Stormwater Assessment Pilot Study in the Wai'ula'ula Watershed, West Hawai'i

Volume 1

Overview and Recommendations

Photo courtesy of USDA NRCS

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1. Introduction

1.1 Overview

Evaluating the effect of a proposed action on stormwater runoff is a required part of environmental review process in Hawaiʻi. The stormwater assessment process is intended to achieve two goals. The first is full disclosure of direct, secondary, and cumulative impacts of a proposed action on stormwater quantity and quality. Cumulative impacts refer to the combined effects of many small actions occurring over time.[1] Requirements for assessing cumulative impacts stem from recognition that an action might have negligible impact by itself but be important when the collective impact of all past, proposed, and future actions is considered. The second goal of the stormwater assessment process is to provide an opportunity to propose mitigation measures that will minimize adverse impacts of the proposed action. In recognition of the limitations of previously-used methods for stormwater assessment, the Hawaiʻi Coastal Zone Management Program (hereinafter CZM) has undertaken a three year project to document and evaluate previous methods of stormwater assessment, propose an improved method, and evaluate the possible use of NOAA's Nonpoint-Source Pollution and Erosion Comparison Tool (N-SPECT) in the assessment process. The third year of the overall project will focus on providing training on the improved method.

In 2011, CZM contracted with James Juvik of the University of Hawaiʻi at Hilo and PBR-Hawaiʻi to investigate past approaches for evaluating stormwater impacts of new developments proposed in Hawaiian watersheds and to propose improvements to these approaches. Their investigative work documented assessment methods used in the last thirty years in Hawaiʻi, based on examination of environmental impact statements (EIS) during this timeframe. References below to the ***Year-1 Stormwater Impact Assessment Project*** refer to the final project report resulting from the efforts of Dr. Juvik and PBR-Hawaiʻi.[2]

This three volume report describes efforts in the second year of the project. We evaluated the effectiveness of several assessment methods both in terms of ability to disclose impacts and in terms of relationship to management measures which are a part of Hawaiʻi's coastal nonpoint pollution control program. This was accomplished through a case study involving application of these methods to hypothetical new developments in the lightly developed Waiʻulaʻula watershed, which is located on the Island of Hawaiʻi. The Waiʻulaʻula watershed was selected because it is in a fast-growing area of leeward Hawaiʻi Island (hereinafter West Hawaiʻi) and contains the only perennially-flowing stream in West Hawaiʻi. Moreover, the stream supports native fauna and discharges near a reef in a bay with water quality concerns. Thus, although the watershed is in generally good condition, there are legitimate concerns about future degradation of habitat and water quality (MKSWCD, 2011).

Building on the work in the ***Year-1 Stormwater Impact Assessment Project,*** we have identified a specific approach for stormwater assessment that represents typical past practice. We then applied this method to seven hypothetical future developments in the Waiʻulaʻula watershed in West Hawaiʻi. Results so obtained were compared to results obtained using NOAA's Nonpoint-Source Pollution and Erosion

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[1] According to Federal and State guidelines (40 CFR 1508.7 and §11-200-16, HAR), environmental impact statements should address cumulative impacts in addition to impacts triggered directly by the proposed action (hereinafter "direct" impacts). Cumulative effects refer to actions whose impacts are small individually but contribute to significant impacts when associated with the sum of all past, present, and future actions.

[2] Department of Geography and Environmental Studies at the University of Hawaiʻi and PBR Hawaiʻi (2011). Stormwater Impact Assessment Project: Final Report. Office of Planning, State of Hawaiʻi.

Comparison Tool (N-SPECT) (NOAA, 2004). In fact, a major portion of the study consisted of evaluating N-SPECT's suitability as a tool for conducting quantitative assessments of stormwater impacts and predicting load reductions from various mitigation measures.

The N-SPECT model was used to predict the impact of new development on runoff volume, nutrient loads, and soil erosion. In the Waiʻulaʻula watershed, it was applied to fourteen hypothetical developments representing five categories of development: low-density urban, rural, resort, high-density urban and industrial (Figure 1). Each of the parcels is currently undeveloped or minimally-developed and is slated for future development under the County of Hawaiʻi General Plan (Hawaiʻi County 2005). The category of development was based on Hawaiʻi County's Land Use Pattern Allocation Guide (LUPAG). Impacts were predicted by comparing pre-development stormwater loads with post-development loads. Assessments were carried out under several precipitation scenarios (average annual and various design storms) and two levels of development (50% build-out and 100% build-out). To examine cumulative impacts, we modeled stormwater loads under existing conditions, and after development of all fourteen parcels. To provide a context for interpretation of modeling results, we have reviewed existing studies and placed the hypothetical proposed developments in the context of State and County general plans.

Recognizing the limitations of past practices, the ***Year-1 Stormwater Impact Assessment Project*** proposed a new method of stormwater assessment. We applied this "proposed new method" to two hypothetical new developments in the Waiʻulaʻula watershed. Predicted impacts were estimated with and without mitigation measures. Models were used to estimate load reductions resulting from various mitigation measures. Two suites of measures were considered: a "business as usual" (BAU) scenario and a scenario employing a variety of innovative Best Management Practices (IBMPs). Results were evaluated in terms of 1) whether the method was able to disclose direct, secondary, and cumulative impacts, and 2) whether the method promoted the use of Low Impact Development design principles and permanent BMPs. Our analyses focused on *post*-construction impacts, because existing federal regulations require mitigation measures that adequately address construction-related impacts.

This report is comprised of three volumes:

Volume 1: Overview and Recommendations

Volume 2: Use of the N-SPECT model to Quantify Direct and Cumulative Impacts

Volume 3: Comparison of Typical Past Practice and a Proposed New Approach

Volume One (this document) summarizes the results of studies that are presented in volumes two and three. The summary is organized as follows: (*i*) N-SPECT modeling of direct and cumulative impacts, (*ii*) application of the typical past practice for stormwater assessment, and *(iii)* application of the proposed new method of stormwater assessment. These three methods are then critiqued. The report concludes with recommendations for an improved practice for conducting stormwater assessments in Hawaiʻi. These recommendations build on the method proposed in the ***Year-1 Stormwater Impact Assessment Project,*** but differ from it in several respects. Our recommendations address both assessment methodology and the regulatory framework in which assessment takes place.

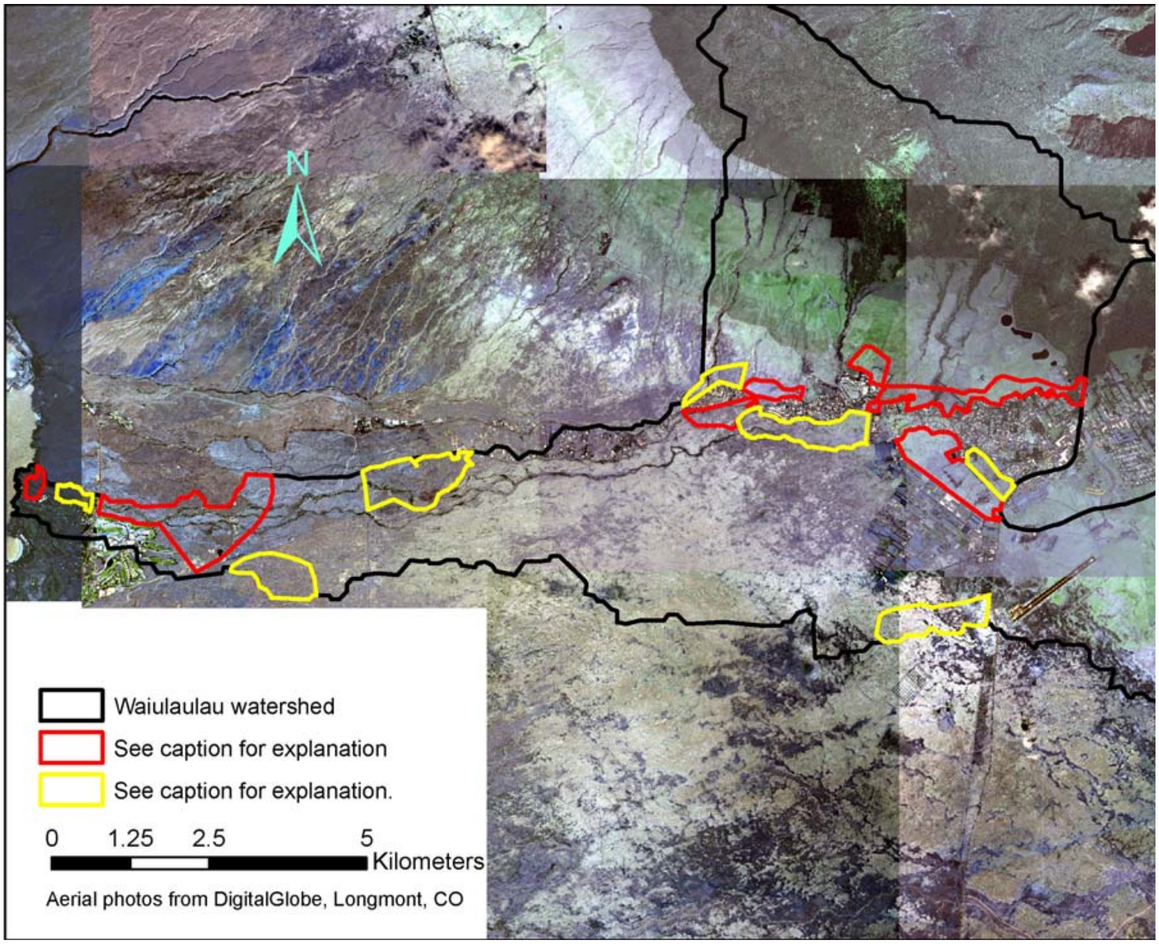

Figure 1: Hypothetical new developments analyzed in this study.

