

Suggested Procedure - QAI 366
Convert the scanner-space values to absorbed dose values

Rev 0.3

I. PURPOSE

For use when doing dosimetry on scanned images of GAFCHROMIC[®] dosimetry films.

II. SCOPE

Digitized dosimetry film images contain data related to the amount of light transmitted or reflected from the film at defined locations. This QAI describes the general procedure for converting the scanner-space values (i.e. the values measured by the scanner) to absorbed dose values thereby converting the digitized images to images in dose space.

III. EQUIPMENT AND MATERIALS

1. Exposed sheets of GAFCHROMIC[®] dosimetry film – films should be the same size and from the same lot.
2. One or more sheets of GAFCHROMIC[®] dosimetry film which have been exposed to known radiation doses. A film can contain areas exposed to many different doses. All films should be of the same size and from the same lot as the exposed films above.
3. An unexposed sheet of GAFCHROMIC[®] dosimetry film of the same size and from the same lot as the exposed films above.
4. Film scanner – preferably with 16-bit response capability, but not less than 12-bit response in each measurement channel, e.g. greyscale, RGB.
5. Scanner control software. This is often supplied by the scanner manufacturer. Alternatively software such as ImageAcquisition (www.ispcorp.com) is especially useful with Epson and Microtek flatbed RGB color scanners. Vidar scanners can be controlled with a Twain interface supplied by Vidar, or through the interface of RIT113 software (www.????).
6. Dosimetry or image analysis software, e.g. FilmQA[™] (www.3Cognition.com), Mira AP (www.axres.com), Photoshop (www.adobe.com), Picodose TA (Tecnologie Avanzate, Torino, Italy) having the capability to perform pixel-by-pixel image arithmetic operations, e.g. image addition, subtraction, division, scaling, etc.

IV. PROCEDURE

The procedure that follows describes the use of an Epson Expression 1680 transparency film scanner and Epson Scan software. However, the procedure can easily be adapted to other flatbed scanners and software as well as to scanning done in reflection mode. For Vidar scanners, the procedure provides instructions and guidance where the operation and control of a Vidar scanner differs substantially from that of a flatbed scanner.

Since it will be necessary to perform image arithmetic, it is best to produce a set of scanned images that are all the same size so that mathematic operations can be done on a pixel-by-pixel basis. For example, the pixel value in the first image is divided by the value of the corresponding pixel in the second image.

1. The procedure also requires the use of a scanner flatness correction as described in QAI-365: APPLICATION OF SCANNER FLATNESS CORRECTION TO GAFCHROMIC® DOSIMETRY FILM IMAGES
2. Confirm that the lot number and the size of all the exposed and unexposed films are the same.
3. Determine the orientation of each film so that all films are scanned in the same orientation.
4. Looking at the scanner, the film is placed on a rectangular glass bed. The top and bottom edges are shorter than the sides. The scan starts at the top edge and finishes at the bottom edge. Note that on the Epson Expression 1680 the maximum scan area is smaller than glass bed and is offset to the top right corner. Marks at the top left edge and near the bottom of the sides mark the maximum size of the scan area.
5. Place a film on the glass centered left-to-right in the scan area and at the top of the scan bed.
6. For a Vidar scanner one edge of the film should be registered against the stop at the left side of the feed area. All films must be scanned in the same orientation and with the same defined field size.

The following steps describe the set-up and operation of the Epson Scan software. The procedure provides for the disabling of image adjustment functions, the delineation of the scan area and the saving of these settings so they can be recalled for future use.

7. Steps 7 to 11 describe the procedure for setting up the Epson scanner options for the first time. If this has already been done, skip to Step 12. If using a Vidar scanner, follow the manufacturers directions to set up the scanning options and skip to Step
8. With Epson scanners having a transparency adapter you will see window similar to that in Figure 1 when you scan for the first time. Set the menu options to:
 - “Professional Mode”
 - “Current Setting”
 - “Transparency”
 - “Positive Film”
 - “48-bit Color”

Then:

Enter the spatial resolution desired for scanning. Recommend 75 dpi.
Uncheck the options for “Unsharp Mask Filter” and “Descreening Filter”
In the dropdown menu by the side of “Preview” make sure to check “Normal”

