

# Calibrating Photoshop Curves for Digital Negatives using a UV Densitometer

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# Presentation Outline

- Background
- Tools & Materials
- Setup
- The Calibration Process
- Results
- Lessons Learned & Observations

## First, a Little Background...

- Dan Burkholder described the color table method in the 2<sup>nd</sup> edition of his book, making digital negatives for contact printing in 1999.
- 1999 View Camera article on “Effects of Pyro in Platinum Printing” discussed the effects of different colors of stain on UV light in making platinum prints
- Keith Schreiber showed me the work he was doing with colorized digital negatives using this method in January 2003 at his studio in Tucson.
- Rather than the CMYK colors of 0-71-71-0, Keith was attempting to approximate the color of pyro negatives for use in platinum/palladium printing and came up with a CMYK color schema of 0-45-100-51
- In June of 2003, after working with Keith and a professor at Cuyahoga Community College in Cleveland where I teach, I incorporated the method into my platinum/palladium printing class.
- Shortly thereafter, I began teaching this digital method in other venues.

# The Dilemma

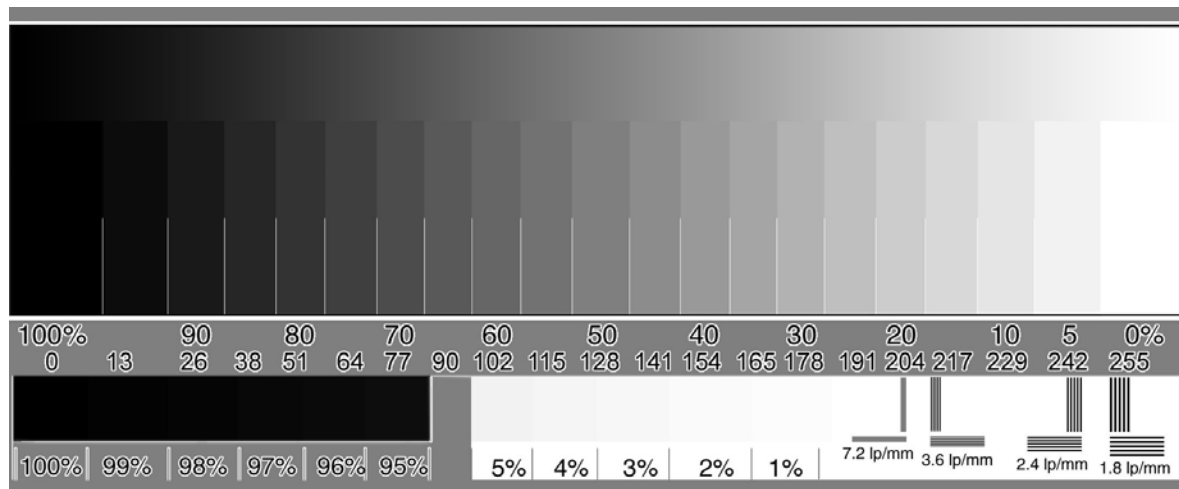
- I teach platinum/palladium printing with digital negatives at multiple locations in northeastern Ohio e.g. Cleveland Institute of Art, Cuyahoga Community College, The University of Akron, Hiram College, workshops, etc.
- Challenges of working in totally different computer hardware environments
  - Varying ages of computer systems – e.g. from Quadras to G5 Macs
  - Some environments networked with network printer drivers
  - Mix of Macs and PCs
  - Different default configuration settings in Photoshop
  - Different versions of printer drivers
  - Different models and ages of printers – Epson 1280 a common thread
- Slightly different Photoshop curve need for each situation
- Needed a calibration method to adapt easily to different teaching environments

# Calibration Requirements

- Find a method of calibration that can be done in a few hours time and preferably without having to make any platinum prints
- Reduce or eliminate trial-and-error methods for calibrating a curve
- Method must be able to work with different monitor working space profiles, driver variations, printer age, and printer types
- Must be able to adapt quickly to variations in material characteristics e.g. ink batches and Pictorico material
- Consistent, repeatable results

