Autonomous Spectral Image Processing Tool

Module for ERDAS IMAGINE®

User’s Guide

Version 4.1

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Table of Contents

1.1 Introduction to the Autonomous Spectral Image Processing Tool (GeoPalette™) ....... 7
   1.1.1 Background ........................................................................................................... 7
2.1 About this User’s Guide ........................................................................................................ 7
   2.1.1 Icons ....................................................................................................................... 7
   2.1.2 Typographical Conventions ....................................................................................... 7
   2.1.3 Sample Data for GeoPalette Tutorial ...................................................................... 8
   2.1.4 Image Characteristics that can lead to processing problems for GeoPalette ............ 8
3.1 GeoPalette Software Operational Steps ........................................................................... 8
   3.1.1 Getting Started with the Software ........................................................................... 8
   3.1.2 Guidelines for Data Entry ....................................................................................... 8
   3.1.3 Step-by-Step Guide to Using the GeoPalette Software ........................................ 9
       3.1.3.1 Starting a Session ............................................................................................. 9
       3.1.3.2 GeoPalette Project Setup ............................................................................... 12
       3.1.3.3 GeoPalette Processing Phases .......................................................................... 12
       3.1.3.4 GeoPalette Processing ..................................................................................... 13
       3.1.3.5 Running the GeoPalette Material Identifier Process Option .......................... 18
       3.1.3.6 Adjusting Signature Threshold Values for the Material Identifier Process.... 20
       3.1.3.7 Viewing GeoPalette/RINAV Results ............................................................... 24
       3.1.3.8 Manipulating GeoPalette Results with the IMAGINE Viewer ....................... 28
4.1 GeoPalette Tutorial ......................................................................................................... 31
   4.1.1 Data Sets ................................................................................................................. 32
   4.1.2 GeoPalette Processing Tutorial ............................................................................ 33
   4.1.3 Evaluation of RINAV Results ................................................................................. 40

Table of Figures

Figure 1. Select Autonomous Spectral Image Processing ....................................................... 10
Figure 2. GeoPalette Project Setup Tab ............................................................................... 11
Figure 3. GeoPalette Processing window ............................................................................. 13
Figure 4. Sensor Type Specified ......................................................................................... 14
Figure 5. Specifying the Desired Output Layers from the RINAV Process tab .................. 15
Figure 6. GeoPalette Data Generation processing status windows ................................... 16
Figure 7. GeoPalette Data Generation processing completion status ................................ 16
Figure 8. GeoPalette Processing window with selected layers ......................................... 17
Figure 9. GeoPalette Processing Results Quality Indicator ................................................. 18
Figure 10. Material Identifier Project Setup Interface ........................................................ 19
Figure 11. Choosing to run Material Identifier ................................................................. 20
Figure 12. Adjusting the threshold value for Material Identifier ........................................ 21
Figure 13. Selecting the spectral signature file for Material Identifier ............................... 22
Figure 14. Material Identifier processing status ............................................................... 22

4 - Applied Analysis Inc.
Figure 15. Material Identifier processing completion status ........................................ 23
Figure 16. Material Identifier output results displayed over the original image ........ 23
Figure 17. Material Identifier output results ‘swiped’ over the original image .......... 24
Figure 18. Land-Water Material ID classes* ............................................................. 25
Figure 19. Secchi Depth clarity ................................................................................. 25
Figure 20. Selection of the GeoPalette results to view ............................................. 26
Figure 21. Selection of the Base Image User-Specified bands .................................. 27
Figure 22. Selection of the results to display in the IMAGINE 2D Viewer ............... 27
Figure 23. Viewing two of the five result layers from GeoPalette ......................... 28
Figure 24. Shape file of the Water Image Over the Base Image ............................... 30
Figure 25. Swipe of Land Cover ID Image Over the Base Image ............................. 30
Figure 26. QuickBird Tutorial Image for Use in Learning the GeoPalette software ... 33
Figure 27. Tutorial Project Setup ............................................................................. 34
Figure 28. Tutorial Input Image and Sensor ............................................................. 35
Figure 29. Tutorial Selection of Output Layers ....................................................... 36
Figure 30. Tutorial Universal Material Filtering (Land Material ID) progress .......... 37
Figure 31. Process Complete .................................................................................... 37
Figure 32. Tutorial - Selecting Layers to View ....................................................... 38
Figure 33. Tutorial Water Subset Layer ................................................................. 39
Figure 34. Tutorial - Selecting Land-Water Interface Land Cover layer ................. 39
Figure 35. Land-Water Interface Land Cover layer displayed ................................. 40
Figure 36. Land-water interface and Land Cover .................................................... 41
Figure 37. Secchi Depth......................................................................................... 42
Figure 38. CDRC output layer* ............................................................................. 43
Figure 39. CDRC UMF layer* .............................................................................. 45
Figure 40. Shallow Hazards layer .......................................................................... 46
Figure 41. Material Color ID output layer .............................................................. 47
1.1 Introduction to the Autonomous Spectral Image Processing Tool (GeoPalette™)

