Washington State Department of Ecology

Environmental Assessment Program

Standard Operating Procedures for the computer analysis of hemispherical digital images collected as part of a temperature Total Maximum Daily Load (TMDL) or Forests and Fish Unit technical study.

Version 2.1

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Signatures on File

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Although Ecology follows the SOP in most instances, there may be instances in which Ecology uses an alternative methodology, procedure, or process.

SOP Revision History

Revision Date	Rev number	Summary of changes	Sections	Reviser(s)
11/3/03	1	First draft of SOP	all	D. Bilhimer
2/26/2007	1.2	Incorporated internal comments	all	D. Bilhimer
4/2/2008	2.0	Extensive changes. Incorporated Forests and Fish unit methods. Added site file management section. Extensively updated technical methods	all	A. Stohr
5/06/2008	2.1	Minor changes. Incorporated Jack and James comments from version 2.0 draft	all	A. Stohr

Environmental Assessment Program

Standard Operating Procedures for the computer analysis of hemispherical digital images collected as part of a temperature Total Maximum Daily Load (TMDL) or Forests and Fish Unit technical study.

1.0 Purpose and Scope

1.1 The objective of this analysis is to estimate total radiation load, canopy cover, and effective shade from photographs taken with a hemispherical fish-eye adapter lens.

1.2 Hemispherical digital photographs are taken looking upwards from beneath the plant canopy, using a 180° fish-eye lens and digital camera. Images are generally taken under the riparian canopy or in the middle of a stream channel. The HemiView© software application is used with these images to determine total solar radiation, canopy cover, and effective shade for a time period selected by the user.

1.3 To perform the analysis, HemiView© converts the full color hemispherical photo to a two-color image where black pixels represent shading vegetation and topography, and white pixels represent sky pixels. Whether a pixel is assigned a shade or sky value is determined by its brightness and color values. The purpose of image processing is to "tune" the hemispherical photo so that shading vegetation that might have a high enough brightness and/or color value to be classified as sky can be diminished and can correctly be classified as shade. Also, portions of the sky that are blue, in an otherwise cloudy sky may be incorrectly classified as shade and these can also be corrected.

1.4 The HemiView© manual suggests that the best photographs are gathered under evenly overcast skies or early in the morning before the sun is present in the picture. Because of uncontrollable weather conditions and many clear sunny days during the summer months when hemispherical photos are typically taken, there may be poor contrast between the riparian vegetation and the sky or the solar disk may be present in the photograph. Raw images from the field may need some image corrections before they can be analyzed using the HemiView© software.

1.5 Analysis generally follows this sequence:

1.5.1 Acquire photos and site-specific station data (using SOP# EAP045)

1.5.2 Decide which pictures will be used and create a station/site file for each location.

1.5.3 View image in HemiView© and decide whether photo editing is needed

1.5.4 Using Adobe Photoshop (or other photo editing software) correct glare and code ignored regions. Save edited image to a new file name.

1.5.5 Classify image to a two color, shade/sky image using the threshold value.

1.5.6 Compile, confirm, and save settings to a .hvs file.

1.5.7 Calculate output values.

1.5.8 Compile output Excel sheets.

1.6 Effective shade values calculated from field collected hemispherical photos can be compared to values estimated with the computer model, SHADE. During TMDL analysis, the model SHADE is typically used to estimate effective shade resulting from riparian vegetation. The model usually calculates shade at 100 meter intervals along a stream. Effective shade values generated for Hemispherical photos taken in the middle of a stream channel give a field measured value to compare against the model generated value. The 1-visible sky fraction from HemiView© photos taken under the riparian canopy, can be used as the vegetation density input to the computer model SHADE.

2.0 Applicability

2.1 This procedure applies to all hemispherical photo analysis conducted under a stream temperature TMDL. This procedure includes instructions for Forests and Fish staff who generally take photos in small, steep, headwater stream areas. The procedure is general enough to apply to other situations with only minimal changes to meet a project's unique objectives.

3.0 Definitions

3.1 **Effective Shade:** fraction of total possible solar radiation above the vegetation and topography that is blocked from reaching the surface of the stream and summed over a full day. The effective shade at a particular location (the location of the hemispherical photo) can be calculated, using HemiView©, for any day of the year. Because the solar path across the sky changes each day, the solar exposure a particular location receives will also change each day. Note: To date, studies have covered deciduous "leaf on" portions of the year. For winter analysis, it would not be appropriate to run a winter "leaf off" date with a summer deciduous canopy photo.

3.2 **Canopy Cover:** The percentage of the sky that is blocked by vegetation or topography. Unlike effective shade, this is a largely static quantity (assuming no wind) between full leaf expansion and leaf drop. This value can be measured by a densiometer. The 1-VisSky value calculated by the HemiView© software is the canopy cover.

3.3 **Hemispherical photo:** A hemispherical digital picture. A hemispherical photo is a permanent record of canopy condition.

3.4 **HemiView©:** A proprietary computer software package for the analysis of hemispherical digital images. This software can be found at: http://www.dynamax.com/hemiview.htm

3.5 **Riparian vegetation:** Vegetation occurring along stream corridors.

3.6 **SHADE**: A computer program used by Ecology to estimate stream center effective shade from riparian vegetation and stream channel maps.

3.7 **Thermistor:** A temperature data logger

3.8 **TMDL**: Total Maximum Daily Load

4.0 Personnel Qualifications/Responsibilities

4.1 Persons involved in the field data collection and analysis must have experience and training in the natural, environmental or physical sciences. Relevant computer skills needed for this procedure include the following software packages: HemiView©, Adobe Photoshop Elements, and Microsoft Excel.

4.2 Natural Resource Scientist 1/2/3, Environmental Engineer 1/2/3, Environmental Specialist 1/2/3/4/5, Hydrogeologist 1/2/3/4, Administrative Intern 1/2/3

5.0 Equipment, Reagents, and Supplies

5.1 The analyst must have access to the following computer software: HemiView©, an image processing program such as Adobe Photoshop Elements©, and Microsoft Excel. This procedure assumes the hemispherical photos have already been collected under the standard operating protocol for hemispherical digital photography field surveys. That protocol covers all equipment necessary to acquire the hemispherical photos.

6.0 Summary of Procedure

6.1 Define sites (stations) in HemiView©. For Forests and Fish staff this should be the first step. For TMDL staff, this can be done first or during step 6.4 HemiView© analysis settings. It is acceptable to have more than one photo assigned to each site. For example, TMDL staff often have three photos assigned to each site, these are C= center of stream, LB = riparian zone on the left bank, RB = riparian zone on the right bank.