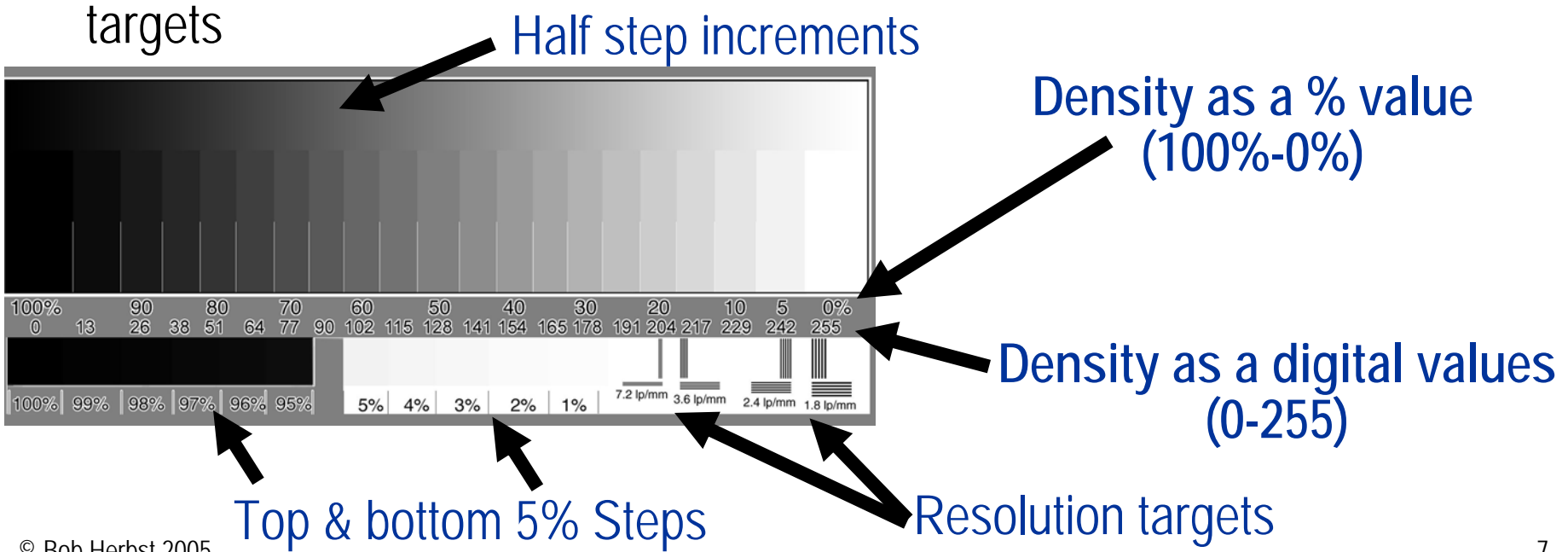
# Materials and Printing Method

- Using Indexed Color / Color Table method for colorized negatives described by Keith Schreiber at APIS 2003
- Calibration standardized for using 1 drop of 5% NA2 for a 4x5 print
  - FeOx / NA2 / Pd mixture is 6-1(5%)-6 drops
- Most work done on Epson 1280 printers but method applies to all printers
- Pictorico OHP transparency film
- The digital step wedge (courtesy of Keith Schreiber)



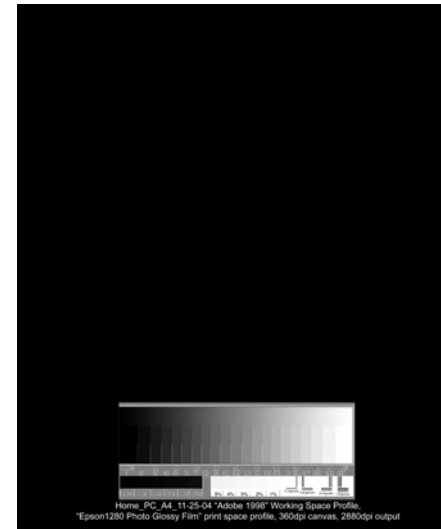
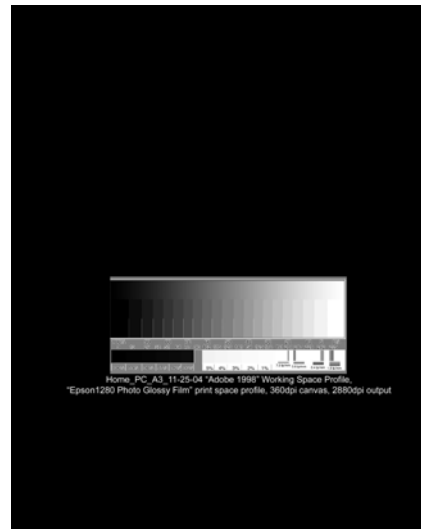
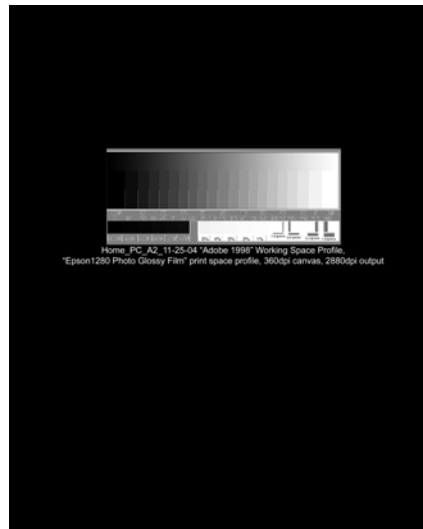
# Features of the Digital Step Wedge