Parcels outlined in yellow were modeled using N-SPECT and analyzed using past and proposed methods of stormwater assessment. Parcels outlined in red were also modeled using N-SPECT but were not analyzed using the past and proposed stormwater assessment methods.

1.2 Assessment Methods and Tools

1.2.1 Typical Past Practice

In the past, stormwater impacts of new development have typically been assessed through compilation of relevant data (*e.g.*, rainfall, topographic slope, soil type and erodibility, FEMA flood zones) and a general discussion of anticipated construction related erosion impacts and potential for cumulative impacts. Proposed mitigation measures or BMPs were then identified as a way to reduce construction and post-construction erosion. Volume Three and the ***Year-1 Stormwater Assessment Project*** contain more detailed information past practices.

1.2.2 Proposed New Method

The proposed new method for conducting stormwater assessments is the outcome of the ***Year-1 Stormwater Assessment Project***. The new method, which is described in detail in Volume Three, consists of seven steps:

Step 1:
Collect the background information that is pertinent to developing a stormwater pollution prevention plan (SWPPP) for a NPDES permit

Examples of background information include rainfall intensity, land use, soils, stream inventory, and watershed boundaries.

Step 2
Determine if the watershed drains into receiving waters that have impaired water quality according to the State's Section 303(d) list or have been identified as high priority for restoration

If the watershed is impaired, go to step 3

If the watershed is not impaired, go to step 4

Step 3
Propose mitigation measures that make the project eligible for Leadership in Energy and Environmental Design (LEED) certification

Propose onsite mitigation measures to reduce pollutant generation between pre-and post-development that would be eligible to meet LEED-NC SS 6.1 and 6.2 credits, as well as comply with a TMDL allocation, if available. Mitigation measures should address, as a minimum, the pollutant with TMDL allocations, but should also consider other potential sources generated by the various land uses within the watershed as well as pollutants transported by groundwater.

Note that under the LEED program, it is often necessary to design systems that meet specific targets (*e.g.* removing 80% of post development suspended sediment). A combination of observational data and modeling would be used to demonstrate that the mitigation action meets the target.

Step 4

Determine if the watershed drains into "sensitive" receiving waters

The sensitivity of the receiving waters to these pollutants depends on flushing capacity, habitat quality, or beneficial designated use.

If the watershed is sensitive, go to step 5

If the watershed is not sensitive, go to step 7

Step 5

Determine if receiving waters are already stressed.

If the watershed is sensitive, determine if the receiving waters are already stressed by doing a watershed plan or a rapid assessment model. Options for rapid assessment models include the Rational Method, TR-55, RUSLE, MUSLE, or the Simple Method.

Step 6

Mitigation measures for watersheds

For development projects in watersheds that are impaired or sensitive, mitigation measures should be proposed that result in reduction of stormwater loads. For projects in watersheds that are sensitive but not already stressed, mitigation measures should be proposed that result in no net increase of stormwater loads. Examples of onsite and offsite mitigation measures include narrower roads, permeable pavement, riparian buffers, vegetated swales, and constructed wetlands. There are several different models that could be used to assess net increase in runoff and pollutant loads. Commonly used models include the rational method, SCS model, TR-55 model, and RUSLE.

Step 7

Comply with applicable NPDES and Grading Permit requirements

All projects must comply with NPDES and Grading Permit requirements. These requirements will vary according to the nature of the project.

1.2.3 The N-SPECT Model

The Non-Point Source Pollution and Erosion Control Tool (N-SPECT) was developed by the Coastal Services Center of the National Oceanic and Atmospheric Administration (NOAA) with the goal of estimating the impact of land use change on the amount of pollutants delivered to coastal waters (NOAA, 2004). The current version of the model (as of early 2012) is implemented in a Geographical Information System (GIS) framework as an add-on to ArcGIS, which is a commercial software package that enjoys widespread use.

N-SPECT predicts pre-development and post-development stormwater runoff (as a volume), stormwater pollutant concentrations (as mass per volume of water), and stormwater pollutant loads (as mass per time exported by the watershed or any sub-watershed). The pollutants that can be modeled include total nitrogen (TN), total phosphorus (TP), total lead, total zinc, and sediment. N-SPECT has two options for estimating sediment. The first is to assume that sediment concentration in stormwater is a function of land use/land cover. The second is to run the Revised Universal Soil Loss Equation (RUSLE) (Renard *et al.* 1997), which is the standard engineering technique for estimating average annual soil erosion. N-SPECT's data needs consist of standard data sets that can easily be obtained for any location in Hawaiʻi. N-SPECT can be used to estimate average annual quantities, or it can be applied to specific storm events, including design storms.[3]

N-SPECT is not designed to predict discharge/peak flows[4], baseflow,[5] baseflow loads, or evaluate the impact of BMPs. In standard operation, the model is not able to discriminate between presence and absence of BMPs, nor predict the impact of any particular BMP.

Land cover is a key parameter of N-SPECT, which is designed to run using the C-CAP land use/land cover data set, a nationally-standardized database of land cover and land change information for the coastal regions of the U.S. (NOAA Coastal Services Center 2000). Using the standard parameterizations, land cover types include grassland, forest, cultivated land, scrub, low-intensity development, and high intensity development. For any given soil group, each land cover type has a different Curve Number (CN), a parameter that determines the amount of runoff. N-SPECT uses a modified version of the SCS CN model to predict average-annual stormwater runoff. The model multiplies the resulting runoff volume by assumed pollutant concentrations (see Box 1). Pollutant concentrations vary by land cover. For any given land cover type the user may enter custom values or use default concentrations.

[3] A design storm is a hypothetical event that occurs rarely. For example, the 100-year storm has one chance in a hundred of being exceeded in any given year. Design storms are often used in engineering analysis.

[4] Discharge is the amount of water flowing in a stream in a given amount of time. It has units of volume per time (cubic feet per second or cfs). Peak discharge is the maximum discharge rate in a given storm or a given year.

[5] "Stormwater" is water flowing over the ground or in channels immediately after a hard rain. Between storms, the water flowing in streams is derived from groundwater and is called "baseflow".

In Hawaiʻi, as elsewhere, nutrients and sediments are the most common water pollutants. Nitrogen (N) and phosphorus (P) are the two elements that are most likely to lead to excessive algae growth and oxygen depletion. N and P can occur in different forms, including particulates, dissolved inorganic forms, and dissolved organic forms. "Total Nitrogen" (TN) and "Total Phosphorus" (TP) refer to the sum of particulate, inorganic, and organic forms. Pollutants can be expressed as concentrations (amount per unit volume of water) or as loads (amount leaving a watershed in a given amount of time). For sediment, the "Total Suspended Solids" (TSS) parameter is a measurement of concentration. To obtain load values, one multiplies concentration by discharge (volume of water flowing past a point in a given amount of time).

Box 1. Explanation of water quality parameters (TN, TP, and TSS).

2. Pilot Study Results

Study Design

N-SPECT was used to predict direct and cumulative stormwater loads in hypothetical new developments located in the Waiʻulaʻula Watershed (Figure 1). These developments are located in areas that are currently undeveloped but are slated for future development under the Hawaiʻi County General Plan (Hawaiʻi County 2005) and Land Use Pattern Allocation Guide (LUPAG). Fourteen parcels meeting this description were identified. These included one resort parcel, one rural parcel, one industrial parcel, six small parcels slated for low density urban use, and four parcels slated for urban expansion. N-SPECT was used run using ne for several precipitation scenarios, including average annual conditions and several design storms (the 10-yr 1-hour storm, the 2-year, 50-year, and 100-year 24-hour storms.)

Seven parcels were singled out for analysis using the Typical Past Practice Assessment Methodology. The seven included the resort, rural, and industrial parcels, two low-density urban parcels (one with high rainfall and one with low rainfall), and two urban expansion parcels (one with high rainfall and one with low rainfall). Two of these parcels were examined in greater detail using the Proposed New Method Assessment Methodology. These two parcels were selected because they are adjacent to streams and represent the two most common categories of potential development, namely low density urban and urban expansion. Federal and state guidelines recommend use of the 2-year storm when estimating pollutant loads in a Clean Water Act context, so the 2-year storm was used during application of the past and proposed assessment methodologies. When estimating impacts with regard to erosion, however, we followed standard practice and federal guidelines by conducting evaluations at the average annual time scale.

2.1 N-SPECT Modeling

Direct Impacts

N-SPECT predicts that development will triple runoff volume within the parcels that are slated for future development. The exact amount of increase depends on the precipitation scenario and type of proposed development. Parcels designated for urban expansion are expected to experience increases of 200-500% and account for about three-quarters of the increased runoff from all parcels. In contrast, areas designated for resort, rural, and low-density urban development are expected to experience an increase in runoff of about 45%. These figures are averages for a development category; values can be higher or lower depending on soils and pre-development land use.