1.1.1 Background

AAI’s Autonomous Spectral Image Processing tool (GeoPalette) is an advanced imagery exploitation tool. This version of GeoPalette was developed as an add-on module for the ERDAS IMAGINE 2014 image processing software. It is designed as an aid for image analysts to automatically detect and locate specific shoreline and river features of interest in multispectral imagery, such as bottom characteristics of interest, water clarity, and in a future release, water depth. An additional module provides the user with a material identification tool (MI Process) for the detection of materials in an image based on their spectral signature.

Applied Analysis Inc. has developed a software module for ERDAS IMAGINE named, Autonomous Spectral Image Processing tool (GeoPalette) to help image analysts automatically detect and map river characteristics such as bottom type, obstructions in the river, water clarity, and water depth. GeoPalette provides the analyst with a semi-automated processing approach requiring very limited user interaction. The tool is designed to work with multispectral imagery and requires that images have at least four spectral bands (must include a blue, green, red, and VNIR band).

2.1 About this User’s Guide

This document is designed as a brief, but comprehensive guide on how to effectively use the GeoPalette module. The guide provides in-depth instructions on how to use the software, along with a review of the output layers and guidance as to what types of image conditions may affect results.

Note that GeoPalette is the commercially available module name and RINAV is a similar version, which is only available to U.S. Government organizations. As the software is in transition, you will encounter references to RINAV throughout the GeoPalette module interface and this guide.

2.1.1 Icons

The following icons are used in this document to immediately direct the user to important points:

- Indicates tips for shortcuts or more effective use of GeoPalette.
- Indicates reminders or emphasizes important points.

2.1.2 Typographical Conventions

The names of menus, menu options, buttons, and other user interface displays are stated in bold type.
For example:
‘Select GeoPalette Project Setup from the Autonomous Spectral Image Processing menu.’

2.1.3 Sample Data for GeoPalette Tutorial

The GeoPalette software comes with demo data that can be used to exercise the software as the user learns how to use it. See Section 4.1 (at the end of this document) for a tutorial on how to operate the GeoPalette software with the demo data provided, and also how to properly interpret the results.

2.1.4 Image Characteristics that can lead to processing problems for GeoPalette

There are certain conditions within images that can result in poor software performance and should be avoided. Please reference the GeoPalette Release Notes (separate document) for a complete discussion of these image conditions.

3.1 GeoPalette Software Operational Steps

3.1.1 Getting Started with the Software

The GeoPalette software is integrated with ERDAS IMAGINE to take advantage of its image handling tools. The most commonly used tools with GeoPalette are:

- Viewer for Image Display
- Open Raster Layer
- Raster Options
- Arrange Layers
- Raster Attribute Editor
- View Zoom/Pan
- Swipe
- Inquire Cursor

For a detailed discussion of these functions, the user should refer to the documentation that is supplied with the ERDAS IMAGINE software.

3.1.2 Guidelines for Data Entry

Data necessary to perform the GeoPalette functions are entered via dialog boxes. Three important data entry guidelines must be followed when using the GeoPalette software.

1) This version of the GeoPalette software is designed to work with images in the ERDAS IMAGINE *.img, NITF (2.0 or 2.1), or GeoTIFF image formats only. To work with images in other data formats, use the ERDAS IMAGINE IMPORT/EXPORT function to convert imagery to *.img format before running
the image through GeoPalette. The exception is for images with R-functions geomodels. Images with R-functions cannot be processed for depths with the .img (IMAGINE) image extension. These R-function images should first be converted to NITF 2.x images (.ntf) using the IMAGINE IMPORT/EXPORT tool.

2) GeoPalette software will accept input images with a space in their base file names or in their file paths. The image file does not need to be renamed or moved to a different location. If the user runs GeoPalette using a *.bcf file (batch commands), spaces are also permitted.

3) GeoPalette will process imagery with more than four (4) spectral bands. Images that exceed four bands will automatically be subset so that the image contains only four (4) specific bands. For proper GeoPalette performance, the four bands need to correspond to the blue, green, red, and NIR wavelengths. Imagery from the Landsat TM/ETM+ sensors, for example, can be input as is, except that the thermal band(s) need to be removed prior to processing. Landsat 8 cannot be processed with GeoPalette in this release.