6.1.1 Some general information about the HemiView© site file is true for all users. Each station/site/photo will need the following information: name, description, latitude (in decimal degrees), longitude, altitude (meters), and magnetic declination (degrees). (Figure 1) You must enter this information in HemiView© through a data entry screen for each individual station. This site location information will be saved to a file called sites.csv that is kept in your C: drive at the location where HemiView© software isinstalled. The default location is C:\Program Files\Delta-T\HemiView\sites.csv. This file will continue to grow larger as you add stations each year. If the HemiView©

software is reinstalled on your computer, the sites.csv file will be reset to the initial file that came with the software. Figure 1 shows the sites.csv file with the seven stations that come with the software plus two added by Ecology. Attempts to directly edit this file to add stations, resulted in a .csv file that was not usable by HemiView©.

HemiView Sites File, version 2					
SiteName	Description	Lat	Long	Alt	Decl
Burwell	Cambridge UK: home of Delt	52.27	0.32	15	-3
Lawrence	Kansas USA: home of HEMI	40	-95	200	4
Brisbane	Australia: a site in the southe	-27.5	153	10	11
Reykjavik	Iceland: a site with a large m	64	-22	20	-19
Arctic	Severnaya Zemlya, Siberia	80	100	0	33
Antarctic	South Pole station	-89.9	180	1500	152
Equatorial	Galapagos	-1	-92	10	6.3
T11apxDayton	dayton	46.22	-118.3	200	-3
sno36.3test	hemi in the middle of the stre	47	121.3	15	3

Figure 1. Example of the HemiView© sites.csv file.

6.1.1.1 For Forests and Fish staff, all descriptive data for each station is compiled into a spreadsheet/dbf file. Fields to include in this file should include HemiView© settings such as lens and solar model type, elevation, declination, azimuth and zenith angles, image id, etc. Treat this file as though it will be imported into db format—e.g., limit field codes to about eight characters, do not use spaces in field codes, etc. Arrange fields in logical order—e.g., region, stand, segment, station, etc. An example file format is shown in Appendix Table A-1. Additional examples and information are available from Jack Janisch. Jack's y:directory has examples of the 2004 format that can be copied and adapted to your purpose

6.1.1.2 For TMDL staff wanting to set up the stations in advance, it is easiest to get all of the station data together in an Excel file. The file can be printed to make in easier to enter into HemiView©.

6.1.1.2.1 First, make a backup copy of the sites.csv file in C:\Program Files\Delta-T\HemiView\sites.csv. e.g. copy and paste the file to the same directory. This will create a second copy named "copy of sites.csv".

6.1.1.2.2 Second, create the Excel file. This can be done either with an existing Excel file (you may already have one with latitude and longitude coordinates for each site), or with one that you can create by opening the sites.csv file in Excel. This would look like Figure 1 above. If you create your Excel file by opening the sites.csv file, remember to 'Save As' to a new name. Add all of your stations and location information. This should include: SiteName, Description, Latitude (decimal degrees), Longitude, Altitude (meters), and Declination). See section 6.1.2.4 for information on how to find declination values. Note: Forests and Fish staff will enter 0 for declination, because they adjust for this during their field data collection. When all station information is complete, 'Save As' to the directory where your photos are. This spreadsheet may be printed and is available for you to reference during data entry through HemiView©.

6.1.2 In HemiView© Select SETTINGS<SITE<NEW. To geographically orient the hemispherical photo with the expected sun path, the location of that image must be defined. Enter site data using the site properties form by selecting from the command bar SETTINGS<SITE<NEW (see Figure 2). Each site should have:

6.1.2.1 Name to link the picture to a location or monitoring station on the river.

6.1.2.2 Latitude and longitude in decimal degrees.

6.1.2.3 Elevation (meters).

6.1.2.4 Magnetic declination for that site. Magnetic declination can be calculated using the calculator at: http://www.ngdc.noaa.gov/seg/geomag/magfield.shtml. The direction of magnetic declination is east of north and recorded as decimal degrees. Decimal degrees equal the degrees + minutes/60, for example 17º 22´ E becomes 17.37º E.

6.1.2.5 Magnetic declination for Forests and Fish work should be set to zero, because it was corrected for when the photos were taken

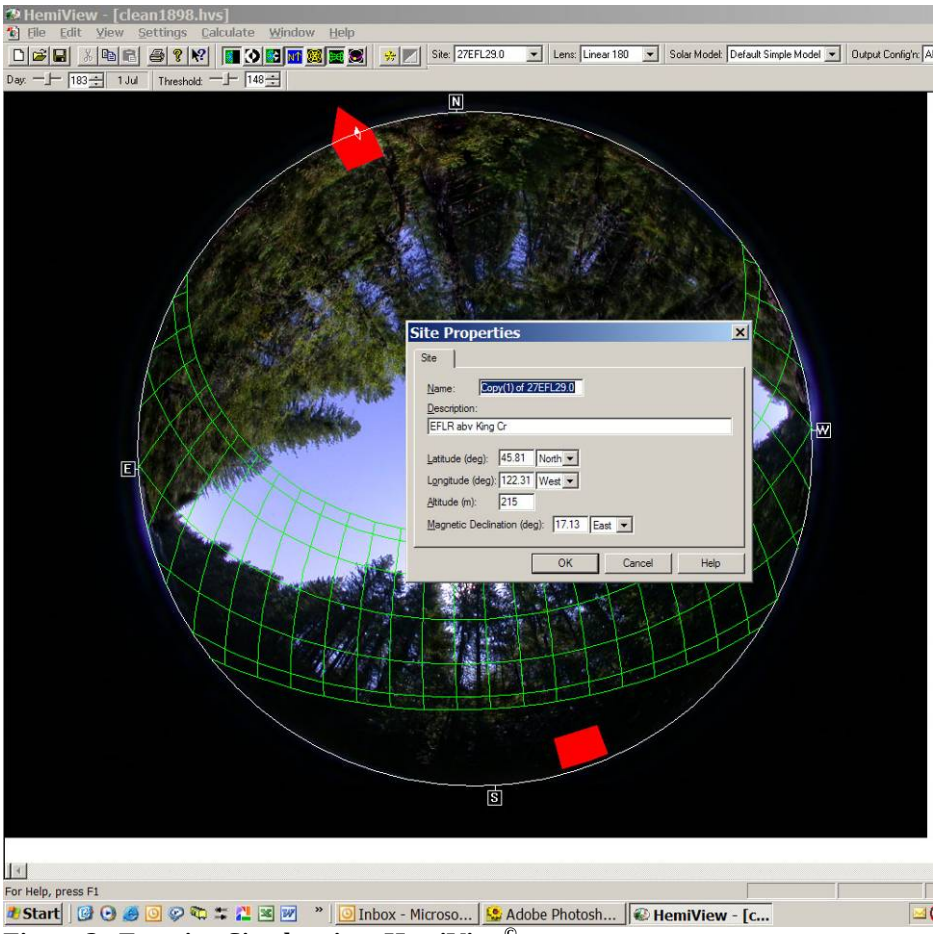

Figure 2. Entering Site data into HemiView©.