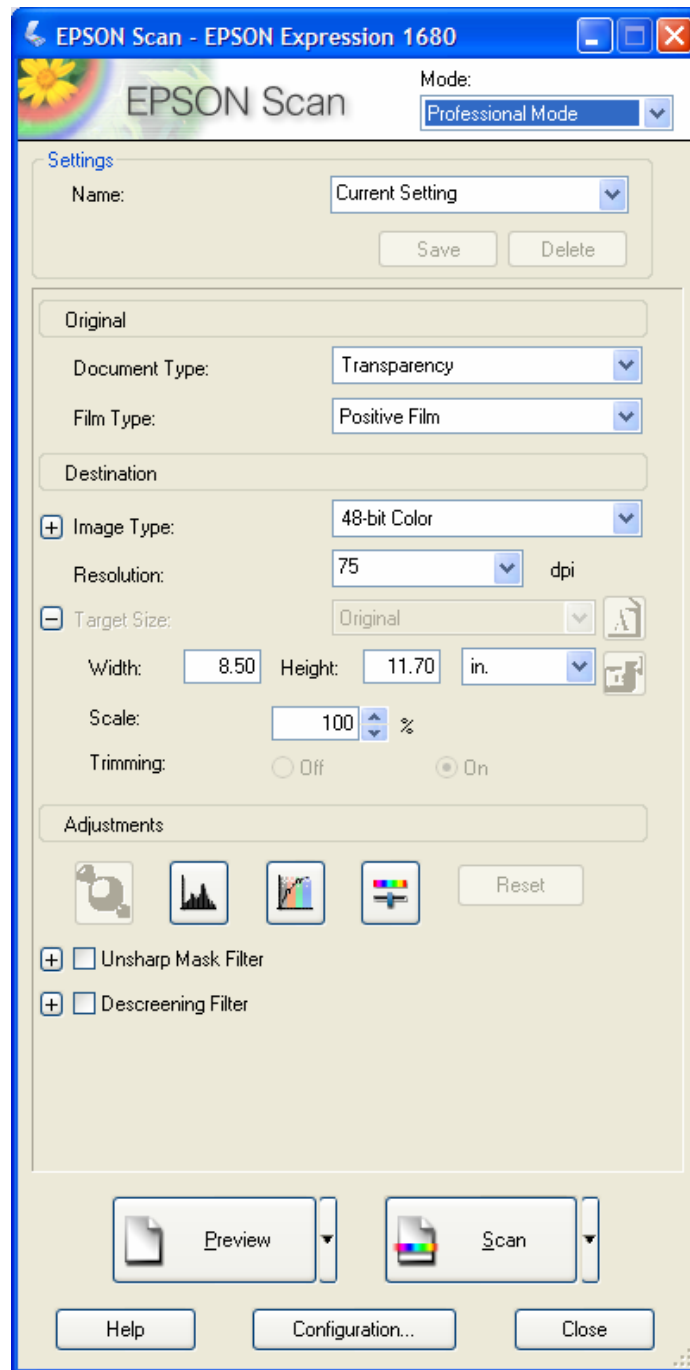


Figure 1

8. Open the “Configuration Window”.

Under the “Color” tab (Figure 2) check “No color correction”

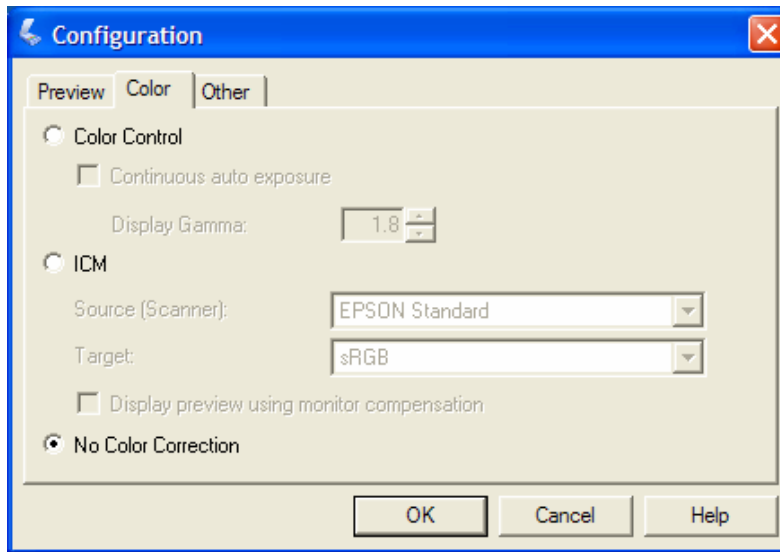


Figure 2

Under the “Other” tab (Figure 3) check “**Save settings**”

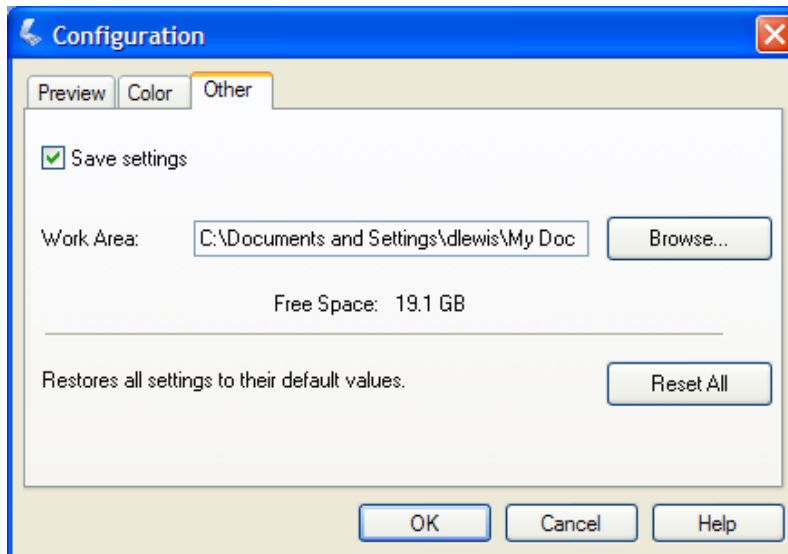


Figure 3

After closing the “Configuration Window” the “Scan Window” should look similar to Figure 4.