4) The GeoPalette software will perform optimally if there are no artifacts within the input image. For example, some Landsat imagery contains image artifacts along the edges of the image. The existence of these pixels can severely skew the image calibration process, which in turn, will result in poor GeoPalette results. Artifact areas within an image should be removed prior to processing with GeoPalette.

3.1.3 Step-by-Step Guide to Using the GeoPalette Software
This section explains in detail how to perform the primary GeoPalette software functions. Each step is explained in detail with illustrations to help provide clear instructions. The guide also describes the results of the GeoPalette process with tips for additional application of results.

3.1.3.1 Starting a Session
To begin using the GeoPalette software, the user should perform the following:

1) Begin an ERDAS IMAGINE 2014 session.

2) Select the Raster tab on the IMAGINE toolbar ribbon and then select the Unsupervised classification, and down to the Autonomous Spectral Image Processing menu item.
Figure 1. Select Autonomous Spectral Image Processing
3) The *Autonomous Spectral Image Processing* wizard interface appears.

![Image of GeoPalette Project Setup Tab]

**Figure 2. GeoPalette Project Setup Tab**
3.1.3.2  GeoPalette Project Setup

1) To start a new GeoPalette project, navigate to the desired folder using the Browse button (see Figure 2), then enter a project file name and press the Enter key. At this point, the Next button will become active. Click Next to continue.

To continue work on an existing GeoPalette project or review a previous project, navigate to the project location, and select the project filename.rpj, then click Next.

2) To jump to a specific GeoPalette module (i.e., GeoPalette Project Setup, GeoPalette Processing, RINAV Process, or MI Process), just click the Next button to reach the desired interface window and follow the directions for that process. There isn’t a back button, so the user needs to click on a tab to revisit a previous interface for making changes, reviewing settings, etc.

3.1.3.3  GeoPalette Processing Phases

GeoPalette processing involves the three basic phases

1. Pre-processing

2. Data generation
   a. RINAV – Shore Zone & Riverine Navigational Analyzer
   b. MI Process – Material Identifier

3. Assessment of results

Pre-processing is the step that creates a water-only image and shape file. This involves automatic data quality checking of the image, calibrating the image to units of reflectance, identifying the water and land components, and then subsetting the image to a water-only image.

The image format is converted to the proprietary .aai image format to improve processing performance and result in shorter processing times.
3.1.3.4  GeoPalette Processing

1) To start the GeoPalette process, enter the image filename (click Browse button) and select the appropriate sensor from the dropdown listing (see Figure 3). The current list of default sensors includes IKONOS, GeoEye, Landsat-4, -5, and -7 TM, QuickBird2, PLEIADES, SPOT6, and a 4-band version for WorldView2. The 4-bands of the WorldView2 sensor used for processing are the blue, green, red and NIR bands. If the image name as a character string that relates to the sensor type, the GeoPalette software will automatically select the appropriate sensor (i.e. if the image filename contains “QB02” character string, the software will automatically choose QUICKBIRD2 for the sensor type.

**Figure 3. GeoPalette Processing window**
2) If the required sensor is not included in the selections from the dropdown listing, the user’s sensor type can be added to the dropdown list upon request. Contact AAI customer support (see end of this document) for details.

The current set of sensors in the dropdown menu restricts the use of GeoPalette to data from the IKONOS, GeoEye, Landsat TM/ETM, QuickBird2, SPOT6, PLEIADES and WorldView2 satellites.

The *.saf file is a file that specifies the band characteristics of the sensor, including center wavelengths and widths of each sensor band (in nanometers). SAF files are provided with the ERDAS IMAGINE software, but should not be used if the sensor is listed in the dropdown menu.

For GeoPalette to perform properly, the sensor that collected the imagery needs to have the appropriate band wavelengths in the B, G, R, NIR spectral regions.

![Figure 4. Sensor Type Specified](image)

- GeoPalette Project Setup
- GeoPalette Processing
- RINAV Process
- MI Process
- About

GeoPalette creates any or all of the following image-derived products:
- RINAV and/or Material Identifier.
- Enter the (MSI) image filename and sensor source.
- Provide an output location for your result files.
- Select any or all choices by checking the Application Boxes below.
- Click Next to proceed to the next screen.

**Input Image File:** (*.img)  
QB_lowerCape_29aug07 qb5011_01_p001.i

**Output Directory Name:**  
c:/rnav_tests/tutorial_run/

**Select Application(s):**
- Shore Zone and Riverine Navigational Analyzer
- Material Identifier

**Sensor Information:**
QUICKBIRD2

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14 - Applied Analysis Inc.
3) If interested in processing only an area of interest, the user may subset the full image prior to processing. It is important the image or subset image include at least 10% land area to ensure adequate processing quality. Testing with this 32-bit GeoPalette version has shown successful processing with uncompressed images up to 500MB in file size.