N-SPECT assumes that nutrient concentrations vary with land use. Development usually increases nutrient concentration and increases runoff volume, resulting in elevated post-development nutrient loads. (See box on the previous page for an explanation of “loads”, TP, and TN.) N-SPECT predicts that development will increase TP loads by a factor of 2-8 (depending on precipitation scenario) in the areas slated for high intensity development. In areas slated for low intensity development, reductions or very small increases to TP loads are predicted. N-SPECT predicts that development will increase TN loads by between 80% and a factor of 7 (depending on precipitation scenario) in the parcels that are slated for high intensity development. Smaller increases (20-50%) are expected in areas slated for low intensity development.

N-SPECT has two options for predicting sediment impacts. The first is to assume that the concentration of total suspended solids (TSS) in storm runoff varies with land use. The second is to use the Revised

Universal Soil Loss Equation (RUSLE), which assumes that soil erosion is related to topographic factors, soil and vegetation factors, and the ability of raindrops to dislodge soil (Renard *et al.* 1997). These two methods of predicting sediment impacts gave very different results, with the RUSLE predictions being more credible. RUSLE predicted that development will *reduce* average annual soil erosion to about 20% of pre-development values. Reductions are greatest for high-intensity development but are still significant for low intensity development. The reductions make sense if one considers that soil cannot erode if it is covered by pavement or buildings.

In the absence of loading goals for the watershed, it was difficult to assess the ecological significance of projected increases to loads and runoff. The developments represent only a small part of the entire watershed. If the developer is required to implement mitigation measures that result in no net increase of loads, however, the ability to predict the outcome of these measures may be more important than the ability to interpret the significance of load numbers. This topic is discussed further in section 5 and in Volume 3 of this report.

Running the model under many precipitation scenarios (the 2-year 24-hr storm, the 10-year 1-hr storm, the 100-year 24-hr storm and the average annual rainfall) was not as informative as we originally anticipated. Although runoff and load numbers vary among the different scenarios, the overall picture was similar for each, particularly when results are expressed as a percentage change. In terms of design of certain BMPs, for example detention basins, the choice of design storm will affect the level of protection afforded by the BMP.

Cumulative Impacts and 50% Build Out

New developments are typically built in stages, and as many as several decades may pass before construction is complete. Predicted impacts at 50% build out are approximately half of what is predicted at full build out. However, they are not exactly half because rainfall, soils, and topography vary across a proposed development parcel.

The combined effect of past and future development represents the cumulative impact of development. At full build out developed areas are predicted to contribute about 15%, 30%, 20%, and 5% of the entire watershed’s load of runoff, TP, TN, and sediment, respectively. Numbers vary with precipitation scenario. The "urban expansion" land use designation is expected to contribute a majority of the increase, with low density designations having less impact. Non-urbanized uses (mostly grassland and forest) are the greatest contributors to runoff and pollutant loads, reflecting the fact that the General Plan anticipates that most of the watershed will be remain undeveloped.

2.2 Application of Typical Past Practice

For each of the proposed developments we compiled data on rainfall, topographic slope, soil type, soil erodibility classification, and FEMA flood hazard zones. We then discussed anticipated construction-related erosion impacts and evaluated whether or not there is a potential for cumulative impacts. With multiple large developments already proposed for the Waiʻulaʻula watershed and other watershed areas slated for urban and suburban expansion under the County’s LUPAG, there is significant potential for cumulative impacts on water quality and watershed health. Each new development increases the overall imperviousness of the watershed. Developments planned and permitted without regard to their incremental effects when added to other past, present, and reasonably foreseeable future projects, may result in unintended but serious environmental effects. We then proposed mitigation measures intended to reduce construction-related erosion and runoff. The last step in the process was to propose mitigation measures intended to reduce post-construction runoff and erosion. The measures we recommended included infiltration basins, vegetated filter strips, planting vegetation, non-development buffers around natural drainage features, porous pavement, and constructed wetlands.

2.3 Application of the Proposed New Method

Overview

The proposed new method was applied to hypothetical developments in the Waiʻulaʻula watershed. Results are summarized below. Please refer to Volume Three for additional detailed information. The parcels slated for possible development are largely undeveloped grasslands that are adjacent to existing developed areas. They are located in the middle-upper reaches of the large Waiʻulaʻula watershed in an area of moderate rainfall (25-35 inches per year). Dammed perennial streams flow intermittently across or adjacent to the parcels slated for development. The streams have high ecological value insofar as all native freshwater fish species are found in them. There is also a diverse population of native aquatic insects.

The Waiʻulaʻula watershed does not contain any surface waters identified as impaired by the State of Hawaiʻi, nor has it been identified as a high priority for restoration. However, it has been identified as a watershed in need of protection. The receiving waters are categorized as "stressed" because of reduced water quality in Waikoloa Stream as it passes through Waimea town and in nearshore coastal waters near the stream outfall. In summary, the watershed is categorized as sensitive and stressed, but not impaired. It is, therefore, recommended that mitigation measures reduce post-development stormwater loads to below those for existing conditions. If this goal is met then Hawaiʻi County drainage regulations (maintain pre-development runoff conditions after the construction has been completed) are more than satisfied.

Proposed Mitigation Measures

Two sets of mitigation measures were proposed. The first is the "business as usual" (BAU) measures representing the status quo. The "innovative best management practices" (IBMP) scenario incorporates more green design principles and innovative stormwater management practices that are not yet very common in Hawaiʻi.

In the "business as usual" (BAU) scenario, dry wells capture all runoff from impervious areas.[6] In the "innovative best management practices" (IBMP) scenario, there are a variety of measures for reducing impervious area and promoting infiltration close to the source of runoff, including riparian buffers, permeable paving, bioretention, cluster development, pocket parks, and shortened hillslope lengths. Out of necessity, the IBMP scenario also made limited use of dry wells.

The proposed method also requires BMPs during the construction period. In Hawaiʻi County, grading and erosion control plans must be prepared and approved before a permit is issued for a development project. These plans must include existing and proposed contours, erosion and sediment control measures,

[6] "As a general rule, dry wells on the Island of Hawaiʻi are designed to accommodate a flow rate no more than 6 ft^3/s" (Kuba 2005). It is unclear if dry wells are engineered to accommodate a specific amount of flow generated by a specific catchment area and recurrence interval.

limits of grading providing proper setbacks from the property lines, location of any structures or easements, and any drainage patterns or devices. If more than one acre is disturbed, a National Pollutant Discharge Elimination System (NPDES) permit must be obtained from Hawaiʻi Department of Health. The NPDES permit regulates stormwater runoff from the construction site. Permit conditions require a commitment to use standard BMPs to control erosion and stormwater discharges. Examples of standard BMPs include protection of natural vegetation, soil stabilization, and use of sediment basins or erosion fences.

Quantitative Evaluation of Stormwater Loads

N-SPECT was used to evaluate stormwater loads under existing, unmitigated post-development, and mitigated post-development conditions. Both the BAU and IBMP mitigation scenarios reduce post-development runoff and total nitrogen loads to well below existing loads. In large measure, this is because dry wells are extremely effective. For total phosphorus loads in parcel 9, BAU and IBMP are more than sufficient to reduce loads to below those for existing conditions. In parcel 12, however, BAU mitigation may not be sufficient to meet load reduction targets. IBMP mitigations are marginally better and do reduce post-development loads to below existing conditions. In summary, proposed mitigation efforts are more than sufficient with the possible exception of the BAU scenario in parcel 12. This suggests that additional measures targeted at phosphorus loads should be considered.

High-intensity development decreases soil erosion because soil that is covered by pavement or buildings cannot erode. In parcel 9, however, unmitigated low-intensity development is predicted to increase erosion. Models predict that load reduction targets can be met with BAU mitigation but not with the proposed IBMP. This prompted the proposal of additional mitigation measures that, when combined with the original IBMP measures, were sufficient to reduce erosion below existing levels.

N-SPECT is not capable of estimating peak discharges, which must be reduced below pre-development levels. The TR-55 model was, therefore, used to evaluate peak flows. Results indicate that dry wells are highly effective and reduce peak discharges below pre-development values. The reduction for BAU was greater than the reduction for IBMPs, which deliberately reduce impervious areas.

One reason for examining two parcels was to evaluate if the assessment method was equally appropriate for low-intensity development (parcel 9) and high-intensity development (parcel 12). In terms of application of the proposed method and subsequent results, however, there was not much difference between the two parcels. The only possible difference was that in the high-intensity parcel it was difficult to reach load reduction targets for total phosphorus in the BAU scenario.

It is notable that, in some cases, results of the modeling forced a reconsideration of proposed mitigation measures.

2.4 Discussion

There are several aspects of the pilot study in the Waiʻulaʻula watershed that may make it difficult to apply these methods to the other counties in Hawaiʻi.

1) **Not all counties have easily-accessible LUPAGs.** While all counties have projected future urban growth and changes in land use, the majority have not mapped this information in a GIS-accessible format. Therefore, while this project was able to conduct the various GIS-based modeling exercises in areas identified for future growth in the Waiʻulaʻula watershed using the GIS layer for LUPAG, this would not be as easy in the majority of counties within the State that have not made this information easily-accessible.

2) **The Pilot Study did not model a BAU scenario without dry wells.** The primary mitigation measure used in Hawaiʻi County for post-development stormwater management is dry wells (the BAU practice). Because this BMP is so effective at capturing stormwater runoff, it makes other measures, particularly Low Impact Development (LID) practices that limit impervious areas, seem ineffective by comparison. However, the models do not account for the negative aspects of dry wells (for example, effects on groundwater) or certain positive aspects of LID practices (aesthetics, reduced thermal pollution, vegetative buffers serving to trap pollutants from upslope). Modeling results, therefore, could be interpreted to promote a disincentive to using LID practices that limit impervious areas.