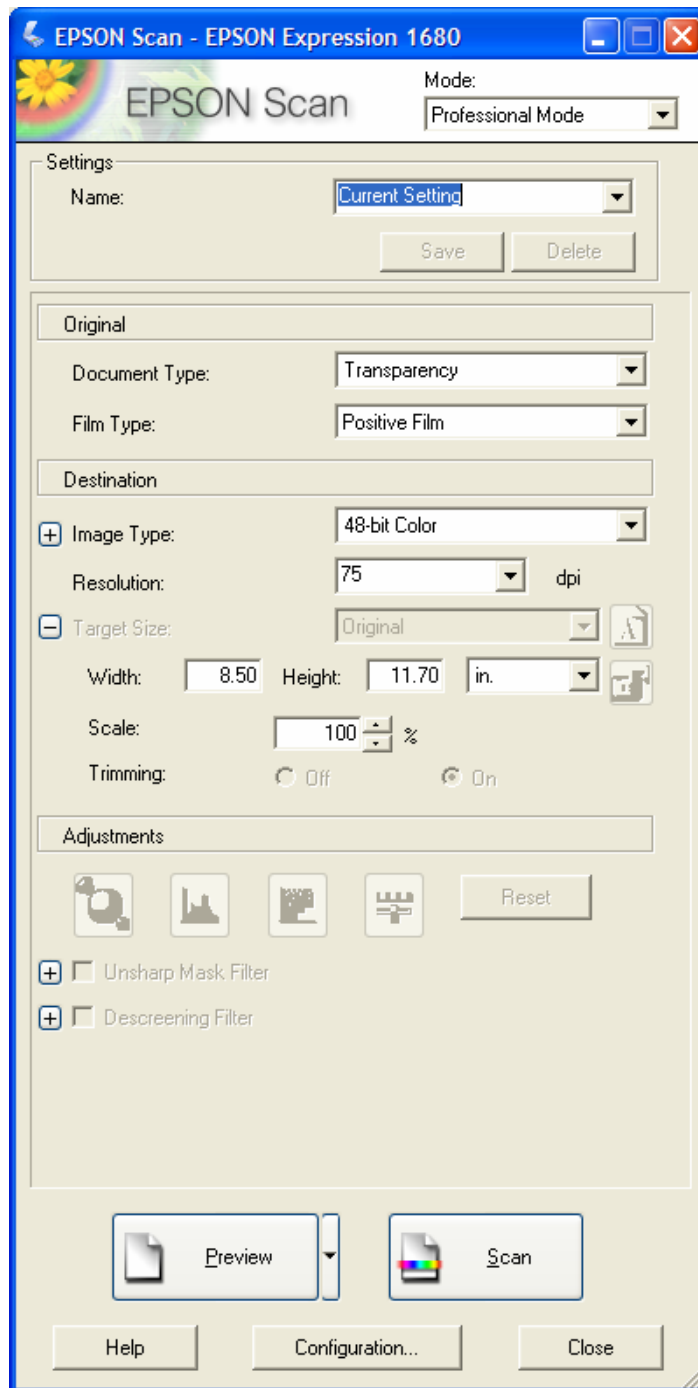


Figure 4

9. With an EBT film placed on the scanner at the top of the scan glass and centered left-to-right, make a “Preview” scan. The “Preview” window will open with the film image. If necessary adjust the position of the film left-to-right to center it and re-take the “Preview” image. In Figure 5 note that in the “Adjustments” area of the left hand window no buttons are activated. They were disabled by unchecking “Continuous auto exposure” and checking “No color correction” in Step 8. Color correction and auto-exposure are **undesirable** for dosimetry because they re-scale the scanner response for each image.

