterbody types. A problem with circular logic can arise when using compliance with some narrative criteria as a metric. The basic criteria state that waters shall be free from soil particles from erosion (except where present in compliance with HAR §11-54-4(c)). The regulation at HAR §11-54-4(c) specifies land management, treatment, and impact conditions under which erosion of soil particles can be considered to be compliant with the basic criteria. One of the conditions is that “the severity of impact of residual soil reaching the receiving body of water is deemed to be acceptable”. A metric is needed to define whether the particular uses are supported when soil residuals are present. If use is not supported, then water quality impacts of the soil erosion are not acceptable, even if all prescribed management practices and technology have been applied.

EPA guidance indicates that when making a determination of whether or not a criterion is met one should consider not only the specific conditions as stated in the regulation, but also the implicit or inferred conditions. The data should be representative of ambient conditions under which criteria are to be met. This includes consideration not only of the criteria conditions, such as a chemical concentration, but also the duration and frequency of occurrence of the condition and its relationship with hydrologic conditions.

Workgroup submittals indicated that water chemistry and bacterial data for assessment against criteria should be interpreted within the context of visual assessment and observations such as weather conditions, usage, presence of trash, observations regarding water movement patterns (for instance wind and current in ocean or flow in streams). The workgroup emphasized the need for observations and data collection to be conducted by trained personnel.

## **9.2. Data Availability and Quality**

### **9.2.1. Readily available data**

The DOH is required to “assemble and evaluate all existing and readily available water quality-related data and information” 40 CFR Part 130.7 (b)(5) specifies that, at a minimum, all existing and readily available water quality-related data includes information about the following classes of waters:

- those waters identified in the most recent 305(b) reporting as uses threatened or not supported,
- waters for which dilution calculations or models indicate nonattainment,
- waters identified as not attaining standards in nonpoint source assessments, and
- waters with water quality problems as reported by local, state or federal agencies, members of the public or academic institutions.

Reporting requirements include a description of the methodology, data and information used to identify impaired waters, and a rationale explaining why any readily available data was not used. The proposed designated use checklist provides documentation of how existing and readily

available data is used in making use attainment decisions. The following considerations were identified by the workgroup and DOH:

- Need to share data between DLNR, Coastal Zone Planning, County government and DOH
- Need to automate procedures from monitoring to reporting
- Consider use of Environmental Information Systems (One Stop project)
- Conformity with EPA Assessment Decision Database (ADB)
- Use ADB mapping and reporting functions

One of the challenges to implementing use of existing and readily available data from a variety of sources, even within the same agency, is to have compatible formats and protocols for sharing data. Varying information technology security requirements amongst agencies can result in one agency not being able to easily to access another's data or models.

### **9.2.2. Monitoring Design**

The workgroup expressed concerns about interpretation of data in the context of what is expected given factors that introduce variability across waterbody types (salinity, depth, water movement) and factors that introduce variability within a given data set for a waterbody types or sampling location (such as changes in climatic factors – wind, rain, temperature)

A number of concerns regarding representative sampling were identified:

- the sampling location
- the period of record
- the spatial extent data can be construed to represent
- the temporal extent data can be construed to represent
- the number of samples required
- the range of conditions the data represent (wet, dry, elevation, water depth, water movement)

There were concerns that given the limited monitoring resources of DOH and others (e.g. watershed groups), the amount of chemical and biological data currently required would lead to some impairments not being listed due to insufficient data. On the other hand, there was a concern that larger data sets were needed to be able to discern change due to anthropogenic sources from basic variability in the data due to other causes. The monitoring task group identified the desire for decisions to be made based on data sets that adequately address different sources of variability (e.g. elevation, water movement, climatic factors), but also recognized the need to allow both professional judgment and common sense to be used when the data do not meet a specific set of criteria.

These concerns reflect a need for decisions to be based on data that adequately characterizes the variability of the data set. The 2006 methodology addresses these concerns by providing data requirements such as a six-year time frame, minimum number of samples, requirements for sampling locations (e.g. upper and lower elevations for streams). However, a rigid application of these rules can lead to discarding valuable data and potentially failing to report impaired waters as a result. The Data and Monitoring Task Group identified the need to have the flexibility to vary from these data requirements employ best professional judgment and common sense when determining if data is adequate to make a decision.

It was recognized that there is variability both between waterbody types and within decisions units. Characteristics such as surface area, depth, water movement, and water use should be considered when determining location of sampling sites and sample size requirements. Classifying waterbodies by type allows identifying sufficient similarities that support certain environmental conditions and uses. It is then possible to establish a range of expected conditions

and uses to be supported due to the nature of the systems themselves (salinity, temperature, elevation, and geomorphology) Optimum sample sizes, locations, and conditions may vary among waterbody types,

It was noted that 10 samples maybe adequate if all results are fairly homogenous and not close to the criteria against which they are being compared, but that 10 samples may not be adequate if there is large variability or the results are very close to the standard. It was suggested that quality assurance analysis could be used to explain relative alpha and beta errors associated with the decisions based on the sample results.

Information was submitted to the workgroup (See Appendix B June Harrigan-Lum Report to Water Quality Working Group, July 2, 2008, and Appendix C Report #2 to Water Quality Working Group, August 10, 2008) that provides methods of determining the sample size needed to cover variability at a site. The method determines the sample size needed to characterize variability based on an analysis of the variability of the data. This work suggests that for well-mixed ocean waters along open coasts that the 10 samples used as a data requirement in 2006 is adequate in most cases.

“The variability within a string of data values is one of the best indicators of appropriate sample size; if more and more data values are added to a set but the variability of numbers within that set does not change, you will have more numbers but not more information on variability of the quality of waters” “Sampling values, especially from well-mixed surface ocean waters along open coastlines are, for all practical purposes, readily simulated by sets of random numbers, in which all numbers within a range matching the range found in actual data have an equal probability of being measured in a water sample, as is true in surface coastal waters receiving patterns of land-based runoff characteristic of an area.” Harrigan-Lum July 2, 2008

For freshwater streams an example is provided that uses an approach of clustering data to reduce variability of data set, and therefore reducing sample size required to characterize water quality. Data is organized by watershed classes as described by Mike Kido, University of Hawaii at Manoa, Stream Research Center. The watershed classes provides a basis for combining small stream data sets into larger sets with reduced within-cluster variability, and reduces the number of samples needed to characterize water quality within a stream cluster. The method provides an “eyeball type” graphical method for estimating water quality sample size.

The described approaches to limiting sample sizes need to be validated with additional data sets from a variety of waterbody types. These approaches provide not only feedback to monitoring system design, but also help to define decision units using probability based monitoring design or data variability to determine the geographic area represented by a sampling location. If systems are sufficiently similar, data sets can be combined. Decision units can be defined as the areas represented by data sets.

### **9.2.3. Data Quality**

DOH is required to consider, not only its own data but also existing and readily available data from other agencies, academic institutions and the general public. DOH is required to provide a rationale for any decision to not use any existing and readily available data and information. It is important that the data used in attainment decisions be of known quality, so the primary data quality consideration is that there be quality control documentation.

Generally speaking, agency and academic generated data will have documentation, but program specifics, such as protocols and analytical methods may vary. The workgroup did express concern about data quality, but did not suggest a change from current practice of requiring documentation to be provided upon request by DOH. Documentation of data quality may improve if DOH were to issues some guidelines for documentation.

It was noted that county level planning agencies often require water quality monitoring as a conditions of permits. Counties need clear guidance on monitoring design and data quality objectives to ensure that the data collected will be of benefit and used for decision-making purposes. The need for statewide planning guidance was identified.