![Image of GeoPalette interface](image)

**Figure 5.** Specifying the Desired Output Layers from the RINAV Process tab

4) To begin processing, click on the **Apply** button (Figure 5).

⚠️ During GeoPalette/RINAV processing, various job status progress bars will appear in the Process List window, providing feedback on progress (Figure 6).
If available disk space is insufficient for the GEOPALETTE processing run, the user will see an entry at the bottom of the project file (*.rpj) stating how much disk space is available. Once the run is underway, the user can open the *.rpj to check for messages.

Figure 6. GeoPalette Data Generation processing status windows

5) After the image has been processed, the progress bar will indicate if the run completed successfully (see Figure 7) with no errors. A review of the GeoPalette CORENV confidence indicates the degree to which a run completed with high confidence results. A confidence value that ranges from 80 to 90% indicates only moderate confidence results, and a value below 80% signals that the results are of low confidence (see Figure 10 for an example of CORENV files with the confidence values noted).

Figure 7. GeoPalette Data Generation processing completion status

For low confidence results, the user may want to choose another image to process, if available.

After running this option, the analyst can run data generation and assessment without re-running pre-processing because GeoPalette checks for the existence of intermediate result files. If intermediate result files are found to exist, then GeoPalette skips any sub-processes and continues on to the next sub-process until intermediate result files are found not to exist. Then GeoPalette proceeds as normal.

Also, if for some reason GeoPalette is interrupted, the user can re-apply GeoPalette without having to start from the beginning and without having to remove intermediate
result files. GeoPalette examines for the existence of intermediate result files and continues processing from that sub-step where the interruption occurred.

6) If the user chooses to output only selected layers, the layers can be checked-off (do not process) and only the checked layers will be created. There are some layers that depend upon the creation of intermediate data layers, so the user may get some of the output layers, even if there were not checked.

7) In this example (see Figure 8), the following output layers (images) will be created –
   a. Land Material ID
   b. Bottom Reflectance
   c. Bottom Material ID
   d. Shallow Hazards
   e. Water Clarity

Figure 8. GeoPalette Processing window with selected layers
8) The GeoPalette CORENV (Environmental Correction) file provides an indication of the quality of atmospheric correction. This text file is found in your output folder with a .corenv file extension.

This CORENV confidence indicates that the results have a high confidence and can be used with certainty.

This CORENV indicates that the results have only modest confidence, and should be used with caution.

This CORENV indicates low confidence due to image quality problems, and another image should be selected for processing if possible

**Figure 9. GeoPalette Processing Results Quality Indicator**

### 3.1.3.5 Running the GeoPalette Material Identifier Process Option

The user has the option of only running Material Identifier from the GeoPalette Processing interface by checking the box labeled **Material Identifier**. When using this option, the process uses an existing spectral signature file and finds occurrences of the material within the image based on its spectral properties. The output result is both a raster and shape file that delineates the detections of the material within the image. The Material ID process runs much faster than the RINAV process and can be used alone or run along with RINAV. If the material of interest is accurately identified in the image, then the user can be confident with the threshold value in the spectral signature file. Adjustments can be made to the threshold to achieve accurate material detections with fewer false positives.
Figure 10. Material Identifier Project Setup Interface
3.1.3.6 Adjusting Signature Threshold Values for the Material Identifier Process

The user has the option of adjusting the signature threshold to improve material identification and minimize false positives.

1) Use a text editor (i.e. Windows Notepad) to open the signature file for editing

2) See Figure 12 to locate the threshold value within the signature text file

3) Change the threshold number to increase or decrease the signature threshold
   - Lower the threshold to tightly constrain detections
   - Raise the number to “open” the tolerance and allow more detections
   - Increasing the threshold too far could increase “false alarms”
   - Make adjustments in small increments (i.e. 0.005 to 0.01)
4) Save the File when finished with edits and be sure to maintain the *.txt filename extension.

![Figure 12](image-url)

**Figure 12. Adjusting the threshold value for Material Identifier**
Figure 13. Selecting the spectral signature file for Material Identifier

Figure 14. Material Identifier processing status
Figure 15. Material Identifier processing completion status

Figure 16. Material Identifier output results displayed over the original image
3.1.3.7 Viewing GeoPalette/RINAV Results

Following a successful run of GeoPalette, the user should use the IMAGINE 2D Viewer interface to review the GeoPalette results. A description of the output layers is provided below.

Once viewing the interface (Figure 20), the user can choose to review a number of results.

- **Water Subset Layers** – This result is a GIS file which defines all areas in the image that have been identified as water. This single band water only image is in ERDAS IMAGINE image format. If the Vector Water Segmentation option was specified, then a shapefile is also created and can be used directly in ESRI’s ARC GIS software, and other similar GIS software packages.