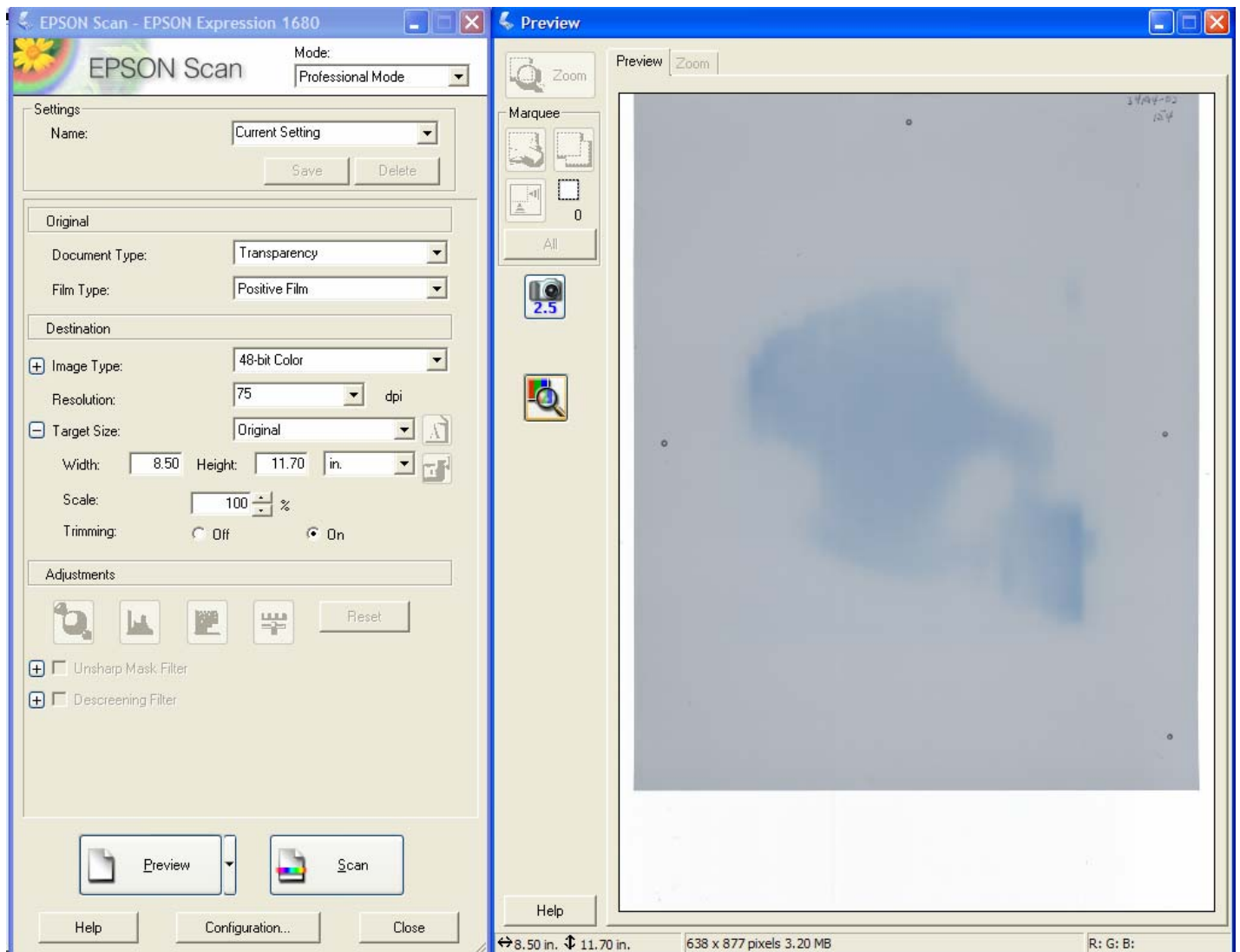


Figure 5

Useful tip: Once the film has been centered, it will help in positioning subsequent films if you mark the border of the scan window to indicate the location of the film edges.

10. Place the cursor in the “Preview” window and draw an area of interest at the border of the film image as shown in the right hand window of Figure 6.