### **9.3. Decision Rules**

The goals and regulatory mandates of the Clean Water Act water quality management programs are protection of the chemical, physical and biological integrity of the nation's waters in order to support recreation and protect wildlife and aquatic life uses. A critical component of developing the methodology is to define decision rules for use attainment decisions. The methodology incorporates the existing 2004 Rules of Logic and 2006 Decision Criteria for Listing and Delisting (as shown in figures 8-11 of this report). Therefore the data requirements and decision rules for determining attainment with narrative and numeric criteria have not changed from the 2006 methodology. Within both the existing and proposed decision rules, the failure to meet a water quality criterion classifies a waterbody as impaired and results in listing on the 303(d) list

The proposed methodology additionally classifies a waterbody as impaired and includes it on the 303(d) list if it fails to meet other metrics for attainment of uses. The alignment of the stated uses with a set of metrics gives an equivalence equation so assessment methodology is consistently applied. The use of a designated use attainment checklist and accompanying tools such as the metric evaluation worksheet provides documentation of the basis of the attainment decision

In the reviewing the proposed methodology, the workgroup was asked to comment on decision rules. There was concurrence that if all metrics are met, then the use is attained, and that if no metrics are met, then the use is not supported and waters are impaired. The workgroup was asked to comment on further logic for deciding when a use is attained based on multiple metrics. It was noted that metrics could be weighted in decision rules. The workgroup did not provide any specific suggestions for decision rules. Therefore in the proposed methodology, the metrics are equally weighted and decision rules are set at the most protective default value. If a criterion is not met, or any metric for an individual use fails, then the use is not supported. If the use is not supported, then the water quality is impaired and must be listed on the state's 303(d) list.

This protective approach may raise concerns such as increasing agency workload or burdens to the regulated community. Such socioeconomic factors should not be paramount in decisions of use attainment. Socioeconomic factors are considered in the development of the water quality standards, and in the application of the anti-degradation policy. For instance when water bodies are classified into classes ranging from those with the highest quality requirements (pristine waters) and those where the use is considered supported even though there maybe consumptive degradation in accordance with provisions of the anti-degradation policy. The methodology allows DOH to make best use of available data to protect water quality and beneficial uses, and to resolve any issues regarding standards, data quality or assessment methodology in accordance with figure 5.

## 10. Recommendations

### 10.1. *Tools for Use Attainment Determination*

Further development of the methodology is required for metrics that are not compared to numerical or narrative criteria, Threshold values need to be established for indicators to determine whether metrics are met. The workgroup specifically identified the need to determine the following:

- HSVAP elements that should be utilized for Class 1a and 1b aesthetic enjoyment use
- HSBP elements that should be utilized for Class 1a aesthetic enjoyment use
- HSBP elements that should be used for Class 1b support and propagation of native aquatic life;
- CRAMP elements or thresholds that should be utilized for aquatic life, recreational, aesthetics, aquatic life support, and conservation of coral reef uses in marine waters; and
- Elements of other DAR tools such as Atlas of Watersheds, Point Quadrant Method, and estuary compendium that might be used in the context of use attainment decisions.

Indices and bioassays should be further developed for use as metrics for use attainment. It is recommended that DOH, EPA, DAR and others as appropriate re-establish the working group to address how differences in bioassessment and habitat assessment protocols should be considered in the context of use attainment decisions. DOH is obligated to consider readily available data including HSBP, HSVAP, CRAMP, and other protocols or to provide a rationale as to why the data was not used in the decision.

Data for evaluation of attainment of basic criteria can be gathered by multiple parties through the use of a worksheet as an information-gathering tool. This tool could be employed by DOH, DLNR, and trained volunteer observers to collect basic criteria information when visiting waterbodies

### 10.2. *Data Availability and Quality*

For 2008, the DOH should use existing and readily available data including not only chemical and microbiological data, but also visual, biological and habitat data (HSVP, HSBP, and CRAMP) to evaluate use attainment according to metrics in the Designated Use Checklist

In preparation for the 2010 reporting cycle, DOH should continue to develop the monitoring program in order to allow evaluation of data using statistical summaries, data clustering and probabilistic approaches. Specific recommendations include:

- examine the 2008 assessment data sets to identify waterbodies where probabilistic approaches could be employed in 2010,
- develop probabilistic monitoring design for candidate waterbodies
- Collect data for 2010 assessment using probabilistic design.

It is recommended that DOH develop a portal and standardized format for submittal of data to be used for criteria and use attainment decisions. This will facilitate data sharing with other agencies and sources outside of DOH as well as use of other existing sources of data within DOH (e.g., permittee generated ambient water quality data or effluent monitoring data) This would allow DOH to effectively manage data, efficiently provide documentation of data, streamline data analysis, and support automated reporting, Full method implementation including consistency with EPA assessment database and automated reporting, will require DOH to:

- Define and map water quality decision units
- Develop a waterbody inventory
- Geo-referenced sampling locations

DOH should use the EPA Data Quality Objectives process to develop guidelines for third party monitoring program design and data quality documentation. The draft DOH Environmental Planning Office Quality Assurance Plan (QAP) should be revised to include objectives for data for metrics not currently addressed such as biological data for assessment of coral reef conservation use.

### **10.3. Decision Rules**

For the 2008 reporting cycle, it is recommended that DOH continue to use 2004 Logic Rules and 2006 decision criteria for evaluation of criteria.

Decision Rules should be the following default logic.

- If all metrics are met, use is supported;
- If any metric fails, then use is not supported, waterbody is impaired)

Rules and logic for deciding if use is attained are currently set at the most protective default level. As the method is tested there may be a need to further develop decision rules and logic (ie weighting of metrics). . It is recommended that the Task Groups continue to work to develop metrics and decision rules for each use.

Future development of methods could include an index for each use within each waterbody class, incorporating appropriate metrics. Assessment would be based on index score rather than a detailed list of metrics. Decision rules would then be contained within the index. Such indices can incorporate factors such as geomorphology, water volume and velocity, water depth, salinity and other factors that influence water quality data variability. Indices allow the sorting of waterbodies by common environmental characteristics prior to comparison of monitored chemical, physical, biological and habitat data.

## **11. Conclusions**

The DOH convened an Integrated Water Quality Reporting Workgroup to seek input on the development of new methods of assessing attainment of beneficial water uses designated in state WQS. The workgroup concluded that there is no “across the board” method of assessing all uses. The workgroup recommended the use of a designated use checklist methodology that can be utilized with existing regulations, assessment tools and decision rules. The methodology provides an assessment framework that is adaptable as regulations and assessment tools change and develop over time. The methodology can be put to use in the 2008 assessment with existing tools and decision rules. The full implementation of the methodology needs additional development of data gathering tools, metrics or threshold indicators, and decision rules for each use designated in the regulations.

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# Appendices

***Appendix A***  
***Designated Use Checklist***

## Designated Use Checklists

**Designated Uses** (definition) – “Uses that society, through state and federal governments, determines should be attained in the waterbody.

Examples include warm water aquatic ecosystems, public water supply, and recreational fishing.” (Source:

[www.epa.gov/watertrain/cwa/glossary](http://www.epa.gov/watertrain/cwa/glossary))

Hawaii Water Quality Standards at Hawaii Administrative Rules (HAR) §11-54-03(1) state, “It is the objective of Class 1 waters that these waters remain in their natural state as nearly as possible with an absolute minimum of pollution from any human-caused source.” The basic conditions to be maintained in Class AA Marine Waters and Class I Marine Bottoms use the phrase “natural pristine state”.

The checklist places the designated uses for each waterbody type under the general requirement of “natural waters – not degraded by consumptive uses” for Class 1 Inland Waters, Class AA Marine Waters, and Class I Marine Bottoms. The term “natural waters – degraded by consumptive uses” is used for Class 2 Inland Waters, for Class A Marine Waters, or for Class II Marine Bottoms. The checklist is to be used to sort waterbodies into EPA’s use support categories in the Integrated Report.