6.1.3 Put a copy of your site file in the directory where your project HemiView© photos are stored. This will ensure that you keep a permanent copy of your site files with your photos and that it will not be overwritten by new installs of software. This copy should be uniquely named for the basin or project on which you are working e.g. basin_sites.csv. This will avoid confusion with the sites.csv file that HemiView© can only access through the installation directory.

6.2 **Initial HemiView© Photo Evaluation.** View image in HemiView© and decide whether photo editing in Adobe Photoshop (Step 6.3) is needed for proper classification.

6.2.1 Open an image in HemiView©. The image will open and need to be resized by selecting from the command bar VIEW<50%.

6.2.2 Select SETTINGS<CLASSIFIER SETTINGS from the command bar and set the color to ignore as Red 255, Green 0, Blue 0, and check the box as shown in figure 3.

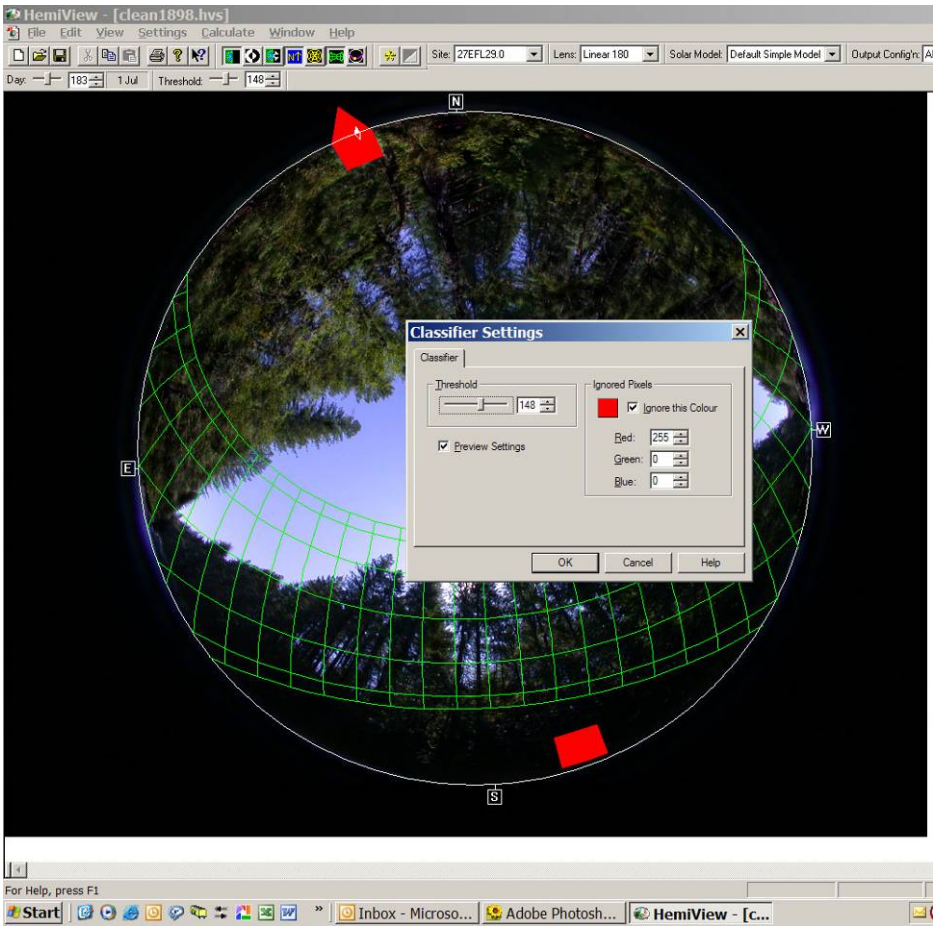

Figure 3. Classifier settings in HemiView©.

6.2.3 Turn on the classified image by selecting VIEW<CLASSIFIED from the command bar or click on the toolbar button that looks like a half color and half black & white snowflake. It is this image view upon which HemiView© bases its calculations. The task is to

assess whether HemiView© is classifying the image properly and, if not, adjust as necessary with Adobe Photoshop in step 6.3.Adjust the threshold level so that the shading vegetation is properly represented by the black pixels and that the sky is also properly characterized by the white pixels (see Figure 4). Flip back and forth between the full-color image and the classified image to see how well the software is classifying it. Whether a pixel is assigned a shade or sky value is determined by its brightness and color values.

6.2.4 When the solar disc is present in the photo, adjusting threshold may not correct the image without substantial loss elsewhere. So, examine the solar disk first. If the program classifies the solar disc correctly as sky then move on to check the horizon and other features.

6.2.5 Sometimes it is more difficult to get a proper threshold setting near the image horizon. If you cannot find a threshold setting that properly classifies the image, then rework the pixel brightness in Photoshop Elements and try it again in Hemiview.

6.2.6 If HemiView© correctly classifies the sky (white) vs. shading features (black) with no photo editing, then save or move a copy of the image to the final_HemiView folder (see Records Management section 7.0), skip the image processing step 6.3 and move directly to HemiView© analysis, step 6.4.

6.2.7 If the solar disc, blue and cloudy sky, or other features are causing the photo to be classified incorrectly then move to step 6.3 and edit the image.

