

# Tutorial for the Nonpoint-Source Pollution and Erosion Comparison Tool (N-SPECT)

*Extension for ESRI® ArcGIS™*



with a focus on the Wai'anae region of Oahu, Hawai'i

Updated January, 2006



**NOAA Coastal Services Center**  
LINKING PEOPLE, INFORMATION, AND TECHNOLOGY

## Table of Contents

---

Introduction to N-SPECT .....	1
Overview.....	1
Technical Requirements.....	1
Background.....	2
Getting Started with N-SPECT .....	4
Installation.....	4
Activating N-SPECT.....	5
Tips on Using N-SPECT.....	5
Basic N-SPECT Analyses – Baseline Conditions.....	6
Introduction.....	6
Exercise 1 – Baseline Analysis (Accumulated Effects).....	7
Start ArcMap™ .....	7
Start N-SPECT.....	8
Initialize the Analysis Environment.....	8
Choose the Analysis Outputs and Run N-SPECT.....	9
View the Results.....	10
Enhance the Data Display – Create a Hillshade.....	11
Spatial Patterns and Landscape Associations of Sediment and Pollutants.....	13
Exercise 2 – Baseline Analysis with Local Effects.....	18
Restart ArcMap and Initialize N-SPECT.....	18
View the Results.....	19
Conclusion.....	20
Advanced N-SPECT Analysis – Management Scenario .....	21
Introduction.....	21
Exercise 3 – Analysis with a Management Scenario (Local Effects).....	21
Select an Area of Interest.....	22
Add a Management Data Layer to ArcMap.....	22
Start N-SPECT and Open a Project.....	23
Add a Management Scenario.....	23
Run N-SPECT.....	24
View the Results.....	24
Compare the Pollutant Yields at the Local Scale (Nitrogen) .....	26
Calculate the Percent Change in Pollutant Yields (Nitrogen).....	29
Exercise 4 – Analysis with a Management Scenario (Accumulated Effects).....	30
Initialize ArcMap and Re-Initialize N-SPECT.....	30
View the Results.....	31
Compare the Accumulated Results at the Watershed Scale (Nitrogen) .....	31
Conclusion.....	33
Advanced N-SPECT Analysis – Alternative Land Use.....	34
Introduction.....	34
Exercise 5 – Analysis with a New Land Use Scenario (Accumulated Effects).....	34
Add a Land Use Data Layer to ArcMap.....	35
Start N-SPECT and Open a Project.....	35
Select Drainage Basins for Processing .....	36
Add a Land Use Scenario.....	37
View the Results and Compare to Baseline Data (Nitrogen) .....	39
Conclusion.....	40
Works Cited .....	41

# Introduction to N-SPECT

---

## Overview

The NOAA Coastal Services Center has developed the Nonpoint Source Pollution and Erosion Comparison Tool (N-SPECT) to examine the relationships between land cover, soil characteristics, topography, and precipitation in order to assess spatial patterns of surface water runoff, nonpoint source pollution, and erosion. N-SPECT is a geographic information systems (GIS) tool implemented in Environmental Systems Research Institute's (ESRI®) ArcMap™ software package, and requires the Spatial Analyst™ extension. Land cover, topography, soils, and precipitation data sets are used to estimate rainfall runoff volume, suspended sediment loads, and pollutant concentrations and total loads at both the local (pixel) and watershed scales.

Coefficients representing the contribution of each land cover class to observed pollutant concentrations are applied to land cover data sets to approximate pollutant loads and concentrations. The default coefficients provided with N-SPECT were derived from published studies and local water quality sampling data. For each pollutant analyzed, water quality ratings are assigned spatially by comparing pollutant concentrations calculated by N-SPECT to user-defined water quality standards.

Knowledge of the distribution of water quality can help resource managers and planners target areas needing attention. N-SPECT also provides functionality to compare current land cover conditions to theoretical changes in both land use and land cover. The results of N-SPECT analyses are intended to be used as screening tools to help understand and predict the impacts of management decisions on water quality and, potentially, on nearshore coral health.

N-SPECT is designed to be portable to any watershed, provided the user has access to the necessary data. Data provided with N-SPECT cover the Wai'anae region, located on the western side of Oahu, Hawai'i and include USDA SSURGO soils data, USGS digital elevation model data, and NOAA Coastal Change Analysis Program (C-CAP) land cover data. The user's manual provides a detailed discussion of the interfaces within N-SPECT and the data required to perform an analysis. The technical guide explains in more detail where the data were acquired for the Wai'anae study area and how the data were processed to be compatible with N-SPECT. This document walks a user through the basic operation of N-SPECT and explores advanced analysis options through the applications of different land use and land management scenarios.

## Technical Requirements

N-SPECT is implemented in ESRI's ArcGIS™ software package, and requires the Spatial Analyst extension. The minimum system requirements for N-SPECT include

- CPU speed: 450 MHz minimum, 800 MHz or higher recommended
- Processor: Pentium 1 or higher
- Memory/RAM: 128 MB minimum, 256 MB or higher recommended

## Background

---

Coastal and inland water quality issues are of increasing concern among water resource managers and planners worldwide as pollution and sediment levels from point sources and nonpoint sources continue to mount. Specific physical, chemical, and biological characteristics of water have direct impacts on its suitability for agriculture, industry, recreation, drinking, and habitat for fish and wildlife. Stream water quality is a function of several parameters, such as temperature, sediment loads, inorganic chemistry, dissolved oxygen, nutrients (primarily nitrogen and phosphorus), pH, and toxic metals and organic compounds (EPA, 1986; Newson and Newson, 2000). The detrimental effects of poor water quality can also be conveyed to coastal waters where reef ecosystems and estuaries suffer from high nutrient and sediment loads (U.S. Coral Reef Task Force, 1999; Clark, 1995). Understanding the factors that affect water quality requires an understanding of human impacts on water quality and a basic familiarity with natural watershed processes.

Human activities impact surface water quality in many ways: wastewater discharges can increase nutrient concentrations; construction, mining, and agriculture can increase suspended sediment loads; and stream channelization, water withdrawal, and impoundments can affect water temperatures (Oki, 2003). Surface water (and groundwater as well) draining agricultural areas can exhibit increased levels of herbicides, pesticides, and nutrients (Anthony et al., 2004). Runoff from urban areas can contain elevated levels of pesticides, nutrients, metals, and oil. Urbanization and channelization further exacerbate problems associated with surface water runoff as impervious surfaces prevent infiltration, increase mobilization of pollutants, and expedite their transport to receiving waters. Pollutants and sediments found in surface waters can often be traced to specific point sources where management actions can be focused to improve water quality. In many other instances, however, pollutants and sediments cannot be traced to distinct points of origin. In these cases, water quality can be examined in a larger spatial context to relate landscape patterns (both natural and anthropogenic) with downstream pollutant and sediment loads. Similarly, predicting the impacts of land use changes on water quality requires an understanding of the physical processes related to nonpoint source pollution.

Geomorphic and hydrologic patterns and processes vary throughout landscapes. Aquatic properties, including water quality, vary temporally and are highly dependent upon spatial location in the channel network. Landscapes are composed of landform elements such as hillslopes, channels, and valleys, and are hierarchically organized systems (Frissell et al., 1986) in which distinct watershed processes operate at certain spatial and temporal scales. Catchments and their associated drainage networks are products of interactions between underlying geologic substrates and exogenic geomorphic processes (i.e., physical, chemical, and biological weathering) that develop over long temporal scales (i.e.,  $10^5$  to  $10^6$  years). Drainage basins can be classified climatically depending on characteristics like mean annual precipitation, mean annual temperature, vegetation, weathering rates, and flow regime, all of which contribute to background levels of transported sediments and nutrients (Wohl, 2000). Subcatchments and their associated stream segments are affected by processes that operate over medium-length time scales (i.e., 1,000 to 10,000 years) and are composed of channel reaches, flood zones, and aquifers (Poole, 2002). This mid-hierarchical level introduces spatiotemporal heterogeneity into water quality due to groundwater inputs and mixing downstream of tributary confluences.

Contaminants introduced to streams from aquifers can be detected and often related to land uses, and their amounts and concentrations depend upon the sizes of the aquifers and stream discharge. Individual valleys and their associated channel reaches are dynamic over short-time scales (i.e., 10 to 100 years). Water quality is strongly affected at this scale. For instance, hillslopes adjacent to channel reaches provide direct sources of water, sediments, and assorted pollutants, and riparian conditions both control the delivery of these materials to streams and influence water temperatures. Land use changes strongly affect this spatial scale, and the consequences of management decisions can be assessed at this level. Reaches are composed

of channel units, the smallest spatial scale discussed here. Channel units are typically synonymous with aquatic habitats, experience change over very short time scales (i.e., 1 to 10 years), and are thus an important scale for many aquatic biologists. Water quality is not typically altered by nonpoint sources at this scale (though it can be severely impacted by point source pollution) and can be an appropriate scale at which to set management goals for fish and wildlife. The hierarchical framework outlined here is intended to provide the reader with a concept of natural systems that reveals the landscape element patterns and watershed processes known to influence nonpoint source pollution and erosion.

The natural flux of pollutants and sediments from pristine landscapes tends to be small in comparison with fluxes from landscapes disturbed by human activities (National Research Council, 2000). This has become more profound in recent years as several major environmental issues have emerged in coastal areas. The combinations of global population growth, dense habitation of America's coastal counties, pollution, habitat loss, coastal hazards, marine and beach debris, oil spills, global climate change, overfishing, loss of biological diversity, and nonindigenous species currently perplex coastal managers (*Coastal Challenges*, 1998). Land use strategies and natural resource management plans have become ever more important in the effort to address these issues. Best management practices (BMPs) adapted to discrete areas are effective restoration and conservation tactics. Examining these issues at the landscape scale can promote the identification of the effects of management decisions.

N-SPECT was developed as a screening level tool, not as an exact engineering tool, to provide spatial analytical support to resource managers seeking to understand the nonpoint source pollution and sedimentation associated with land use changes and management decisions. Analyses are approached from the watershed or subwatershed scale and estimate surface water, pollutant, and sediment fluxes throughout the landscape. While N-SPECT does not explicitly model these materials in coastal waters, the results from its analyses can be used to parameterize nearshore mixing models.

## Getting Started with N-SPECT

---

### Installation

N-SPECT is delivered to the user in an InstallShield application named *setup.exe*. To install N-SPECT, double-click on *setup.exe* and follow the instructions. The InstallShield wizard will then extract the main N-SPECT application as well as the associated data and documentation and save it to the user-specified directory. It is recommended that the user accept the default settings and install N-SPECT on the C:\ drive. To ensure that the installation was complete, navigate to C:\NSPECT and browse the contents of the folder. The following folders and files should be present:

**Table 1. Contents of C:\NSPECT**

Folder	Subfolder	File
bin		FixPath.dll NSPECT.dll vbalFIBr6.dll
help		NSPECT.chm TechnicalGuide.doc UsersManual.doc Tutorial.doc
metadata		
projects		Waianae.xml
waianaedata <sup>1</sup>		Agriculture.shp annual_prec dem_30 Development.shp event_prec_1 event_prec_2 event_prec_3 Golf_Course.shp landcover landcover.lyr rfactor soils.shp soils1 soilsk1
workspace		
wsdelin	waianae <sup>1</sup>	basinpoly.shp dem2b demfill flowacc flowdir lsgrid nibble wshed
		nspect.mdb

<sup>1</sup> Files within these folders are listed as they appear in ArcCatalog™.

## Activating N-SPECT

The installation process automatically registers the N-SPECT application with ArcMap™. To make sure that this process was successful, open a new, empty ArcMap document. N-SPECT should appear as a toolbar somewhere in the window but if it doesn't, it can be activated by clicking *Tools* → *Customize* and placing a check next to N-SPECT. It can also be activated by right-clicking in the open space next to the other toolbars and selecting N-SPECT from the list shown. N-SPECT is now ready for use.

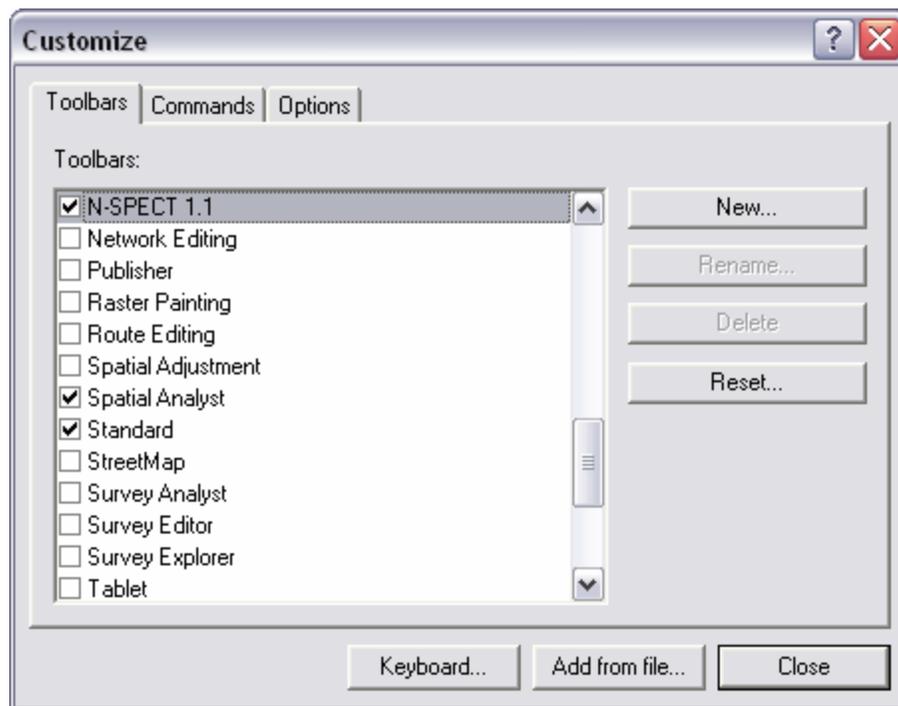


Figure 1. Adding the N-SPECT toolbar to ArcMap

## Tips on Using N-SPECT

- Save N-SPECT projects with names that describe their intent. All output data sets are saved with generic names such as "Accumulated Runoff" or "RUSLE Sediment Mass," but the group data layers that organize unique data sets from independent analyses retain the project name.
- N-SPECT project files retain detailed information such as the input data sets, pollutant coefficients, precipitation scenarios, and output analyses.
- A common error message that appears during analyses states, "ArcMap has reached the maximum number of GRIDS allowed in memory." At this point, exit N-SPECT and save the ArcMap project. Exit ArcMap, start a new ArcMap project, and restart N-SPECT. This error occurs because ArcMap 8.x is programmed to hold a maximum number of rasters (~50) at a time.
- For the purposes of this tutorial, it is recommended that the user start a fresh ArcMap project after each group of exercises. Data sets from previous exercises are saved to the working directory at C:\NSPECT\workspace and can be added by selecting the group data layer that contains the relevant data sets.

# Basic N-SPECT Analyses – Baseline Conditions

---

## Introduction

This section of the tutorial walks the user through a basic run of N-SPECT using the provided data. Advanced options such as the inclusion of customized land use scenarios and alternative management scenarios will not be exercised in this section (see Advanced N-SPECT Analyses). The output data sets from this analysis will instead represent baseline approximations of surface water runoff, erosion caused by surface water runoff, and pollutant mobilization caused by surface water runoff against which past, present, and future land use and land management scenarios can be compared.

The procedure outlined below includes detailed instructions for setting up the model, including which specific input data sets are to be used and which output data sets are desired. Detailed explanations about why certain data sets are needed are not included in this tutorial. Furthermore, the technical background for processing steps (i.e., erosion, pollutant, and runoff calculations) is also absent. To learn more about the design and independent components of N-SPECT, see the user's manual included in the C:\NSPECT\help folder. To learn more about the scientific reasoning and procedures operating behind the scenes in N-SPECT, see the technical guide also included in the help folder.

**Table 2. Basic N-SPECT analysis overview**

<b>Overall Objective:</b> <ul style="list-style-type: none"><li>❖ Run a basic analysis with N-SPECT and produce baseline runoff, erosion, and pollutant load data sets for an annual time scale.</li></ul>
<b>Important Learning Objectives:</b> <ul style="list-style-type: none"><li>• Gain familiarity with the N-SPECT user interface.</li><li>• Learn which data sets are necessary to run the model.</li><li>• Understand the properties associated with the Pollutants tab.</li><li>• Understand the properties associated with the Erosion tab.</li><li>• Understand the function of the “Local Effects Only” option.</li><li>• Learn to visually assess the data output.</li></ul>
<b>Basic N-SPECT Procedure:</b> <ol style="list-style-type: none"><li>1. Start ArcMap.</li><li>2. Start N-SPECT.</li><li>3. Initialize the analysis environment.</li><li>4. Choose the analysis outputs in Pollutants and Erosion tabs.</li><li>5. Run N-SPECT.</li><li>6. View the results.</li></ol>

## Exercise 1 – Baseline Analysis (Accumulated Effects)

This exercise demonstrates a basic analysis with N-SPECT, in which the accumulated effects of runoff, nonpoint source pollution, and erosion are estimated. Each N-SPECT analysis will follow the same basic procedure outlined here. Accumulated effects include the expected pollutant or sediment concentration at a cell, including contributions from upstream cells.

### Start ArcMap™

The first step in running a basic N-SPECT analysis is to add the two data sets to the ArcMap table of contents that are required to run the model for an annual time scale: a raster that contains C-CAP land cover data, and a raster that represents R factor values. If these layers are not present in the table of contents, N-SPECT will not run successfully. (N-SPECT is directed to all other necessary input data sets in the analysis setup window).