For each waterbody, fill out an appropriate checklist table for its waterbody class:

<b>Waterbody class</b>	<b>Table #</b>
Inland 1a	Table 1
Inland 1b	Table 2
Marine AA	Table 3
Marine Bottom I	Table 4
Inland 2	Table 5
Marine A	Table 6
Marine Bottom II	Table 7

CHECKLIST FOR EVALUATING EXTENT TO WHICH A STATE WATERBODY MEETS ITS DESIGNATED USES

Waterbody Class: **Inland Waters Class 1a** (Table 1)

Date:

Time:

Waterbody Name:

Geocode ID:

Your Name & Contact Information:

Watershed Name:

<b>Designated Uses</b> for Inland Waters Class 1a	<b>Metrics</b>	<b>Metric Evaluation Tools</b>	<b>Is metric met?</b> Yes No Don't Know	<b>Decision Rules</b>	<b>Result of Decision Logic - Use is:</b> Supported <b>+</b> Not supported <b>X</b> TMDL exempt <b>(4a 4b 4c)</b> Insufficient data <b>?</b>
Science & education	1. Access to State waters available 2. Minimally polluted runoff 3. Trash absent	Waterbody evaluation, visual assessment	1. 2. 3.		
Baseline references from which human-caused changes can be measured	1. Access to State waters available 2. Basic Criteria for all waters met (HAR §11-54-4) 3. Specific Inland Water Criteria met where applicable (HAR §11-54-5.2)	Waterbody evaluation Chemical analysis Metric evaluation worksheet for basic criteria	1. 2. 3.		
Protection of native breeding stock	1. Basic Criteria for all waters met (HAR §11-54-4) 2. Specific Inland Water Criteria met where applicable (HAR §11-54-5.2) 3. HSBP score $\geq$ 60% reference for streams	Waterbody evaluation Chemical analysis Metric evaluation worksheet for basic criteria Toxicity testing HSBP protocol (?) Watershed Atlas (?) Point Quadrant Method (?)	1. 2. 3.		

CHECKLIST FOR EVALUATING EXTENT TO WHICH A STATE WATERBODY MEETS ITS DESIGNATED USES

Waterbody Class: **Inland Waters Class 1a** (Table 1)

Date:

Time:

Waterbody Name:

Geocode ID:

Your Name & Contact Information:

Watershed Name:

<b>Designated Uses</b> for Inland Waters Class 1a	<b>Metrics</b>	<b>Metric Evaluation Tools</b>	<b>Is metric met?</b> Yes No Don't Know	<b>Decision Rules</b>	<b>Result of Decision Logic - Use is:</b> Supported <b>+</b> Not supported <b>X</b> TMDL exempt <b>(4a 4b 4c)</b> Insufficient data <b>?</b>
Compatible recreation, defined as swimming, wading, paddling, trail walking, viewing aquatic life, fishing	1. Compatible recreation present 2. Trash absent 3. Specific Criteria for inland recreational waters are met HAR §11-54-8(a) 4. Absence of hazardous levels of leptospirosis 5. Fish tissue contaminants do not exceed FDA action levels	Waterbody evaluation Microbiological analysis Fish tissue analysis	1. 2. 3. 4. 5.		
Aesthetic enjoyment (in sense of a community value)	1. HSVP elements 2. HSBP reference for streams 3. Narrative criteria at §11-54-4(a) are met	Waterbody evaluation Metric evaluation worksheet for basic criteria HSVP protocol (?) HSBP protocol (?) photography	1. 2. 3. 4.		
Other Uses	1. Cultural uses present	Consultation with cultural practitioners	1.		

CHECKLIST FOR EVALUATING EXTENT TO WHICH A STATE WATERBODY MEETS ITS DESIGNATED USES

Waterbody Class: **Inland Waters Class 1b** (Table 2)

Date:

Time:

Waterbody Name:

Geocode ID:

Your Name & Contact Information:

Watershed Name:

<b>Designated Uses</b> for Inland Waters Class 1b	<b>Metrics</b>	<b>Metric Evaluation Tools</b>	<b>Is metric met?</b> Yes No Don't Know	<b>Decision Rules</b>	<b>Result of Decision Logic - Use is:</b> Supported <b>+</b> Not supported <b>X</b> TMDL exempt <b>(4a 4b 4c)</b> Insufficient data?
Domestic water supplies	1. Waterbody used as a drinking water source 2. Meets Safe Drinking Water Act criteria with or without treatment 3. Basic Criteria for all waters met (HAR §11-54-4) 4. Specific Inland Water Criteria met where applicable (HAR §11-54-5.2)	List of Drinking Water Sources Chemical analyses Microbiological analysis Metric evaluation worksheet for basic criteria	1. 2. 3. 4.		
Food processing	1. Waters used as food processing water source 2. Meets Safe Drinking Water Act criteria with or without treatment 3. Basic Criteria for all waters met (HAR §11-54-4) 4. Specific Inland Water Criteria met where applicable (HAR §11-54-5.2)	Chemical analyses Microbiological analysis Metric evaluation worksheet for basic criteria	1. 2. 3. 4.		

CHECKLIST FOR EVALUATING EXTENT TO WHICH A STATE WATERBODY MEETS ITS DESIGNATED USES

Waterbody Class: **Inland Waters Class 1b** (Table 2)

Date:

Time:

Waterbody Name:

Geocode ID:

Your Name & Contact Information:

Watershed Name:

<b>Designated Uses</b> for Inland Waters Class 1b	<b>Metrics</b>	<b>Metric Evaluation Tools</b>	<b>Is metric met?</b> Yes No Don't Know	<b>Decision Rules</b>	<b>Result of Decision Logic - Use is:</b> Supported <b>+</b> Not supported <b>X</b> TMDL exempt <b>(4a 4b 4c)</b> Insufficient data?
Protection of native breeding stock	1. Basic Criteria for all waters met (HAR §11-54-4) 2. Specific Inland Water Criteria (HAR §11-54-5.2) met where applicable 3. For streams HSBP score $\geq$ 60% reference	Waterbody evaluation Chemical analysis Metric evaluation worksheet for basic criteria HSBP (?) Watershed Atlas (?) Point Quadrant Method (?)	1. 2. 3.		
Support and propagation of aquatic life	1. Basic Criteria met for all waters (HAR §11-54-4) 2. Specific Inland Water Criteria (HAR §11-54-5.2) met where applicable 3. HSBP reference for streams 4. Fish tissue contaminants below FDA action levels	Waterbody evaluation Chemical analysis Metric evaluation worksheet for basic criteria Toxicity testing HSBP protocol (?) Fish tissue testing Watershed Atlas (?) Point Quadrant Method (?)	1. 2. 3. 4.		

CHECKLIST FOR EVALUATING EXTENT TO WHICH A STATE WATERBODY MEETS ITS DESIGNATED USES

Waterbody Class: **Inland Waters Class 1b** (Table 2)

Date:

Time:

Waterbody Name:

Geocode ID:

Your Name & Contact Information:

Watershed Name:

<b>Designated Uses</b> for Inland Waters Class 1b	<b>Metrics</b>	<b>Metric Evaluation Tools</b>	<b>Is metric met?</b> Yes No Don't Know	<b>Decision Rules</b>	<b>Result of Decision Logic - Use is:</b> Supported <b>+</b> Not supported <b>X</b> TMDL exempt <b>(4a 4b 4c)</b> Insufficient data?
Baseline references from which human-caused changes can be measured	1. Access to State waters available 2. Basic Criteria for all waters met (HAR §11-54-4) 3. Specific Inland Water Criteria met where applicable (HAR §11-54-5.2) 4. Selected HSBP metrics	Waterbody evaluation Chemical analysis Metric evaluation worksheet for basic criteria HSBP Protocol (?)	1. 2. 3. 4.		
Science & education	1. Access to State waters available 2. Minimally polluted runoff 3. Trash absent 4. Selected HSBP metrics	Waterbody evaluation HSBP protocol (?)	1. 2. 3. 4.		
Compatible recreation defined as swimming, wading, paddling, trail walking, viewing aquatic life, fishing	1. Compatible recreation present 2. Human-generated trash absent 3. Specific Criteria for inland recreational waters are met HAR §11-54-8(a) 4. Absence of hazardous levels of leptospirosis 5. Fish tissue contaminants below FDA action levels	Waterbody evaluation Microbiological analysis Fish tissue analysis	1. 2. 3. 4. 5.		