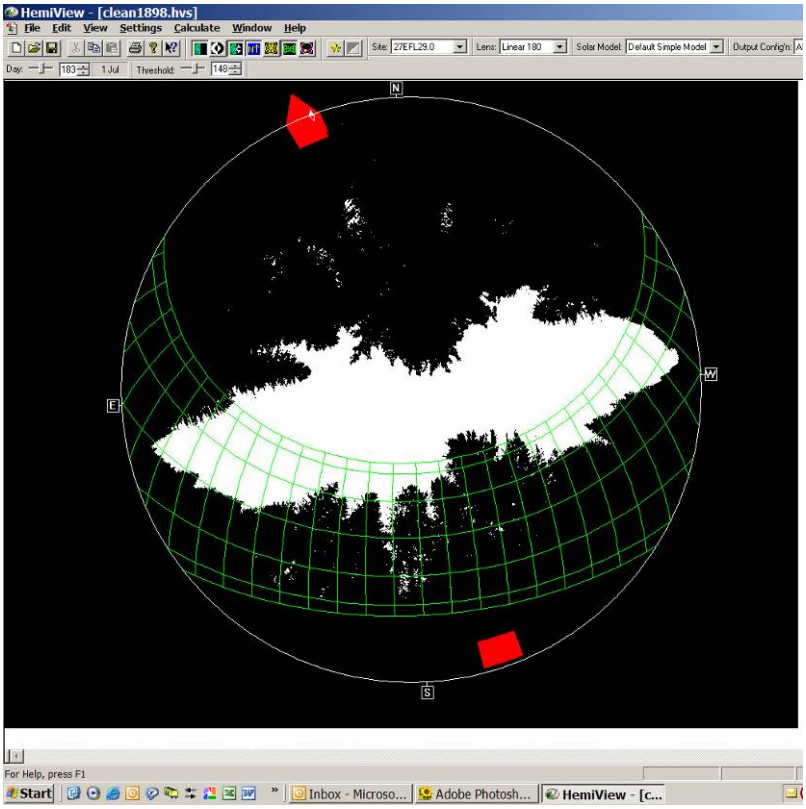

Figure 4. A classified hemispherical photo with an appropriate threshold setting.

6.3 **Image Processing in Adobe Photoshop.** The image processing procedure uses Adobe Photoshop elements to correct color and brightness problems with the original image if HemiView© is not classifying it correctly. Generally, the less editing and fewer decisions we make about classification the better. There are a range of revision tools in Adobe Photoshop Elements so pick one that works without being heavy-handed.

6.3.1 Open your original hemispherical photo in Adobe Photoshop Elements. Save your image with a new name such as, DSCN0298clean.tif, in the TIFF file format.

6.3.2 Photo editing suggestions from TMDL staff.

6.3.2.1 Select the magic wand tool from the tool bar (see figure 5) and move the wand into the sky portion of the image.

Figure 5. Magic wand tool in Photoshop Elements.

6.3.2.1.1 The magic wand tool selects pixels of color based on the color values of neighboring pixels. Using this tool allows you to select the sky pixels around the complicated shapes of riparian vegetation. Hold the SHIFT key and click the left mouse button several times while in different parts of the sky to select as much of the sky as you can (see Figure 6 for example)

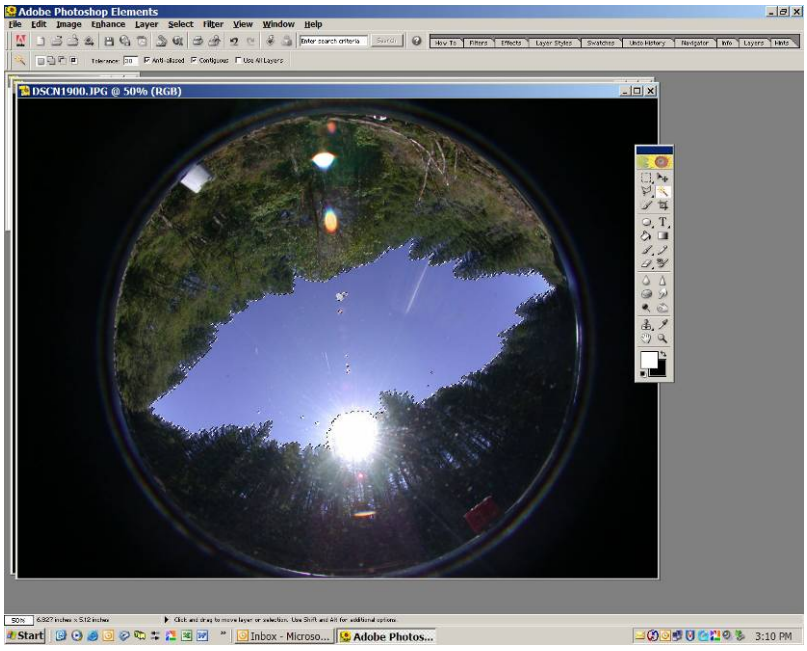

Figure 6. Using the magic wand tool to select the sky pixels. The sky pixel selection follows the outline of the tree canopy with a dashed line.

6.3.2.2 Select the brightness/contrast control menu from the command bar as shown in Figure 7.

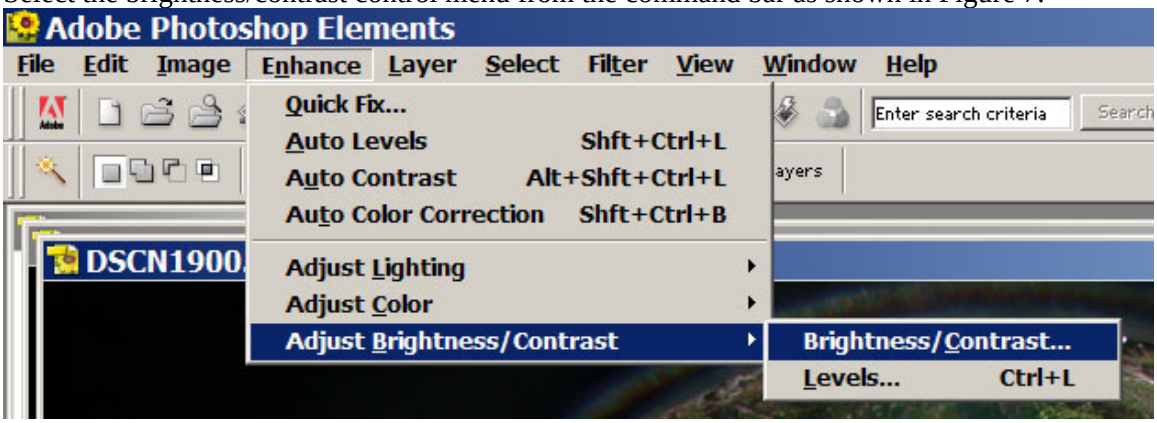

Figure 7. The adjust brightness/contrast menu.

6.3.2.2.1 This will open the tool with slider controls for brightness and contrast. Adjust the sky pixel brightness so that it is a very high value. In HemiView© the sky pixels have the highest brightness values. Adjusted sky pixels should look something like the example in Figure 8. Often the solar disc can also be dealt with by simply copying a section of sky and pasting over it.

Figure 8. Sky pixels brightened.

6.3.2.3 Besides the magic wand tool there are other selection tools that are also useful. The polygon selection tool is very useful for masking the image orientation markers. Here are some common tools that may come in handy (use the help function in Elements to learn more about using each tool):

6.3.2.3.1 *Dodge and burn tools*, for brightening or darkening pixels similar to the brightness controls only it functions as a paintbrush style that you can freehand with the mouse.