- The digital step wedge is divided into 21 equal steps representing density as a relative percentage from total black (100%) to pure white (0%)
- An important feature of this step wedge for the calibration process is also dividing the density range into 21 equal steps in digital values from 0-255
- Other features include half step values over the whole range, single percentage swatches for the top and bottom 5% density, and resolution targets



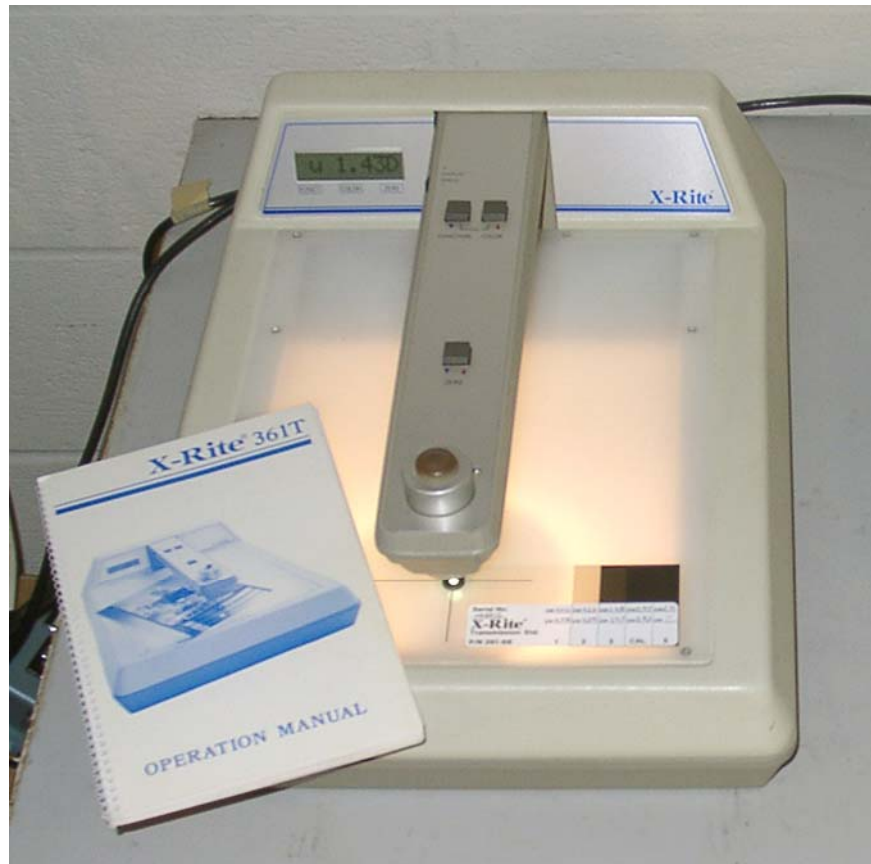
# Calibration Master Files

- Created four identical master files with the step wedge at different locations on the canvas. In this way, one sheet of Pictorico can be used for four calibration attempts saving ink and Pictorico material.
- Text layer below wedge allows curve identifier, Photoshop configuration data and setting information to be printed with the wedge for reference.