   While dry wells are used extensively on the Island of Hawaiʻi, they are used less often on the other Hawaiian Islands. Therefore, without this BAU practice, the modeled IBMP scenario may prove to be more effective at reducing runoff volumes and pollutant loads than the BAU practices used in the absence of dry wells. This merits further future study using a development scenario on another island.

3. Critique of Methods

3.1 Critique of Past Practices for Stormwater Assessment

The typical past practice appears to be adequate with respect to identifying and mitigating construction related impacts. While the typical past practice identifies actions that will mitigate post-construction stormwater impacts, it does not quantify impacts (either with or without mitigation) nor evaluate their significance.

The typical past practice mentions cumulative impacts but does not quantify, analyze, or discuss them. This is not adequate.

The typical past practice is narrow in scope. It does not address secondary impacts such as groundwater contamination resulting from dry wells. Nor does it address the possible impacts to aquatic, riparian, or coastal habitats either within the proposed development or in affected downstream areas.

3.2 Critique of the Proposed New Method for Stormwater Assessment

3.2.1 Feasibility of Applying the Proposed Method

The difficulty in applying the proposed method will depend on whether the watershed is sensitive or not, stressed or not, impaired or not, and whether or not it has a TMDL.[7] Watersheds for which a TMDL has been developed may be easier to work with because extensive data collection and analyses have already been conducted prior to the preparation of an EIS. The Waiʻulaʻula watershed is stressed (but not impaired), sensitive, and does not have a TMDL. This meant that extensive analysis was required by the proposed method. In our experience, it was possible to apply the proposed method to the Waiʻulaʻula watershed. Two factors greatly facilitated this. First, a watershed plan exists. Second, a pollutant load model had already been developed (refer to Volume Two of this report). Without the watershed plan and existing model application, it would have been very difficult to fully apply the proposed method. As it was, application was time consuming, especially the step in which load reductions were predicted for each of the various BMPs.

[7] The total maximum daily load (TMDL) is an estimate of the amount of given pollutant that can enter a given stream or receiving waters (in a given amount of time) without exceeding water quality criterion. The maximum allowable load is typically allocated between different uses, for example, contributions from sewage treatment plants, agriculture, and urban stormwater runoff. The TMDL is a non-binding management measure within the Clean Water Act.

3.2.2 Adequacy of the Proposed Method

In comparison with past assessment practices, the proposed new method has the following advantages:

1) Fuller disclosure of site conditions;

2) Places the stormwater impacts in the context of the watershed;

3) Incentives to incorporate green design elements, including a variety of best management practices;

4) Recognition that mitigation efforts are especially important for ecologically-sensitive or impaired watersheds;

5) Promotes the use of quantitative techniques for determining the effectiveness of mitigation measures;

6) TMDL load targets, in areas with existing TMDLs, are given explicit consideration. This ensures that the impact of the project does not exceed the ability of the watershed to absorb loads.

The following limitations of the proposed new method are noted:

1) Secondary and cumulative impacts are not explicitly addressed;

2) The narrow focus on Clean Water Act regulatory concerns neglects certain other related considerations such as stream channel condition and the effects on the pollution abatement functions of wetlands and riparian areas;

3) In watersheds that are neither ecologically-sensitive nor currently impaired, the proposed method does not require the developer to propose and evaluate post-construction BMPs. Post-construction BMPs will eventually be required when the project reaches the stage of county permits, but it would be better to consider them early in the process during preparation of an EIS.

4) The modeling tools underestimate the load reduction from stream buffers. This is because they do not recognize that buffers trap sediment and particulate nutrients that originate uphill from the buffer. Riparian buffers have other important benefits, such as stabilizing streambanks, preserving important habitats, and providing recreation.

5) The link between stormwater impacts and flood hazards is not explicit. These two topics are typically covered in separate chapters of an EIS. In addition, County drainage design requirements are not incorporated into the analysis.

6) The methods to determine if a watershed is stressed are unrealistic. Watershed plans are too great an effort and the rapid assessment models do not measure the gap between where the watershed is and where is should be.

Step 5 of the proposed method recommends several alternatives for determining whether or not a sensitive watershed is stressed. These alternatives include preparing a watershed plan or applying a rapid assessment model. The specific rapid assessment models mentioned in the ***Year-1 Stormwater Impact Assessment Project*** are described in Appendix D. If a watershed plan already exists it should certainly be consulted. If one does not exist, however, it is not always practical to prepare one during the environmental assessment process just to determine whether a sensitive watershed is stressed. Watershed plans are expensive (~$100,000-200,000) and require local capacity and community buy-in. Further, it takes time to prepare one (~1-3 years), so it may not fit into the timeframe for preparation of an EIS. The rapid assessment models are not necessarily a good solution either. These models can provide quantitative estimates of runoff, peak flows, and pollutant loads. Unless there is a TMDL, however, it can be difficult to interpret results in the absence of watershed-specific criteria of stress. Under the proposed method, the reason for determining if a sensitive watershed is stressed is to determine if mitigation measures should result in no net increase in loads (not stressed) or in a load reduction (stressed). Unless the amount of reduction is specified, however, “no net increase” and “reduce” are functionally equivalent (a 1% reduction does not really differ from “no change”).

Rapid assessment models can also be used to evaluate the effectiveness of proposed mitigation measures. In this context, the models can be used to calculate percent load reduction so there is little difficulty in evaluating the significance of results. Nevertheless, there are a number of drawbacks to these models:

1) The models recommended by the ***Year-1 Stormwater Impact Assessment Project*** were not designed to estimate load reductions for specific mitigation measures. Applying them for this purpose is not straightforward.
2) Estimates are only as reliable as parameter values and model assumptions.
3) Applying the models is time-consuming and, therefore, expensive.

3.2.3 Strengths and Weaknesses of N-SPECT

From the viewpoint of stormwater assessment, the principal strengths of the N-SPECT model are:

1) Data needs are easily satisfied. The GIS data required to run a simple analysis within N-SPECT are generally widely available and can be downloaded from online sources.
2) Default parameter values and standardized datasets mean that the model can be run without time-consuming calibration and parameter estimation. Further, the GIS platform facilitates convenient processing of input and output data.
3) It is relatively easy to predict the direct and cumulative impacts[8] to runoff volume, erosion, and nutrient loads. It is also relatively easy to model the entire watershed in order to place results in a larger context.

[8] In Hawaiʻi County modeling of cumulative development is facilitated by the existence of the LUPAG GIS data, which describe anticipated future development. This may not be the case in other counties.

From the viewpoint of stormwater assessment, the principal limitations of the N-SPECT model are:

1) There are no tools for predicting peak flow rate. With respect to stormwater, it is well-known that one of the primary adverse effects of urbanization is the associated increase in peak discharge. If N-SPECT is used to evaluate runoff volume and stormwater loads, then another model will be needed to evaluate peak flows.
2) There are no tools for modeling the impacts of BMPs. This is a barrier to the use of the model by developers that are proposing mitigation measures to reduce stormwater impacts.
3) C-CAP vegetation/land use categories can be too broad to accurately reflect variability across the watershed. This limitation is understandable but does limit the precision of model predictions.
4) There are no tools for estimating secondary impacts to groundwater, nor for predicting stream channel erosion/sedimentation.
5) Pollutant coefficients (average concentration of a particular pollutant in runoff from a particular vegetation/land use type) may or may not be appropriate for the watershed.
6) There is no way to account for loss of runoff and pollutants in losing stream reaches.[9]
7) There are no tools for interpreting the ecological significance of predicted loads.

As a GIS-based model, N-SPECT is easier to apply to large watersheds than many other models. It is not all that easy, however, and requires time and a certain level of expertise. As an example, when employing personnel with some skill in GIS and some background in hydrology it took about six person-months of manpower to conduct the modeling studies described in Volume Two of this report. It is estimated that the time could have been cut to two months using experts.

[9] Losing streams experience loss of water (and dissolved pollutants contained therein) as the result of infiltration into the streambed. When this occurs, pollutants generated upstream may not reach the ocean. In the Wai‘ula‘ula watershed, many of the channels adjacent to and downstream of the “proposed” developments are losing reaches.

4. Management Context

4.1 Conformance with Applicable County, State, and Federal Regulations

Existing State and county statutes, ordinances, and rules intend to ensure that land use activities are generally sited and conducted in a manner that minimizes harm to the environment. The Hawaiʻi Land Use Law (Chapter 205, HRS) places all lands into four districts - Urban, Agricultural, Rural and Conservation - and outlines allowable in each district. The more sensitive the lands (*i.e.*, Conservation) the more restricted the uses. The county general plans provide guidelines for decision-makers regarding future growth and development and protection of natural and cultural resources. They guide the patterns of future development in each county based on long-term goals; identify the visions, values and priorities important to the people of each county; and provide the frameworks for regulatory decisions. In the case of urban development, the plans provide the legal basis for all subdivision, zoning, drainage and related ordinances and guide revisions to the county code. In Hawaiʻi County, the LUPAG provides a visual guide in map form to direct the location, types, and intensity of future land uses.

Specific permit processes at the State and county levels endeavor to ensure that development activities are sited appropriately (*i.e.*, away from sensitive resources) and conducted in a manner that minimizes direct, secondary and cumulative effects to natural and cultural resources.