1. Open a new ArcMap document.
2. Click on the Add Data button  and navigate to the C:\INSPECT\waianaedata directory.
3. Select *landcover.lyr* and *rfactor* (hold down the control button to select both).
4. Click Add.



The initial data view should appear as it does below.

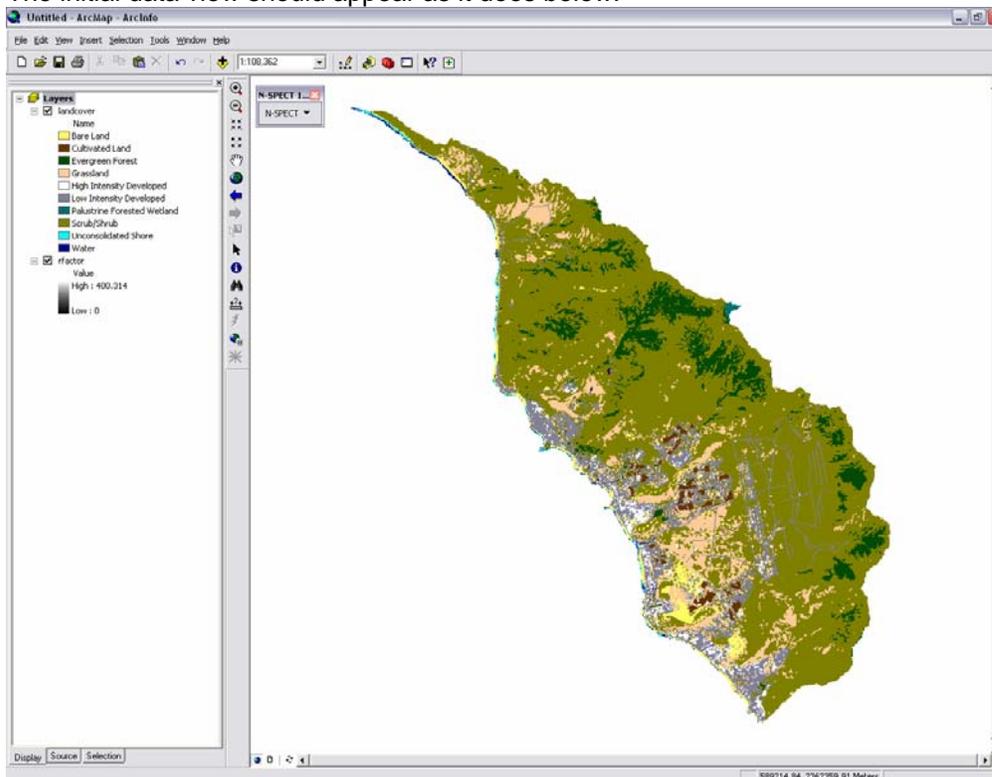


Figure 2. Initial data view with required data layers.

## Start N-SPECT

1. Activate the N-SPECT toolbar if it isn't already present (see [Activating N-SPECT](#)).
2. Select Run Analysis from the N-SPECT dropdown menu.



Figure 3. N-SPECT toolbar

## Initialize the Analysis Environment

An N-SPECT analysis is parameterized in this window. The basic project information is defined and the input data sets are selected in the upper panels of the interface (Figure 4).

1. Name this project Waianae\_Baseline.
2. Set the working directory to C:\NSPECT\workspace. This will be the default working directory for all new projects.
3. In the land cover section, choose the raster named landcover and set the type to CCAP.
4. In the soils section, make sure the soils definition is set to Waianae.
5. In the miscellaneous section, nothing should be checked.
6. In the precipitation scenario, select the scenario named Annual Precipitation.
7. In the watershed delineation section, select the delineation named Waianae.
8. In the water quality standard section, select the standard named Long Term Criteria.

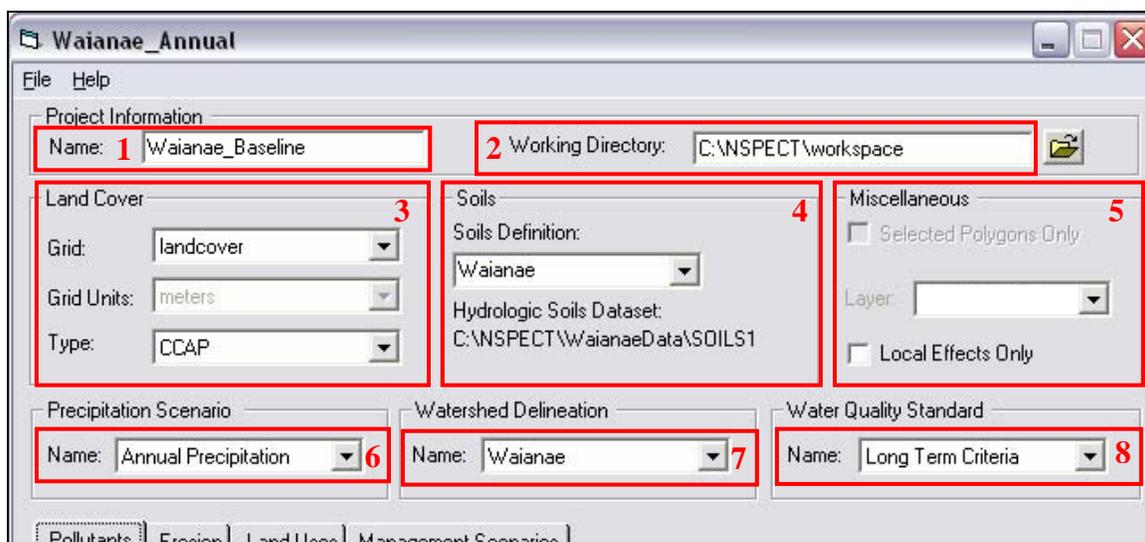


Figure 4. Interface for N-SPECT project parameterization.

## Choose the Analysis Outputs and Run N-SPECT

The desired data outputs are chosen in the lower panels of the N-SPECT interface. In this case, nitrogen is the pollutant of interest and will be revisited in later sections.

1. With the Pollutants tab active, click in the Apply box next to Nitrogen (Figure 5).
2. Click in the empty cell to the right of Nitrogen under Coefficient Set. Click the drop-down arrow and select NitSet. See that Type I appears in the adjacent cell.
3. Click on the Erosion tab.
4. Click on the box in front of Calculate Erosion for Annual Type Precipitation Scenario (Figure 6).
5. Click Use GRID and select rfactor from the drop-down box.
6. Click Run at the bottom of the interface.
7. Click Save to save the new N-SPECT project to the default directory. Once a project is saved it can be reopened later and re-run. However, if any settings are changed before a subsequent run, they will be saved automatically and the original settings will be lost.
8. Sit back and wait for a few minutes while N-SPECT runs.

	Apply	Pollutant Name	Coefficient Set	Which Coefficient
	<input type="checkbox"/>	Phosphorus		
1	<input checked="" type="checkbox"/>	Nitrogen	NitSet 2	Type 1
	<input type="checkbox"/>	Total Suspended Solids		
	<input type="checkbox"/>	Zinc		
	<input type="checkbox"/>	Lead		

3

Run Cancel

Figure 5. Interface for N-SPECT pollutant selection.

4

5

6

Run Cancel

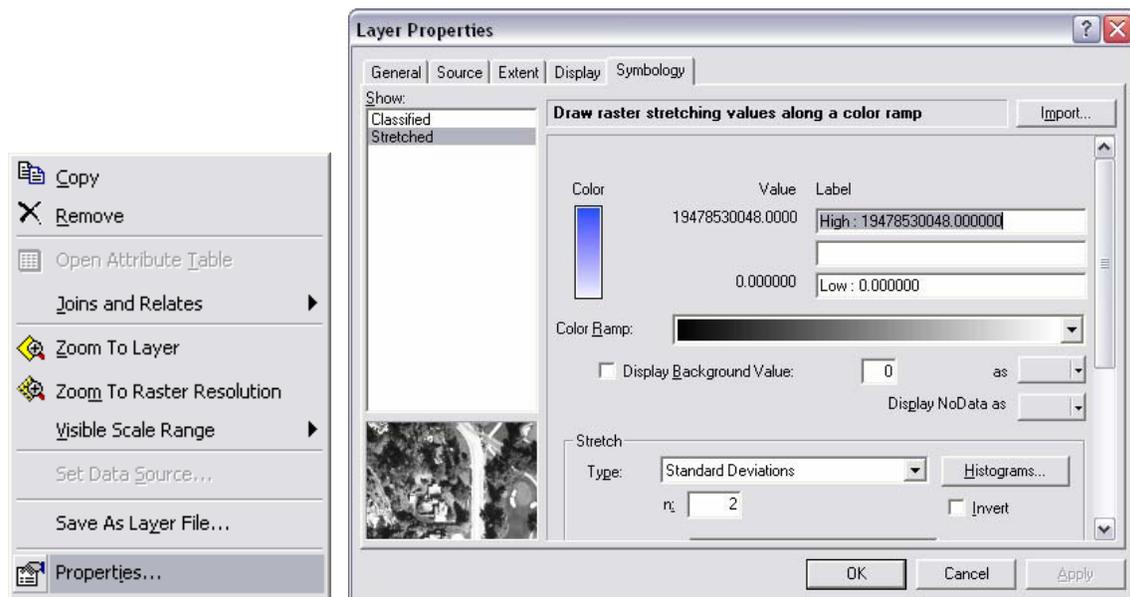
Figure 6. Interface for N-SPECT erosion calculation.

NOTE: The RUSLE equation is used to calculate erosion for annual estimates. RUSLE requires an R factor as an input to estimate erosion. MUSLE, which is used to calculate erosion from a single storm event, does not require an R factor value. Notice how the Erosion tab changes based on the precipitation scenario that is selected (annual or event).

## View the Results

Once N-SPECT finishes processing the data, six new rasters are produced and organized within a group layer named according to the project name, Waianae\_Baseline. Rasters produced by N-SPECT are displayed using predetermined color ramps and a default stretch type of minimum-maximum. The default color ramps are useful for viewing the true range of data values, but tend to reduce the display contrast. The following steps change the appearance of the output data to better enable visualization.

1. Turn on Accumulated Runoff (L) (i.e., make it visible).
2. Right-click on Accumulated Runoff (L) and then click on Properties.
3. Click on the Symbology tab.
4. Select Standard Deviations from the Stretch Type drop-down menu.
5. Click OK.



6. Examine the drainage network patterns across the Wai'anāe landscape, noting the degree of channel sinuosity and channel branching (Figure 7).

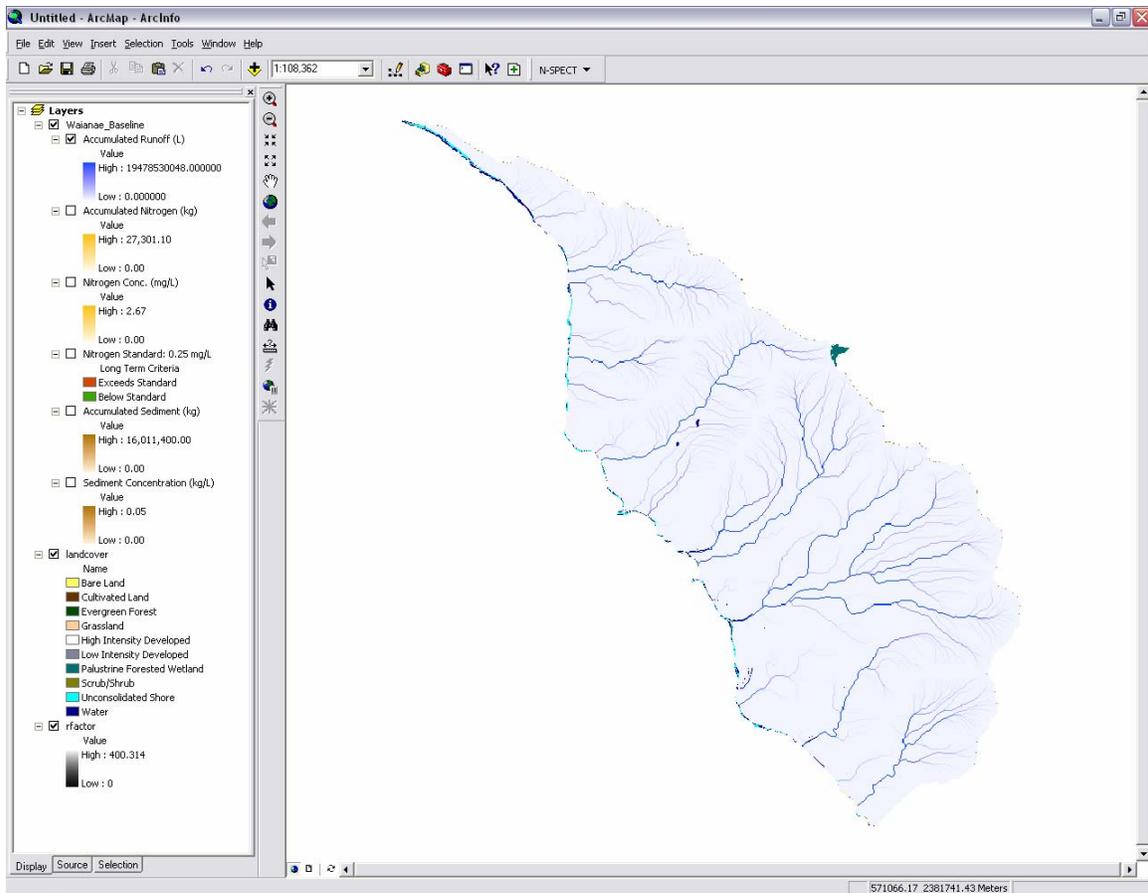


Figure 7. Accumulated Runoff (L) raster revealing drainage patterns.

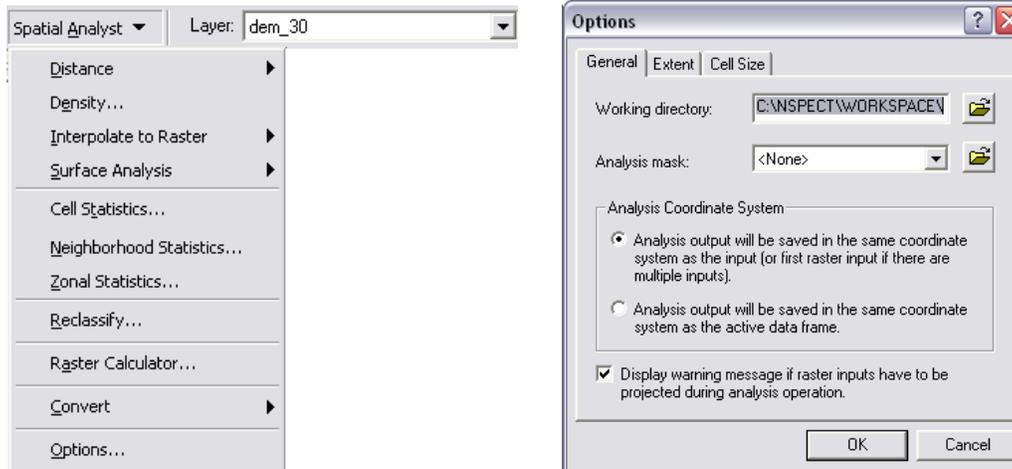
### Did You Know?

Understanding the physical processes associated with certain drainage patterns helps resource managers and land use planners focus their attention on catchments whose nearshore environments are likely to suffer from increased sediment and pollutant loads, and to then target areas that are susceptible to erosion. **Drainage patterns** reflect the ability of landscapes to flush suspended materials through their drainage networks (Dunne and Leopold, 1978). The Wai'anae region is characterized by dendritic drainage networks in various stages of development. The larger catchments exhibit well developed (i.e., extensively branched) networks, while the smaller catchments contain many small tributaries that feed main channels like the pinnae of pinnate leaves. These drainage patterns indicate that streams in the Wai'anae transport sediment and pollutants very quickly (i.e., flashy flow regimes) without much opportunity for instream or floodplain deposition, and that the nearshore environments receive most of the materials that are transported from upstream sources.

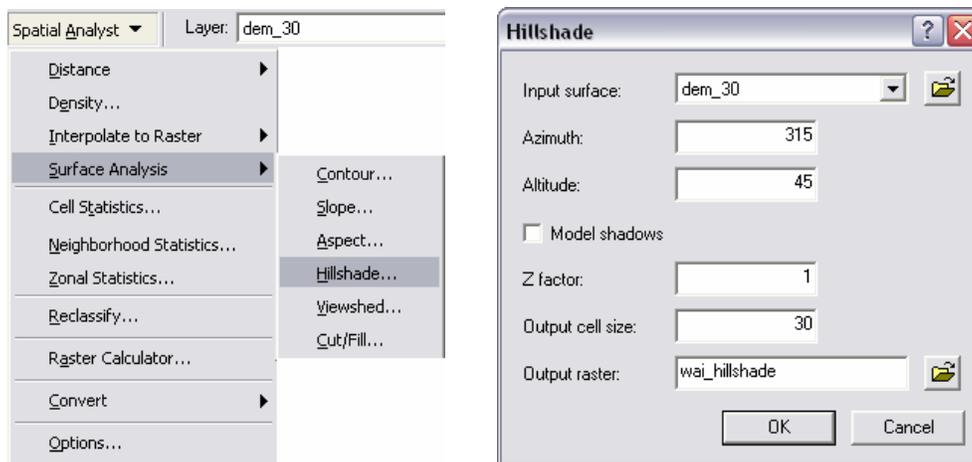
### Enhance the Data Display – Create a Hillshade

Figure 7 displays the accumulated runoff raster produced by N-SPECT. While it is possible to infer the locations of drainage divides, it is difficult to visualize the topography beneath the drainage networks. Creating a sun-illuminated view of the topography and placing it beneath the N-SPECT data helps the user to visualize unique watersheds and better understand the topographic influence on runoff, sediment, and pollutant production patterns across the landscape.