6.3.2.3.2 *Stamp tool,* for cloning other parts of the image using the mouse. This can be useful for covering up anomalies such as sun glare (bright spots with riparian vegetation behind it); basically covering up what HemiView© would incorrectly interpret as sky and making sure the pixels are classified as shading vegetation. This can also be helpful for removing the little dark "bubbles" that show up sometimes when adjusting the sky brightness using the magic wand tool.

6.3.2.3.3 *Paint brush tool,* useful for removing highlights on tree trunks or sun flares by painting a black color over the part of the image that is definitely vegetation or some other shading feature.

6.3.2.3.4 *Note: Don't create vegetation in the image where there is none now. If sun flares or hotspots have obscured the canopy any touchups should be minimal and an assessment of whether or not to analyze the picture should be considered.*

6.3.2.4 The next step is to mask the north/south orientation markers. Before you begin, check to see if this step is necessary by opening the image in HemiView© (see 6.2). Notice the influence of the orientation markers when toggling between the 'classified' and 'normal' views. If the orientation markers do not influence the 'classified' image, then skip to 6.3.3. Typically the area occupied by markers in the photo is small (< a few percent) and they lie on the image perimeter. Thus HemiView© will categorize them as shade or vegetation. If the orientation markers add an artificial component, then proceed with the following directions.

6.3.2.4.1 Use the polygon selector tool to select around each marker (see Figure 9).

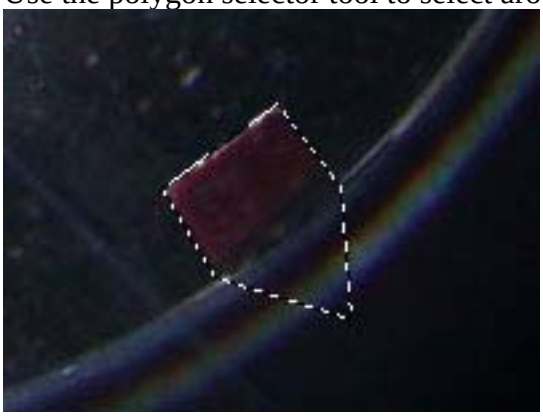

Figure 9. North orientation marker selected for masking.

6.3.2.4.2 Use the paint can and paint brush tools to paint the stencil color inside the polygon selection. Using the selector tool ensures that you change the color values only of the marker itself. Use stencil color value of Red 255, Green 0, and Blue 0. Paint the north marker with a pointed end to separate it from the south marker (figure 10). Check the field notes to determine if the red or the white marker was used for north. If it wasn't recorded it should be easy to determine the southern direction by which marker is closer to the sun.

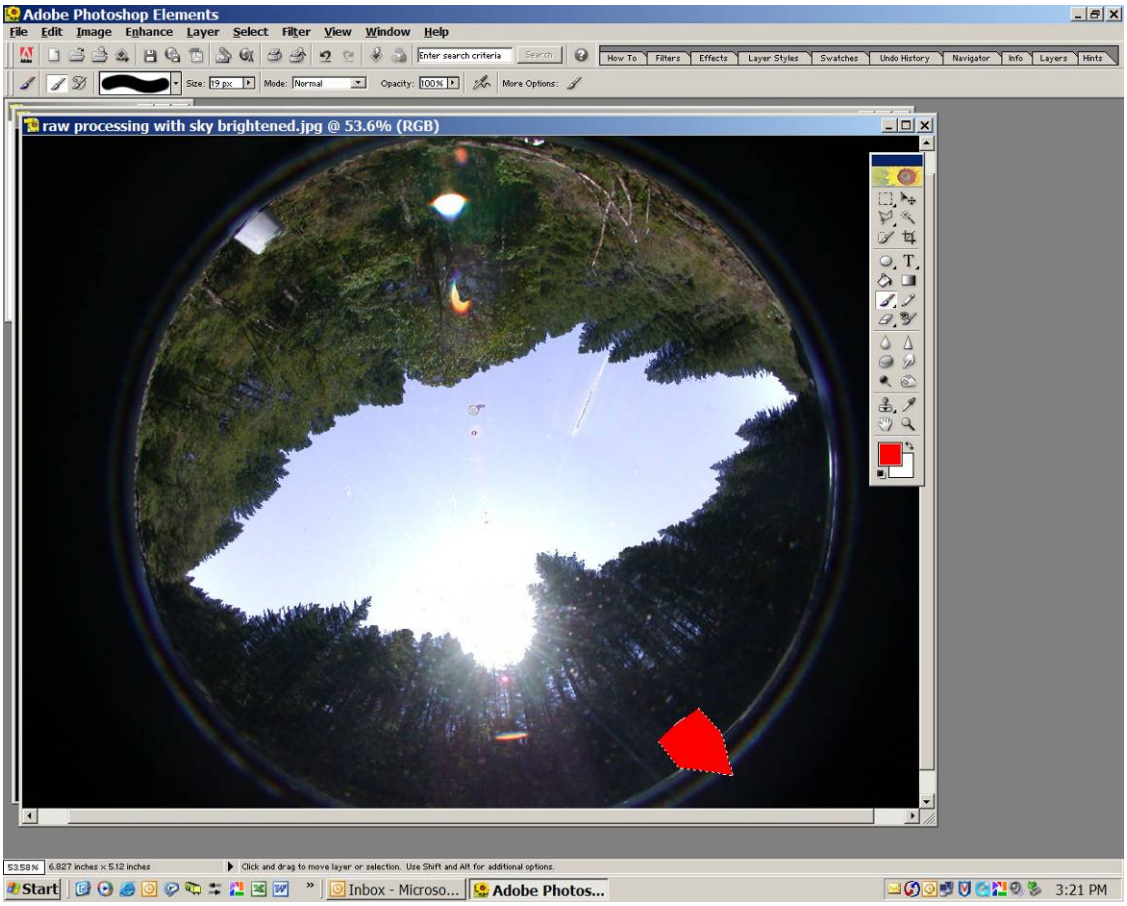

Figure 10. Masking orientation markers.

6.3.3 Photo Editing suggestions from Forests and Fish staff

6.3.3.1 When the solar disc is present in the photo, adjusting threshold may not correct the image without substantial loss elsewhere. So, examine the solar disk first. If the program classifies the solar disc correctly as sky then move on to glare and other corrections. Otherwise, the solar disc can often be masked by darkening the image slightly, then copying and pasting a small section taken from elsewhere in the image. This reduces the contrast enough to split out vegetation from sky without drastic alteration of other settings. It also preserves image fine structure, often lost when the spray can or other heavy handed editing techniques are used. Generally, the less editing and fewer decisions we make about classification the better. Briefly describe your edits and record them as QA, along with threshold, in the spreadsheet.