In urban areas, the county has the lead in the control of erosion during site development and ensuring proper site planning and stormwater management to protect sensitive natural features, through its ordinances and rules related to zoning, subdivisions, drainage, and erosion and sediment control. If development activity will disturb one acre or more of total land area, then a National Pollutant Discharge Elimination System (NPDES) permit is required from the Hawaiʻi Department of Health (DOH). The permit process is described in Chapter 11-55, HAR, "Water Pollution Control" (http://gen.doh.Hawaiʻi.gov/sites/har/AdmRules1/11-55.pdf). A County grading permit is required for any grading and grubbing work before a NPDES permit can be issued. The grading permit allows the grading, while the NPDES permit regulates stormwater runoff from the construction site. In addition, for development within a county's Special Management Area (SMA), a permit process administered by the county planning department ensures that developments in these more-sensitive coastal areas are consistent with Hawaii's Coastal Zone Management (CZM) Program objectives and policies under Chapter 205A, HRS.

Through the EIS process, State and county agencies can ensure that developers are upholding standards for construction and post-construction runoff loadings and volumes, consistent with the goals of the above State and county regulatory mechanisms, by providing a uniform yet flexible process for assessing the impacts of proposed land use activity on stormwater.

4.2 Hawaiʻi Coastal Nonpoint Pollution Control Program

In 1990, the U.S. Congress required coastal states to develop and implement coastal nonpoint pollution control programs (CNPCP) to be approved by the National Oceanic and Atmospheric Administration (NOAA) and the U.S. Environmental Protection Agency (EPA). The Hawaiʻi CNPCP, jointly administered by the Hawaiʻi CZM Program and DOH, is designed to protect coastal waters from polluted runoff and to restore impaired coastal water quality.

As part of this program, the State must implement management measures, as outlined in the *Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters* (EPA 1993). In the context of the CNPCP, management measures are defined as

> *economically achievable measures for the control of pollutants from existing and new categories and classes of nonpoint sources of pollution, which reflect the greatest degree of pollutant reduction achievable through the application of the best available nonpoint pollution control practices, technologies, processes, siting criteria, operating methods, and other alternatives (EPA 1993, p. 1-5).*

More simply stated, each management measure can be thought of as a goal towards which the State, county, local communities, and landowners can strive in order to improve water quality.

There are twelve management measures that apply to urban areas. These management measures address the management of polluted runoff from all types of urban activities in Hawaiʻi. The management measure particularly relevant to this project is the management measure for new development. This management measure seeks to control urban runoff and to treat associated pollutants generated from new development, redevelopment, and new and relocated roads, highways, and bridges. For design purposes, post-development peak runoff rate and average volume should be based on the 2-year/24-hour storm.

A. New Management Measures

(1) By design or performance:

- **a. After construction has been completed and the site is permanently stabilized, reduce the average annual total suspended solid (TSS) loadings by 80%. For the purposes of this measure, an 80% TSS reduction is to be determined on an average annual basis,* or**
- **b. Reduce the post-development loadings of TSS so that the average annual TSS loadings are no greater than predevelopment loadings, and**

(2) To the extent practicable, maintain post-development peak runoff rate and average volume at levels that are similar to predevelopment levels.

Sound watershed management requires that both structural and nonstructural measures be employed to mitigate the adverse impacts of storm water. Nonstructural Management Measures II.B and II.C can be effectively used in conjunction with Management Measure II.A to reduce both the short- and long-term costs of meeting the treatment goals of this management measure.

As noted above, the county has the lead in the control of erosion during site development and ensuring proper site planning and stormwater management to protect sensitive natural features, through its ordinances and rules related to zoning, subdivisions, drainage, and erosion and sediment control. Through the EIS process, State and county agencies could require developers to uphold the CNPCP standards for post-construction runoff loadings and volumes.

Chapter 10, Hawaiʻi County Code (HCC), "Soil Erosion and Sediment Control," administered by the Hawaiʻi County Department of Public Works (DPW), requires a permit for grading and grubbing of land, and stockpiling of material in excess of 500 cubic yards. All grading, grubbing, and stockpiling permits and operations must conform to erosion and sediment control standards and guidelines. Hawaiʻi County is currently in the process of revising this ordinance.

In Hawaiʻi County, all urban developments (with very few exceptions) have been mandated to maintain pre-development runoff conditions (Chapter 27, HCC, "Floodplain Management"). Pre- and post-development runoffs are calculated using the County "Storm Drainage Standard." The minimum criteria used for runoff calculations are a 1-hour, 10-year storm event. This requirement inhibits conveyance of development runoff into natural drainage systems. It specifies that stormwater shall be disposed into drywells, infiltration basins or other approved infiltration methods. Chapter 23, HCC, "Subdivision," and Chapter 25, HCC, "Zoning," contain these same requirements.

Chapter 25, HCC, "Zoning," provides for Cluster Plan Development, in which exceptions are made to the density requirements of the single-family residential (RS) district on lands greater than two acres so that permitted density of dwelling units contemplated by the minimum building site requirements is maintained on an overall basis, and desirable open space, tree cover, recreational areas, and scenic vistas are preserved. It also provides for Project Districts, which are intended to provide for a flexible and creative planning approach rather than specific land use designations for quality developments on lands greater than 50 acres, establishing continuity in land uses and designs while providing for a comprehensive network of infrastructural facilities and systems. These provisions encourage Low Impact Development (LID) practices.

Typically, large development proposals must undergo numerous permit processes, with their associated environmental assessments and extensive public review. Development in the Conservation District triggers a Conservation District Use Permit (CDUP) from DLNR; development within the county's Special Management Area (SMA) requires an SMA permit from the County planning department. Chapter 343, HRS, and Chapter 11-200, HAR, both about Environmental Impact Statements, require the preparation of an environmental assessment (EA) and/or environmental impact statement (EIS) for proposed activities that trigger the environmental review process. Some of the trigger conditions include: (1) use of State or county lands or funds; (2) use within the conservation district; (3) use within a shoreline setback area; (4) use within an historic site; (5) reclassification of conservation lands; and (6) certain amendments to a county general plan.

The county administers the SMA permit process. SMAs are a subset of the State's coastal zone and include all lands and waters beginning at the shoreline and extending inland or *mauka* at least 100 yards. The SMA permit process ensures that developments in these more-sensitive coastal areas are consistent with coastal zone management program objectives and policies. Although each county has its own procedures for administering SMA permits, the requirements and review processes for SMA applications are based on Chapter 205A-26, HRS ("Special management area guidelines"). The county requires a permit applicant to describe the proposed development in terms of the CZM objectives and policies.

5. Guidance and Recommendations

The following recommendations for conducting stormwater assessments build on the recommendations in the ***Year-1 Stormwater Impact Assessment Project****. Our recommendations do differ from the Year-1 recommendations in several important respects, however.*

5.1 Assumptions

The recommendations are based on the following assumptions:

i. In the context of EIS, the purpose of stormwater assessment is to 1) transparently describe expected impacts of development on downstream fresh and coastal waters, and 2) incorporate into the proposed development low impact design and management practices that minimize adverse impacts.

ii. It is in the best interests of everyone to have a uniform yet flexible process for assessing the impact of a proposed action on stormwater. This ensures that the public and decision-makers have access to relevant information and also provides a standard of due diligence for organizations preparing stormwater assessments.

iii. Proposed projects will vary in the level of analysis that is appropriate. For example, small renovation projects in urbanized watersheds will require less analysis than large new developments near ecologically-sensitive coastal waters. The recommendations listed below are relevant primarily to large projects involving urban development of previously-undeveloped or lightly-developed lands.

iv. The burden of disclosing impacts falls on the developer.

v. As things stand now, any recommendations regarding stormwater assessment procedures are non-binding. As long as this remains the case, cost-effective methods of conducting assessments will be favored by developers.

vi. In general, at this time the EIS process does not include enforceable mitigation goals. [Hypothetical examples of mitigation goals would include: no net increase in load unless the receiving waters are impaired, in which case mitigation should reduce loads to less than 50% of pre-existing loads.]

vii. Contrary to past practices, assessments should address cumulative and secondary impacts.

viii. Preparers of EIS can reasonably be expected to access and analyze readily-available standard datasets, including those that are normally analyzed with GIS.

ix. Costly quantitative modeling of unmitigated direct and cumulative impacts is warranted only in certain circumstances. The cost of modeling can be justified most easily when it will result in effective mitigation and improved design.

x. Existing federal regulations (NPDES permits for construction-related stormwater) provide more or less satisfactory mitigation of stormwater impacts during the construction period.

5.2 Recommendations Regarding the Framework for Stormwater Assessment

Limitations of Current Regulatory Framework

Stormwater assessment is most often conducted within the framework of an Environmental Impact Statement (EIS). Currently, there are no regulations or requirements for use of a specific stormwater assessment process. Nor is there an enforceable requirement for certain levels of mitigation. The developer has considerable discretion and is under no obligation to follow the recommendations laid forth in sections 5.3 and 5.4. It follows that an improved stormwater assessment methodology will only be effective if required by regulatory mechanisms and/or permit processes. Insofar as creating new regulatory mechanisms would be difficult, it would be preferable to use existing, largely-unenforced regulations.