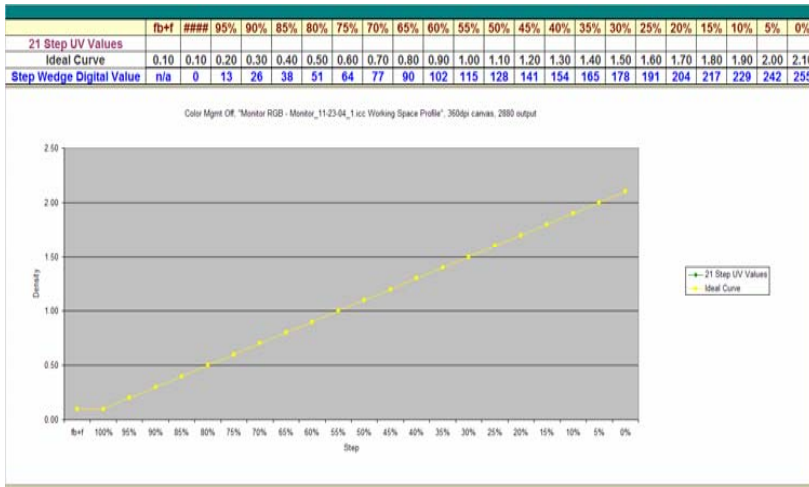
# UV Densitometer - The Key to This Process

- Curve calibration done with an X-Rite 361T UV densitometer
- Other brands of UV densitometers will work as well.

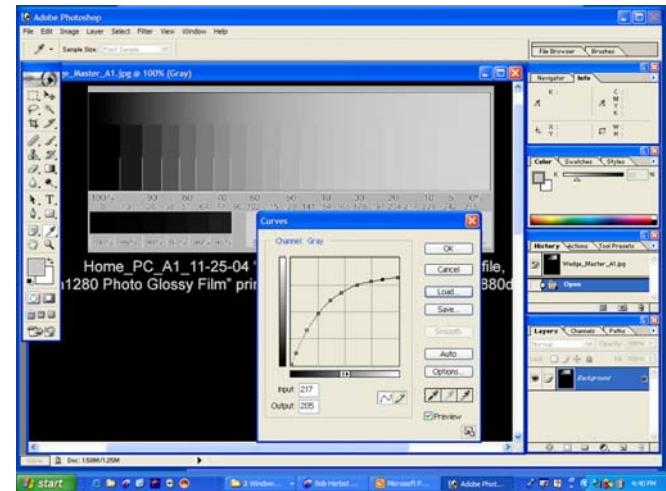


# Setting Up for Calibration

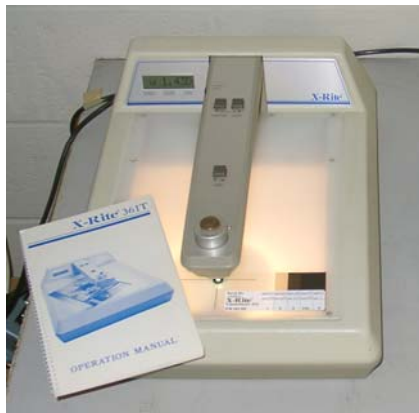
- Set up the densitometer, computer, and printer together