6.3.3.2 Now examine the image for glare. For example, on sunny days, glare on tree trunks will be classified as sky. As with the solar disc, small sections of the image can be copied elsewhere to preserve the general stand structure. Sometimes odd reflections also show up in the image so approach them the same way.

6.3.3.3 Then move on to foliage. If the threshold is too low, light flecks will show up as vegetation. If too high, foliage edges will wash out and be classified as sky. Focus on conifer foliage in the mid taurus of the image because the distortion is generally higher at the photo perimeter and foliage may be washed out at zenith. Then adjust the sky/vegetation threshold to a value between full opacity and full transparency of the conifer foliage, toggling between the actual image and classified image. Zoom in and out as needed. Try to balance over-estimation of direct overhead canopy gaps and under-estimation of perimeter canopy gaps overall. For a through discussion of this, see the HemiView© help file.

6.3.3.4 Finally, sometimes hardhats and other objects are caught in the photos. If these objects fall inside deep shade, then they probably don't require action because HemiView© would treat the region they block as shade anyway. On the other hand, objects that block sun flecks should be coded so that the software ignores that section of the image. Coding requires that the corrected photo be saved in a non-compressed format such as tiff. If more than a few percent of the image are blocked (for example, a hand over the lens), the image is not usable.

6.3.4 Once the desired balance of brightness and anomalies has been reached, select FILE<SAVE AS and convert the image to a .tif file format with no file compression. Using the .tif format keeps the orientation markers the correct color value for the classifier in HemiView©.

6.3.5 Once editing is complete, select a threshold value as described above. Record the setting for use in the analysis. The threshold value is also recorded automatically in the HemiView© output sheets.

6.4 **HemiView© Analysis Settings.** Open the processed image in HemiView©. The image will open and need to be resized by selecting from the command bar VIEW<50%.

6.4.1 Select SETTINGS<CLASSIFIER SETTINGS from the command bar and set the color to ignore as Red 255, Green 0, Blue 0, and check the box as shown in Figure 11.

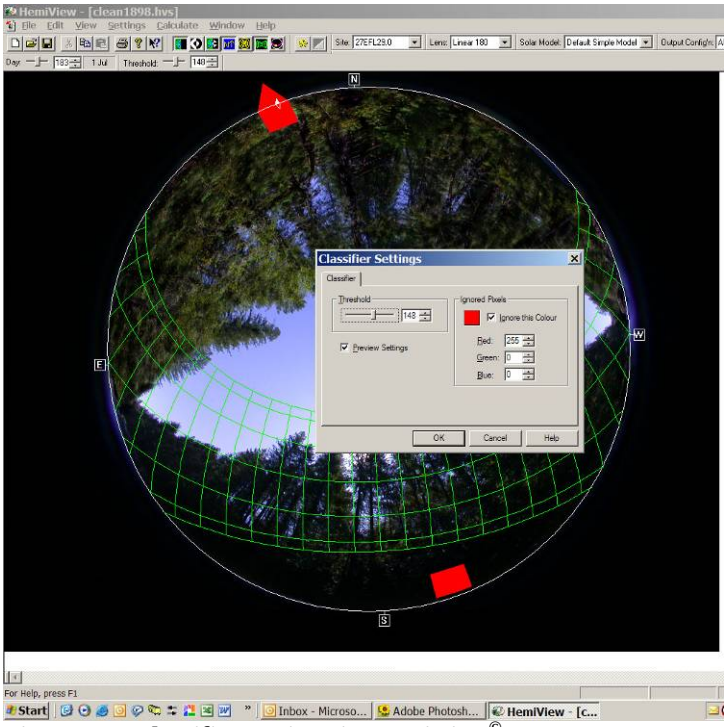

Figure 11. **Classifier settings in HemiView©.**

6.4.2 If the image was worked in Photoshop, the threshold value needs to be selected now. Follow the procedure outlined in steps 6.2.3 to 6.2.7 to select a threshold value.

6.4.3 To geographically orient the hemispherical photo with the expected sun path, the location of that image must be defined. Select the site using SETTINGS<SITE<SELECT. If the site has not been entered, enter site data using the procedure outlined in step 6.1.2.

6.4.4 The next step is to orient the image to true north. Determine which marker was north on the platform (red or white).

6.4.5 Turn on alignment by clicking on the blue N up arrow marker. Then rotate the white alignment ring to center the diamond shape (near the N) with the camera platform north marker (Figure 12). The diamond shape is magnetic north and defines north for HemiView©. Notice that an east declination adjustment causes the diamond to be left of north because the camera points upward. If the declination is 0, the N marker and the diamond should align. Try changing the declination to a different value to see the effect.

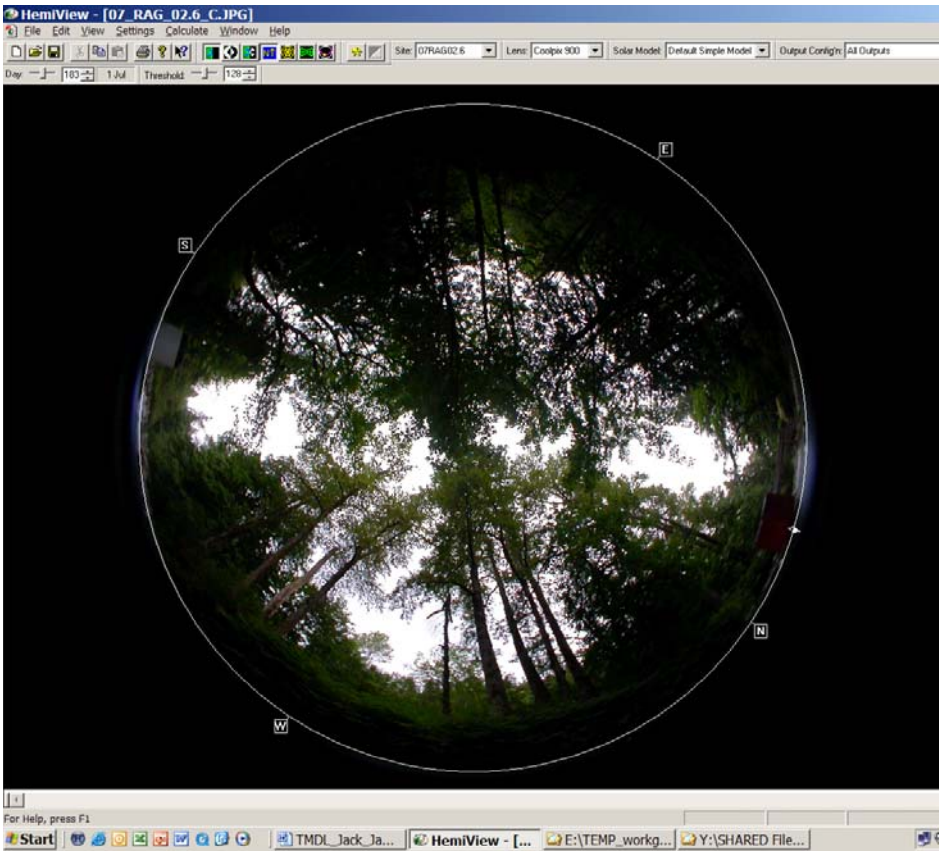

Figure 12. Align image in HemiView©.