- **Land Cover ID Layer** - This result is a material identification single band image in ERDAS IMAGINE image format. The pixels that have been identified as water will appear blue, whereas all other pixels are color-coded based on the predominant land cover type. An example of the legend is shown below:
Figure 18. Land-Water Material ID classes*

*Note: The legend shown above is a condensed version since there exists 600+ material classes in this layer and it is not possible to represent all legibly within the legend.

- Water Clarity Layer - This result is an image-derived estimated Secchi Depth represented with a single band image in ERDAS IMAGINE image format. Secchi Depth is a measure of water clarity. In general, the greater the Secchi Depth, the deeper one can effectively discriminate and retrieve the bottom material characteristics of the water body. A low Secchi Depth indicates low water clarity and increased obscuration of the bottom. The mean Secchi Depth for the image multiplied by 2 can be used to estimate the maximum depth for which bottom materials can be effectively discriminated and identified in the image. The pixels are color-coded as shown the Secchi Depth key below:

![Secchi Depth Key](image)

Figure 19. Secchi Depth clarity
• Material Identification Layer - This result is a single band raster image in ERDAS IMAGINE format and identifies submerged bottom materials. This layer is helpful for a contextual understanding of the bottom characteristics. The legend for this layer is shown below:

![Legend Image](image)

*Note: The legend shown above is a condensed version since there exists 600+ material classes in this layer and it is not possible to represent all of them in the legend.

![Figure 20](image)

**Figure 20. Selection of the GeoPalette results to view**

To display results in the IMAGINE Viewer, select the base image from the **Input Base Image Filename** (input image is automatically selected, click the Browse button to choose a different image if desired), then select the layer(s) to display from the **Select results to display** options and click **Apply**.

Also, the base image can be displayed using Natural, Infrared or a User Specified Color. The R, G, B values can be dialed in using the increments as shown in Figure 21.
Figure 21. Selection of the Base Image User-Specified bands

Figure 22. Selection of the results to display in the IMAGINE 2D Viewer

The ERDAS IMAGINE 2D viewer will display the base image and the selected result layers in IMAGINE viewers (Figure 22). If the Water Subset Layer image and Land Cover ID image are selected, two viewers will open with the Land Cover image appearing in one viewer and the water only image file appearing in another viewer (all on top of the base image). The user may be prompted to create pyramid layers for the image prior to the image being displayed.
Figure 23. Viewing two of the five result layers from GeoPalette

3.1.3.8 Manipulating GeoPalette Results with the IMAGINE Viewer

The IMAGINE Viewer allows for limited viewing and results manipulation, and does not support further refinement of GeoPalette results through a selective reduction process utilizing the AOI tools. The output files from GeoPalette include the following:

1) Water Only Layer – This is a multi-band image showing pixel reflectance values for the areas in the image that were identified by Material Identifier as water. Land areas are represented by null pixel values. Subtle features in the water are accentuated when the image is viewed with an automatic enhancement stretch, as is typical with the ERDAS IMAGINE Viewer.

2) Land-Water Interface – Land Cover Material Layer – This is a single-band image showing the areas in the image that are identified as non-water, including identification of the various image-derived land cover types using Material Identifier. The image layer is color-coded with up to 600+ distinct classes to allow for higher definition of the land cover characteristics. If the user chooses to display the land cover image without using the View Results menu within the GeoPalette Wizard, this image should be displayed using the Pseudo Color option under the Raster Options tab on the Select Layer To Add menu.

3) Color Material ID Layer – This is a single-band image showing a modified, but relative true color representation of the image over both land and water and is displayed in Pseudo Color.

4) Bottom Material Identification – This is a single band image classifying the various image-derived water bottom cover types using Material Identifier for the areas in the image that were identified as water. This image layer is color-coded with up to 600+ distinct classes, similar to the Land Material ID layer. If the user chooses to display the bottom material cover image without using the View Results menu
within the GeoPalette Wizard, this image should be displayed using the Pseudo Color option under the Raster Options tab on the Select Layer To Add menu.

5) **Dry Bottom Reflectance** – This is a multi-band image showing the pixel reflectance values of the bottom cover materials in the areas originally identified by Material Identifier as water. Similar to the Water Subset Layer, the subtle features in the bottom are accentuated to show greater detail in the bottom materials.

6) **Shallow Hazards Layer** – This is a single band image showing areas where there are subsurface obstacles and obscured areas having uncertain bottom morphology. There are three classes of hazards identified, color-coded as red = Very Shallow, yellow = Shallow, and green = Submerged Vegetation. The red and yellow classes also include unknown areas about which the user should be cautious. For example, if there is a large amount of surface reflection, fog above water, or high amounts of suspended minerals that obscure the bottom, these will be identified as red or yellow hazard classes, depending on how extreme they are.