Microsoft Excel Spreadsheet Template



Photoshop



X-Rite 361T Densitometer



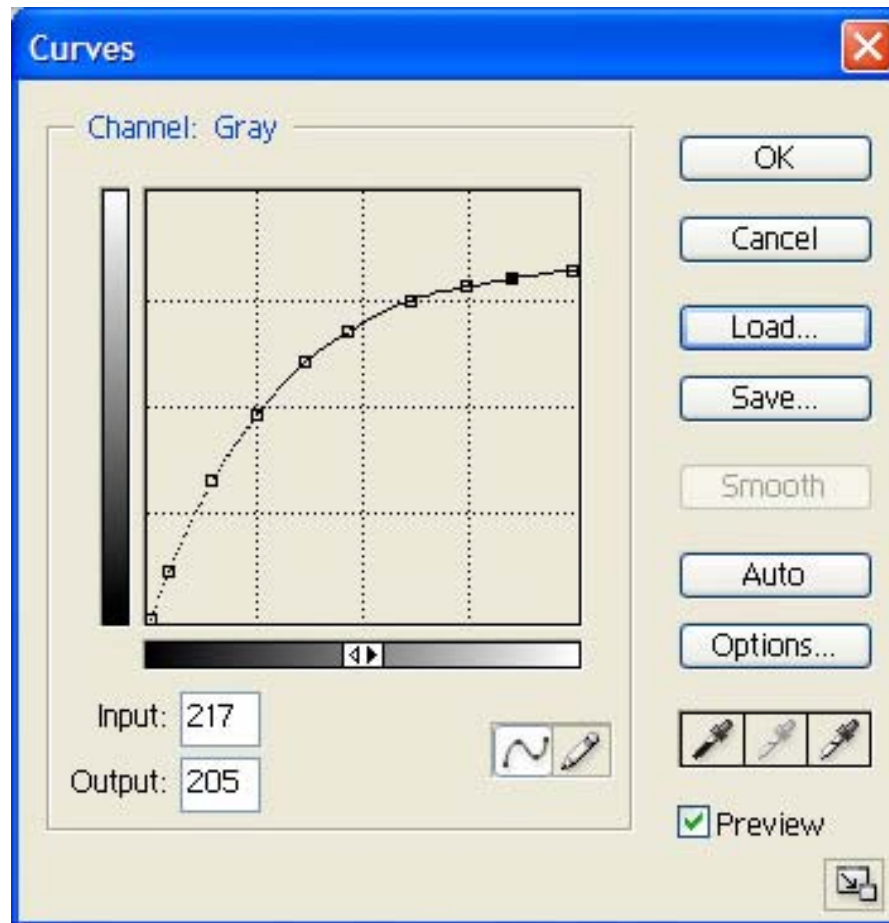
Epson 1280S Printer

# The Calibration Process

1. Start with a basic curve for the CMYK settings (0-45-100-51 initially developed by Keith Schreiber to approximate pyro stain color)
2. Apply the curve to the digital step wedge canvas in Photoshop
3. Colorize the digital step wedge using the Color Table Method
4. Print the file on OHP with a color printer. (Allow ink to dry at least until there is no "wet" appearance on the film.)
5. Measure the UV densities of each step in the wedge and enter the density values into an Excel spreadsheet which includes an x-y chart of the values
6. Compare step densities to an "ideal" straight line density curve already plotted in the same Excel chart
7. Make adjustments to the curve in Photoshop to raise or lower density values at each step as needed
8. Repeat steps 2-8 until the densities of the printed wedge align with the straight line density curve