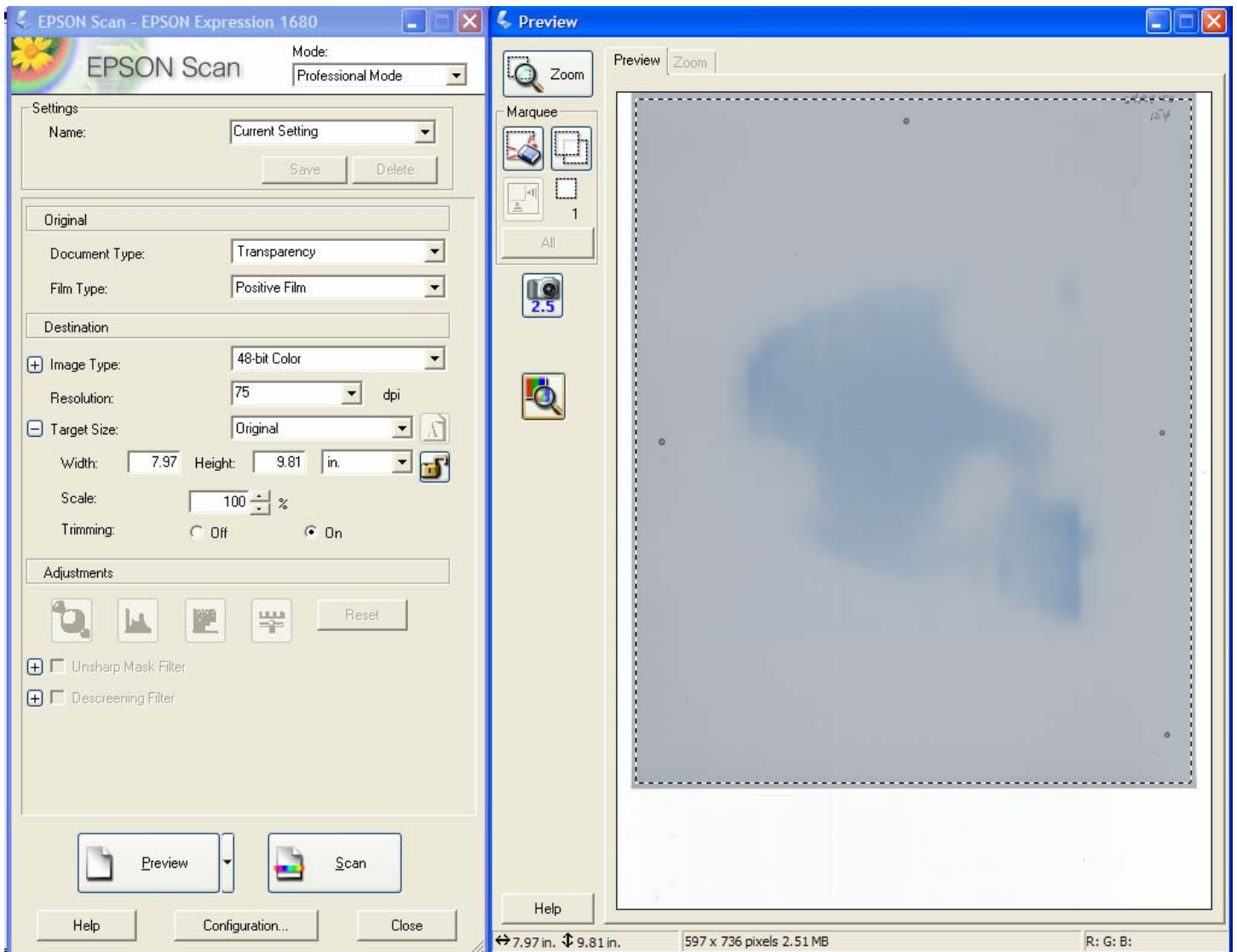


Figure 6

11. Now highlight the “Settings” dialog box – Figure 7. Type in the new settings name, e.g. EBT Film, and save. In future when you select EBT film under “Settings” you will return to all the values/options selected as well as the selected scan area. You are ready to scan your image set.