6.4.6 The alignment ring diameter can be changed. Adjust if needed so that it approximately follows the edge of the photo. This defines the horizon for HemiView©.

6.4.7 open settings>skymap. set azimuth=8 and zenith=18. This sets the number of sectors.

6.4.8 open settings>intercepting surface.

6.4.8.1 For Forests and Fish steep headwater streams only: set azimuth=degrees aspect and zenith=degrees slope. This adjusts the calculations for an inclined surface and direction the slope faces. Check single sided.

6.4.8.2 TMDL settings are 0 azimuth, 0 slope, and single sided.

6.4.9 Select SETTINGS<DAYTRACK to enter the day and time series increment for which you want to run this analysis (for example the modeling day or the critical temperature day at 10 or 15 minute intervals) or by adjusting the day slider on the toolbar. Many TMDL projects use August 1st (day 213 or day 214) as the day to set load allocations because it is a mid-point for the July/August time period which has typically been the critical time period for water temperature.

6.4.10 Instructions for Forests and Fish: as a quirk of HemiView©, the software doesn't calculate indirect radiation via its time series engine. The time series engine is used when summing radiation for a series of days instead of for just one day. So, when there is interest in this quantity, use the long time interval engine, which calculates radiation, loads on a monthly scale. Using this method, monthly radiation loads are divided by number of days per month to estimate daily average. The analyst has to watch the boundaries for blocks of days because they are tied solar patterns such as solstice. Otherwise, however, calculations between the two methods are similar, what the day track toolbar used to select Julian dates. Thus the user has a choice between direct values only via time series or direct+indirect radiation load.

6.4.11 Select lens either from the command bar or from Settings \ Lens \. Select Coolpix 900. This identifies the lens and correction coefficients. This is the current program default.

6.4.12 open settings>solar model. Select default simple solar model. Set diffusion =uniform overcast sky distribution. The light diffusion model assumes equal amounts of diffuse radiation originate from all sky directions. confirm units = W m^{-2} and solar flux = 1370. These are the current HemiView© program defaults. Note that the HemiView© solar model best approximates that of a cloudless day.

6.4.13 The Output configuration can remain at the default setting for TMDL work. Although not all outputs are currently used, removing some outputs doesn't affect the calculation time much and may be useful for some other purpose in the future. For Forests and Fish staff, a subset of the outputs are run and will be discussed in 6.5.2 below.

6.4.14 Select FILE<SAVE from the command bar and save the .hvs (HemiView© settings file) in the same folder as your processed images. This preserves the settings not the image. name the file as for the image so you can find it easily.

6.4.15 Repeat the HemiView© Analysis Process above for each image. Once you've looked at all the images and created their associated .hvs files it is time to run the calculations.

6.5 **HemiView© Analysis Calculations:**

6.5.1 TMDL staff will run calculations for "All Outputs: SETTINGS>Output Configuration>Configuration>All Outputs. The Output Sheets and Values Sheets all are checked for inclusion. TMDL staff should skip step 6.5.2.

6.5.2 Forests and Fish staff will run a subset of the calculations. Configure the summary file to include only worksheets relevant to total radiation load. For example, we are not using global, indirect, or other site factors so we do not need to include these. The summary file should include:

6.5.2.1 corrected values
6.5.2.2 above canopy values, direct and diffuse
6.5.2.3 below canopy values, direct and diffuse

6.5.2.4 overall values
6.5.2.5 visible sky
6.5.2.6 ground cover
6.5.2.7 use cosine corrected values only. Uncorrected values are estimates of total brightness. The cosine correction best models how light is absorbed by a surface.
6.5.2.8 use a single-sided leaf surface model

6.5.2.9 When satisfied with all settings, open settings>output sheets. All sheets checked will be exported during calculations. Be certain the following are checked: a) VALUES, DIFFMONTH, DIFFAB, DIFFBE, DIRAB, DIRBE. Total canopy or image results are summarized in the Values worksheet. ISF= Indirect site factor, defined as proportion of diffuse solar radiation reaching a site relative to a fully open (no canopy) site. GSF= proportion of global radiation under a plant canopy relative to a fully open site. DSF= proportion of direct solar radiation reaching a site relative to a fully open site. Initially you might include SUMMARY, IMAGE, SITE, and COMMENTS but check the output. If this does not supply anything useful there is no need to export them. Also open settings>values sheet. This controls what values are exported per sheet. In addition to all direct radiation categories, also export VISSKY and GNDCOVER. Finally, when ready choose the Calculate icon from the command bar. This generates a multi-page spreadsheet summarizing the image by sector. Additional quantities such as LAI can be exported. The model used to predict LAI may be inappropriate for mixed forest canopy, however.

6.5.3 Work on one image at a time, open the .hvs file and it will bring up all the settings HemiView© needs to analyze the hemispherical photo. Select CALCULATE from the command bar or click on the calculate button (it looks like a yellow snowflake button on the toolbar) and the software will run through all of the calculations specified in the output configuration. Enter a short description in the comments field to help describe the hemispherical photo location in the results spreadsheet (see Figure 13).