While Chapter 11-55, HAR, Appendix C (NPDES general permit authorizing discharges of stormwater associated with construction activity) requires that permanent, or post-construction, BMPs be included in a development's Storm Water Pollution Prevention Plan (SWPPP), this is infrequently implemented. The language of the general permit states:

> "Section 4(b)(2): Construction site best management practices plan containing, at a minimum, the following information:
>
> ...
>
> (J) Descriptions of measures that will minimize the discharge of pollutants via storm water discharges after construction operations have been finished. Examples include: open, vegetated swales and natural depressions; structures for storm water retention, detention, or recycle; velocity dissipation devices to be placed at the outfalls of detention structures or along with the length of outfall channels; and other appropriate measures;
>
> ..."

The general permit does not specify that developments should maintain post-development peak runoff rate and average volume at levels that are similar to pre-development levels.

County and State stormwater regulations and requirements vary. These do not uniformly require pre- and post-development equivalency in terms of peak runoff rates and average volumes. In addition, there are no mechanisms in place to require more stringent standards for post-development stormwater quantity and quality in watersheds that are impaired (*i.e.*, not meeting State water quality standards) and/or sensitive (*i.e.*, containing natural resources sensitive to increases in runoff volumes and pollutant loads). Likewise, in densely-developed urban watersheds where re-development is occurring, pre- and post-development equivalency may not be sufficient to manage stormwater and downstream water quality.

Recommendations for Incorporating Improvements into Permit Processes

1. The regulatory mechanisms and/or permit processes that would benefit from the information garnered by an improved stormwater assessment process should be identified. The stormwater assessment process should then be explicitly incorporated into each relevant regulatory mechanism and/or permit process, so that decisions can be made with improved understanding about the effects of development projects on stormwater and water quality at a watershed scale.

2. State and county regulations and requirements that relate to stormwater should be revised to provide uniformity across the State with respect to mitigation goals for stormwater control and pollutant loadings. At a minimum, regulations should require that post-development peak runoff rate and volume be maintained at levels that are similar to pre-development levels. In addition, regulations should ensure that development does not increase pollutant loads. These minimum requirements should apply to all proposed projects. Stricter requirements may be appropriate in some watersheds, however.

3. The State needs to develop guidelines for more stringent standards for post-development stormwater quantity and quality in watersheds that are impaired, sensitive, and/or highly urbanized, that could be used to guide different permit decisions. For example, in watersheds that are impaired and/or sensitive, post-development peak flows and pollutant loads may need to be lower than in pre-development conditions. Ideally, State and county agencies will coordinate to develop specific and consistent guidelines. Once developed, these guidelines should be incorporated into the appropriate regulations, requirements, and permits.

4. The State and county should require the identification of post-construction BMPs during the project planning and EIS phases of a development project, within their relevant regulatory mechanisms and permit processes.

5. Hawaiʻi should explore the use of in-lieu fee mitigation programs to assist private and public developers in complying with compensatory mitigation for projects that affect streams, wetlands, riparian buffers, and water quality. Developers could be required to offset effects of their development project by putting funds toward restoration efforts on a watershed scale.

5.3 Recommendations for an Improved Guidance for Conducting Stormwater Assessment

The scope of impacts addressed in the EIS should include stormwater volume and peak flow rate, pollutant loads and concentrations,[10] soil erosion, stream channel condition, effects on the pollution abatement functions of wetlands and riparian areas, and effects on downstream ecosystems or aquatic recreational areas.

It is assumed all projects will comply with NPDES stormwater and county Grading Permit requirements. These will vary according to the nature of the project. The NPDES stormwater prevention plan process ensures that construction-related impacts are mitigated according to standard practices.

The stormwater assessment process potentially consists of several parts:

1) Providing general background information that
   a) provides context,
   b) is relevant to direct, secondary, and cumulative impacts, and
   c) provides information about the watershed, namely its condition, importance, and status with respect to management programs.

2) Analyzing background information in the light of the proposed project.

3) Identifying mitigation goals (for example, no net increase in loads or discharges).

4) Proposing actions that mitigate stormwater impacts during and after construction, and discussing the extent to which LID has been incorporated.

5) Proposing mitigation measures that lead to LEED certification.[11]

6) Using models to predict runoff volume, peak flows, pollutant loads, and soil erosion for some or all the following:
   a) Comparing pre-development conditions and post-development conditions (with and without mitigation).
   b) Evaluating conditions after the entire watershed has been fully developed according to the guidelines in the County General Plan.

7) Summarizing anticipated impacts, with explicit discussion of direct, cumulative and secondary impacts.

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[10] Loads (amount of pollutant leaving the development or watershed in a specified amount of time) are relevant to the ecosystem in its entirety while concentrations (amount of pollutant in a given volume of water) are relevant in terms of stress to individual organisms.

[11] LEED, or Leadership in Energy and Environmental Design, provides developers with a framework for indentifying and implementing practical and measurable green building design, construction, operations, and maintenance solutions (US Green Building Council 2005).

Parts 1-4 and 7 would normally be included in any EIS. It is anticipated that the depth of analysis will vary according to the extent of anticipated impacts. Parts 5-6 (detailed quantitative evaluation) would be included when warranted by

- the general level of anticipated impacts,
- regulatory requirements (for example county drainage ordinances), or
- the desire of the developer to emphasize "green" practices.

Developers should be strongly encouraged to perform parts 5-6 (listed on previous page) for watersheds that are impaired. Parts 5-6 should also be considered for sensitive watersheds, whether currently stressed or not.

We recommend that stormwater mitigation measures be proposed for *all* proposed developments, with the goal of no net increase in peak flows, runoff volume, soil erosion, and loads of nutrients and any other pollutants that are of interest. This recommendation is a departure from the ***Year-1 Stormwater Impact Assessment Project***, which does not recommend such proposals in watersheds that are neither ecologically-sensitive nor currently impaired. We recommend that stormwater impacts be evaluated for the two-year 24-hour storm. Soil erosion, however, should be evaluated in terms of average annual values. Some counties require that drainage be designed using events other than the two-year 24-hour event. In such cases, mitigation of peak flows should be assessed with whichever of these events produces the largest peak discharge at the project boundary.

There are situations, for example watersheds that are already degraded or locations where sensitive ecosystems are at risk, where the goal of no net increase may not be sufficient. Section 5.2 (page 25) discusses mechanisms by which stricter mitigation goals could be pursued.

Our recommendations regarding the scope of analysis differ from the recommendations of the ***Year-1 Stormwater Impact Assessment Project*** in that we recommend addressing physical and biological aspects of the stream channel, with a view towards ecosystems and pollution abatement functions. We also recommend explicit discussion of cumulative and secondary impacts.

The ***Year-1 Stormwater Impact Assessment Project*** provides guidance on how to carry out steps 2-6 and, to a lesser degree, step 7. Because the ***Year-1 Report Stormwater Impact Assessment Project*** is concisely-written, evaluators may wish to consult Volume Three of this report, which contains more detailed step-by-step instructions.

5.4 Recommendations for Background Data and Analysis

Our recommendations for the background data to be included in step 1 are more extensive than the recommendations made in the ***Year-1 Stormwater Impact Assessment Project.***

5.4.1 Background Data Recommended for all Stormwater Assessments

- Identify relevant streams, watersheds, and receiving waters.
  - Identify the watershed or sub-watershed in which the proposed development occurs, noting the watershed contributing area upstream of the development and the total contributing area where the main stream enters the ocean.
  - Inventory either perennial or ephemeral stream channels within or adjacent to the project sites.
  - Identify the streams and coastal areas that receive stormwaters generated on the project property.
  - Inventory unique, valuable, and/or sensitive aquatic ecosystems within, adjacent to or downstream of the project sites. Examples include wetlands, coral reefs, anchialine ponds, coastal reserves, and embayments with low flushing capability or low salinity.

- Disclose data that provide a context for impacts to stream channels and riparian areas:
  - Identify FEMA flood hazard zones located within the proposed development.
  - Describe the physical and biological conditions of any stream channels (or other aquatic habitats) identified above.

- Climate and watershed data that are relevant to runoff and erosion:
  - Current and past land uses within the watershed;
  - Average annual rainfall and seasonal distribution;
  - Existing vegetation; and
  - Topographic slope.

- Soil data relevant to runoff and erosion:
  - Hydrological soils group(s);
  - Soil type(s); and
  - Presence of soils categorized by NRCS as highly erodible.

- Data that are relevant to cumulative impacts:
  - Acres of land within the watershed that are currently developed;
  - Acres of land within the watershed that could be developed in the future if development proceeds to full build-out under the guidance of the County General Plan; and
  - Other relevant information about future land use change that is anticipated by the County General Plan.

- Identify relevant prior studies, including:
  - Existing data on peak flows, water quality, or low flows in the streams (or other aquatic features) identified above; and
  - Watershed plans or biological assessments.

- Data relevant to management concerns:
  - Information on whether the watershed is a high priority for restoration based on the Hawaiʻi Watershed Prioritization Process (HWPP);
  - Information on whether the affected streams or their receiving waters are impaired as determined according to the Section 303(d) list in the most recent State of Hawaiʻi Water Quality Monitoring and Assessment Report;
  - Classification of receiving waters, noting if they include Class AA marine waters or Class 1 inland waters; and
  - TMDL reports, if available and relevant.

Volume Three of this report provides information on sources of background data.

5.4.2 Optional Background Data

The following data would be supplied at the discretion of the organization conducting the stormwater assessment. The optional data include: 1) data needed to implement a Stormwater Pollution Prevention Plan, which is eventually required for any construction project, 2) technical data needed to make quantitative assessments, and 3) data needed to establish the sensitivity of receiving waters.