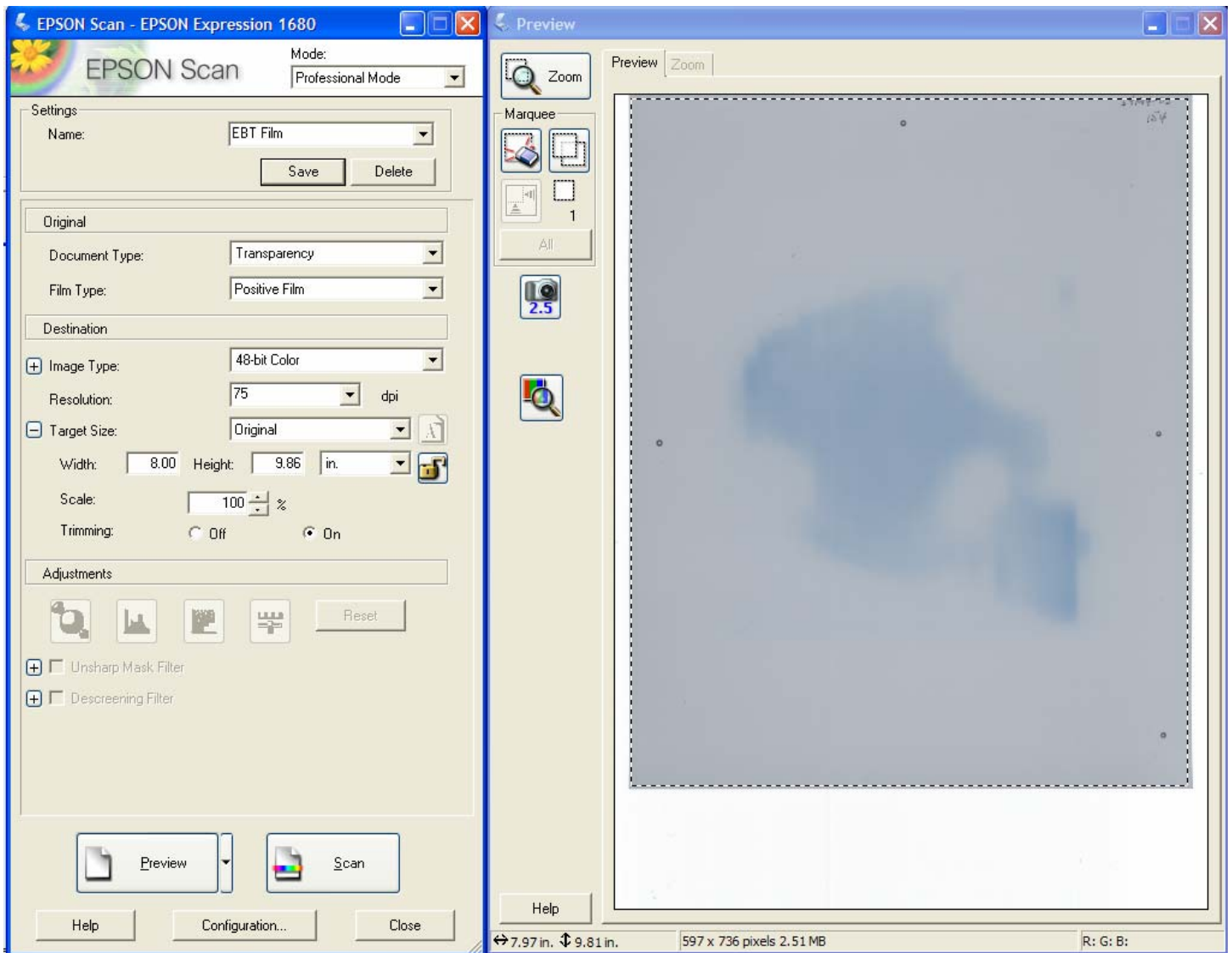


Figure 7

12. Having set up the Options and Selections settings in Steps 7-11 you are prepared for scanning. A window similar to Figure 8 will appear after you activate the “Scan” button. Go to the “Settings” box and select the setting from the drop-down menu. In this case it is “EBT Film”