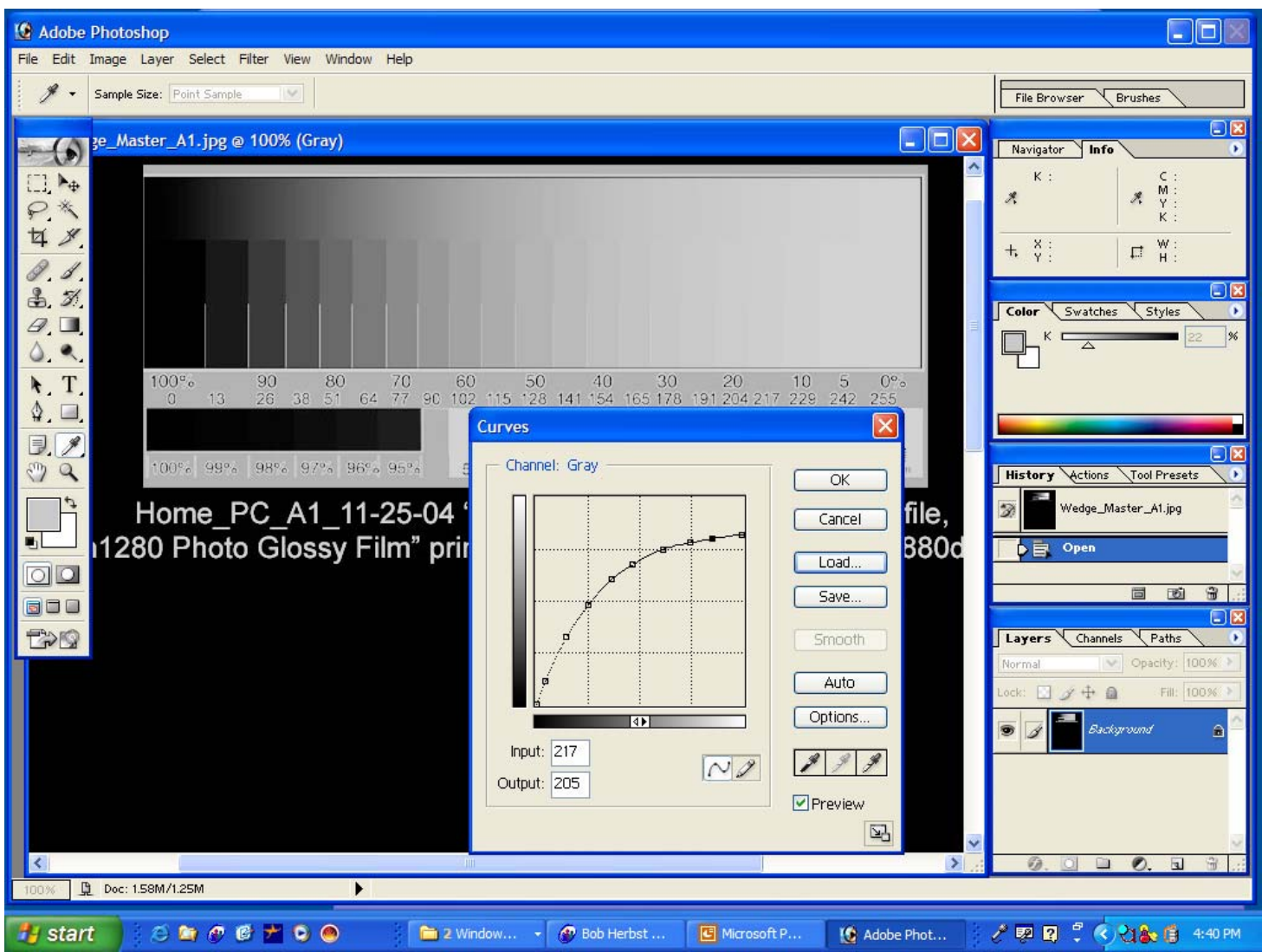
# 1. Start with a Basic Photoshop Curve

- This curve is a derivative from the original supplied to me by Keith Schreiber

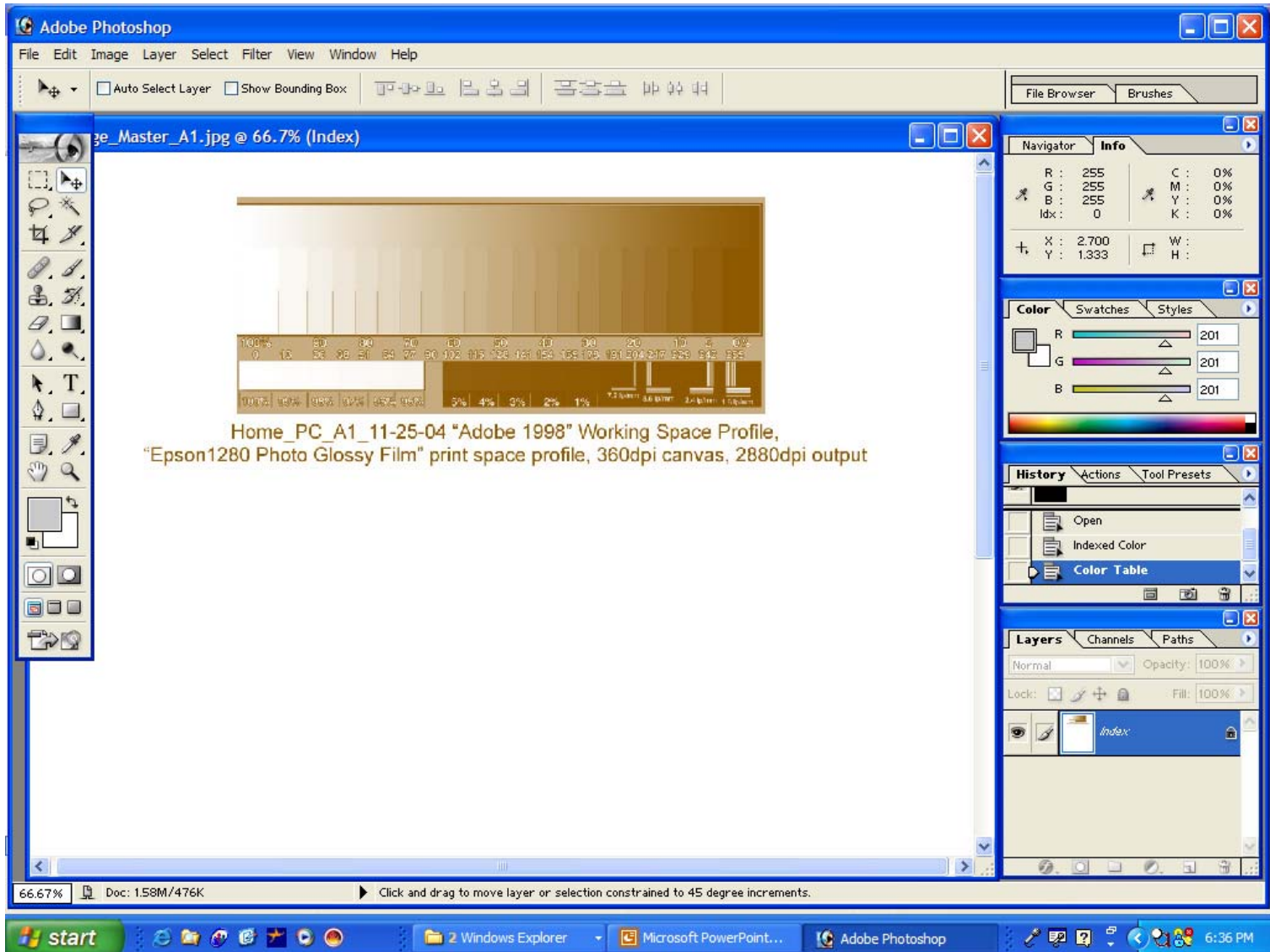


Curve\_H4.acv

# 2. Apply the Curve to the Digital Step