CHECKLIST FOR EVALUATING EXTENT TO WHICH A STATE WATERBODY MEETS ITS DESIGNATED USES

Waterbody Class: **Inland Waters Class 1b** (Table 2)

Date:

Time:

Waterbody Name:

Geocode ID:

Your Name & Contact Information:

Watershed Name:

<b>Designated Uses</b> for Inland Waters Class 1b	<b>Metrics</b>	<b>Metric Evaluation Tools</b>	<b>Is metric met?</b> Yes No Don't Know	<b>Decision Rules</b>	<b>Result of Decision Logic - Use is:</b> Supported <b>+</b> Not supported <b>X</b> TMDL exempt <b>(4a 4b 4c)</b> Insufficient data?
Aesthetic enjoyment (in sense of a community value)	1. HSVP elements 2. HSBP reference for streams 3. Narrative criteria at §11- 54-4(a) are met	Waterbody evaluation HSVP protocol (?) HSBP protocol (?)	1. 2. 3.		
Other uses	1. Cultural uses present	Consultation with cultural practitioner	1.		

CHECKLIST FOR EVALUATING EXTENT TO WHICH A STATE WATERBODY MEETS ITS DESIGNATED USES

Waterbody Class: **Marine Waters Class AA** (Table 3)

Date:

Time:

Waterbody Name: Geocode ID:

Your Name & Contact Information:

Watershed Name:

Designated Uses for Marine Waters Class AA	Metrics	Metric Evaluation Tools	Is metric met? Yes No Don't Know	Decision Rules	Result of Decision Logic - Use is: Supported <b>+</b> Not supported <b>X</b> TMDL exempt <b>(4a 4b 4c)</b> Insufficient data?
Oceanographic research	1. Access to state waters 2. Minimally polluted runoff	Waterbody evaluation, visual assessment	1. 2.		
Support & propagation of marine life	1. Basic Criteria met for all waters (HAR §11-54-4) 2. Specific Marine Water Criteria (HAR §11-54-6) met where applicable 3. Fish tissue contaminants 4. CRAMP elements	Waterbody evaluation Chemical analysis Metric evaluation worksheet for basic criteria Toxicity testing Fish tissue testing CRAMP protocols (?)	1. 2. 3. 4.		
Conservation of coral reefs	1. CRAMP elements (Coral cover, recruitment) 2. Fish population (abundance and diversity) 3. Algae (presence of desirable species, lack of alien invasive species) 4. Physical –chemical factors (sedimentation, rugosity, organic composition, silt/clay fraction)	CRAMP protocols (?) Fish survey data Ecological Gradient Model (?) Algal survey/bioassay (?)	1. 2. 3. 4.		
Conservation of wilderness areas					

CHECKLIST FOR EVALUATING EXTENT TO WHICH A STATE WATERBODY MEETS ITS DESIGNATED USES

Waterbody Class: **Marine Waters Class AA** (Table 3)

Date:

Time:

Waterbody Name:

Geocode ID:

Your Name & Contact Information:

Watershed Name:

<b>Designated Uses</b> for Marine Waters Class AA	<b>Metrics</b>	<b>Metric Evaluation Tools</b>	<b>Is metric met?</b> Yes No Don't Know	<b>Decision Rules</b>	<b>Result of Decision Logic - Use is:</b> Supported <b>+</b> Not supported <b>X</b> TMDL exempt <b>(4a 4b 4c)</b> Insufficient data?
Compatible recreation (defined as swimming, wading, diving, boating, fishing, surfing, viewing aquatic life)	1. Compatible recreation present 2. Trash absent 3. Specific Criteria for recreational use are met HAR §11-54-8 4. No days of beach closure due to bacterial levels 5. Fish tissue contaminants below FDA action levels 6. No reported ciguatera	Waterbody evaluation Microbiological analysis BEACHES Posting Fish tissue analysis Reportable Disease Registry	1. 2. 3. 4. 5. 6.		
Aesthetic enjoyment	1. CRAMP elements 2. Narrative criteria at §11-54-4(a) are met	CRAMP Protocol (?) Metric evaluation worksheet for basic criteria	1. 2.		
Other uses	1. Cultural uses present	Consultation with cultural practitioners	1.		

CHECKLIST FOR EVALUATING EXTENT TO WHICH A STATE WATERBODY MEETS ITS DESIGNATED USES

Waterbody Class: **Marine Bottom Ecosystems Class I** (Table 4)  
 Waterbody Name: \_\_\_\_\_ Geocode ID: \_\_\_\_\_  
 Watershed Name: \_\_\_\_\_

Date: \_\_\_\_\_ Time: \_\_\_\_\_  
 Your Name & Contact Information: \_\_\_\_\_

<b>Designated Uses</b> for Marine Bottom Ecosystems Class I	<b>Metrics</b>	<b>Metric Evaluation Tools</b>	<b>Is metric met?</b> Yes No Don't Know	<b>Decision Rules</b>	<b>Result of Decision Logic - Use is:</b> Supported <b>+</b> Not supported <b>X</b> TMDL exempt (4a 4b 4c) Insufficient data ?
Non-consumptive scientific research	1. Access to state waters 2. Minimally polluted runoff 3. Trash absent	Waterbody evaluation, visual assessment	1. 2.		
Non-consumptive education	1. Access to state waters 2. Minimally polluted runoff 3. Trash absent	Waterbody evaluation, visual assessment	1. 2. 3.		
Aesthetic enjoyment	1. CRAMP elements 2. Narrative criteria at §11-54-4(a) are met	CRAMP Protocol (?) Metric evaluation worksheet for basic criteria	1. 2. 3. 4.		
Passive activities (no intervention or alteration)	1. "Take nothing but photos"; leave nothing behind you.	Photography	1.		
Preservation	1. Above uses are preserved	DU checklist decisions	1.		
Other uses?	1. Cultural uses present	Consultation with cultural practitioners	1.		

CHECKLIST FOR EVALUATING EXTENT TO WHICH A STATE WATERBODY MEETS ITS DESIGNATED USES

Waterbody Class: **Inland Waters Class 2** (Table 5)

Date:

Time:

Waterbody Name:

Geocode ID:

Your Name & Contact Information:

Watershed Name:

<b>Designated Uses</b> for Inland Waters Class 2	<b>Metrics</b>	<b>Metric Evaluation Tools</b>	<b>Is metric met?</b> Yes No Don't Know	<b>Decision Rules</b>	<b>Result of Decision Logic - Use is:</b> Supported <b>+</b> Not supported <b>X</b> TMDL exempt <b>(4a 4b 4c)</b> Insufficient data <b>?</b>
Recreation(defined as swimming, wading, diving, boating, fishing, surfing, viewing aquatic life)	1. Recreation present 2. Trash absent 3. Specific Criteria for inland recreational waters are met HAR §11-54-8(a) 4. Absence of hazardous levels of leptospirosis 5. Fish tissue contaminants below FDA action levels	Waterbody evaluation Microbiological analysis Fish tissue analysis	1. 2. 3. 4. 5.		
Support & propagation of aquatic life	1. Basic Criteria met for all waters (HAR §11-54-4) 2. Specific Inland Water Criteria (HAR §11-54-5.2) met where applicable 3. HSBP reference for streams 4. Fish tissue contaminants do not exceed FDA action levels	Waterbody evaluation Chemical analysis Metric evaluation worksheet for basic criteria Toxicity testing HSBP (?) Fish tissue testing Watershed Atlas (?) Point quadrant Method (?)	1. 2. 3. 4.		