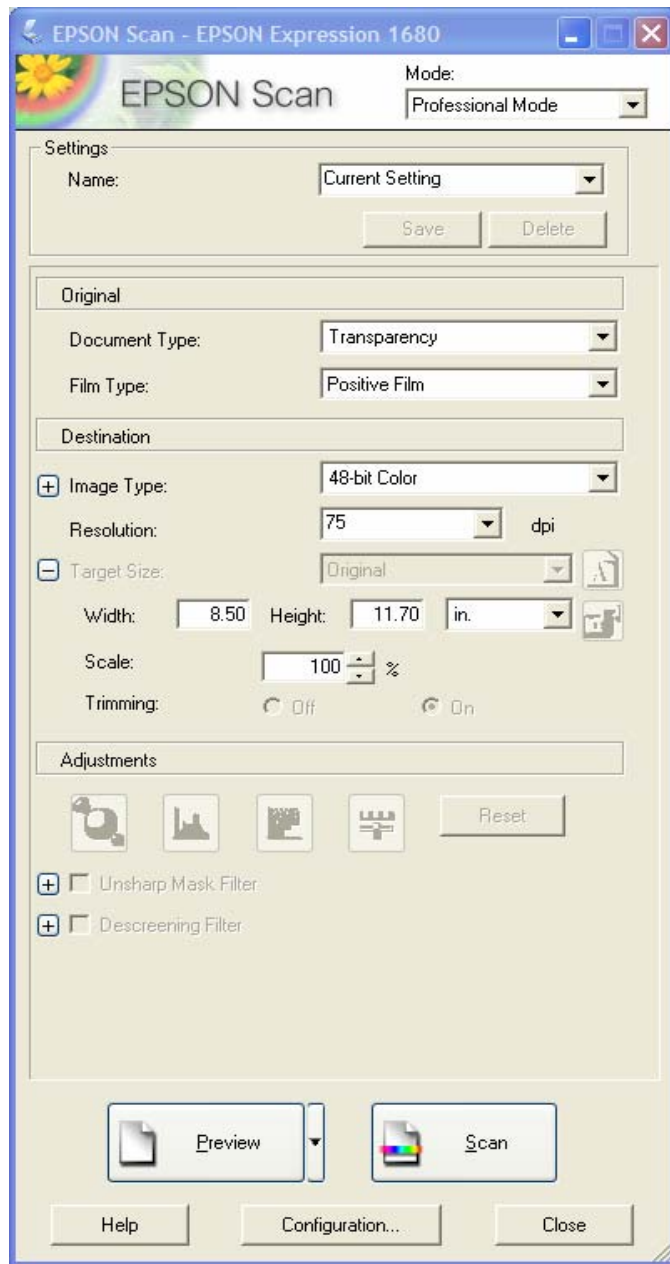


Figure 8

The "Preview" window opens with the scan area highlighted as shown in Fig. 9

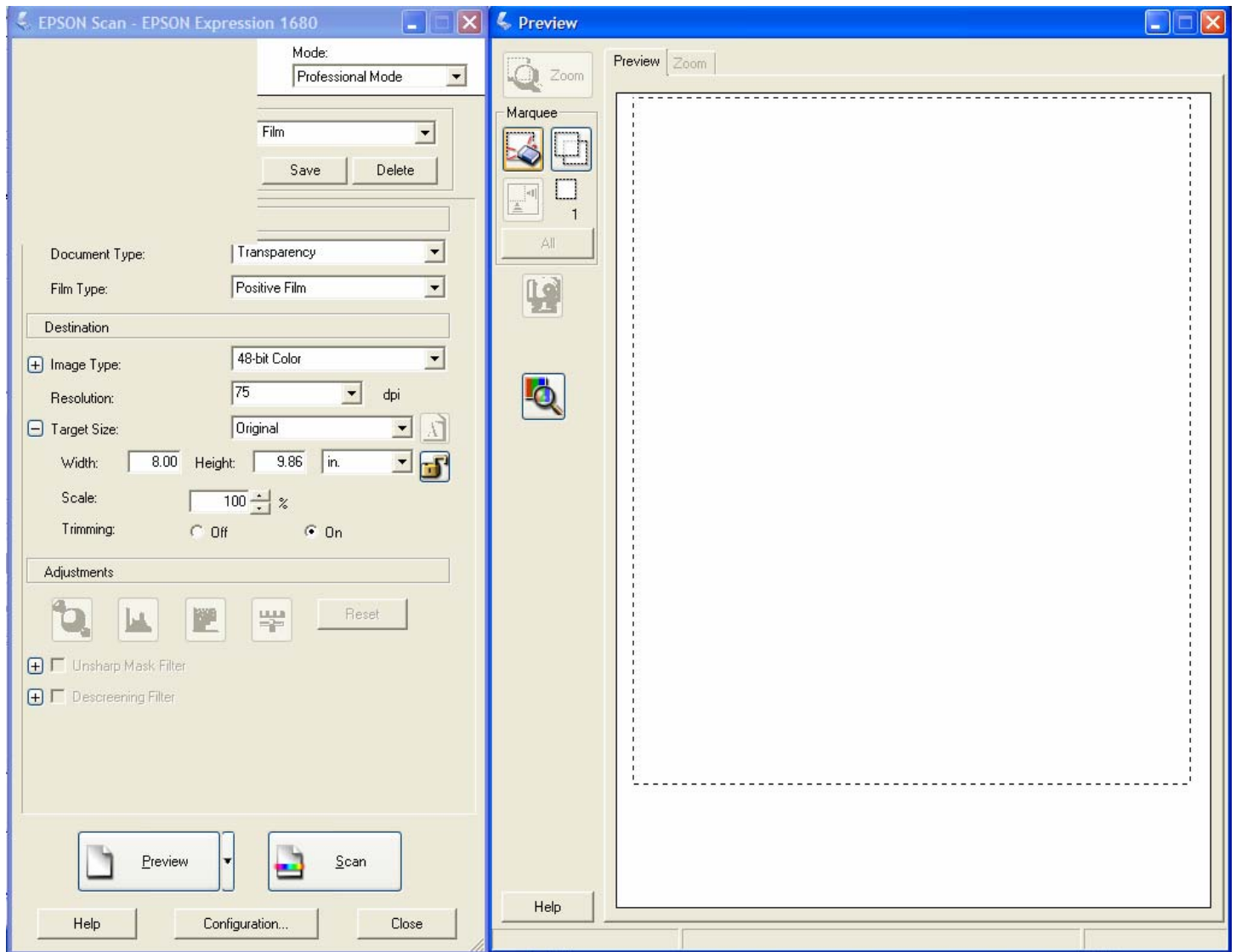


Figure 9

13. Place a film at the top of the scanner and center the film in the scan area. Select “Preview” and obtain a preview scan. The image should appear within the outlined area in the preview window as shown in Figure 10. Once you are satisfied with the positioning you can close the “Preview” window and proceed to scan the set of exposed films as well as the films with the calibrated doses and the unexposed film.