1. Add the Spatial Analyst extension to the toolbar. See Activating N-SPECT for instructions on adding a new toolbar.
2. Click on the Add Data button  and navigate to the C:\NSPECT\waianaedata directory.
3. Select dem\_30.
4. Click Add.
5. Select dem\_30 from the Spatial Analyst Layer drop-down list.
6. Click on the Spatial Analyst drop-down menu and select Options.

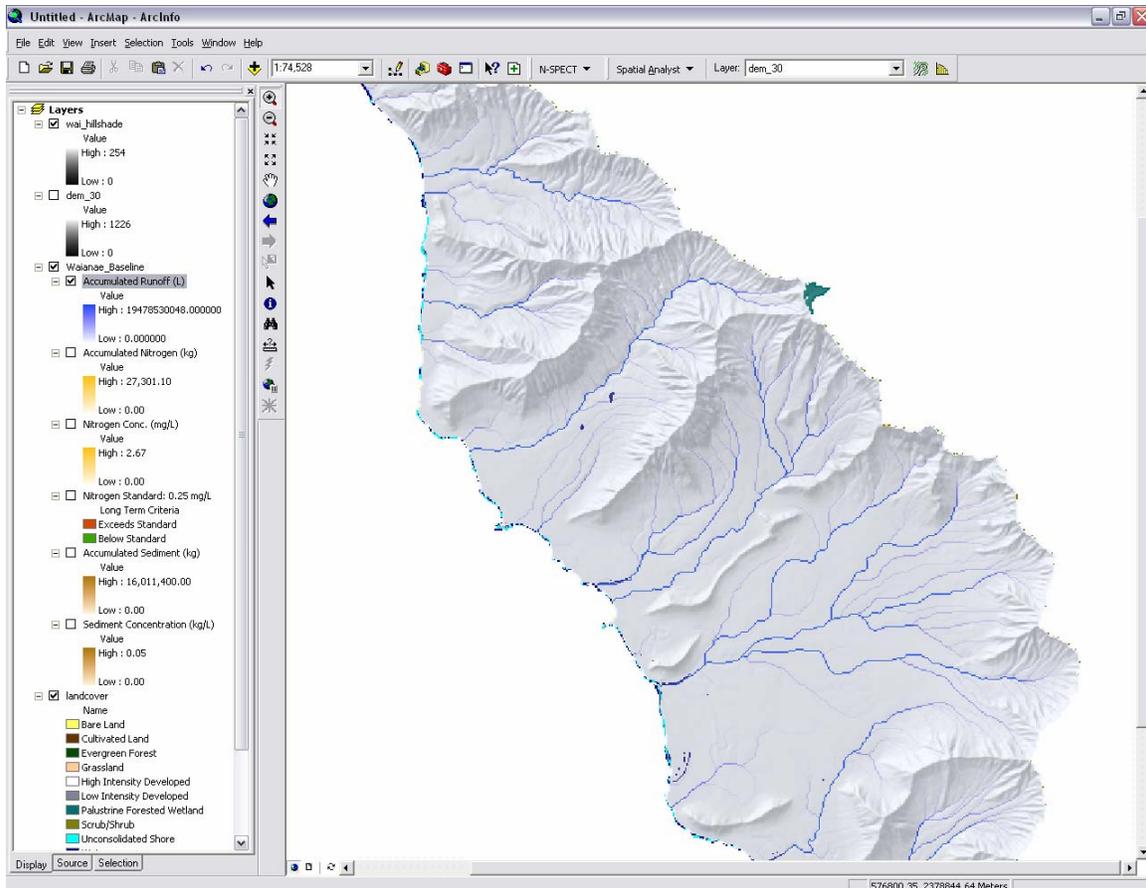


7. Under the General tab, set the working directory to C:\NSPECT\workspace.
8. Click the Extent tab and set the Analysis extent to Same as Layer "dem\_30."
9. Click the Cell Size tab and set the Analysis cell size to Same as Layer "dem\_30."
10. Click OK.
11. Click on the Spatial Analyst drop-down menu, select Surface Analysis, and select Hillshade.
12. Name the Output raster wai\_hillshade and accept all other defaults.



13. Click OK. The new sun-illuminated data layer will be added to the table of contents.
14. Click on the name wai\_hillshade in the table of contents and make sure it is at the top of the list. **NOTE: as new rasters are added to the table of contents during the exercises, wai\_hillshade will have to be moved back to the top of the list to be visible.**
15. Turn off the dem\_30 layer, if it is visible.
16. Right-click on wai\_hillshade and click Properties.

17. Click the Display tab and set the transparency value to 70%. Click OK.
18. Zoom in slightly and re-examine the drainage network patterns, noting the drainage divides and areas with high drainage densities (Figure 8).



**Figure 8. Accumulated Runoff (L) draped over sun-illuminated topography.**

### Did You Know?

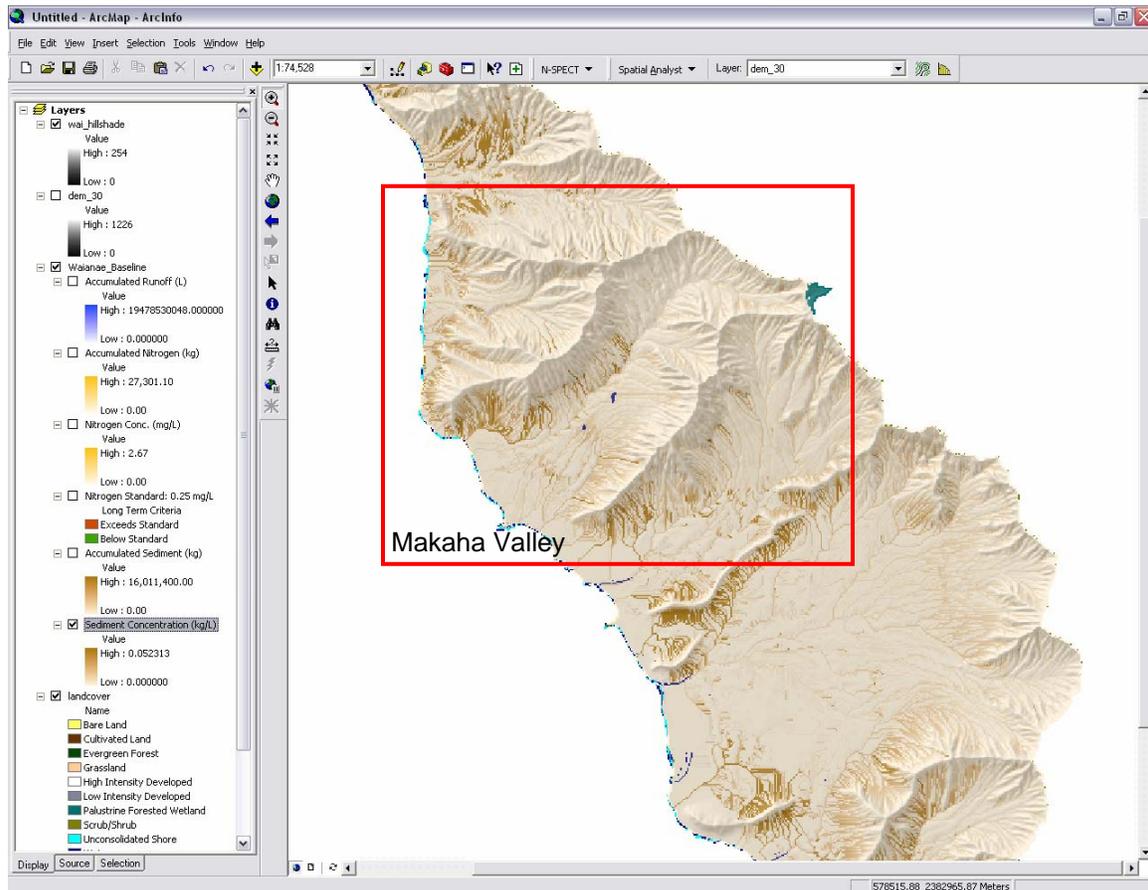
**Drainage density** (the sum of all channel lengths in a catchment divided by the catchment area) represents the degree to which the terrain is dissected. Geomorphic and hydrologic conditions such as the effectiveness of surface runoff and erosion are strongly related to drainage density. Also, the time of concentration of flow in a channel network is related to drainage density (Wohl, 2000). On average, areas with high drainage density have high flood peaks, high sediment production, steep hillslopes, difficulty of access, low suitability for agriculture, and high development costs (Dunne and Leopold, 1978). Drainage densities in the Wai'anae region tend to vary according to basin size and age, and therefore runoff and sediment transport processes are spatially heterogenous.

### Spatial Patterns and Landscape Associations of Sediment and Pollutants

Figure 8 illustrates the influence of topography on rainfall-runoff patterns in the Wai'anae region. Through the GIS functions of flow direction and flow accumulation, sediments and pollutants are transported through landscapes. This section examines these outputs and introduces the task of relating their spatial patterns with landscape conditions.

1. Turn off Accumulated Runoff (L).

2. Turn on Sediment Concentration (kg/L).
3. Right-click on Sediment Concentration (kg/L) and then click on Properties.
4. Click on the Symbology tab.
5. Change the Stretch Type to Standard Deviations. Make sure that n is set to 2.
6. Click OK and evaluate the display.
7. Perform steps 2 through 6 with Nitrogen Conc. (mg/L).



**Figure 9. Sediment Concentration (kg/L) highlighting sediment source areas.**

The darker pixels highlight the areas that contribute much of the overall annual sediment yield in the Wai'anae region (Figure 9). It appears that many of the areas that produce high amounts of sediment are associated with steep slopes. However, the spatial patterns of sediment production are clearly a result of more than topography alone.

8. Using the  tool, zoom into the red area marked in Figure 9. This is Makaha Valley.
9. Alternately view the Sediment Concentration (kg/L) raster and the land cover raster. The display settings may have to be readjusted for optimal clarity.
10. Note the spatial correlations between certain land cover classes and areas (i.e., pixels) from which high sediment concentrations originate (Figures 10 and 11).

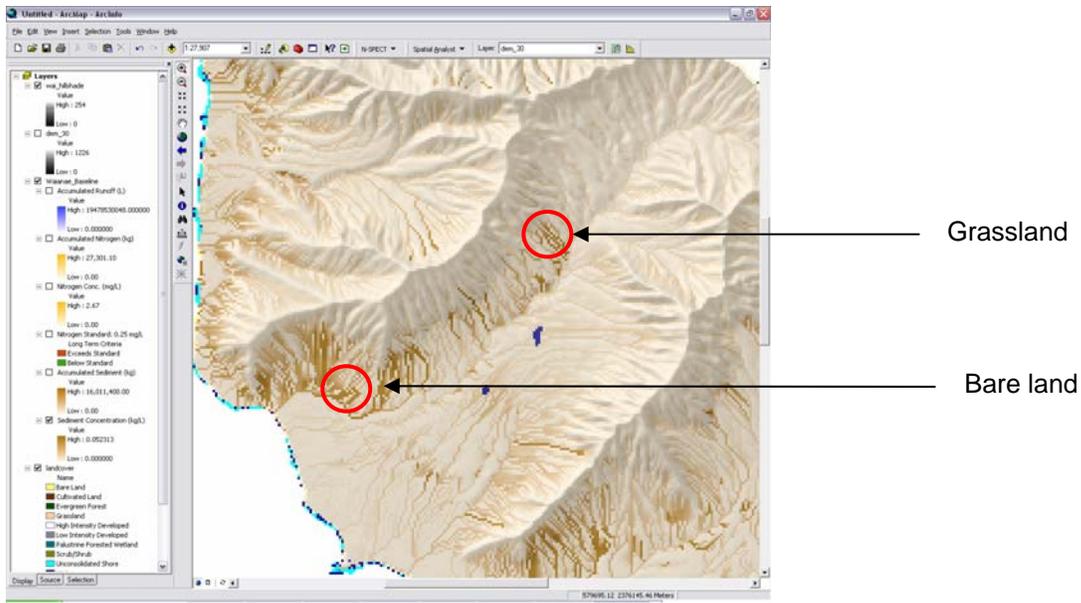


Figure 10. Sediment Concentration (kg/L), Makaha Valley.

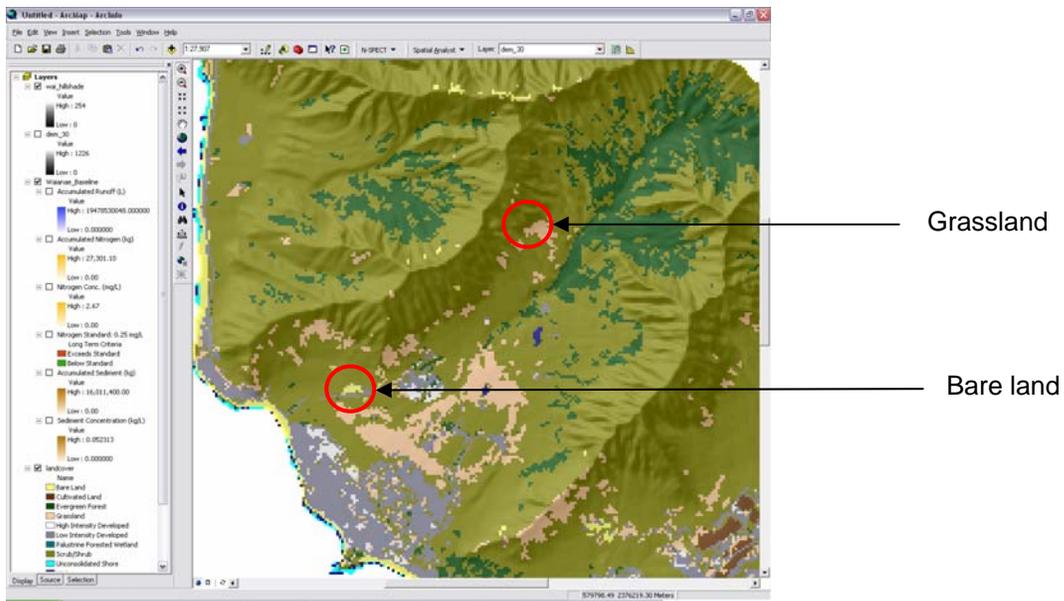
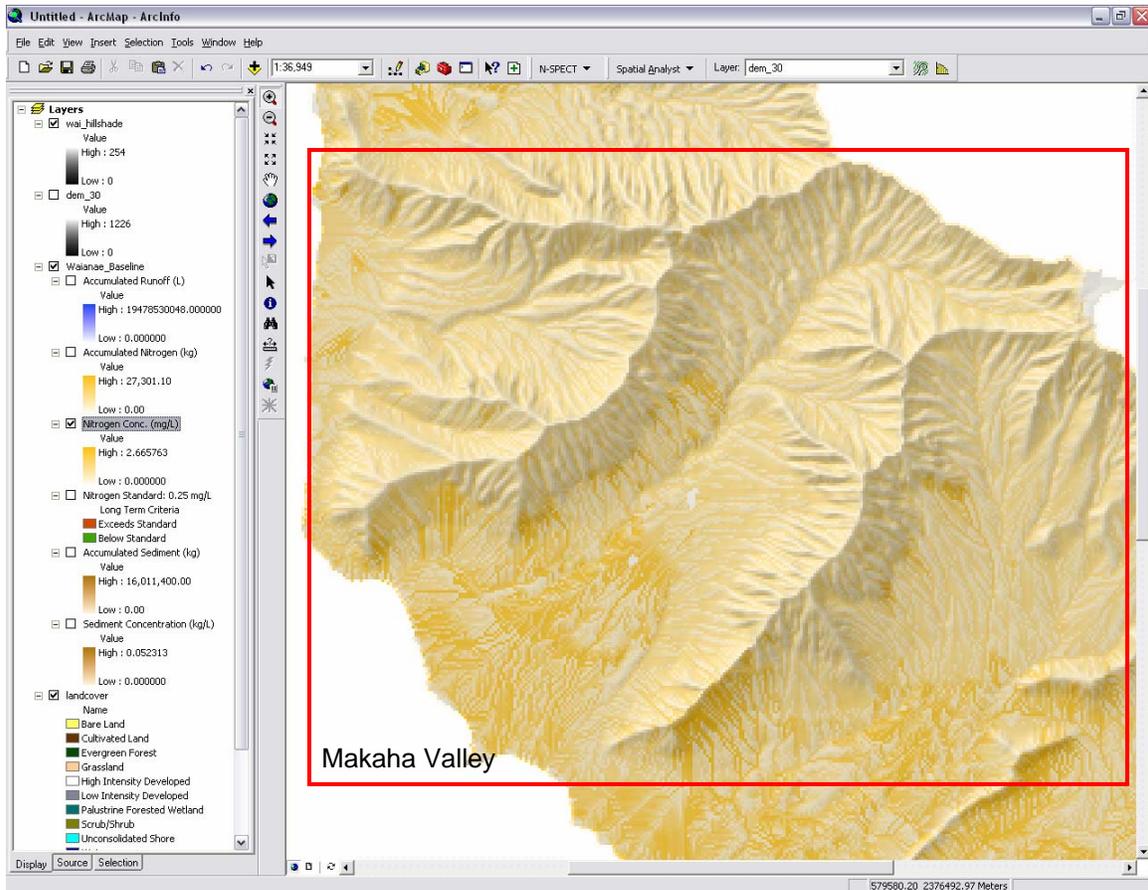


Figure 11. C-CAP land cover, Makaha Valley.