CHECKLIST FOR EVALUATING EXTENT TO WHICH A STATE WATERBODY MEETS ITS DESIGNATED USES

Waterbody Class: **Inland Waters Class 2** (Table 5)

Date:

Time:

Waterbody Name:

Geocode ID:

Your Name & Contact Information:

Watershed Name:

<b>Designated Uses</b> for Inland Waters Class 2	<b>Metrics</b>	<b>Metric Evaluation Tools</b>	<b>Is metric met?</b> Yes No Don't Know	<b>Decision Rules</b>	<b>Result of Decision Logic - Use is:</b> Supported <b>+</b> Not supported <b>X</b> TMDL exempt <b>(4a 4b 4c)</b> Insufficient data <b>?</b>
Agricultural & industrial water supplies, as compatible with protection & propagation of fish, shellfish, wildlife, & recreation	1. Agricultural and industrial water supply use is present and permitted where required 2. Support & propagation of aquatic life use is supported 3. Recreation use is supported	Waterbody evaluation Designated use decisions	1. 2. 3.		
Shipping & navigation, as compatible with protection & propagation of fish, shellfish, wildlife, & recreation	1. Shipping and navigation present 2. Support & propagation of aquatic life use is supported 3. Recreation use is supported	Waterbody evaluation Visual assessment	1. 2. 3.		
Other uses?	Cultural uses	Consultation with cultural practitioners	1.		

CHECKLIST FOR EVALUATING EXTENT TO WHICH A STATE WATERBODY MEETS ITS DESIGNATED USES

Waterbody Class: **Marine Waters Class A** (Table 6)

Date:

Time:

Waterbody Name:

Geocode ID:

Your Name & Contact Information:

Watershed Name:

<b>Designated Uses</b> for Marine Waters Class A	<b>Metrics</b>	<b>Metric Evaluation Tools</b>	<b>Is metric met?</b> Yes No Don't Know	<b>Decision Rules</b>	<b>Result of Decision Logic - Use is:</b> Supported <b>+</b> Not supported <b>X</b> TMDL exempt <b>(4a 4b 4c)</b> Insufficient data <b>?</b>
Recreational purposes defined as Swimming, wading, diving, boating, fishing, viewing aquatic life	1. Basic Criteria met for all waters (HAR §11-54-4) 2. Specific Marine Water Criteria (HAR §11-54-6) met where applicable 3. Specific Criteria for recreational use are met HAR §11-54-8 4. No days beach closure due to bacterial levels 5. Fish tissue contaminants below FDA action levels 6. No reported ciguatera	Waterbody evaluation Microbiological analysis BEACHES Posting Fish tissue analysis Reportable Disease Registry	1. 2. 3. 4. 5. 6.		
Aesthetic enjoyment	1. CRAMP elements 2. Narrative criteria at §11-54-4(a) are met	CRAMP Protocol (?) Metric evaluation worksheet for basic criteria	1. 2.		
Other uses compatible with protection and propagation of fish, shellfish, wildlife, & recreation	1. Cultural uses 2. Support & propagation of aquatic life use is supported 3. Recreation use is supported	Consultation with cultural practitioners DAR commercial fishery reports	1. 2. 3.		

CHECKLIST FOR EVALUATING EXTENT TO WHICH A STATE WATERBODY MEETS ITS DESIGNATED USES

Waterbody Class: **Marine Bottom Ecosystems Class II** (Table 7)  
 Waterbody Name: \_\_\_\_\_ Geocode ID: \_\_\_\_\_  
 Watershed Name: \_\_\_\_\_

Date: \_\_\_\_\_ Time: \_\_\_\_\_  
 Your Name & Contact Information: \_\_\_\_\_

<b>Designated Uses</b> for Marine Bottom Ecosystems Class II	<b>Metrics</b>	<b>Metric Evaluation Tools</b>	<b>Is metric met?</b> Yes No Don't Know	<b>Decision Rules</b>	<b>Result of Decision Logic - Use is:</b> Supported <b>+</b> Not supported <b>X</b> TMDL exempt <b>(4a 4b 4c)</b> Insufficient data <b>?</b>
All uses compatible with protection and propagation of fish, shellfish, wildlife, & with recreation	1. Basic Criteria met for all waters (HAR §11-54-4) 2. Specific criteria at HAR §11-54-7) met	Waterbody evaluation Metric evaluation worksheet for basic criteria			

NOTE: Metric evaluations tools followed by a question mark (?) are those that workgroup members have identified as needing further clarification to determine how elements or data collected using the protocol should be used in the context of use attainment decisions.

***Appendix B***

***Report to Water Quality Working Group. July 2, 2008***

Report to Water Quality Working Group-Summer 2008  
June F. Harrigan-Lum  
July 2, 2008

**Summary:** Ways to limit sample size to only the number (n) needed to cover variability at a site include:

1. Compare the variability in a dataset to that in a set of random numbers drawn from the same range of values found in the actual data for a site. Stop adding data points when the variability in a random number string converges with that of the actual data set. A sample size of  $n=10$  is adequate for this approach.
2. Use the geometric mean instead of the variability. Twice the sample size is needed before geometric means of actual data and random number sets drawn from the same range of numbers as the data converge.
3. Data ranges expected at new sites can be estimated from data sets collected from past sampling of the same or adjacent areas.
4. There are many mathematical formulas available for calculating sample size. Unless you are well-trained in the use of statistics, don't use them; use the simpler methods described below instead.
5. If you have fewer than ten samples from each of several adjacent and similar areas, combine the data.
6. Combining small numbers of samples collected over a period of several years at a site provides more information on variability at a site than does one large sample collected over 1-2 years.
7. The approach to limiting sample sizes described below needs to be validated with additional data sets from a variety of water bodies. Optimum sample sizes may vary among waterbody types, but from the data I've seen over the years a set of 10 samples from an area is adequate, especially if repeated in later years to evaluate time trends.

The water quality topic I was asked to comment on was how to demonstrate that a sample of size  $n$  is (1) representative of the sampling site where it was collected, and (2) representative of nearby areas, whether open coastlines or stream systems. How do we estimate  $n$ ?

Introduction - Data sets are not just strings of numbers which should be as long as possible because "more data are better". The variability within a string of data values is one of the best indicators of appropriate sample size; if more and more data values are added to a set but the variability of numbers within that set does not change, you will have more numbers but not more information on variability of the quality of waters. Sampling values, especially from well-mixed surface ocean waters along open coastlines are, for all practical purposes, readily simulated by sets of random numbers, in which all numbers within a range matching the range found in actual data have an equal probability of being measured in a water sample, as is true in surface coastal waters receiving patterns of land-based runoff characteristic of an area.

Although there are many mathematical formulas available for calculating sample size, they have often been derived for use with special types of sampling and particular statistical distributions and are complicated to use, requiring estimates of statistics such as root mean squares, and are at present based on estimates of the statistical power you want to achieve in your data analysis. Use the simpler methods described below, or hire a statistician to run your data analyses for you. Unless you are moderately well versed in the use of statistics you will have a hard time even talking to a statistician, and it is not necessary for the type of repetitive water quality sampling done for survey exercises such as the biennial Integrated WQ Reports.