7) **Water Clarity Layer** – This single band image layer shows different measures of water quality for the areas in the image that were identified as water.

   a. **Secchi Depth** - This image estimates the Secchi Depth, a traditional indicator of water clarity. Secchi depths are color-coded and displayed as a color ramp, where blue indicates smaller Secchi depths (obscured water column), and red indicates greater Secchi depths (clear water column). Note that Secchi depth should not be confused with water depth. It is traditionally ‘viewed’ from above the water surface rather than from below. It represents the vertical distance in the water column (depth) at which a reference standard object would lose contrast with the background.

8) **Water Only Shape File** – This is a polygon shapefile that shows the water bodies in the image identified by Material Identifier. It is created when the “Apply Land Water Interface Only” option is used for processing. This result layer is only displayed when the Water Subset Layer option is selected and when this shape file has been created. Figure 24 shows the shape file of the demo image. This vector layer can also be displayed in IMAGINE (with Vector license) and ArcGIS and edits can easily be made if desired.
With only limited manipulation of GeoPalette results available within the ERDAS IMAGINE Viewer at this time, the most useful tools exist under the **Utility** menu option on the Viewer main menu. These include the **Swipe** and the **Flicker** tool.

The Swipe tool allows the user to swipe the top layer to reveal the layer immediately beneath it. By clicking on the **Swipe** option, the user can slide the vertical bar from side to side to reveal the imagery underneath, as shown in Figure 25 below.
The names of the GeoPalette result files are shown below, and are in the native image format (e.g., .img, .nitf, .tif), so they can be directly opened in an IMAGINE 2D Viewer.

**Land Water Interface and Land Cover ID Image** –
`qb_lowercape_29aug07qb5011_01_p001_RINAV_reflec_LW_UMF.img`

**Material Color ID Image** –
`qb_lowercape_29aug07qb5011_01_p001_RINAV_reflec_CA_UMF.img`

**Water Only Image** –
`qb_lowercape_29aug07qb5011_01_p001_reflec_LW_UMFWaterOnly_shp_11_1000000000.img`

**Bottom Reflectance Image** –
`qb_lowercape_29aug07qb5011_01_p001_RINAV_CDRC.img`

**Bottom Material ID Image** –
`qb_lowercape_29aug07qb5011_01_p001_RINAV_CDRC_UMF.img`

**Shallow Hazards Image** –
`qb_lowercape_29aug07qb5011_01_p001_ShallowHazards_Uncertain.img`

**Water Clarity Image** –
`qb_lowercape_29aug07qb5011_01_p001_SecchiDepth.img`

**Water Shape File** –
`qb_lowercape_29aug07qb5011_01_p001_Wateronly_shapefile/LWI_water.dbf`
`/LWI_water.prj`
`/LWI_water.shp`
`/LWI_water.shx`

### 4.1 GeoPalette Tutorial

This section presents a tutorial based on one of the provided demo images. Tutorial output results are provided for comparison with the processing outputs from a user run. The tutorial will step the user through initial processing using the wizard interface and subsequent review of the results. For further information about each section, refer to the associated chapter.

The tutorial data set consists of a QuickBird image collected over the coastline area near The Lower Cape of Cape Cod, Massachusetts (acquired 29 August 2007), courtesy of DigitalGlobe. The goal of the tutorial is to acquaint the user with the processing steps in the GeoPalette/RINAV wizard and to generate the water only image, Secchi Depth and Material Identification image.
4.1.1 Data Sets

The GeoPalette module software (on the ERDAS IMAGINE install disk) contains two different images (from QuickBird and GeoEye) for use in learning to run GeoPalette. The software installation does not copy these images to the examples directory of the user’s IMAGINE software installation. The user will need to copy the images and accompanying result files to a local file storage folder. Table 2 lists the image names, acquisition dates, image sizes, and pixel sizes for each of the images. The second image is a subset taken from the full scene.

Table 1. Tutorial Image Data Files

<table>
<thead>
<tr>
<th>IMAGE NAME</th>
<th>IMAGE DATE</th>
<th>IMAGE SIZE (PIXELS)</th>
<th>PIXEL SIZE</th>
</tr>
</thead>
<tbody>
<tr>
<td>QB_lowerCape_29aug07qb5011_01_p001.img</td>
<td>29 August 2007</td>
<td>6876 W x 7123 H x 4 bands</td>
<td>2.4m</td>
</tr>
<tr>
<td>RINAV_ge-1.img</td>
<td>20 April 2009</td>
<td>3793 W x 3634 H x 4 bands</td>
<td>2.0 m</td>
</tr>
</tbody>
</table>

Figure below shows the QB_lowerCape_29aug07qb5011_01_p001.img sample image in a true color rendition (3-2-1 band combination). The user can choose the other image to make practice runs since it is smaller and will run faster; however, the image in Figure 26 (QB_lowerCape_29aug07qb5011_01_p001.img) is used for the tutorial and has example GeoPalette results as part of the tutorial data set.
4.1.2 GeoPalette Processing Tutorial

Prior to using the GeoPalette software, the user needs to have ERDAS IMAGINE running. Start the GeoPalette wizard by selecting *Autonomous Spectral Image Processing* icon from the IMAGINE Raster – Unsupervised (classification) menu.