- Identification of potential pollutant sources resulting from construction activities;

- Presence of contaminated soils;

- Data that are needed to estimate stormwater impacts:
  - Percentage of impervious area before and after construction;
  - Runoff coefficient before and after construction;
  - Rainfall intensities for design storms, particularly the 2-year 24-hour storm and the storm used for drainage design (varies by county);

- Identification of features affecting erosion, namely:
  - The slope and length of hillslopes;
  - rainfall erosivity parameter and soil erosivity parameter k.

5.4.3 Analysis and Discussion Recommended Analysis for all Proposed Projects

We recommend that *all* stormwater assessments discuss or analyze the following points. The depth of analysis would depend on factors such as the size of the project, overall level of impacts, and sensitivity of the receiving waters. There will be some projects for which a short discussion would be sufficient and others for which a detailed analysis is appropriate.

a. Discussion of impacts during the construction period and proposed mitigation efforts.

b. Discussion of anticipated *post*-construction impacts, addressing direct impacts to peak flows, runoff volume, erosion, pollutant loads, and stream channels (or other aquatic habitats/features). Impacts without mitigation should be compared to impacts with mitigation. In addition to standard pollutants (nutrients and sediment), we recommend addressing the potential for introduction of toxic materials such as landscaping herbicides or motor oil drippings onto roadways.

c. Recommendations for maintenance needed to maintain the effectiveness of structural BMPs. For example, the frequency of dry well maintenance could be specified.

d. Discussion of the potential for secondary impacts, for example degradation of groundwater quality as a result of infiltration of urban runoff. In Hawaiʻi County, impacts of dry wells should be discussed.

e. Discussion of cumulative impacts. See Appendix B in Volume 3 for further information. The nature of this discussion could range from qualitative (based on information about extent of past, proposed, and anticipated future development/activities) to quantitative (modeling should be considered in select cases).

5.4.4 Use of Models

The method of stormwater assessment proposed in the ***Year-1 Stormwater Impact Assessment Project*** relies on modeling to determine the effectiveness of mitigation measures proposed for sensitive, impaired, or stressed watersheds. It is our recommendation that modeling or similar quantitative calculations be used to demonstrate the effectiveness of proposed post-construction BMPs. We do not, however, recommend blind reliance on modeling results: common sense, a broad viewpoint, and awareness of model assumptions should be brought to bear on the choice of mitigation options. See Section 5.5 for more discussion on the use of models.

5.5 Modeling of Stormwater Impacts

Models are useful tools for quantifying stormwater impacts, but, obviously, they are only one part of the assessment process. A valid question is the degree to which the use of models should be required or strongly encouraged. Models can be used for a range of assessment practices, including estimating loads under pre-development and post-development conditions, and estimating cumulative impacts. Evaluating potential BMPs is perhaps the most compelling reason to use models. One view is that models are necessary if one needs to demonstrate that proposed BMPs are sufficient to meet mitigation goals. There could, of course, be exceptions for small projects or special circumstances. It is anticipated that developers will be reluctant to conduct expensive modeling studies unless they are required as part of the permit or re-zoning application process. See Section 5.2 for a discussion of this issue.

The counter-argument for use of models is that they are expensive and, if applied naively or inappropriately, they could provide misleading results. Models are comprised of 1) a series of assumptions about watershed processes and anthropogenic impacts, 2) descriptions of processes (for example, runoff generation and flow of water on a slope), and 3) parameters and input data describing watershed condition and processes. The results of a modeling study are, therefore, predicated on model assumptions and parameters. Model outputs should not be accepted blindly but should be evaluated in light of assumptions and parameters. This is as true for N-SPECT as for any other model.

N-SPECT is designed for estimating runoff volumes, pollutant loads, and soil erosion. It is meant for coastal watersheds and has tools for calculating the impact of new developments. These tools are relatively easy and should be considered “first cut” because they are based on a few simple assumptions. The model is well-suited for estimation of cumulative impacts. The existence of default parameter sets and statewide availability of input data makes it relatively easy to apply N-SPECT to a new watershed, at least in comparison to other models. It would take a person with skill in GIS and some background in modeling at least a month to apply N-SPECT to a new watershed and evaluate direct and cumulative impacts. N-SPECT is not designed to estimate peak discharges, so another model would need to be used for that purpose. Volume Three discusses several that can be used to estimate peak flows.

While N-SPECT can be used to evaluate the effectiveness of some mitigation options, it is really not designed for that purpose and its capabilities are limited in this regard. There are other models that have been designed to examine the effect of stormwater BMPs. Two such models that have been used extensively are WinSLAMM and SUSTAIN. These models, which are described in the appendix, evaluate BMPs at the level of detail needed for engineering design. Of course, they are resource-intensive. Another model that may be of interest is the NOAA Coastal Service Center’s *Impervious Surface Analysis Tool*, which is available from http://www.csc.noaa.gov/digitalcoast/tools.

Regardless of what model is used, it would be helpful if there was guidance to help interpret the significance of load predictions. This issue is most pressing in watersheds without a TMDL.

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Appendix: Models for BMP Evaluation

This appendix describes two models (SUSTAIN and WinSLAMM) that were developed for the explicit purpose of proposing and evaluating stormwater BMPs.

SUSTAIN

What it is: *SUSTAIN* (System for Urban Stormwater Treatment and Analysis INtegration Model) is comprised of seven modules integrated into the ArcGIS platform.

What it does: Facilitates the selection and implementation of BMPs and Low Impact Development techniques. It can be used to:

- Develop TMDL implementation plans
- Identify management practices to achieve pollutant reductions in an area under an MS4 stormwater permit
- Determine optimal green infrastructure strategies for reducing volume and peak flows to CSO systems
- Evaluate the benefits of distributed green infrastructure implementation on water quantity and quality in urban streams

Fundamental to the setup and application of *SUSTAIN* is a clear definition of the study objective(s)—*What is the question that is to be answered by the analysis?* For example, the objective of the study might be to identify the set of management options (including both site- and regional-scale techniques) that achieve a required level of pollutant load reduction (*i.e.*, annual load in lbs/yr). For a CSO study, the objective might be stated as "to reduce frequency of overflow through extensive retrofit of the drainage area." The reduction in overflow can be measured by the magnitude of peak flows in a collection system. The study objectives will define the scope and extent of the *SUSTAIN* application, which could include the areas to be modeled, runoff and pollutant factors to be simulated, additional data collection needed, the locations where the output will be evaluated (*i.e.*, assessment points), and the determination of the optimization evaluation factors and control targets (*i.e.*, endpoints). At each control target, *SUSTAIN* is capable of producing outputs in various time averaging periods and frequencies of occurrences that will facilitate the evaluation and comparison of management alternatives. The following lists the examples of output variations:

- Average annual flow volume percent reduction based on an existing condition
- Average annual flow volume
- High-flow rate and allowed maximum duration (user specified)
- Peak-flow value and maximum exceedance frequency

- Average annual sediment/pollutant load percent reduction with respect to an existing condition
- Average annual sediment/pollutant load (load target)
- Average sediment/pollutant concentration (the maximum average concentration allowed)
- High sediment/pollutant concentration and duration (concentration threshold value and allowed maximum duration when concentration exceeds the threshold)
- Long-term average sediment/pollutant load (daily, monthly, annual, or any user specified time frame)

Limits: The post-processor is designed to perform analysis in conjunction with cost-effectiveness curves. The curves can be produced using only the NSGA-II optimization method. While it is possible to use the post-processor to visualize individual storms and time series data generated by the Scatter Search method, a cost-effectiveness curve evaluation uses the full functionality. Another limitation of the post-processor with regard to time series evaluation is that it shows only total inflow versus total outflow through a given node in the network. If an assessment point is also a BMP site, the post-processor does not have the ability to summarize the complete history of surface and subsurface interactions (*e.g.*, infiltration capacity exceedance, underdrain outflow, weir and orifice outflow). In addition, the post-processor has the ability to select and run only those solutions that appear along the cost-effectiveness curve. It cannot be used to directly select, run, and visualize information associated with a specific point that falls below the cost-effectiveness curve.

In a typical application the model will be run using several years of historical rainfall data.

References:

EPA, 2009. SUSTAIN - A Framework for Placement of Best Management Practices in Urban Watersheds to Protect Water Quality (PDF) (EPA/600/R-09/095), 156 pp.

Software is available at <http://www.epa.gov/nrmrl/wswrd/wq/models/sustain/> [Accessed March 27, 2012].