Important: I did not analyze a large amount of data for this mini-report; others will need to apply the approach described below to their own data sets in order to determine if it provides an objective basis for limiting sample sizes without losing information on variation in a data set.

How do you tell if a data set is representative of most of the variation at a sampling site? I used both an actual data set and a string of random numbers to answer this question. The sampling location

and sampler shall remain unnamed in order to focus attention on the topic of discussion instead of on where and whom. The geometric mean, arithmetic mean, standard deviation, and Coefficient of Variation (CV) were calculated for each of three data sets containing nitrate (ug/L) concentrations measured in water samples collected at 0.1 meters (m), 2 m, and 100 m from shore along an exposed coastline over a time period of 81 months (sampling was approximately quarterly). Each data set contained 33 data values. An additional three data sets of n=33 values each were simulated using random numbers from the same range as that seen in each actual data set, and the same statistics calculated. For example, the range in values for the set collected at 2 m from shore is from 19.16 ug/L to 671.86 ug/L; a corresponding random number set was generated using this same range. (Random number generators can be found on the Web, and in many statistics books.)

Why did I use random numbers in this exercise? Only to demonstrate that as sample size is increased beyond the point at which most of the variability in water quality at a site has been included in the data set, adding more sample values is equivalent to adding random numbers, which are numbers having equal probability of being drawn from a larger population, in this example the entire coastal ocean of Hawaii. In other words, materials in runoff dilute from the shoreline seaward; once you know shoreline concentrations then samples collected further seaward will be dilutions of shoreline values. If sample values increase as sampling moves offshore, then water masses from other locations are moving into the area and being sampled, or reef metabolism is affecting water quality. To sample land-based runoff, stay close to the source.

Increasing sample sizes were evaluated by computing the means, standard deviations, and Coefficients of Variation in increments of three values, giving sample sizes of n=3, 6, 9, 12, 15, 18, 21, 24, 27, 30 and 33 measurements. This exercise was repeated for the simulated (random) data, and a sample of the results graphed (Figures 1, and 2).

Only basic calculations are used here – the arithmetic mean describes the center of the distribution of data values in a set and the standard deviation describes the degree to which all of the data values differ from the central value (the mean), and are described in any introductory statistics book. The Coefficient of Variation describes the mean of each data set as a fraction of variability in the set (CV = standard deviation/mean). Once the CV stops steadily increasing or decreasing as data are added, the number of samples in the data set includes most of the variation at the sampling site, and sampling can stop.

Caveat – Do not use data on a log scale to compute CVs; this method does not work because of the shifting definition of zero in different log systems. Therefore, don't calculate CVs for pH data, which are measured on a log scale by pH meters.

Discussion of Figure 1: It is evident from the graph that sample sizes of less than n=10 have variable CVs; the variation drops to a stable level as n increases, indicating that a sample size of about 10 is adequate for the location sampled. Rather than collect larger data sets at the site over a short period of time, say less than one year, wait 2-3 years or so, then resample the site. Resampling is also recommended when changes in land use occur in the adjacent watershed. Time trend analyses will not be reliable until 10 or more years of data are available, so fewer data points collected per year over several years provide more information about the water quality at a site than does a large set of samples collected over 1-2 years, and then ignoring the site for five years or more. Note especially that the CVs for the random sample of numbers (triangles) track the actual sample CVs – that's the point of this exercise.

Discussion of Figure 2: It is evident from this graph that using geometric means to make sample size decisions shows that larger sample sizes are needed before the means flatten out, and that geometric means of the random number samples do not converge with those of the actual samples until a sample size of 21 or greater is reached. Using the CV approach leads to a decision to collect fewer samples with no loss of information on variability (n=10 is adequate). If you think you absolutely have to have stable geometric means in a data set (the sample size at which means of data and random numbers converge), then twice the number of samples will need to be collected.

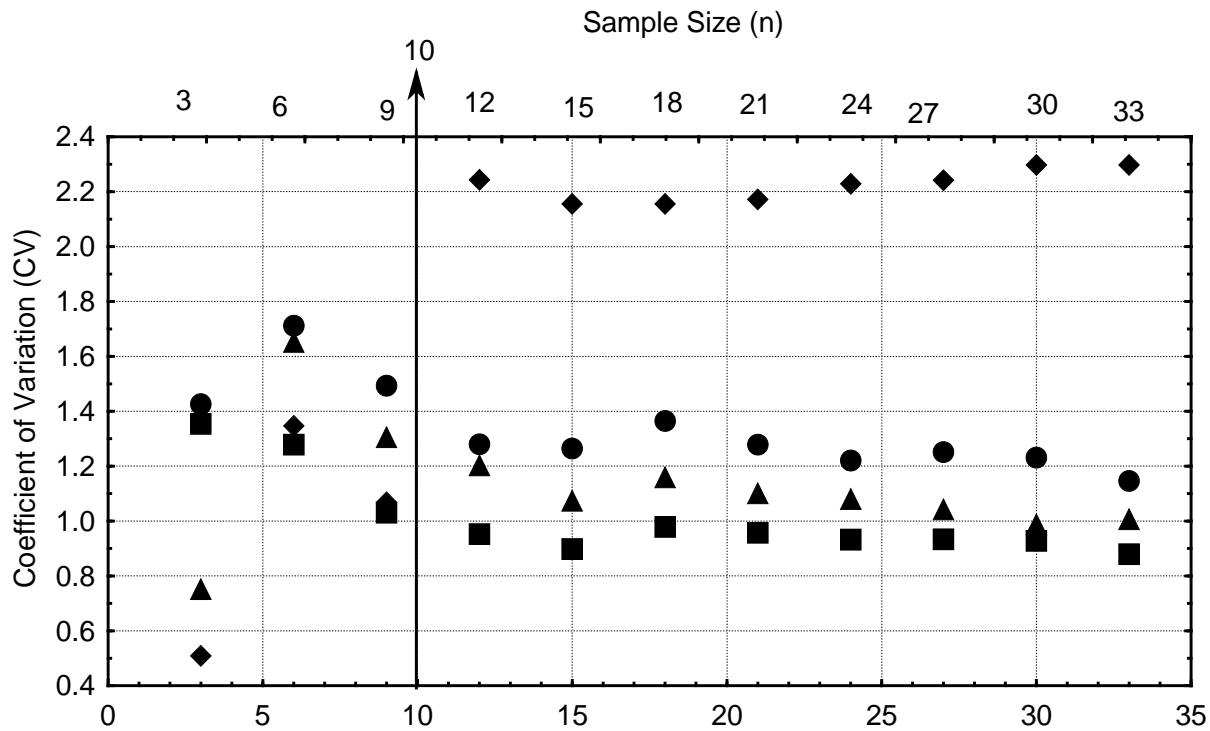
(2) How do you tell if a set of samples can be considered representative of nearby areas, whether open coastlines or stream systems? If locations are matched for exposure, watershed areas, presence of a

stream system, and land use activities, then complete data sets can be collected from one watershed and CVs compared with those of random data sets. Adjacent, similar locations can be spot-sampled, and checked to determine if the data points and their variability fall within the range of those obtained from the sampled watershed. Remember that the key to accepting only spot-sampling of similar locations is resampling at a later date and examining the data for time trends. If none are evident, then the data sets can be combined

I have no stream data sets of comparable length to the coastal ocean data set analyzed here, so I cannot run the same exercise on a fresh water system (data needed would be  $n=33$  values from an upper station, above most human activity, and another of  $n=33$  in length from a lower, but still fresh water, station. If anyone can send me such a data set, I'll analyze it using the methods described above.