The following instructions walk the user through each of the steps for running the tutorial using the *QB_lowerCape_29aug07qb5011_01_p001.img* tutorial image.

Step 1: Create a new RINAV project by navigating to a folder (where the user wants all the output files to go) and entering in a filename (use *tutorial1.prj* for example)
Step 2: Click the **Next** button. When the GeoPalette Processing window appears, choose the input image (*QB_lowerCape_29aug07qb5011_01_p001.img*) and select the sensor type of QUICKBIRD2.
Figure 28. Tutorial Input Image and Sensor
Figure 29. Tutorial Selection of Output Layers

Step 3: Click the **Apply** GeoPalette Process button to launch GeoPalette processing. A number of processing status bars will appear within the Process List window and provide the user with information on progress.
Step 4: After processing completes, the user will see that the processing progress will either indicate 100% and show green for a successful run, or red, for an unsuccessful run. Review the session log for details as to why a run was unsuccessful. Information in the session log can be helpful in debugging the problem and should be saved for AAI customer support.

Step 5: Return to the IMAGINE 2D Viewer window, where the user can choose to view all the results or just specific layers. For this tutorial, the user should open the Water Subset Layer and the Land Cover ID Layer. Open the original input image as a backdrop for the output layers to be reviewed.
Figure 32. Tutorial - Selecting Layers to View

Step 6: Click the **Apply** button and two IMAGINE Viewers will appear, with one showing the Water Subset Layer and the other showing the Land Cover ID Layer, both with the original input image as the background.
Figure 33. Tutorial Water Subset Layer

Figure 34. Tutorial - Selecting Land-Water Interface Land Cover layer
This concludes the tutorial. See the next section for a discussion of these results.

4.1.3 Evaluation of RINAV Results

Once the RINAV run completes, the user can review the following description of the various RINAV results to better understand how to interpret them.

The various internal processing steps that led to the creation of the RINAV results for this image each produced high confidence results, and the final output image results were ranked as “Good.” The ocean is clearly defined in blue and the vegetation is in various shades of green, with the soil/urban areas defined by various shades of tan and brown, as indicated in the accompanying Land Material Identification Key below.
Figure 36. Land-water interface and Land Cover

*Note: The legend shown at the right is a condensed version since there are 600+ material classes (classified according to color, saturation, and intensity) in this layer and it is not possible to represent all of them in the legend.

Image-derived water clarity is indicated in the estimated Secchi Depth image below. In spite of its name, the term Secchi Depth is a standard water clarity metric derived from a traditional field measurement technique, and it corresponds to the depth at which the contrast of an object (black and white patterned Secchi Disk) lowered into the water and viewed from above is effectively lost against the background. The Secchi Depth image represents an image-derived estimate of equivalent Secchi Depth, based on a transformation of image derived subsurface sighting ranges estimated by RINAV. In addition to estimating ranges at which objects will lose contrast against the background, Secchi Depth can also be used to estimate the maximum depth (2 x Secchi Depth) at which bottom material characteristics can be effectively retrieved from the image. The Secchi Depth Color Key accompanies the image
in the figure below. Note in this demo example that the near-shore coastal waters have generally greater clarity than the waters further offshore. The mean Secchi depth for the image pixels identified as water by Material Identifier are indicated in the Figure below, and twice that value provides an estimate of the expected maximum depth from which bottom material characteristics can be retrieved. The retrieved bottom materials are shown and discussed next.

Figure 37. Secchi Depth

The Material Identification Layer is shown in the next figure below, a legend is not provided since the large number of classes that are included would be too lengthy to represent. Each pixel value in the bottom material image is rendered by a combination of hue, intensity, and saturation. There are 12 levels of hue (color) represented, along with 10 intensity and 5 saturation levels. This creates 600 unique colors to represent the bottom material colors.