Table 1. Typical Data Needs for *SUSTAIN* Application

Data	Data Type	Need	Data Source
Land Use	ESRI Grid	Required for defining land use distribution	National Land Cover Dataset (NLCD) (http://seamless.usgs.gov/website/seamless/viewer.php) or locally derived data
Land Use Lookup	Dbf Table	Required for assigning land use categories and groupings	Standard National Land Cover Dataset (NLCD) land cover code for NLCD land use (http://landcover.usgs.gov/classes.asp) or land cover mapping code for locally derived data
External Model	ASCII Text Files	Required for external model linkage	Time series generated by land use model
Digital Elevation Model (DEM)	ESRI Grid	Required for automatic delineation of drainage areas	(http://seamless.usgs.gov/website/seamless/viewer.php) or locally derived source
Stream Network	ESRI Shape File	Required for automatic delineation of drainage stream management practices	National Hydrography Dataset (NHD) (http://nhd.usgs.gov/data.html)
Precipitation	ASCII Text File	Required for internal land simulation and for estimating storm sizes for the post-processor	National Climatic Data Center (NCDC). NCDC Summary of the Day (daily data) can also be obtained from EarthInfo Inc. (http://www.earthinfo.com)
Other Weather Data	ASCII Text File	Required if snow melt is simulated for internal land simulation	NCDC (temperature, evaporation, and wind speed)
Pipes	Data Entry	Required if pipe/conduit is simulated	Shape and dimensions (*e.g.*, length, width, diameter)
Stream Geometry	Data Entry	Required if stream routing is simulated	Cross-sectional geometry (shape and related dimensions)
Management Practices	Data Entry	Required	Characteristics of installed and proposed management practices (*e.g.*, size, shape, media, design specification); dependent on type of practice
Flow	ASCII Text File	Required for calibration of internal modeling of runoff; recommended for system testing	USGS real time data (http://waterdata.usgs.gov/nwis/rt) or local sampling
Water Quality	ASCII Text File	Required for calibration of internal modeling of water quality; recommended for testing of water quality predictions	USGS surface water data (http://waterdata.usgs.gov/nwis/sw) or EPA STORET data (http://www.epa.gov/storet/dwhomeht ml) or local sampling

WinSLAMM

What it is: WinSLAMM is a stand-alone software by PV & Associates.

What it does: The Source Loading and Management Model (SLAMM) was originally developed to better understand the relationships between sources of urban runoff pollutants and runoff quality. It has been continually expanded since the late 1970s and now includes a wide variety of source area and outfall control practices (infiltration practices, wet detention ponds, porous pavement, street cleaning, catch basin cleaning, and grass swales). SLAMM is strongly based on actual field observations, with minimal reliance on theoretical processes that have not been adequately documented or confirmed in the field. SLAMM is mostly used as a planning tool to better understand sources of urban runoff pollutants and their control. Special emphasis has been placed on small storm hydrology and particulate wash off. Many currently available urban runoff models have their roots in drainage design where the emphasis is with very large and rare rains. In contrast, stormwater quality problems are mostly associated with common and relatively small rains. The assumptions and simplifications that are legitimately used with drainage design models are not appropriate for water quality models. SLAMM, therefore, incorporates unique process descriptions to more accurately predict the sources of runoff pollutants and flows for the storms of most interest in stormwater quality analyses. However, SLAMM can be effectively used in conjunction with drainage design models to incorporate the mutual benefits of water quality controls on drainage design. SLAMM has been used in many areas of North America and has been shown to accurately predict stormwater flows and pollutant characteristics for a broad range of rains, development characteristics, and control practices. As with all stormwater models, SLAMM needs to be accurately calibrated and then tested (verified) as part of any local stormwater management effort.

Required data:

- Land use characteristics
- Details of impervious areas (such as location and pitch of roofs, types of driveways, etc.)
- Best management practices, including details at a design level (where the rain gardens are or width of grass swales, etc.)

Parameter files include:

- Rainfall Data
- Runoff Coefficient Data
- Particle Size Data
- Particulate Solids Concentration Data
- Particulate Residue Reduction Data
- Street Delivery Data
- Pollutant Distribution Data

The model appears to run on historical rainfall data, usually for several months at a time. Detailed site-specific information is required on rainfall discharge and pollutant concentrations.

Strengths:

- Evaluates pollution loading at the source area level
- Based on 30+ years of research data on urban stormwater loading
- Does pollutant loads
- Does BMPs

Limits:

- Large amounts of detailed site-specific data required

Outputs:

- Output without controls
- Output with controls
- Runoff volume
- Pollutants
- Particulate solids

Other Notes:

- $300 for new license, per license
- Not intended to be used with design storms, but probably could be adapted
- More focused on smaller storm events
- Does not model mass erosion effects and is not designed for rural conditions
- Does not seem to incorporate C-CAP or otherwise readily-available GIS land cover
- Has own default parameter files so the user does not need to hunt for data

Reference:

P & V Associates, WinSLAMM 9.4 User's Guide Introduction (PDF)
<http://www.winslamm.com/Select_documentation.html> (Accessed April, 5th, 2012).

Glossary

Baseflow. Streamflow that occurs in-between stormflow-generating rains. Baseflow is derived from groundwater discharge.

Best Management Practice (BMP). A specific action, process, method, or technology that is effective and practical for preventing or reducing pollution from nonpoint sources. Management practices are selected for appropriateness to the source, location, and climate.

Cumulative Impacts. Impacts that arise from the sum of all past, present, and reasonably foreseeable future actions. Cumulative impacts can arise from individually minor but collectively significant actions taking place over a period of years.

Design Storm. A hypothetical large rare rainstorm. Sometimes referred to as an “event”. This concept is best understood as an example. Consider a location for which the 1-hour 10-year rainstorm is 2.4 inches. This storm delivers 2.4 inches of rain in one hour and has a 10-year recurrence interval. This means that in any given year there is a 1 in 10 chance that the largest 1-hour rainfall will exceed 2.4 inches.

Geographical Information System (GIS). A computer system for storing and analyzing geographically referenced (map-like) data.

Intermittent stream. A stream that carries water for months at a time but periodically ceases to flow when shallow groundwater is depleted. Intermittent streams differ from **ephemeral streams** in that ephemeral streams are not fed by groundwater and carry water only after rains.

Interrupted stream. A stream that carries water through much of its length but has sections of dry streambeds.

LEED refers to the Leadership in Energy and Environmental Design program, which provides developers with a framework for identifying and implementing practical and measurable green building design, construction, operations, and maintenance solutions (U.S. Green Building Council. 2005).

Loads refer to the amount of pollutant leaving a development or watershed in a specified amount of time. Typical units are kilograms per year or kg per storm event. Loads are relevant to the ecosystem in its entirety while concentrations (amount of pollutant in a unit volume of water) are relevant in terms of stress to individual organisms.

Losing Stream. These streams lose water to streambed infiltration. This means that it is possible for discharge to decrease in a downstream direction. Loads generated upstream may not reach the ocean. Note that a stream may be losing in some reaches and gaining in others.

Peak Flow. The maximum discharge experienced during a runoff event or during the course of year. A stream’s discharge (synonym flow) is the amount of water flowing past a given point in a given amount of time. Units are volume of water per units time: typically cubic feet per second (cfs) or cubic meters per second (cms).

Perennial stream. A stream that carries water at all times. Perennial streams are fed both by stormwater runoff and by groundwater.

Raster. GIS data or models that represent a spatially continuous variable (e.g. land use or rainfall) as an equally-spaced grid of values.

Runoff. As used in this report, runoff is synonymous with stormwater and refers to water flowing over the ground or in streams in response to a hard rain. Runoff occurs during and immediately after a rainstorm. Occasionally this term is used to denote all water in streams, whether derived from "surface" runoff or from groundwater.

Secondary impacts. Impacts which are caused by an action and are later in time or farther removed in distance, but are still reasonably foreseeable. These indirect effects may include growth-inducing effects and other effects related to induced changes in the pattern of land use, population density or growth rate, and related effects on air and water and other natural systems, including ecosystems. (From Chapter 11-200, HAR)

Section 303(d) List. The federal Clean Water Act requires states to regularly describe overall status of water quality statewide and submit a list of waters that do not meet state water quality standards. The most-recent document and list developed by the Hawaii Department of Health is entitled ***2006 State of Hawaii Water Quality Monitoring and Assessment Report: Integrated Report to the U.S. Environmental Protection Agency and the U.S. Congress Pursuant to Sections 303(D) and 305(B), Clean Water Act (P.L. 97-117)***, better known as the Section 303(d) list.

Stormwater is water flowing over the ground or in channels immediately after a hard rain. Stormwater is contrasted with **baseflow**, which is derived from groundwater and comprises the small but steady streamflow in-between hard rains.

Stormwater Assessment. Prediction of the effect of an activity on stormwater. Effects could include changes to the amount runoff, changes to the timing and magnitude of peak flows, and initiation of streambank erosion. This term is most often used in the context of an Environmental Impact Statement.

Total Maximum Daily Load (TMDL). An estimate of the amount of given pollutant that can enter a given stream or receiving waters (in a given amount of time) without impairing water quality. The maximum allowable load is typically allocated between different uses, for example, contributions from sewage treatment plants, agriculture, and urban stormwater runoff. The TMDL is a non-binding management measure within the Clean Water Act, implemented by the Hawaiʻi Department of Health.

Total Nitrogen (TN). "Total" nitrogen refers to the sum of all forms of nitrogen, including particulate, dissolved, inorganic (e.g. nitrate), and organic (e.g. decomposed leaves) forms. Different forms of nitrogen have different levels of bioavailability, but nitrogen changes form readily so it is traditional to analyze all of them together.

Total Phosphorus (TP). "Total" phosphorus is the sum of all forms of phosphorus, including particulate, dissolved, inorganic (e.g. orthophosphate), and organic (e.g. decomposed leaves) forms. In streams a high percentage of phosphorus is in particulate form, so BMPs that reduce sediment loads are usually effective in reducing the amount of phosphorus that enters streams.

Total Suspended Solids (TSS). TSS concentration refers to the amount of sediment (either mineral or organic) in water and has units of mass of solids per unit volume of water.

Water Quality Standards. The criteria used by the State uses to evaluate whether its waters are healthy. Water quality standards address physical, chemical and biological aspects of water quality and set the bar for minimum acceptable quality.

Yield. Pollutant loads divided by the acreage of the area that generates the runoff. Yields have units of mass of pollutant per unit time per unit area. Yields are useful in comparing different geographic areas or examining spatial variations.