Comparing the C-CAP land cover data with the N-SPECT-produced Sediment Concentration (kg/L) raster reveals the associations between areas with high sediment yields and areas classified in the land cover data as grassland, bare land, cultivated land, and low-intensity developed land. It is also evident that the amount of sediment produced by any one land cover class varies based upon other factors that are not clear in this comparison. These subtle differences relate primarily to rainfall depth and soil erodibility.



**Figure 12. Nitrogen Conc. (mg/L) highlighting high concentrations of nitrogen.**

Figure 12 highlights the areas contributing to the overall annual nitrogen yield in the Wai'anae region. The spatial patterns differ considerably from the patterns observed in the sediment raster, and topography seems to be less of an influence than before.

11. Zoom back to the Makaha Valley area again.
12. Alternately view the Nitrogen Conc. (mg/L) raster and the land cover raster. Again, the display settings (i.e. stretch type) may have to be readjusted for optimal clarity.
13. Compare the spatial correlations between land cover classes and areas with high nitrogen concentrations (Figures 13 and 14).
14. Save the ArcMap project as *Exercise1.mxd* in C:\INSPECT.

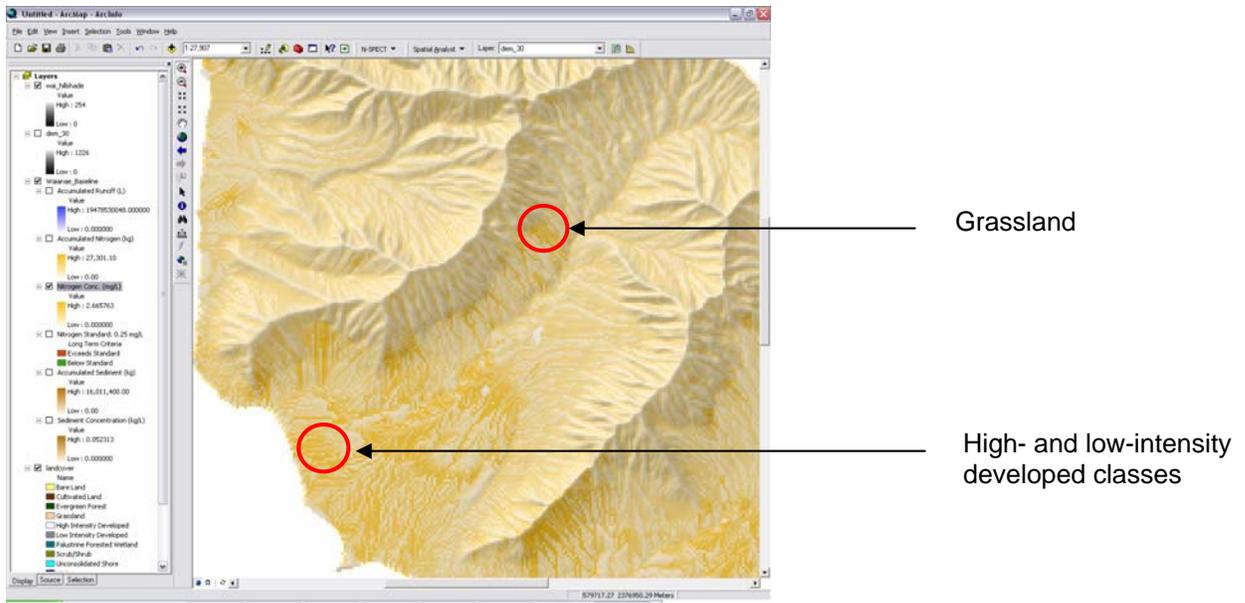


Figure 13. Nitrogen Conc. (mg/L), Makaha Valley.

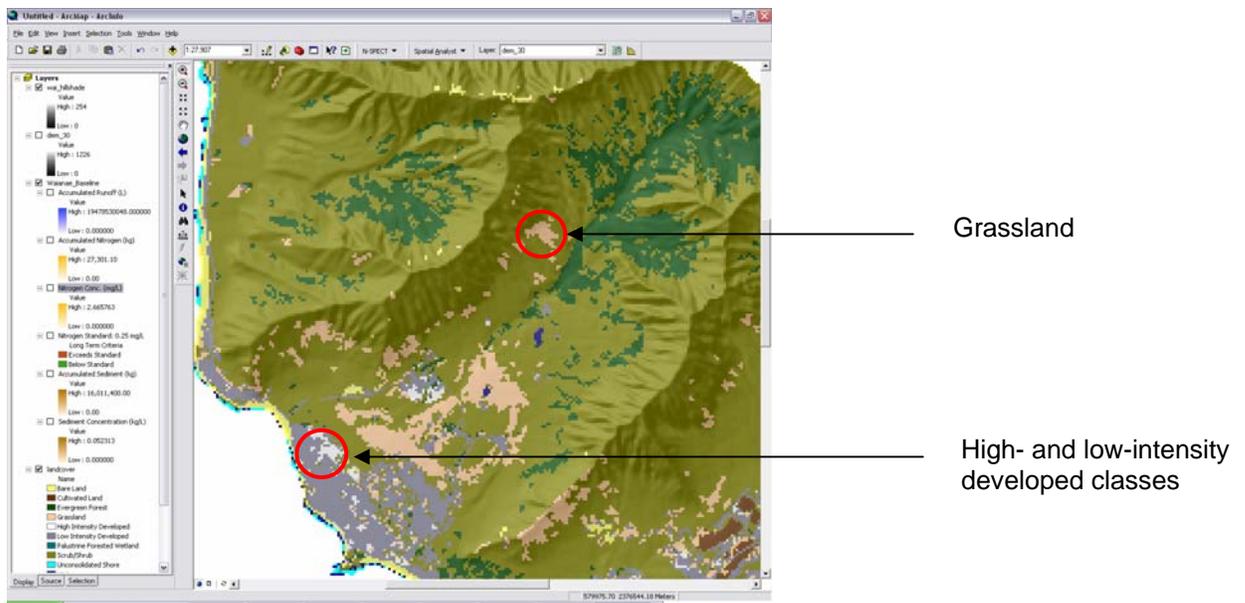


Figure 14. C-CAP land cover, Makaha Valley.

The comparison between the C-CAP land cover data and the N-SPECT-produced Nitrogen Conc. (mg/L) raster reveals the strong nitrogen contribution from grasslands. It is interesting to note that the high values circled in Figure 13 are not propagated down the main stem of the drainage network, whereas the high values observed in the open valley floor are conveyed along flow paths toward the coast. This difference is due to the dilution effect from the accumulated runoff generated further up-valley that is carried down the main stem. Also, note that the nitrogen contribution from the developed classes is difficult to separate from the upstream contributions of other land cover classes. This will be revisited in Exercise 2.

## Did You Know?

Sediment loads and pollutant concentrations are strongly correlated with land uses in upstream contributing areas. Ground water, point sources, and nonpoint sources all contribute to total loads. Storm events dramatically increase nonpoint source contributions by transporting pollutants in solid organic form and adsorbed on soil particles. On Oahu, agricultural and urban areas are the dominant sources of nonpoint source pollution, and nitrogen and phosphorus concentrations frequently exceed state stream-water standards in these areas (Anthony et al., 2004). Coastal waters are very sensitive to high concentrations of sediment and pollutants and, therefore, nonpoint source pollution is an important management issue in Hawaii.

## Exercise 2 – Baseline Analysis with Local Effects

This exercise follows essentially the same procedures as Exercise 1 but enables the Local Effects option in order to produce outputs that represent the results of processes occurring in each individual pixel.

### Restart ArcMap and Initialize N-SPECT

1. Exit the *Exercise 1.mxd* ArcMap project. Start a new, empty ArcMap project. This will clear the grids out of the memory allowing more N-SPECT analyses to run.
2. Click the N-SPECT drop-down menu and select Run Analysis.
3. In the N-SPECT interface, click File on the menu bar and select Open Project.
4. The default directory should be C:\NSPECT\projects. Select *Waianae\_Baseline.xml* and click Open. **Note that Landcover.lyr and rfactor are both added automatically this time.**
5. Change the name in the Project Information section to *Waianae\_Baseline\_LE*.
6. In the Miscellaneous section, click the check box next to Local Effects Only.
7. Click Run.

The screenshot shows the N-SPECT software interface for the 'Waianae\_Baseline\_LE' project. The window title is 'Waianae\_Baseline\_LE'. The interface includes a menu bar (File, Help) and several configuration sections:

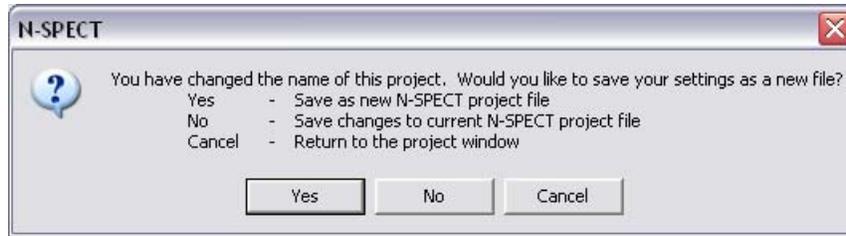
- Project Information:** Name: Waianae\_Baseline\_LE, Working Directory: C:\NSPECT\workspace
- Land Cover:** Grid: landcover, Grid Units: meters, Type: CCAP
- Soils:** Soils Definition: Waianae, Hydrologic Soils Data Set: C:\NSPECT\WaianaeData\SOILS1
- Miscellaneous:** Selected Polygons Only (unchecked), Layer: Waianae Drainage, Local Effects Only (checked)
- Precipitation Scenario:** Name: Annual Precipitation
- Watershed Delineation:** Name: Waianae
- Water Quality Standard:** Name: Long Term Criteria

At the bottom, there is a table for selecting pollutants:

Apply	Pollutant Name	Coefficient Set	Which Coefficient
<input type="checkbox"/>	Phosphorus		
<input checked="" type="checkbox"/>	Nitrogen	NiSet	Type 1
<input type="checkbox"/>	Total Suspended Solids		
<input type="checkbox"/>	Zinc		
<input type="checkbox"/>	Lead		

Buttons for 'Run' and 'Cancel' are located at the bottom right of the window.

8. A window will appear that notifies the user that the project name has changed. Click Yes and save the new N-SPECT project file as *Waianae\_Baseline\_LE*.

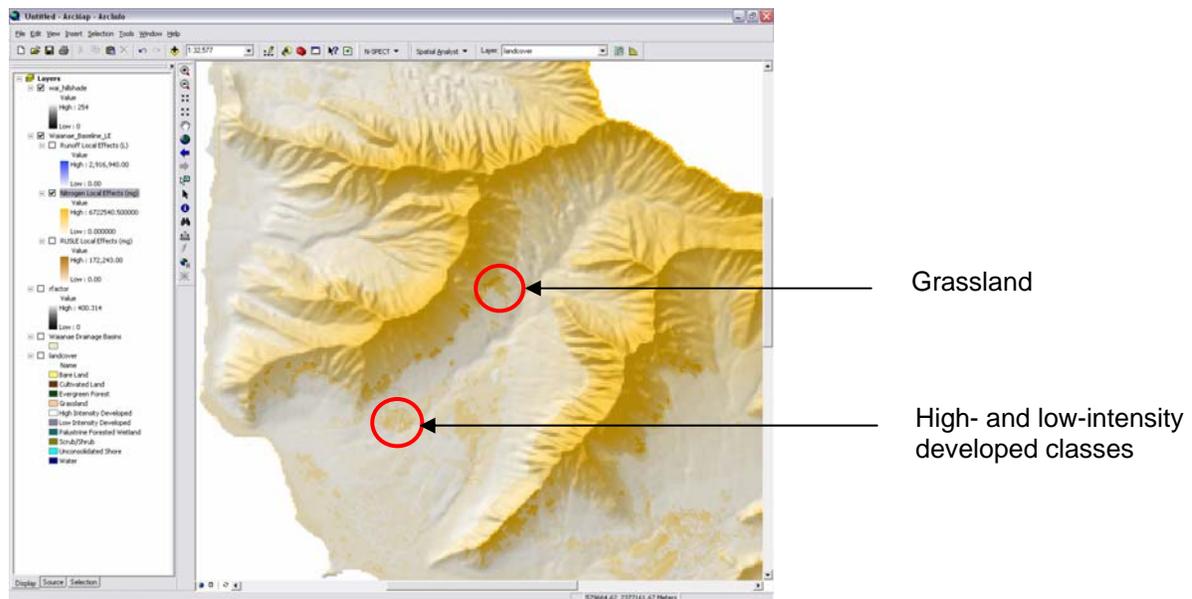


9. Click Save.
10. Sit back and wait while N-SPECT runs.

## View the Results

Once N-SPECT finishes processing the data, three new rasters are produced and organized within a group layer named *Waianae\_Baseline\_LE*. A shapefile named *Waianae Drainage Basins* was added to the table of contents and is visible in the data view (this happens every time an N-SPECT project is opened). The three new raster layers represent the volume of surface runoff, the amount of nitrogen, and the amount of sediment that are produced within each pixel.

1. Click on the Add Data button  and navigate to the *C:\NSPECT\workspace* folder.
2. Add *wai\_hillshade* and change the display transparency to 70% (see Ex. 1, #16-17).
3. Turn off all data layers except *wai\_hillshade*.
4. Turn on *Nitrogen Local Effects (mg)*.
5. Change the symbology stretch type property of *Nitrogen Local Effects (mg)* to standard deviations.
6. Again, compare the areas producing high amounts of nitrogen to the land cover.



**Figure 15. Nitrogen Local Effects (mg) showing nitrogen source areas.**

7. Save the ArcMap project as *Exercise2.mxd*, but do not exit.

In Figure 15, note the very large, oddly shaped area of high nitrogen areas along the ridges. This pattern reveals higher nitrogen concentrations due to the decreased infiltration capacity in the soils that cover the ridge tops. Also, the higher elevations tend to show higher nitrogen values because of the exacerbating effect of higher precipitation values at these elevations. Note that the contribution of nitrogen from the developed classes is also more readily apparent.

## **Conclusion**

These two exercises outlined simple N-SPECT analyses that calculated runoff, sediment loads, and nitrogen concentrations generated by overland flow on an annual time scale. Both accumulated and non-accumulated (local) outputs were generated. Several options were omitted for the sake of simplicity, and the user is encouraged to explore these at a later time. Among these options are analyses with additional pollutants and event-based precipitation selected.

The data sets used to run these simple analyses were not modified in this exercise, and thus the outputs represent baseline conditions associated with the time periods captured by the input data sets. The data produced in these simple analyses were reviewed by visual assessment and a few patterns were noted. Topography was associated with the shape and density of drainage networks. Land cover types were associated with various degrees of sediment and pollutant loads. The interaction between runoff volume and pollutant concentration was also illustrated.

The next two exercises will continue to familiarize the user with the features in N-SPECT and will demonstrate the functionality contained in the land use and land management tabs. Customized land use curve numbers and pollutant coefficients can be incorporated into an analysis to more accurately represent local conditions, and alternative management scenarios can be designed and analyzed to detect changes in nonpoint source pollution and erosion contributed by those areas.

## Advanced N-SPECT Analysis – Management Scenario

### Introduction

This section expands upon the previous section by using the land management scenario feature in order to illustrate the flexibility and decision support functionality offered by N-SPECT. N-SPECT has the capability to incorporate a polygon shapefile, representing a management area that differs from the extant land cover data, into an analysis in order to study its impacts on nonpoint source pollution and erosion. The user will define an area that will change from its existing land cover state to a different, single C-CAP land cover class in order to study the effects of an alternative land use. For this function to work most effectively, the resultant land use type must be predefined and fully parameterized with pollutant coefficients, a curve number, and a cover factor.

The spatial focus of this exercise narrows from the entire Wai'anae region to Makaha Valley. Of all the areas within the Wai'anae region, the Department of Planning and Permitting attributed this watershed with a "Special Area Plan" status to devote more attention to planning and guiding development (City and County of Honolulu, 2000). One of the reasons for this designation was that several hundred acres of land were undeveloped but zoned for residential and resort uses. The valley was also recognized as an important resource area in terms of water resources, rare and endangered plants and animals, and cultural sites.

In this exercise, N-SPECT will help the user predict changes to runoff, erosion, and nonpoint source pollution caused by a proposed land use change by superimposing a hypothetical low-intensity development upon the existing land cover data. The outline below describes the general process the user will follow.

#### Overall Objective:

- ❖ Run an analysis that incorporates a hypothetical management scenario and examines the potential changes to runoff, erosion, and pollution.

#### Important Learning Objectives:

- Understand the properties associated with the Management Scenarios tab.
- Learn to incorporate a management scenario.
- Learn to quantitatively evaluate the data output.
- Understand the relative contributions of different land cover classes to nonpoint source pollution.

#### Advanced N-SPECT Procedure:

1. Add a management scenario (polygon shapefile) to ArcMap.
2. Start N-SPECT and open an existing project.
3. Select the management scenario and set the new land use class.
4. Run N-SPECT and examine the results.