Material names can be accessed from the Raster Attribute Editor when the user clicks on a pixel with Inquire Cursor to query its material identity. The Raster Attribute Editor provides land material names to sea floor materials.
This Material Identification Layer image represents the image-retrieved bottom material reflectance contribution to the water pixel reflectance spectrum. It was corrected for atmospheric, sun angle, and sensor function contributions, water column attenuation effects, and depth. The index of refraction effects of wet vs. dry materials are not included in this release. The resultant Wet Reflectance Bottom image was then autonomously processed to identify the bottom materials. For tactical applications, its interpretation is based on contextual inference, much like the approach used to rapidly interpret Electro-Optical (EO) imagery. The following illustrates the approach.

Figure 38. CDRC output layer*

*Note: Each pixel value in the bottom material image is rendered by a combination of hue, intensity, and saturation. There are 12 levels of hue (color) represented, along with 10 intensity and 5 saturation levels. This creates 600 unique colors to represent the bottom material colors.

There are two basic “bottom” regimes apparent in the Material Identification Layer, an obscured-bottom regime and a visible-bottom regime. The obscured-bottom regime dominates much of the image, and has characteristic dark and featureless texture that discriminates it from the visible-bottom regime. Sometimes glint features and sensor noise can produce a speckled texture in the obscured-bottom regime. The visible-bottom regime is generally brighter, less susceptible to glint and sensor noise contributions, and has more visible structure related to the bottom features. It is also generally closer to the shoreline. Note the relatively well-defined transition separating the two regimes, indicative of a
relatively well-defined shelf structure of the near-shore seafloor in this image. Only the visible-bottom regime reveals a valid characterization of the bottom materials. The results for the obscured-bottom regime do not. Instead, the latter are dominated by a combination of deep-water spectral characteristics, surface glint, and sensor noise and artifacts, and should be ignored. The transition between the two regimes occurs at a depth controlled by water clarity, which can be estimated using the image-retrieved Secchi Depth image (see previous paragraph). For this image the transition occurs at an estimated depth of 8.36m (2 x mean Secchi Depth for the image). Note that the materials in the visible-bottom regime are largely dominated by bright and relatively homogeneous soils, with occasional patches of vegetation. The large-scale homogeneity of the material is characteristic of well-mixed mobile unconsolidated material. Hard-bottom materials, such as rocks and coral, typically have a coarse-scale structure not evident in this image.

A closer look at the vegetation on the seafloor can be seen in the zoomed-in image that follows. The discreet small darker patches intimately associated with the vegetation can be inferred to be dominantly fallow vegetation and organic debris.

Examination of the bottom materials in the complex waterway extending inland leads to the inference that some portions of the waterway, most notably the central primary river, contain bottom materials that are uniform and spectrally similar to the coastal seafloor materials. These portions of the waterway can be inferred to be tidally influenced with dynamic flow characteristics, suggesting they have the potential of being navigable waterways. Other portions of the complex have darker soil components and appear not to be tidally influenced and less dynamic. These latter portions of the complex appear to be isolated from the dominant tidal flow, and their darker color leads to the inference that they may contain deposits of local inland sediments and organic debris, characteristic of coastal marshlands. Note the lighter soil extending from the central river north into the marsh complex. The presence of the lighter bottom material suggests that this may represent a dynamic and possibly navigable waterway within the marsh complex. There are other possible interpretations, but this serves to illustrate the kind of rapid tactical assessment that can be made by contextual inference using the image-derived Bottom Material ID layer.
Figure 39. CDRC UMF layer

*Note: Each pixel value in the bottom material image is rendered by a combination of hue, intensity, and saturation. There are 12 levels of hue (color) represented, along with 10 intensity and 5 saturation levels. This creates 600 unique colors to represent the bottom material colors.

Another useful piece of information that can be inferred from the bottom characteristics in this image is the average gradient and slope of the seafloor. The transition from the obscured-bottom regime (speckled) to visible-bottom regime occurs at an estimated depth of 8.36m. The visible-bottom regime extends to the shoreline (zero depth), allowing general seafloor gradients and slopes to be calculated anywhere along the coast using the Slope Query tool described above, which will be included in a future release. To do this, place the ts4 aoi on the transition boundary, rather than on the last low tide feature, and assign it an elevation of the ts3 value -8.36m. Even without the Slope Query tool, however, it can be quickly inferred by simple inspection that slopes are steeper along the Atlantic (eastern) side of the Cape than along the Cape Cod Bay (western) side, based on the relative widths of the visible bottom on the two sides (a narrower width has a steeper inferred general seafloor slope). It can also be quickly inferred that the general seafloor gradient becomes progressively flatter toward the south on the Bay side. This information, whether by simple inspection or using the Slope Query tool, can be used to quickly narrow down candidate approaches and landing routes.
Figure 40. Shallow Hazards layer
This concludes the discussion of GeoPalette/RINAV results for the tutorial image set.
Need Assistance?

Contact AAI for GeoPalette Support: (978) 392-4500 x270