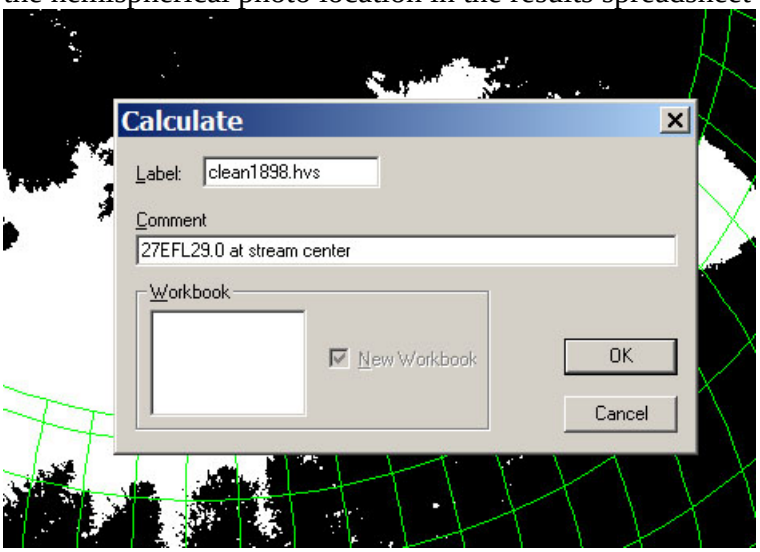

Figure 13. Calculate dialog box in HemiView©.

6.5.4 Once the calculations have been completed you will see a spreadsheet very similar in appearance to an Excel spreadsheet. Each time you run the calculate function it will append the new results to the end of the previous calculations. If the HemiView© program is closed and later re-opened, results will be added by default to a new spreadsheet. To append results to an existing spreadsheet, select the spreadsheet from FILE<OPEN< type .xls before running calculations with new images.

6.6 Additional Calculations with HemiView© Output files.

6.6.1 Forests and Fish staff calculations - VISSKY can be read directly from the values page. To estimate total radiation load, diffuse and direct above- and below-canopy fractions must be summed in various ways. For each month in the analysis period (May-September), do the following:

6.6.1.1 begin with direct radiation, DIRAB and DIRBE. These are totaled in the workbook by month. For each month of interest, divide the monthly value by # of days in each month for both the above- and below- canopy fractions.

6.6.1.2 for DIFFAB and DIFFBE, begin with the annual values sheet. Apportion these annual totals using the monthly proportions found in the DIFMONTH sheet. Divide the result by the number of days in each month* of interest. As above, apply this method for both above- and below- canopy fractions. The units should W m^{-2}.

6.6.1.3 If applying meteorological data, apply the corrections by recalculating radiation loads for at least one photo per stand, setting slope=0. The correction factor is the difference between loads on the inclined surface vs. the flat surface.

6.6.1.4 Calculate canopy cover as 1-VISSKY. Convert to percent as needed.

6.6.1.5 *: HemiView© divides the year into 12 periods (months) that have approximately equal lengths. Because HemiView© calculates based on whole days, the month boundaries must be at midnight. The beginnings of months 1 and 7 are aligned with the solstices, so each half year covers the sun's track from one extreme to the other. HemiView© calculates month end dates by dividing each half year into 6 equal periods, then using the closest midnight.

6.6.1.6 Process all remaining canopy photos in the same manner and compile results in a spreadsheet or dbf file. Once the data is compiled in the spreadsheet/db file, there is probably no need to keep the many workbooks the program will generate but temporarily store them in a subdirectory for future reference.

6.6.2 TMDL staff calculations - Canopy cover and percent effective shade are the two values most likely to be needed for a temperature TMDL analysis.

6.6.2.1 Calculate canopy cover as 1-VISSKY. Convert to percent as needed

6.6.2.2 Effective shade is the fraction or percentage of incoming solar radiation above the vegetation and topography that is blocked from reaching the surface of the water. Calculate effect shade fraction as 1 – (DIRBE + DIFFBE) / (DIRAB + DIFFAB). Where DIRBE = Direct radiation below canopy; DIFFBE = Diffuse radiation below canopy; DIRAB = Direct radiation above canopy; DIFFAB = Diffuse radiation above canopy. Convert to percent as needed.

7.0 Records Management

7.1 All original hemispherical photos should be maintained in their raw electronic form in one data folder (e.g. named hemi_initial). Copies should be used for the image processing and HemiView© analysis steps and should be kept in a separate data folder (e.g. named hemi_final). Both folders should be kept with the other project files either on a network drive or on your local computer.

7.2 A final copy of the sites.csv file should be stored in the hemi_final directory. The sites.csv file may be shared with other HemiView© users. This file should be renamed so that users know which project sites are contained in that file, e.g. Snoqualmie_sites.csv.

8.0 Quality Control and Quality Assurance Section

8.1 Image processing should not include substantial changes to the image (adding or subtracting vegetation not in the original image would be entirely improper). Any changes made should be consistent with the vegetation in the original image.

8.2 The final spreadsheet output should be reviewed before finalizing to ensure that:

8.2.1 All images were processed correctly using the correct site and image orientation settings.
8.2.2 Any duplicate results or calculations with errors have been removed.
8.2.3 The image was classified with the 255 Red pixels ignored.
8.2.4 The analysis day is correct.

9.0 Safety

9.1 This procedure involves working at a computer in an office setting and no special safety procedures are necessary other than normal office guidelines. Give your eyes a break occasionally from staring at these images.

10.0 References

10.1 Stohr, A. and D. Bilhimer. 2008. Standard Operating Procedures for hemispherical digital photography field surveys conducted as part of a temperature Total Maximum Daily Load (TMDL) or Forests and Fish Unit technical study. EAP045. Environmental Assessment Program, WA Department of Ecology.

10.2 Rich, Paul M., et al. 1999. HemiView© User Manual. Delta-T Devices, Ltd. http://www.delta-t.co.uk/products.html?product2005092818855

Appendix A

Table A-1 Example descriptive data file for Forests and Fish project stations.

YY	REGION_ID	REG CD	STAND_ID	STAND_CD	STREAM	TYPE	STATION	LAT	LONG	THRESHOLD	ASPECT	SLOPE (%)	SLOPE (DEC)	ARCTAN	DEGREE
03	CAPITOL_FOREST	CF	SEESAW	SESA	M	T3	Top	46.93232	123.12258	169	308		0	0.0000	0.0000
03	CAPITOL_FOREST	CF	SEESAW	SESA	M	T3	B	46.93685	123.12361	131	32		0	0.0000	0.0000
03	CAPITOL_FOREST	CF	SEESAW	SESA	A	T5	C	46.93068	123.12269	154	360	30	0.3	0.2915	16.6992
03	CAPITOL_FOREST	CF	SEESAW	SESA	A	T5	P	46.92996	123.12201	154	332	22	0.22	0.2166	12.4074
03	CAPITOL_FOREST	CF	SEESAW	SESA	B	T5	C	46.56181	123.7506	135	342	10	0.1	0.0997	5.7106
03	CAPITOL_FOREST	CF	SEESAW	SESA	B	T5	P	46.56104	123.7449	135	342	15	0.15	0.1489	8.5308