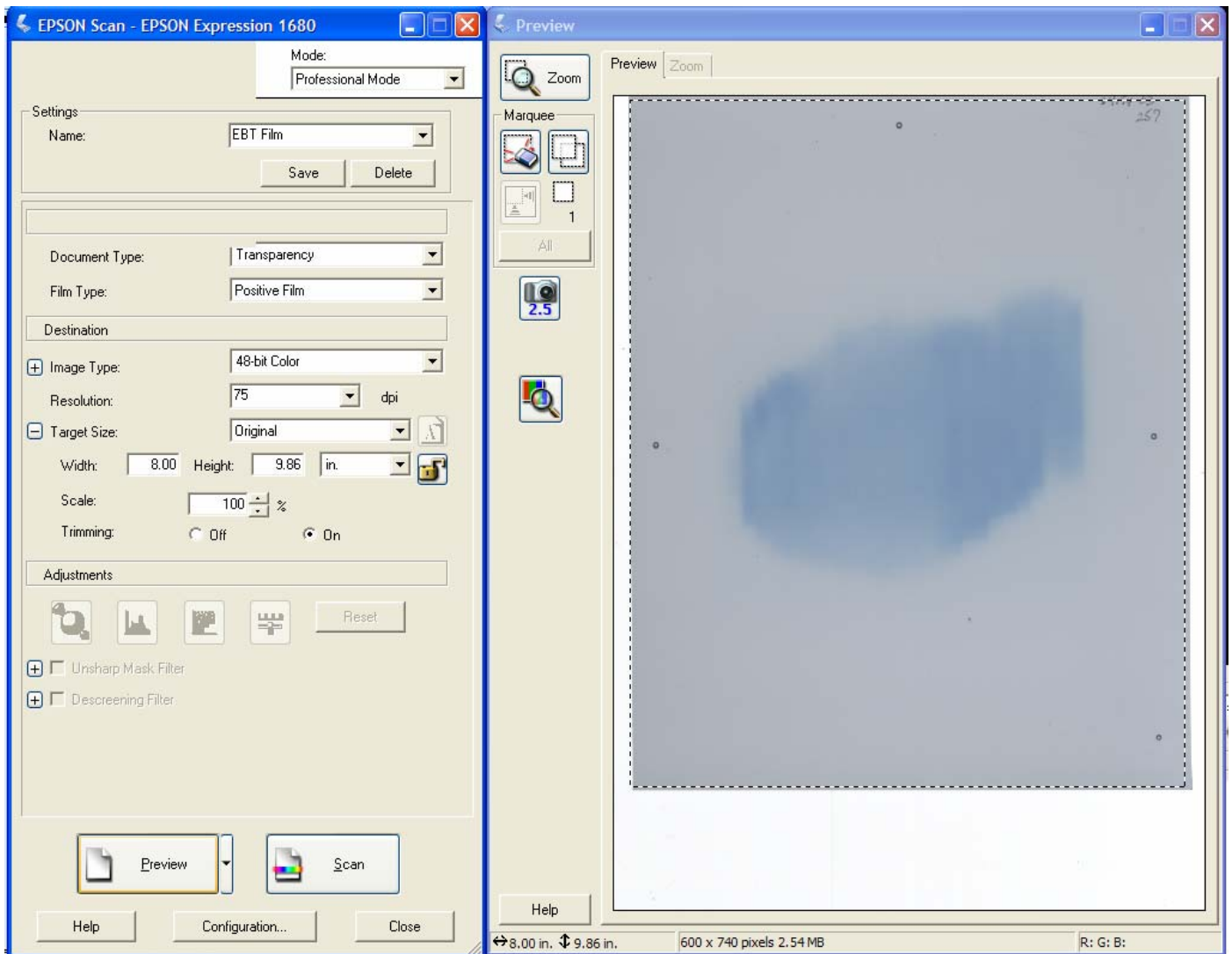


Figure 10

If you are using FilmQA™ software, there is a menu option to select which color channel (red, green or blue) of an RGB image to use for calibration and data analysis. If you are using FilmQA™ or other software with the ability to split the RGB image into selected channels skip to Step 23. For image analysis software not having an embedded routine to extract a selected color channel, a separate software would be used to perform this operation. The following steps describe the extraction of image data for the red color channel from the RGB image. The procedure assumes the use of software (e.g. Picodose TA, Matlab, Photoshop) that can perform this separation.

14. Since GAFCHROMIC dosimetry film produces blue images the greatest response is obtained in the red color channel. Scan data obtained in RGB mode can now be split into individual channels to extract the data for the red channel. The following describes the use of Picodose TA to accomplish this. The RGB data can be split by other software such as Photoshop and Matlab.
15. Open Picodose TA.
16. Click IMAGES on the menu bar.

17. Select “Import” and click “RGB acquisition options...”
18. In the “RGB acquisition options” window check “Red only” and click “Confirm”
19. Select IMAGES on the menu bar. Select “Import” and on the drop-down menu select “File tiff RGB 24/48 bit”
20. Select and import the RGB image.
21. A window will open containing the R (red) image. Save the red image.
22. Import the other images and extract and save the red color channel data.

23. Apply a scanner flatness correction to all the images in the set, including the calibration image(s) as described in QAI-365: APPLICATION OF SCANNER FLATNESS CORRECTION TO GAFCHROMIC® DOSIMETRY FILM IMAGES. The output of this operation is a set of corrected images referred to as flattened images. **Note that in FilmQA™ software, the application of the flatness correction is an automated function performed by selection of a menu item the “Apply background corrections” within the Calibration window and complete with a single mouse click.**

24. Select and open the flattened image of the calibration film.
25. Choose an area of interest in the center of the first exposed region of the film, measure the mean scanner response value in the region of interest and associate this value with the dose applied in this region. Measure other exposed regions in the film image similarly and associate those mean scanner response values with the corresponding dose values.
26. If there is more than one calibration film, open the relevant flattened image and measure and associate the mean scanner response values of the exposed areas with the corresponding dose values.
27. Open the flattened image of the unexposed film and measure the mean scanner response value for zero dose.
28. Plot all the scanner response values vs. dose (including the response at zero dose). Select and fit a polynomial function appropriate to the number of data points. For an nth order polynomial it is preferable to have $>(n+2)$ data points. A third or fourth order polynomial usually provides a satisfactory fit.
29. Use the selected polynomial function to convert the scanner value data in the film images to dose values. This generates a set of dose value images and these dose value images can be compared and analyzed for the correspondence to the corresponding treatment plan images.

VII. DEFINITIONS

Scanner-value space: These are values measured by the scanner and relate to the amount of light transmitted or reflected by the film, depending whether the film is measured in transmission or in reflection. The scanner-space values may be expressed in many different ways including visual density, optical density, % transmission, % reflection, relative transmission, etc.

VIII. AFFECTED DEPARTMENTS

Effects all operating departments.

IX. REVISIONS TRACKING

Revision 0.3 - This is a newly documented procedure.

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