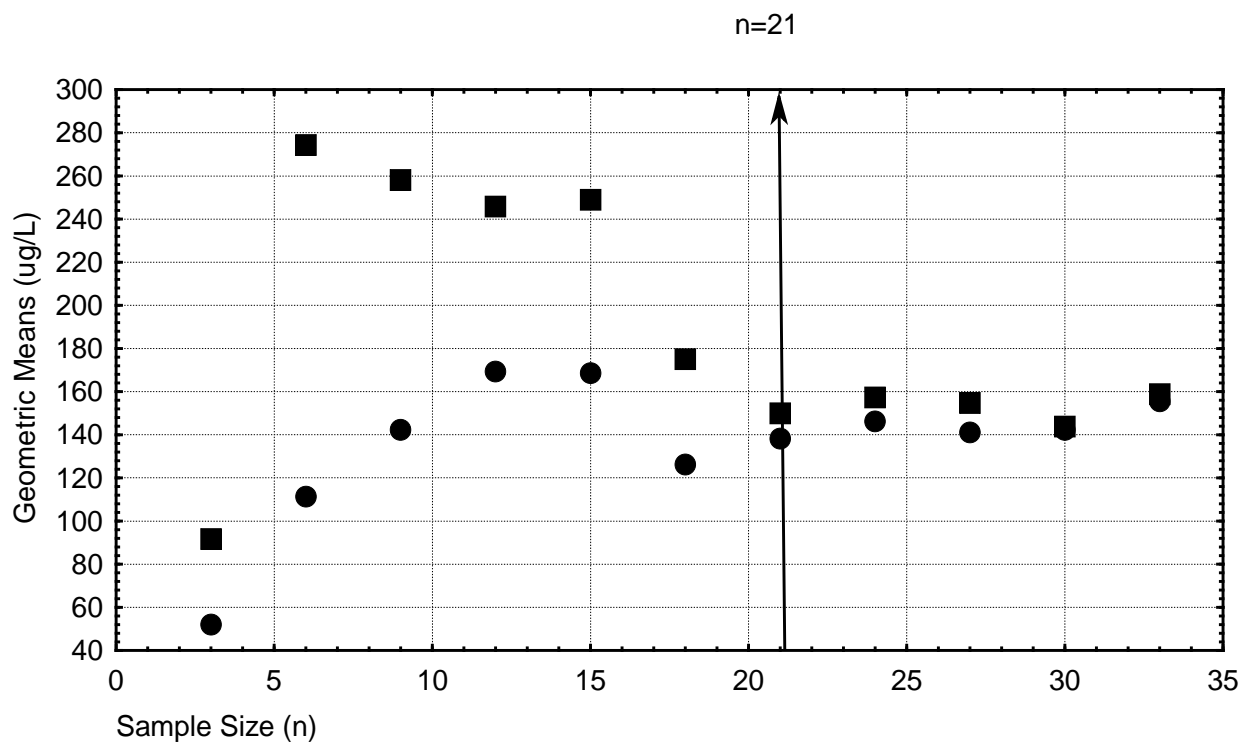
A comment on probabilistic sampling: This is the latest sampling buzzword, and may work along open coastlines, but I've haven't seen it applied in Hawaii yet. It may or may not be useful in Hawaii.

Figure 1: Relationship Among Increasing Sample Sizes (n) and Variability of Data Values Within Each Sample (CV).  
 Diamonds-100 m from shore; Circles-0.1 m from shore; Triangles-CVs for Random Number set; Squares-2m from shore.



NO3, Surface, 0 m From Shore  
 NO3, Surface, 2 m From Shore  
 NO3, Surface, 100 m From Shore  
 CV, Random Sample of Numbers

Figure 2: Relationship Among Increasing Sample Sizes and Geometric Means For Each Sample Size. Squares-Means for Random Number set; Circles-NO3,0.1 m from shore



NO3, 0.1 m From Shore, meang  
Random Values, meang

***Appendix C***

***Report #2 to Water Quality Working Group. August 10, 2008***

Report #2 to Water Quality Working Group – Summer 2008  
On Limiting Sample Sizes for Water Quality Monitoring in Fresh Water Streams  
June F. Harrigan-Lum  
August 10, 2008

**Summary:** Ways to limit sample size to only the number (n) of data points needed to include most of the short-term variability at a fresh water stream site across five years or less of sampling effort include:

1. Organizing stream water quality data by watershed/stream classes (clusters), developed by Mike Kido, University of Hawaii at Manoa, Stream Research Center, provides a basis for combining small stream data sets into larger sets with reduced within-cluster variability, and reduces the number of samples needed to characterize water quality within a stream cluster.
2. An example is presented below using combined data from two clusters, Cluster 10 along the south shore of Oahu (urban streams) and Cluster 14 along the coast of Hawaii north of Hilo (rural streams). The parameter Nitrate-N is used in this example.
3. Rather than generate random numbers, as in the first water quality report on coastal waters, using the cluster approach reduced variability enough to support using a simpler graphical method to estimate minimum sample sizes by first ordering data by date collected, then removing the highest 10 % of the values (the spikes), then computing geometric means and Coefficients of Variation (CVs) for increasing sample sizes. The minimum sample size needed to obtain data sets that incorporate most of the variability in a cluster of streams without repetition is found at the point where the geometric means and CVs flatten out along lines with close to zero slope, indicating that very little change is occurring as more data points are added to the set.
4. This is an “eyeball” type of graphical approach to estimating water quality sample sizes recommended for incorporation into DOH/CWB stream sampling plans. The data are intended to be added to a stream database that is constantly augmented with new data points for the biennial Clean Water Act Integrated Report on Water Quality in Hawaii, and are not used in statistical comparisons.
5. The method is also useful to quickly identify the streams within a cluster most in need of management attention – these are the streams that disproportionately contribute to the highest 10 % of values in the combined data set.
6. Use of the stream cluster approach to collecting and analyzing water quality data will both simplify stream monitoring and bring water quality information into the existing GIS regional framework for watershed classification, which will support a more integrated understanding of landscape features, ecosystems, water use, and water quality conditions within clusters of similar streams in similar watersheds.

**Introduction:**

Background information on estimating sample sizes for future water quality sampling plans is provided in my first report to the Working Group, dated July 2, 2008, and will not be repeated here. The first report showed an example using data from coastal waters; this report is focused on sample size estimation for fresh water streams.

As in the first report, the water chemistry parameter Nitrate-N (ug/L), commonly measured in all water bodies and often highly variable, is used to demonstrate the methodology proposed for streams. Although Hawaii has numerous short streams flowing seaward on all the major islands, large variations in flow volume and in land-based runoff volumes and their included pollutants suggest at first glance that a great deal of data are needed to adequately sample water quality variations over time. However, numerical model approaches to sorting watersheds and their streams into classes (clusters) based on geomorphology, hydrology, and biological community characteristics have been developed over the past decade by Mike Kido of the Stream Research Center, University of Hawaii at Manoa. Water quality chemistry data, such as nitrate concentrations, are not presently included in the sorting criteria for streams, but an initial approach to analyzing nitrate data within stream/watershed cluster 10, south shore

of Oahu and within stream/watershed Cluster 14, along the coast north of Hilo, Hawaii, shows that geometric means, reflecting magnitude of the nitrate concentrations, and Coefficients of Variation (CV, which presents means as fractions of standard deviations), reflecting variability of the measurements in a sample, are surprisingly consistent in their values among streams within a cluster, and different between the clusters. These clusters were chosen to represent very different watersheds, from streams in windward rural areas of the Big Island north of Hilo (Cluster 14) to urban streams along the south shore of Oahu (Cluster 10).