### Exercise 3 – Analysis with a Management Scenario (Local Effects)

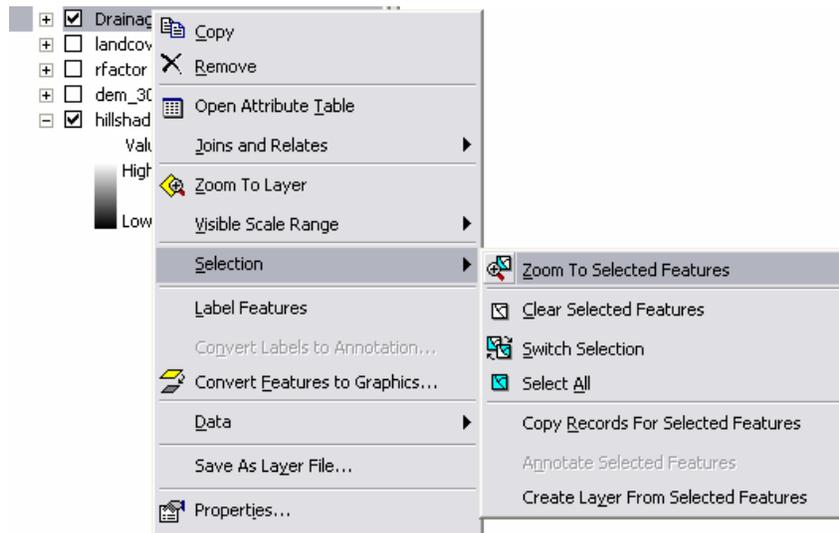
This exercise incorporates a hypothetical management scenario in the analysis of nonpoint source pollution and erosion and seeks to illustrate the local effects of such a land cover change. Exercise 4 will analyze the downstream effects of this change. This exercise also illustrates the use of the Selected Polygons Only feature by constraining the N-SPECT analysis to the largest portion of Makaha Valley.

## Select an Area of Interest

1. Open Exercise2.mxd if it was closed. Turn off all data layers except wai\_hillshade and Waianae Drainage Basins.
2. Using the Select Features tool , click on the polygon that covers the full length of Makaha Valley (see Figure 16 for the correct polygon).

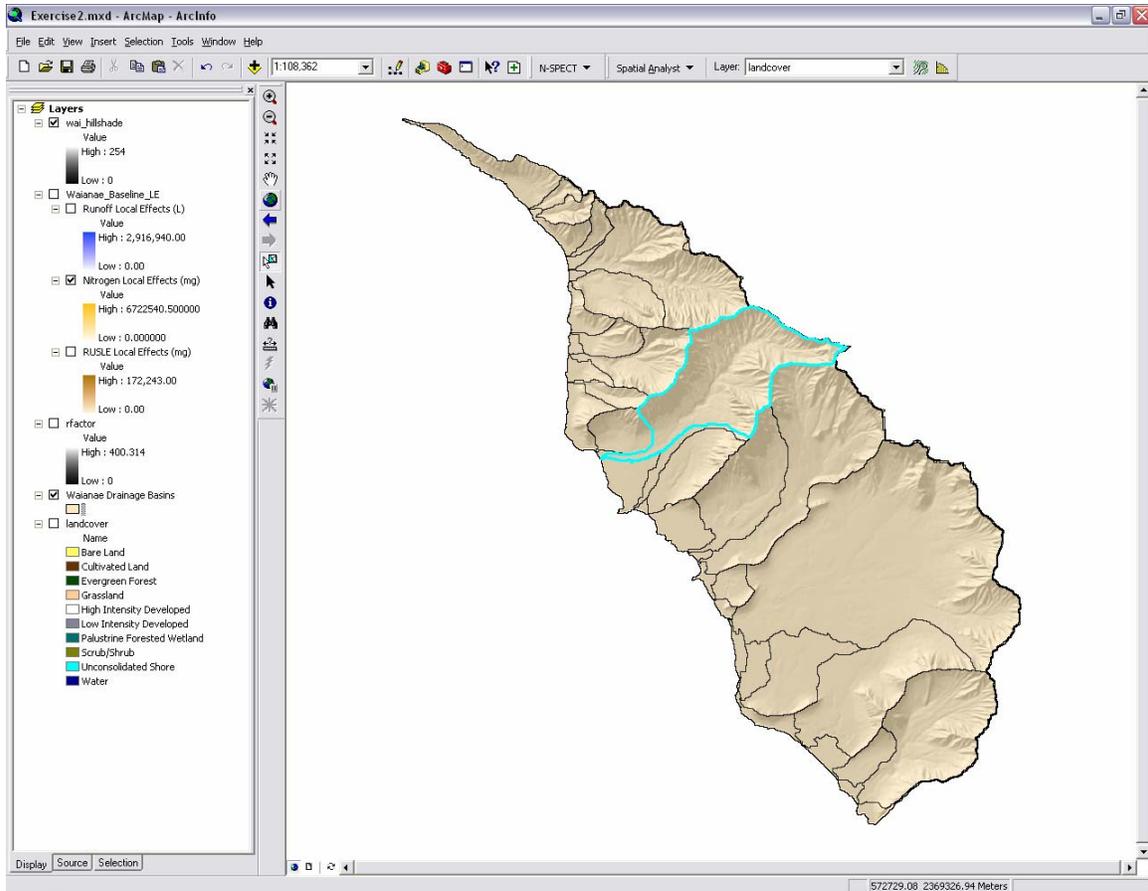
While Makaha Valley officially includes the few polygons located just to the south of the selected polygon, this exercise will concentrate on the largest hydrologically delineated portion of the valley in order to simplify the analysis and to focus attention on a single outlet from which upstream land use changes can be detected.

3. Right-click on Waianae Drainage Basins in the table of contents, highlight Selection, and click on Zoom to Selected Features.



## Add a Management Data Layer to ArcMap

1. Click on the Add Data button  and navigate to the C:\NSPECT\waianaedata folder.
2. Select *Development.shp* and click Add. This shapefile contains a polygon that represents a medium-sized, hypothetical, low-intensity residential development.
3. Note the location of the new management scenario polygon. It should fall inside Makaha Valley, the selected Waianae Drainage Basin polygon.



**Figure 16. Wai'anae Drainage Basins visible, with a large part of Makaha Valley selected.**

### Start N-SPECT and Open a Project

1. Click the N-SPECT drop-down menu and select Run Analysis.
2. In the N-SPECT interface, click File on the menu bar and select Open Project.
3. The default directory should be C:\NSPECT\projects. Select *Wai'anae\_Baseline\_LE.xml* and click Open. If Wai'anae Drainage Basins is added again, remove this duplicate so that the only copy in the table of contents is the one with Makaha Valley selected.
4. Switch back to the N-SPECT analysis window. Change the name in the Project Information section to *Wai'anae\_Management\_LE*.
5. In the Miscellaneous section, click the check box next to Selected Polygons and select Wai'anae Drainage Basins from the Layer drop-down menu.
6. Under the erosion tab, turn off Calculate Erosion for Annual Type Precipitation.

### Add a Management Scenario

1. Click on the Management Scenarios tab.
2. Click in the open cell beneath the "Change area layer" column.
3. Click the drop-down arrow and select Development, the shapefile added previously.
4. Click in the open cell beneath the "Change to class" column and select Low Intensity Developed.
5. Click the open check box beneath Apply to include the management scenario in the analysis.

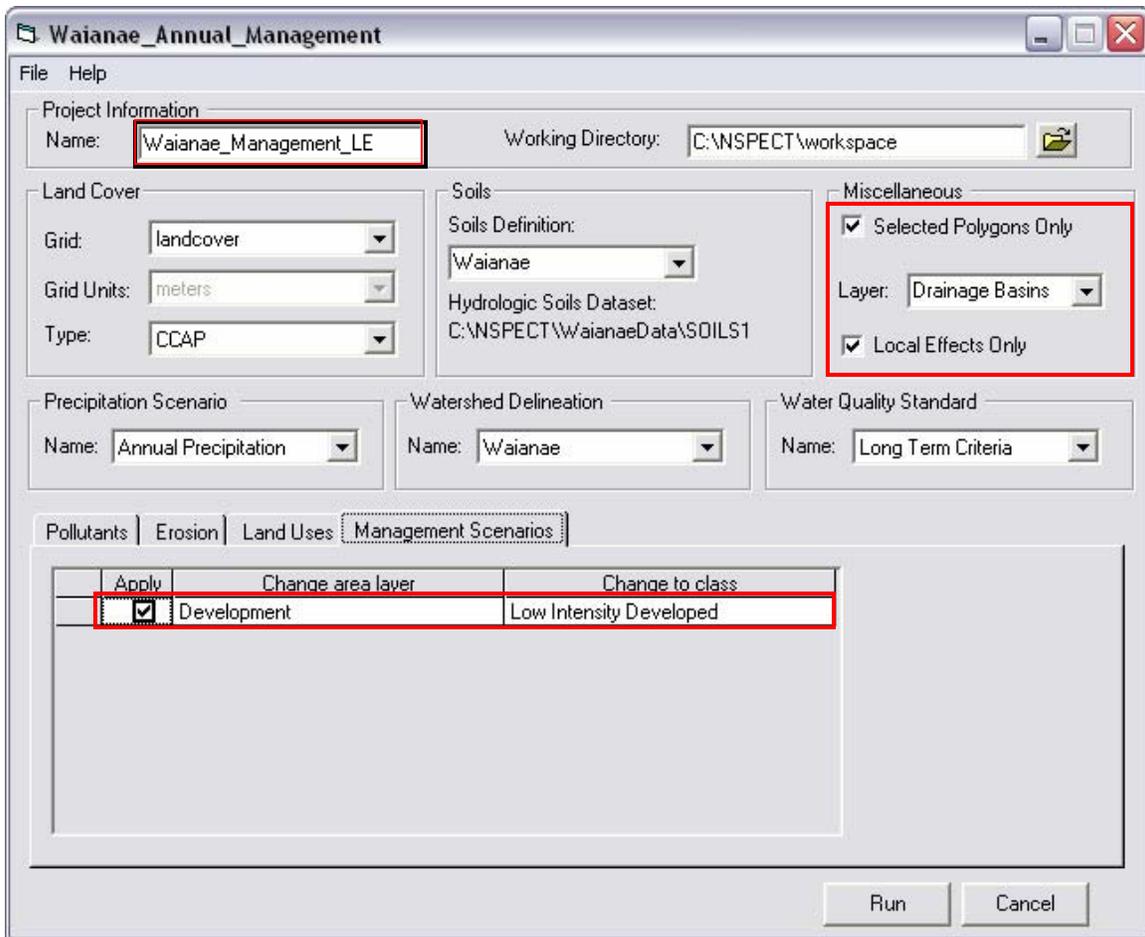


Figure 17. Interface for N-SPECT Management Scenarios.

## Run N-SPECT

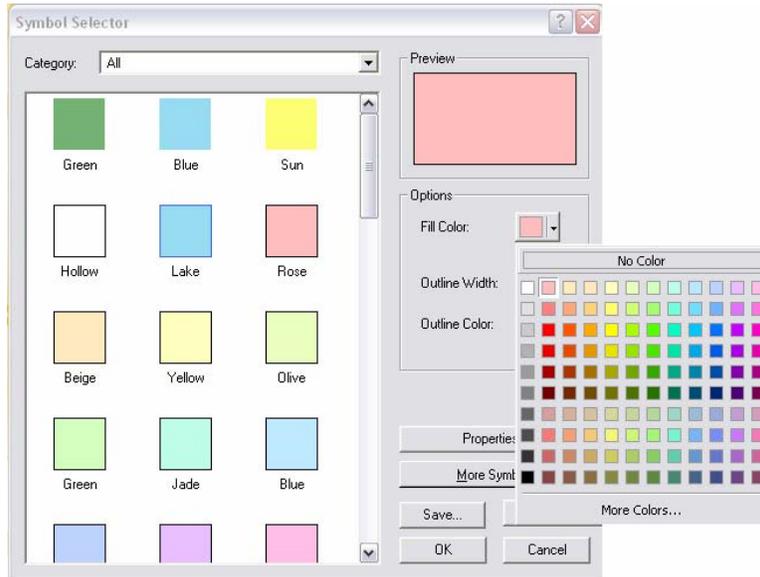
1. Click Run
2. Click Yes and click Save to save this new N-SPECT project as Waianae\_Management\_LE.
3. Sit back and wait while N-SPECT runs.

## View the Results

The data output should include three rasters (Runoff Local Effects (L), Nitrogen Local Effects (mg), and RUSLE Local Effects (mg)) arranged within a group data layer called Waianae\_Management\_LE. The spatial extent of these data sets should cover the selected portion of Makaha Valley and no more, thus representing the products of annual rainfall-runoff processes for nonpoint source pollution and erosion. The next several steps will walk the user through the process of making it easier to visualize the changes that occurred as a result of incorporating a management scenario.

1. Click and drag wai\_hillshade and the Development data layer to the top of the table of contents. Zoom to southwest half of Makaha Valley.
2. Turn off all data layers except Waianae Drainage Basins and Development.
3. In the table of contents, click in the shaded box that symbolizes the data layer named Development.
  - Development
  -
4. Click on Fill Color and select No Color.

- Click OK. The management scenario should now appear as an outline on the map.



- Change the Stretch Types for the three new rasters to standard deviations.
- Turn on the Nitrogen Local Effects (mg) raster in the Waianae\_Baseline\_LE group.
- While watching the Development area on the map, turn on the new Nitrogen Local Effects (mg) raster (in the Waianae\_Management\_LE group) and try to detect differences in the values contained therein. Toggle this top layer on and off several times while comparing the two data layers. Other slight differences may be noticed outside of the Development polygon. These differences are due to the different ranges of symbolized values contained in the two rasters.
- Repeat steps 7 and 8 for Runoff Local Effects (L) and RUSLE Local Effects (mg).

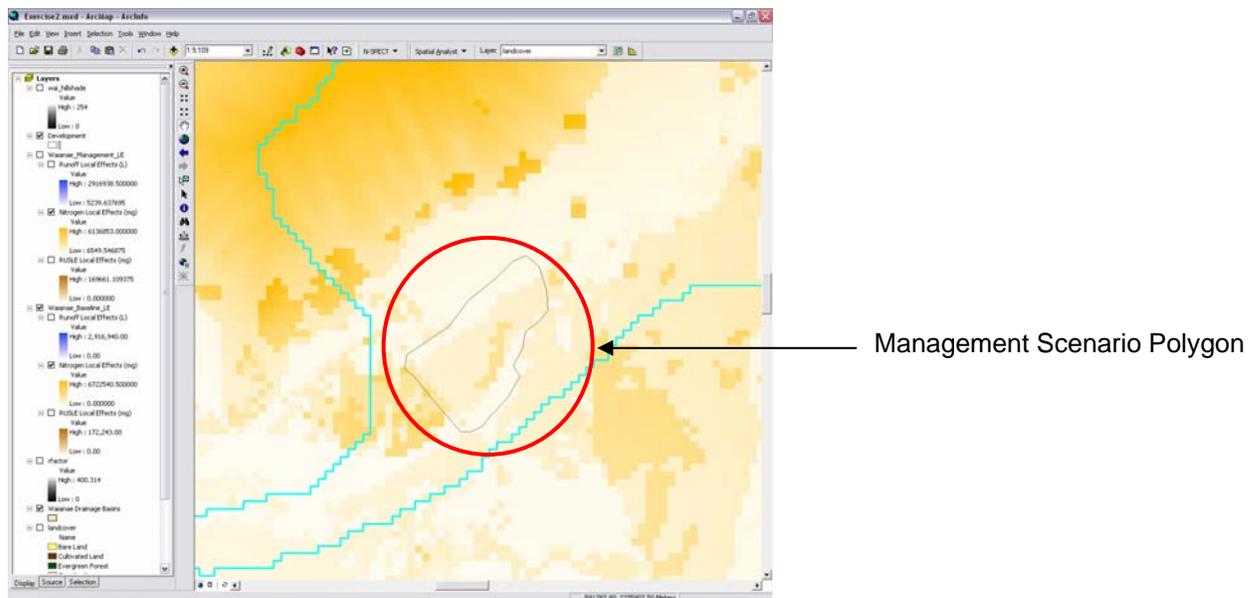
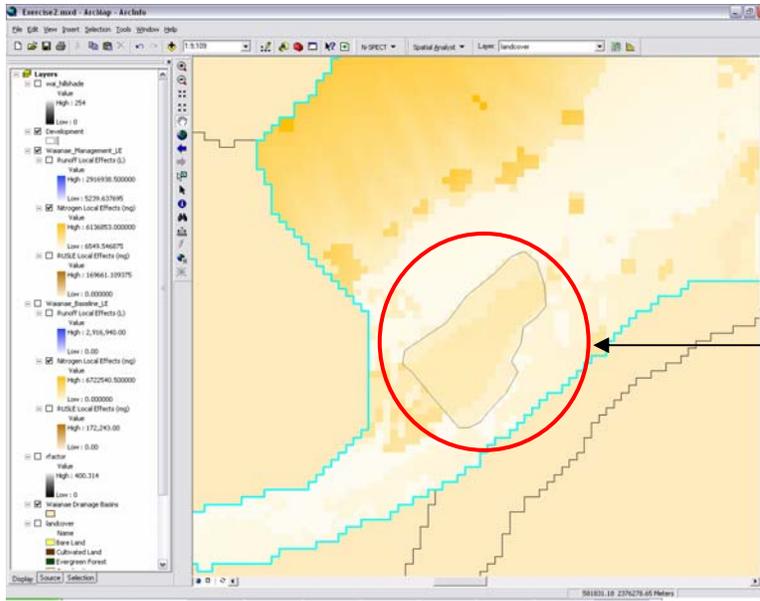


Figure 18. Nitrogen output prior to applying the management scenario (baseline levels).



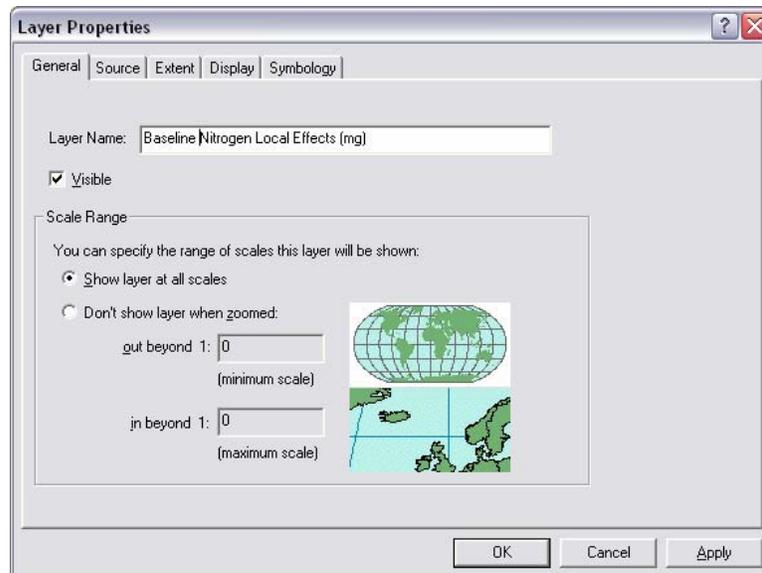
Management Scenario Polygon

**Figure 19. Nitrogen outputs with the low-intensity developed management scenario applied. Note the higher values within the Development polygon.**

### Compare the Pollutant Yields at the Local Scale (Nitrogen)

The following steps utilize GIS functionality contained in the Spatial Analyst™ extension. A simple raster calculation is performed in order to quantify the changes viewed above. The output raster represents the net difference in nitrogen mobilization caused by the inclusion of the hypothetical land management scenario.

1. First, modify the name of the baseline Nitrogen Local Effects (mg) raster (contained in the Waianae\_Baseline\_LE group) by right-clicking on the name in the table of contents, selecting Properties, and clicking on the General tab. Change the name to Baseline Nitrogen Local Effects (mg). Click OK.

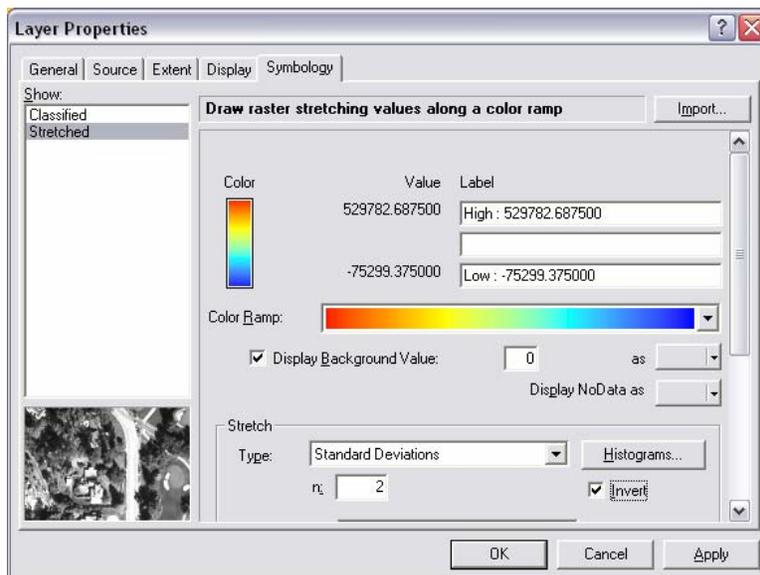


2. Change the name of the Nitrogen Local Effects (mg) raster contained in the Waianae\_Management\_LE group to Management Nitrogen Local Effects (mg).

- Click the Spatial Analyst drop-down menu and select Raster Calculator.



- Enter the following expression in the blank text box:  
**Nit\_Man\_Local = [Management Nitrogen Local Effects (mg)] - [Baseline Nitrogen Local Effects (mg)]**  
 Pay special attention to the punctuation and spaces or the function will fail.
- Click Evaluate.
- A new raster named Nit\_Man\_Local should appear in the table of contents. Change the symbology of this raster from Classified to Stretched (Symbology tab in Layer Properties). Choose the spectrum color ramp to represent the data.
- Place a check mark next to Display Background Value. This makes all the pixels that did not change invisible. Place a check mark next to Invert to associate red with high values.
- Click OK.



The Nit\_Man\_Local raster now appears to occupy only the area within the Development polygon. The values range from approximately -74,299 mg (shown in blue) to approximately 529,782 mg (shown in red). Since the baseline nitrogen data was subtracted from the modified nitrogen data, the high values in Nit\_Man\_Local represent increases in nitrogen output, while the low values represent decreases in nitrogen output due to the changes in land cover.

9. Note the location of the decreases in nitrogen output.
10. Zoom in to the area covered by the Development shapefile.
11. Turn off all layers except Nit\_Man\_Local, Landcover, and wai\_hillshade.
12. Turn off Nit\_Man\_Local and note the land cover classes that were changed to low-intensity developed by the management scenario.

It is interesting to note that the decreases in nitrogen output are spatially correlated with pixels that are classified as grassland in the C-CAP land cover data, while the increases are correlated with the C-CAP scrub/shrub land cover class. This effect results from the pollutant coefficients that are associated with these land cover classes, and reveals the relative contributions of these three different land cover classes to pollutant loads.

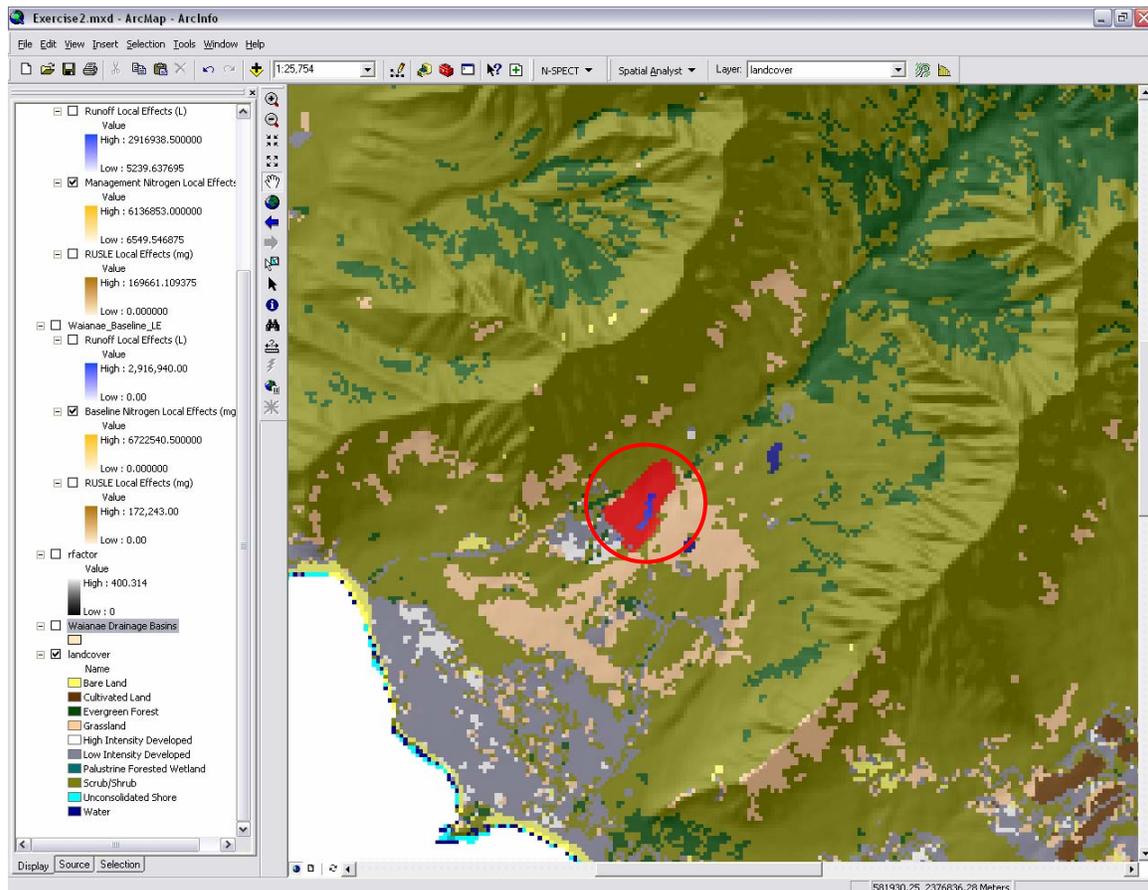


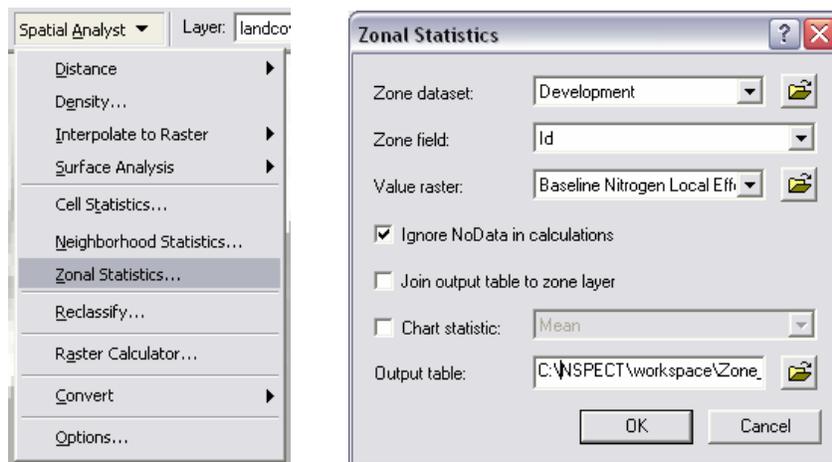
Figure 20. Local changes in nitrogen output resulting from a management scenario.

13. Save the ArcMap project as *Exercise3.mxd*.

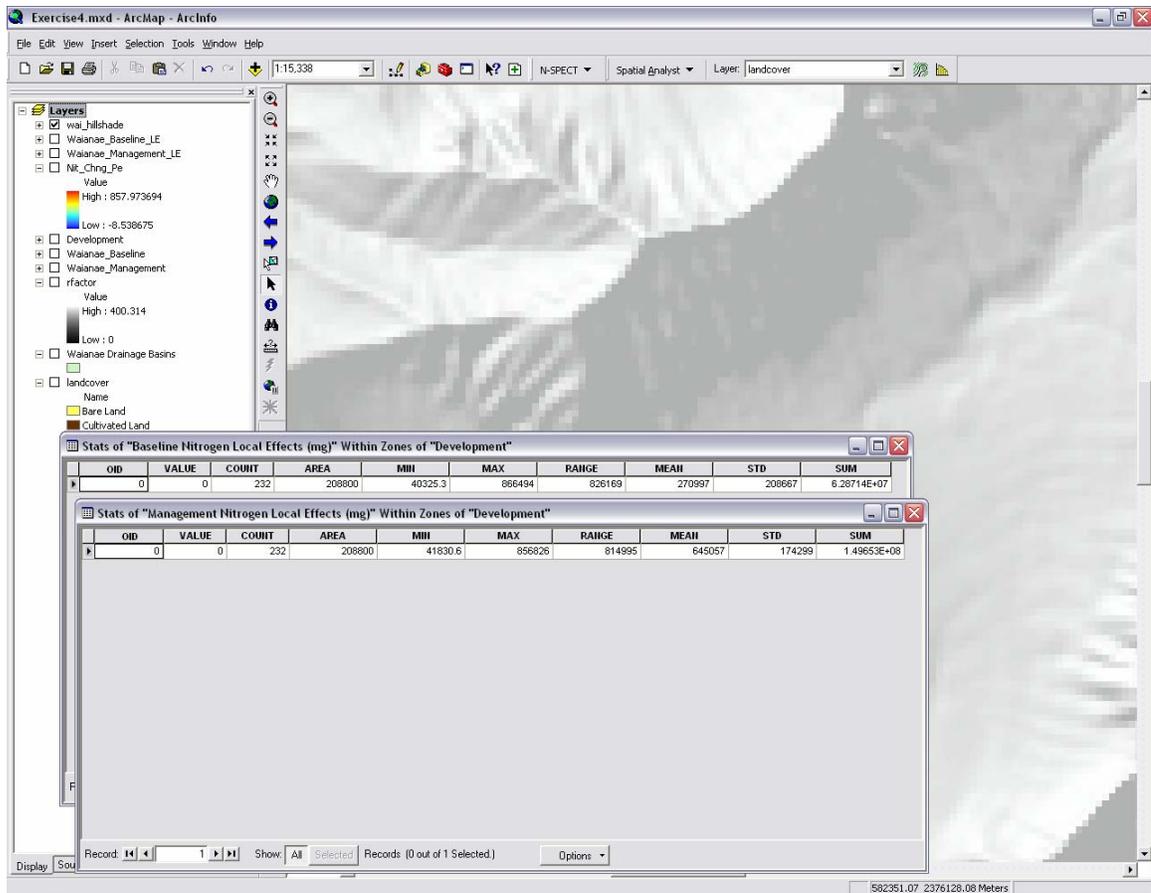
## Calculate the Percent Change in Pollutant Yields (Nitrogen)

The relative increase in nonpoint source pollution loads caused by the change in land cover from scrub/shrub and grassland classes to low-intensity developed is not readily apparent using regular visualization techniques. A more quantitative approach is used to expose the changes caused by the land use change.

1. Add the Waianae\_Baseline\_LE data layer (C:\NSPECT\workspace) and change the name of Nitrogen Local Effects (mg) to Baseline Nitrogen Local Effects (mg).
2. Add the Waianae\_Management\_LE data layer (C:\NSPECT\workspace) and change the name of Nitrogen Local Effects (mg) to Management Nitrogen Local Effects (mg).
3. Click the Spatial Analyst drop-down menu and select Zonal Statistics.
4. Designate the Development polygon as the zone data set.
5. The zone field can be Id.
6. Designate Baseline Nitrogen Local Effects (mg) as the value raster.
7. Place a check in the first box to ignore NoData in calculations.
8. Leave the second check box empty.
9. Clear the check from the third box so as not to produce a chart.
10. Save the output table in C:\NSPECT\workspace\ and name it Zone\_Baseline\_Nit.dbf.
11. Click OK.



12. Repeat steps 3-11 above, but designate Management Nitrogen Local Effects (mg) as the value raster and save the output table as Zone\_Management\_Nit.dbf.
13. Several different statistics were calculated for the raster values that fell within the Development polygon, including the sum of the pixel values.
14. Use a manual calculator to determine the percent change from baseline to management nitrogen yields using the following expression and values from the stats tables:



**Figure 21. Zonal statistics tables produced for baseline and management nitrogen yields within the area covered by the development polygon.**

$$\text{Percent Change} = 100 * (\text{Management SUM} - \text{Baseline SUM}) / \text{Baseline SUM}$$

The percent change should be approximately 138%, which indicates that, based on the assumptions we've made, the total nitrogen yield from the study area would more than double if a low intensity development were to be built.

**NOTE:** It is important that the user remember that the numerical results are only estimates and that there is quite a bit of error associated with these values. Therefore, exact numerical change estimates should not be relied upon as fact. The signs and magnitudes of these values should be treated as general indicators of the direction and degree to which such management decisions impact nonpoint source pollution and erosion.

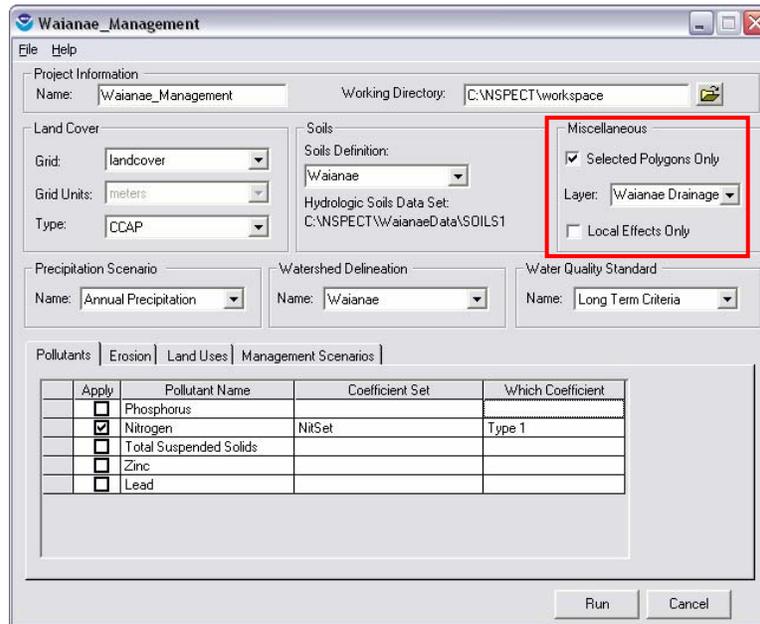
### Exercise 4 – Analysis with a Management Scenario (Accumulated Effects)

This exercise follows essentially the same procedures as Exercise 3 but disables the Local Effects option in order to produce outputs that represent the downstream accumulation of processes occurring in each individual pixel.

#### Initialize ArcMap and Re-Initialize N-SPECT

1. Start a new, empty ArcMap project.
2. Click the N-SPECT drop-down menu and select Run Analysis.
3. In the N-SPECT interface, click File on the menu bar and select Open Project.
4. The default directory should be C:\NSPECT\projects. Select *Waianae\_Management\_LE.xml* and click Open.

- Turn off all layers except Waianae Drainage Basins. Use the select tool to select the Makaha Valley polygon again (See Exercise 3: Select an Area of Interest).
- Change the name in the Project Information section to Waianae\_Management.
- In the Miscellaneous section, disable the Local Effects Only option. Make sure that Waianae Drainage Basins is displayed in the drop down menu for Selected Polygons Only.
- Click Run.