**An explanation of the GIS-based watershed/stream classification methodology and an example of an application are presented in: “Kido, M.H., 2008. Hawaii Island – Stream Condition Along a Human Disturbance Gradient. Technical Report to the Hawaii Department of Health-Environmental Planning Office. April 2008, Honolulu, Hawaii.”**

Cluster 10 contains 8 stream/watershed combinations; of these, data (n=84) from five perennial streams are included in the DOH/Clean Water Branch Master Data Set, current through 2006 (Table I). Because the Master Data Set includes relatively small numbers of sampling events for each stream, the similarity among watersheds/streams within a cluster was used as a rationale for combining data from these five streams into a single set. The same approach was used for Cluster 14, consisting of 44 streams; data from 11 of these streams (n=160) were combined for analysis (see Table 1).

### **Methodology:**

First, data within Cluster 10 and Cluster 14 were sorted by date, so that a time component would be preserved in the results. Effects of differing numbers of samples from each stream introduced additional variability into the final combined data sets, adding to the within-stream and across-stream variability already present. Second, the highest ten per cent of values were removed from each analysis, and set aside for the moment. These peak values are highly non-linear and best handled separately from the main analysis. Third, geometric means and CVs were computed for sample sizes increased by n=3 at a time (Cluster 10 data set), or by n=6 at a time (the larger Cluster 14 data set). The geometric means and CVs were then plotted against sample size (Figure 1).

I repeated the calculations using random numbers generated within the range of the data sets (less the 10 % peak values), but found that the higher variability of stream data as opposed to coastal data, augmented by effects of combining data from different but related streams within a cluster as well as the uneven sample sizes across a cluster made the results more difficult to interpret than in the coastal waters example. Examination of Figure 1, however, shows that the geometric means and, especially, the CVs are relatively consistent across a cluster, and differ mainly between the two clusters. The geometric means and the CVs of the remaining 90 per cent of the data sets (n=144 for Cluster 14; n= 76 for Cluster 10) vary only minimally after sample size n=30 out to the maximum sample sizes (see Fig. 1); n=30 was chosen by observation of the graph as representative of the entire set of geometric means and CVs, which after sample size n=30 lie along lines of slope near zero on the graph. Note that, in order to spread out for observation the low numbers for CVs at the bottom of the y-axis, the y-axis has a log scale.

**When analyzing combined data sets, it is unnecessary to collect data beyond the point at which increasing sample size does not affect the slope of the lines connecting the statistics plotted, geometric means and CVs, which in this case form nearly straight lines with slopes near zero.** For both clusters, points beyond a sample size of 30 represent repetition, and do not add significantly more information. I added polynomial curves to Figure 1 to emphasize the initial change in the statistics plotted, followed by a stable series of values; the curves do not serve any other purpose than to show stable slopes after n=30 and can be dropped in daily work, as long as a clear trend emerges along a line of approximate zero slope. At this point, sampling efforts can be directed to other stream clusters.

Returning to the highest 10% of values from each cluster – the stream cluster approach also proves useful in identifying those streams within a cluster most in need of management attention relative to whatever parameter is being analyzed. For example, peak nitrate concentrations in Cluster 10 range from 1130 ug/L to 1750 ug/L in Moanalua Stream (n=1) and Kalaa Stream (n=7); in Cluster 14 the contributing streams are Wailoa (n=6) and Kapehu (n=10). These streams have significantly higher

nitrate concentrations than do the other streams in their cluster; the contributing nitrate sources should be identified and mitigated to the extent possible.

The Watershed Health Index (WHI) calculated for each watershed/stream combination by Kido (Excel Spreadsheet) is included in Table I. The geometric means for nitrate concentrations in each stream are not significantly correlated with the corresponding Watershed Health Indices, but on a stream-by-stream basis suggest two options for watershed management approaches. As stream nitrate concentrations are strongly influenced by fertilizer applications in the watershed, a decision must be made by stream managers to focus runoff/fertilizer control measures on either streams in watersheds with both high Watershed Health Indices and high geometric means for nitrate concentrations (Cluster 14, Wailoa, WHI = 78; Nitrate-N geometric mean of 155.77 ug/L). Or, focus management measures on streams with low Watershed Health Indices and high nitrate concentrations, such as Kalauao (cluster 10, geometric mean of 522.22 ug/L; WHI = 53), which needs all the help it can get to improve conditions.

### **Conclusion & Recommendation:**

When developing a sampling plan for streams, I recommend following Kido's watershed/classification model and randomly select 3-5 perennial streams within a cluster, depending on the number of streams it contains. If each stream is sampled 10-12 times, and about 3-5 other streams in the cluster are randomly selected and spot-sampled, say twice each, including both upper and lower stations in a spot-sample, then the resulting data set, less the 10 % peak values, should total more than 40-50 points. Then convert the raw data to lists of geometric means and CVs, using sample size increments of  $n=3$ , as described above, and plot against increasing sample size; if the statistics lie on a reasonably flat line after sample size 21 or 24, then stop sampling the cluster and go on to another one. If not, then additional sampling will be necessary. This method requires analyzing data from a stream cluster as soon as 40-50 data points have been accumulated, but remember that the analysis is very likely to save sampling time and effort, as the data set will be limited to only those data necessary (i.e., collected before the point where repetition of field values sets in).

Now that a GIS-based geographical and biological watershed classification framework has been developed for Hawaii, it is timely to begin incorporating water quality data. As additional fieldwork is completed to verify the predicted Watershed Health Indices, and parameters other than nitrate are sorted into clustered data and analyzed, opportunities to include aspects of water quality data in the watershed/stream classification model will become apparent, bringing the DOH water quality monitoring data into a coherent watershed classification and management framework.

A similar regional approach to data amalgamation in coastal areas should also be developed, and linked to the adjacent watershed classifications (Kido, 2008).

Acknowledgements: Many thanks to Mike Kido, Stream Research Center at the University of Hawaii, Manoa, for permission to use his stream cluster data files, including the Watershed Health Index file.

TABLE I. Some Characteristics for Stream Clusters 10 and 14.

Cluster No.	Stream Name	Sample Size	Range (ug/L)	Geometric Mean (ug/L)	Range Less 10% Peak Values (ug/L)	Collection Dates	Watershed Health Index (Does Not Include WQ Data)
10	Kalauao	19	64-1750	522.22	---	---	53
	Halawa	7	7-630	48.95	---	---	31/8
	Moanalua	12	6-1690	28.95	---	---	44
	Kalihi	22	7-432	112.51	---	---	36
	Nuuanu	24	14-349	80.22	---	---	30/19
<b>Total</b>		<b>84</b>	<b>6-1750</b>	<b>112.50 (n=84)</b>	<b>6-1090</b>	11/3/2000 to 8/26/2004	
						---	
14	Wailoa	9	27-442	155.77	---	---	78
	Pukihae	12	1-75	4.97	---	---	56
	Mali	12	3-59	18.69	---	---	61
	Honolii	26	1-51	11.44	---	---	89
	Kapue	12	1-20	5.93	---	---	87
	Kaeiei	10	9-27	16.24	---	---	63
	Kalaoa	12	5-52	16.18	---	---	36
	Kapehu	22	1-1970	37.46	---	---	38
	Paheehee	12	1-56	14.87	---	---	49
	Kolekole	25	10-55	14.51	---	---	84
	Hakalau	8	1-17	6.42	---	---	71
<b>Total</b>		<b>160</b>	<b>1-1970</b>	<b>14.55 (n=160)</b>	<b>1-59</b>	1/10/2001 to 9/1/2005	

Figure 1. Geometric Means (ug/L) Vs. Coefficients of Variation for Nitrate-N in Stream Cluster 10 vs Stream Cluster 14. Sample Size = 6 (top axis, Cluster 14); Sample Size=3 (bottom axis, Cluster 10). Recommended Sample Size for Both Clusters = 30 (red circles).