- Save the new N-SPECT project as Waianae\_Management.
- Sit back and wait while N-SPECT runs.

## View the Results

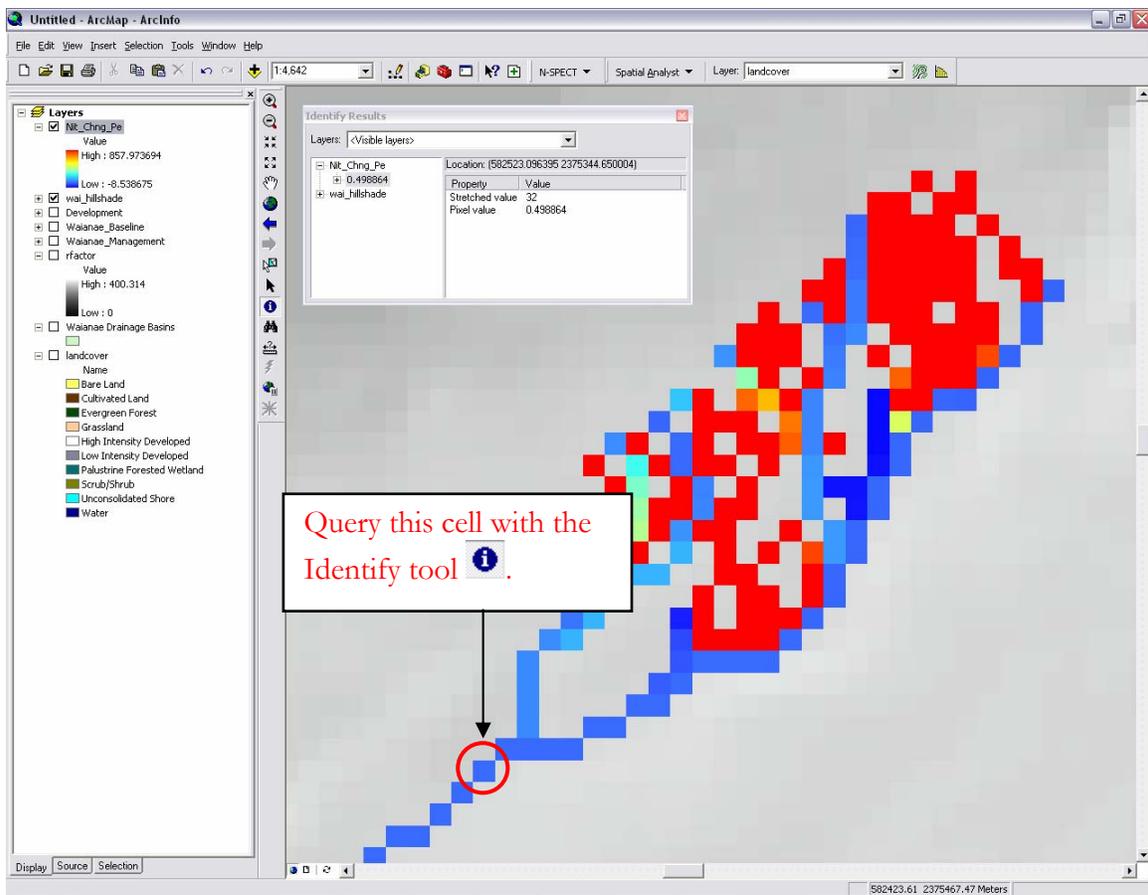
Once N-SPECT finishes processing the data, six new rasters are produced and organized within a group layer named Waianae\_Management.

- Add wai\_hillshade to the table of contents and adjust its transparency to 70%.
- Turn off all data layers except wai\_hillshade and Development.
- Change the symbology of Development so that it is hollow, as in Exercise 3.
- Change the name of Accumulated Nitrogen (kg) to Management Accumulated Nitrogen (kg). Change the stretch type to standard deviations.
- Add the data layer group created in exercise 1, entitled Waianae\_Baseline (located in C:\NSPECT\workspace).
- Change the name of Accumulated Nitrogen (kg) in the baseline group to Baseline Accumulated Nitrogen (kg). Change the stretch type to standard deviations.
- Turn on Management Accumulated Nitrogen (kg).
- Drag wai\_hillshade and the Development layer to the top of the table of contents. Zoom to the Makaha Valley area so that the development polygon is shown in detail.
- Contrast Management Accumulated Nitrogen (kg) with Baseline Accumulated Nitrogen (kg) by viewing them one at a time. Notice how similar they appear.

## Compare the Accumulated Results at the Watershed Scale (Nitrogen)

The relative increase in nonpoint source pollution loads caused by the change in land cover from scrub/shrub and grassland classes to low-intensity developed is not readily apparent using regular visualization techniques. A quantitative approach is used to calculate the percent change in nitrogen yield at the watershed scale.

1. Activate the Spatial Analyst toolbar if it is not visible in the ArcGIS interface.
2. Click the Spatial Analyst drop-down menu and select Raster Calculator. Calculate the change in accumulated nitrogen using the following expression:  
**Nit\_Chng = [Management Accumulated Nitrogen (kg)] - [Baseline Accumulated Nitrogen (kg)]**
3. Click the Spatial Analyst drop-down menu and select Raster Calculator. Calculate the percent change in accumulated nitrogen using the following expression:  
**Nit\_Chng\_Per = con([Baseline Accumulated Nitrogen (kg)] <> 0, (100 \* ([Nit\_Chng] / [Baseline Accumulated Nitrogen (kg)]))**
4. The new raster, Nit\_Chng\_Per, appears in the table of contents. Change the symbology of this raster from Classified to Stretched (Symbology tab in Layer Properties). Choose the spectrum color ramp to represent the data.
5. Place a check mark next to Display Background Value. This makes all the pixels that did not change invisible. Place a check mark next to Invert to associate red with high values.
6. Click OK.
7. Turn off all layers except Nit\_Chng\_Per and wai\_hillshade.
8. Zoom to the area downstream of the hypothetical development.
9. Use the Identify tool  to query the value of the pixel downstream of the confluence of the two contributing streams draining the development.
10. Save the ArcMap project as *Exercise4.mxd* and exit ArcMap.



**Figure 22. Identification of the percent change in nitrogen load caused by a land use change.**

## **Conclusion**

In this exercise, the development scenario is likely to increase the total amount of nitrogen exported from the watershed by approximately 0.5 percent. Although 0.5% seems small, keep in mind the change is produced by changing land cover in only 0.2 km<sup>2</sup> of a total watershed covering 14.1 km<sup>2</sup>. The difference in nitrogen yield from the development area is 86.7 kg, which translates to a 138% increase in nitrogen exported from the development.

Exercises 3 and 4 introduced the management scenario feature of N-SPECT and taught the user how to apply a hypothetical land use change to existing land cover conditions. The hypothetical scenario incorporated in these exercises is realistic in the Makaha Valley given the current development boom on Oahu. Using scenarios such as this one allows managers to better understand the consequences of land use changes and their effects on nonpoint source pollution and erosion.

The management scenario feature is particularly useful in instances where the resultant land cover class is known and already has pollutant coefficients stored within N-SPECT (i.e., it is one of the land cover classes listed in the land cover type table (LCClass) in the N-SPECT geodatabase). If the resultant land cover class is not in the table, or pollutant coefficients associated with a certain land cover class are not stored in the geodatabase, then the user must utilize the advanced functionality of the land use tab within the N-SPECT interface.

## Advanced N-SPECT Analysis – Alternative Land Use

---

### Introduction

This section expands upon the previous section by incorporating an alternative land use scenario in order to further illustrate the flexibility and decision support functionality offered by N-SPECT. The user will create a new land use scenario with customized pollutant coefficients in order to study the effects of changes to land cover and land use.

The C-CAP land cover data packaged with N-SPECT were produced in 2001. Since then, the standard classification scheme originally used by NOAA Coastal Services Center to develop the C-CAP data was merged with the USGS National Land Cover Database (NLCD) scheme to promote consistent land cover products throughout the country. The end result of this partnership was a new classification scheme, called the Coastal NLCD, that added some new land cover classes to the original C-CAP scheme and in essence refined the original grassland and developed categories.

The geodatabase to which N-SPECT refers during analyses contains 10 of the original C-CAP land cover classes as the default land cover classification scheme. Also contained within the geodatabase is a table that links each class to specific values for USDA-defined curve numbers and cover factors (descriptions of these factors can be found in the [Technical Guide](#)). The original C-CAP grassland class included both managed and natural herbaceous cover, thus lumping together areas such as meadows, pastures, and golf courses. The new Coastal NLCD scheme breaks apart these three examples into grassland/herbaceous, pasture/hay, and developed/open space classes respectively.

The current version of N-SPECT with the original C-CAP data does not distinguish between the three classes mentioned above, yet each class clearly impacts nonpoint source pollution and erosion differently. This exercise uses the land use tab to allow the user to add a new land use scenario complete with new coefficients that more accurately reflect the underlying conditions of the selected layer. In this case, a shapefile will be added to the project that covers the area of two existing golf courses in Makaha Valley, and new coefficients will be defined for this type of land use.

#### Overall Objective:

- ❖ Run an analysis with a customized land use scenario and produce modified runoff, erosion, and pollutant load data sets for an annual time scale.

#### Important Learning Objectives:

- Understand the properties associated with the Land Use tab.
- Learn to parameterize a new land use scenario.
- Learn to quantitatively evaluate the data output.

#### Advanced N-SPECT Procedure:

1. Start N-SPECT and open an existing project.
2. Add a new land use scenario and define the new coefficients.
3. Run N-SPECT and examine the results.

### Exercise 5 – Analysis with a New Land Use Scenario (Accumulated Effects)

This exercise incorporates a land use scenario in the analysis of nonpoint source pollution and erosion and seeks to illustrate the accumulated effects of spatially delineating an area with unique land cover characteristics. In this case, the Makaha Valley Country Club and the Makaha Resort Golf Club were hand-digitized from a 2.8 meter resolution Quickbird multispectral image of the Waianae region.

## Add a Land Use Data Layer to ArcMap

1. Open a new ArcMap project.
2. Click the Add Data button  and navigate to the C:\NSPECT\workspace folder.
3. Select wai\_hillshade and click Add.
4. Change the display properties of the hillshade raster to 70% transparent.
5. Click the Add Data button  and navigate to the C:\NSPECT\waianaedata folder.
6. Select Landcover.lyr and Golf\_Course.shp and click Add. Golf\_Course.shp is a polygon shapefile that represents existing golf courses in Makaha Valley.
7. Right-click on Golf\_Course in the table of contents and click on Zoom to Layer.
8. Activate the landcover raster (it should be below Golf\_Course).
9. Now note the C-CAP land cover classes covered by the new land use polygon. The dominant land cover class is grassland, which appears throughout the Makaha Valley. The shapefile named Golf\_Course will be used to attribute new pollutant coefficients to the area it covers.

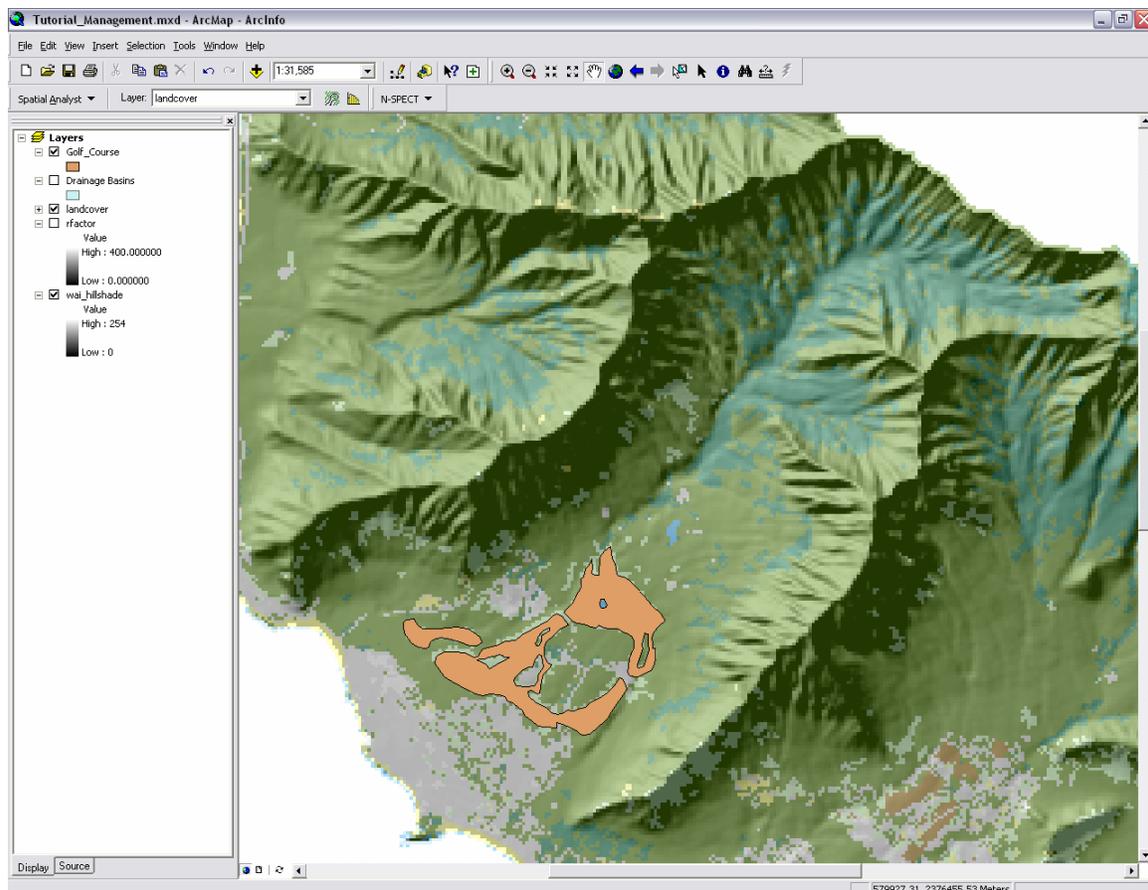


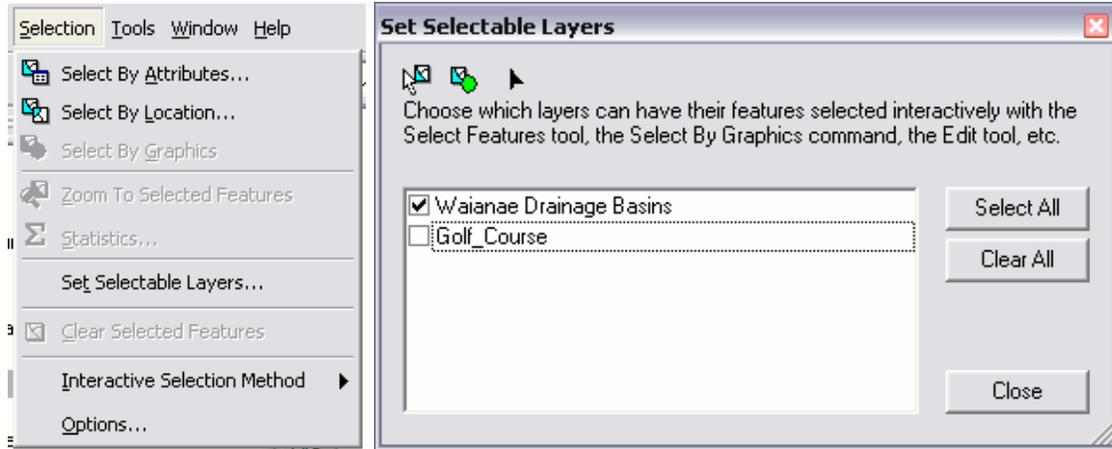
Figure 23. Golf\_Course.shp displayed on top of the land cover data layer.

## Start N-SPECT and Open a Project

1. Click the N-SPECT drop-down menu and select Run Analysis.
2. In the N-SPECT interface, click File from the menu bar and select Open Project.
3. The default directory should be C:\NSPECT\projects. Select *Waianaes\_Baseline.xml* and click Open.
4. Change the name of the project in the Project Information section to *Waianaes\_LandUse\_Accum*.

## Select Drainage Basins for Processing

1. Keep the N-SPECT interface open, and switch to the ArcGIS window (use the taskbar).
2. Click the Selection menu on the ArcGIS Main Menu and select Set Selectable Layers.
3. Remove the check mark next to Golf\_Course and click Close.



4. Use the select features tool  to select the seven polygons of Makaha Valley.

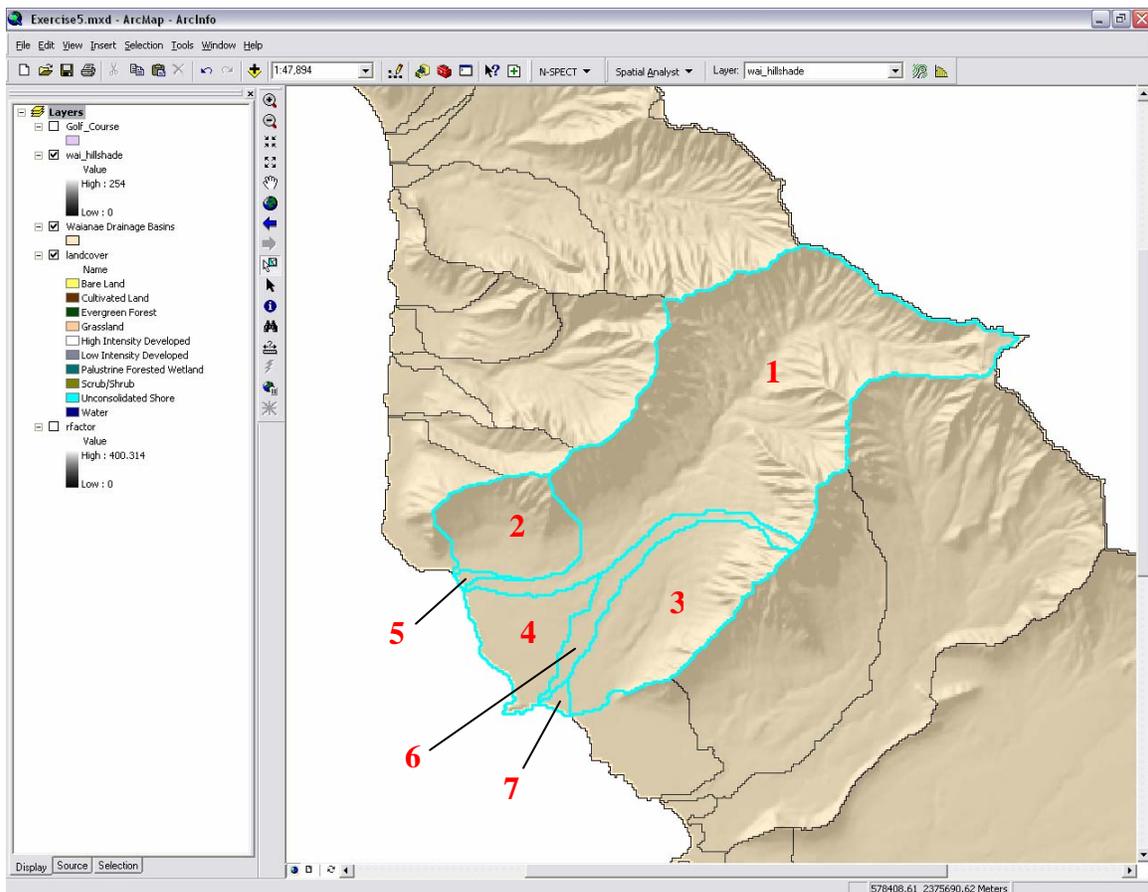
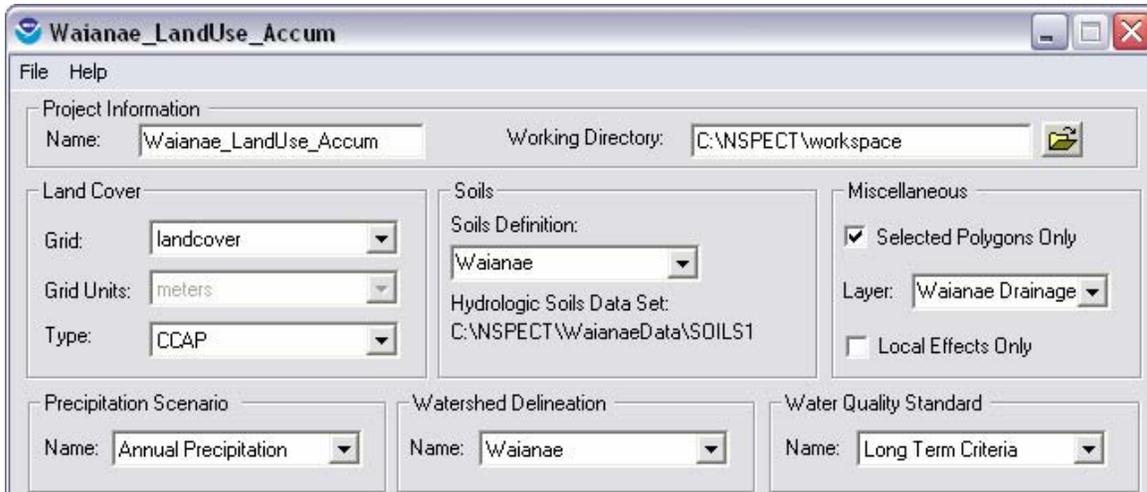


Figure 24. Seven selected polygons of Waianae Drainage Basins.

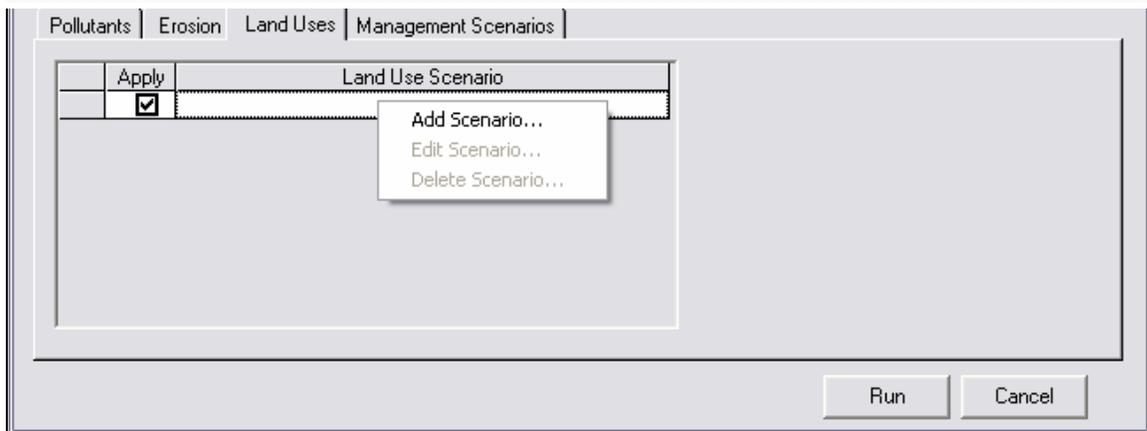
5. Save the ArcMap project at this point. Name it Exercise5.mxd.
6. Switch back to the N-SPECT interface window, place a check in the Selected Polygons Only box from the Miscellaneous drop-down menu, and select Waianae Drainage Basins.



**Figure 25. Interface for Waianae\_LandUse\_Accum project setup.**

### Add a Land Use Scenario

1. Click the Land Uses tab.
2. Right-click in the open cell below Land Use Scenario and click Add Scenario.



**Figure 26. Interface for N-SPECT land use scenarios.**

3. Name the scenario Golf Course.
4. Select Golf\_Course from the Layer drop-down menu.
5. Enter the following values in the SCS curve number cells:

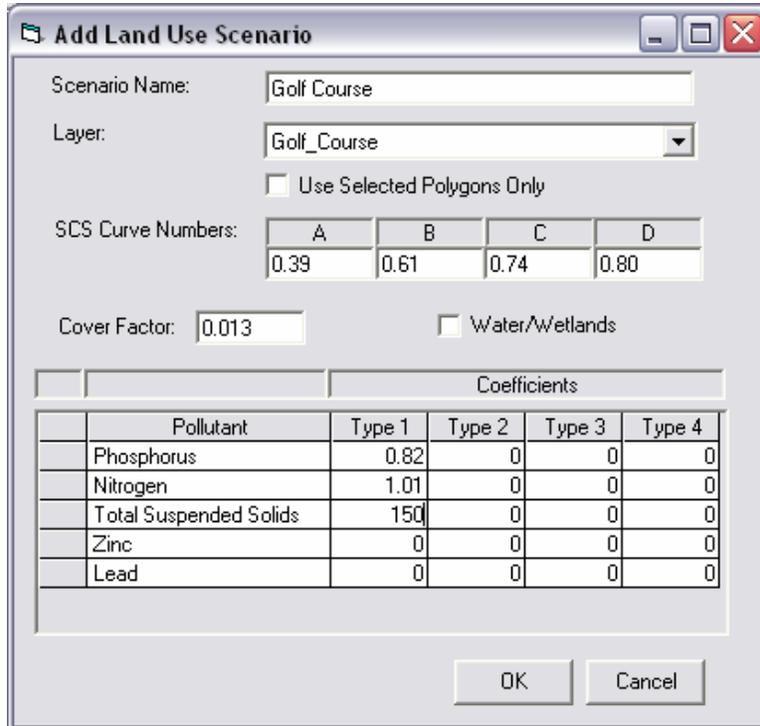
A	B	C	D
0.39	0.61	0.74	0.80

These factors represent the infiltration capacity of the soil and range from 0.00 (0%) to 1.00 (100%), with 0.00 being no runoff and 1.00 indicating no infiltration. The categories A through D represent four hydrologic soil types, again relating to infiltration capacity where soil type A has a higher infiltration capacity than soil type D. Curve numbers play an important role in N-SPECT's runoff depth estimation calculations. The values used in this example are the same as those included in N-SPECT for the C-CAP grassland land cover class. If different values are known to represent a certain land use better than those included with N-SPECT, then this dialog box is where they can be entered.

6. Leave the check box for Use Selected Polygons blank. This option could be enabled if the scenario shapefile held multiple polygons of which one or a few were selected for land use changes. Also leave blank the Water/Wetlands check box.
7. Enter 0.013 for the Cover Factor.
8. Enter the following values in the pollutant coefficient cells:

Pollutant	Type 1
Phosphorus	0.82
Nitrogen	1.01
Total Suspended Solids	150
Zinc	0
Lead	0

These factors were observed in the Neuse River Basin in North Carolina (Line et al., 2002). They are associated with a single golf course and are used in this example purely as alternatives to those included with N-SPECT for the grassland land cover class and shouldn't be construed as Makaha-specific values. The values are nutrient loading estimates represented as event mean concentrations (mg/L). If different values are known to exist for a certain land use, they can be entered here.



**Figure 27. Interface for a new Land Use Scenario**

9. Click OK.

10. Place a check in the box next to the new scenario, Golf Course, to apply it during the analysis.
11. Click Run.
12. Click Yes and click Save to save the new N-SPECT project as Waianae\_LandUse\_Accum.
13. Wait while N-SPECT processes the new scenario.

### View the Results and Compare to Baseline Data (Nitrogen)

The six raster outputs are arranged under the Waianae\_LandUse\_Accum group layer name. They can be viewed using the techniques outlined in the first four exercises. The next few steps will use the raster calculator feature of Spatial Analyst to quantitatively compare the new outputs to the baseline data. The focus is still on nitrogen.

1. Change the name of Accumulated Nitrogen (kg) under the Waianae\_LandUse\_Accum group to Land Use Accumulated Nitrogen (kg).
2. Add the Waianae\_Baseline group layer to the table of contents.
3. Rename Accumulated Nitrogen (kg) under the Waianae\_Baseline group to Baseline Accumulated Nitrogen (kg).
4. Click the Spatial Analyst drop-down menu and select Raster Calculator.
5. Enter the following expression in the open text box:  
**Nit\_LU\_Accum = [Land Use Accumulated Nitrogen (kg)] - [Baseline Accumulated Nitrogen (kg)]**
6. Click Evaluate.
7. The new raster, Nit\_LU\_Accum, appears in the table of contents. Change its symbology so that values equal to 0 are not visible, and low to high values are shown as blue to red.

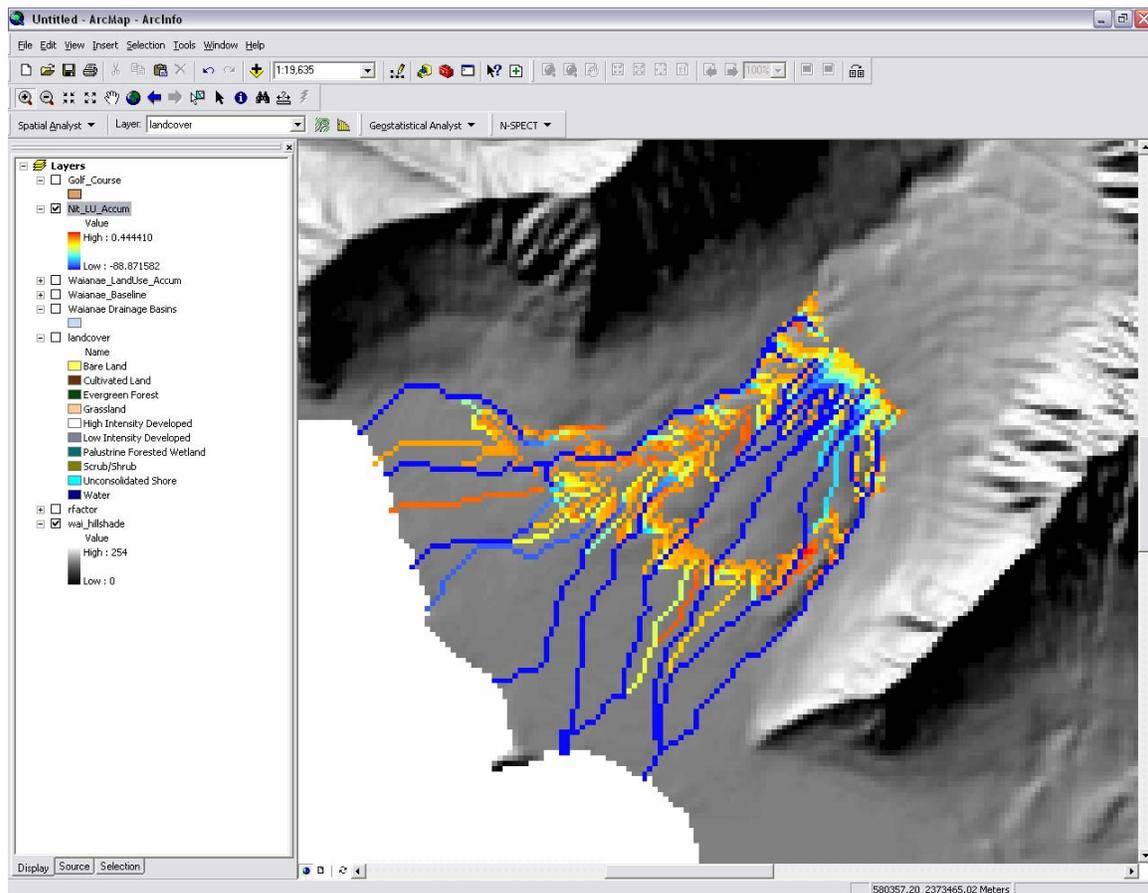


Figure 28. Nit\_LU\_Accum illustrating the accumulated effects of a land use scenario

8. Use the Identify tool  to query the values of the pixels that represent the mouths of the streams of the area affected by the golf course. The values returned represent the net estimated differences in nitrogen loads in kilograms caused by the change in coefficient values for the area delineated by the Golf Course shapefile.

## **Conclusion**

This exercise illustrated the changes to N-SPECT outputs that accompany the inclusion of an alternative land use scenario. In this case, the land use feature was used to force N-SPECT to incorporate a land cover class that is not uniquely represented by the original C-CAP land cover classification scheme. With proper data preparation, the land use scenario feature can be used to address other land use issues that would benefit from user defined pollutant coefficients, curve numbers, and cover factors.

The advanced analysis functions of N-SPECT include additional land use scenarios and alternative land management scenarios. These functions can be used separately or together to provide the user with a flexible, easily customizable tool for assessing nonpoint source pollution and erosion. Further analysis could be conducted to determine the percent change in nitrogen load due to the inclusion of different land cover and pollutant coefficients.

## Works Cited

---

- Anthony, S.S., C.D. Hunt, A.M. Brasher, L.D. Miller, and M.S. Tomlinson. 2004. *Water quality on the island of Oahu, Hawaii*. U.S. Geological Survey Circular #1239, Reston, VA.
- City and County of Honolulu, Department of Permitting and Planning. Wai'anae Sustainable Communities Plan. July 2000. Accessed September 15, 2004, at <http://honoluluodpp.org/planning/Waianae/Wai5.pdf>.
- Clark, J.R. 1995. *Coastal zone management handbook: Boca Raton, Florida*. Boca Raton, FL: CRC Lewis Publishers.
- Coastal challenges: a guide to coastal and marine issues*. 1998. National Safety Council's Environmental Health Center, Washington D.C.
- Dunne, T., and L.B. Leopold. 1978. *Water in environmental planning*. New York: W.H. Freeman and Company.
- Environmental Protection Agency (EPA). 1986. *Quality criteria for water: 1986*. USEPA, Office of Water Regulations and Standards, Washington D.C.
- Frissell, C.A., W.J. Liss, C.E. Warren, and M.D. Hurley. 1986. A hierarchical framework for stream habitat classification: viewing streams in a watershed context. *Environmental Management*. 10: 199-214.
- Line, D.E., N.M. White, D.L. Osmond, G.D. Jennings, and C.B. Mojonier. 2002. Pollutant export from various land uses in the Upper Neuse River Basin. *Water Environment Research*. 74 (1).
- National Research Council. 2002. *Clean coastal waters: understanding and reducing the effects of nutrient pollution*. Washington, D.C.: National Academy Press.
- Newson, M.D. and C.L. Newson. 2000. Geomorphology, ecology, and river channel habitat: mesoscale approaches to basin-scale challenges. *Progress in Physical Geography*. 24 (2): 195-217.
- Oki, D.S. 2003. *Surface water in Hawaii*. U.S. Geological Survey Fact Sheet 045-03, Honolulu, HI.
- Poole, G.C. 2002. Fluvial landscape ecology: addressing uniqueness within the river discontinuum. *Freshwater Biology*. 47: 641-660.
- U.S. Coral Reef Task Force. 1999. Draft recommendation of the water and air quality working group to the U.S. Coral Reef Task Force. Accessed September 14, 2004, at <http://coralreef.gov/airwaterwg/airwt.cfm>.
- Wohl, E. 2000. *Mountain Rivers*. Washington, D.C.: American Geophysical Union