Wedge Canvas in Photoshop

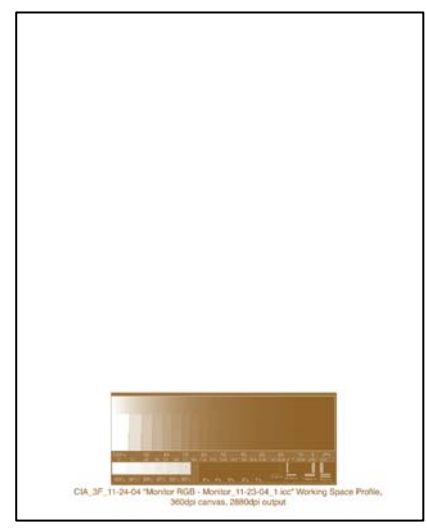
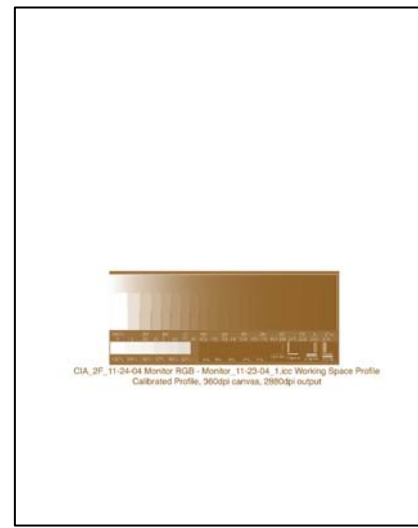
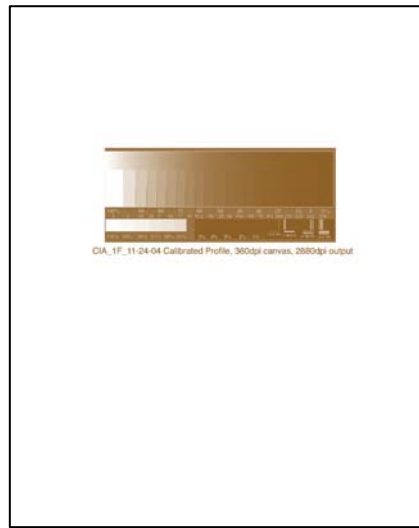
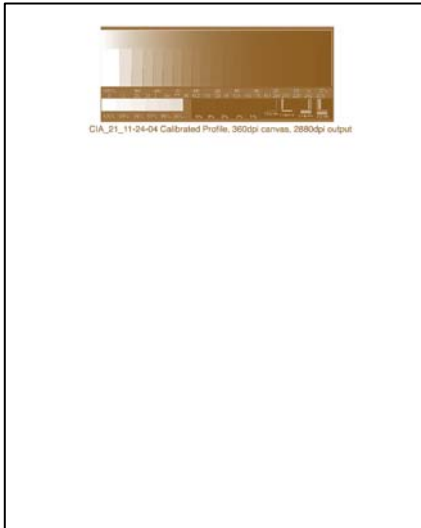


# 3. Colorize the Digital Step Wedge Using the Color Table Method



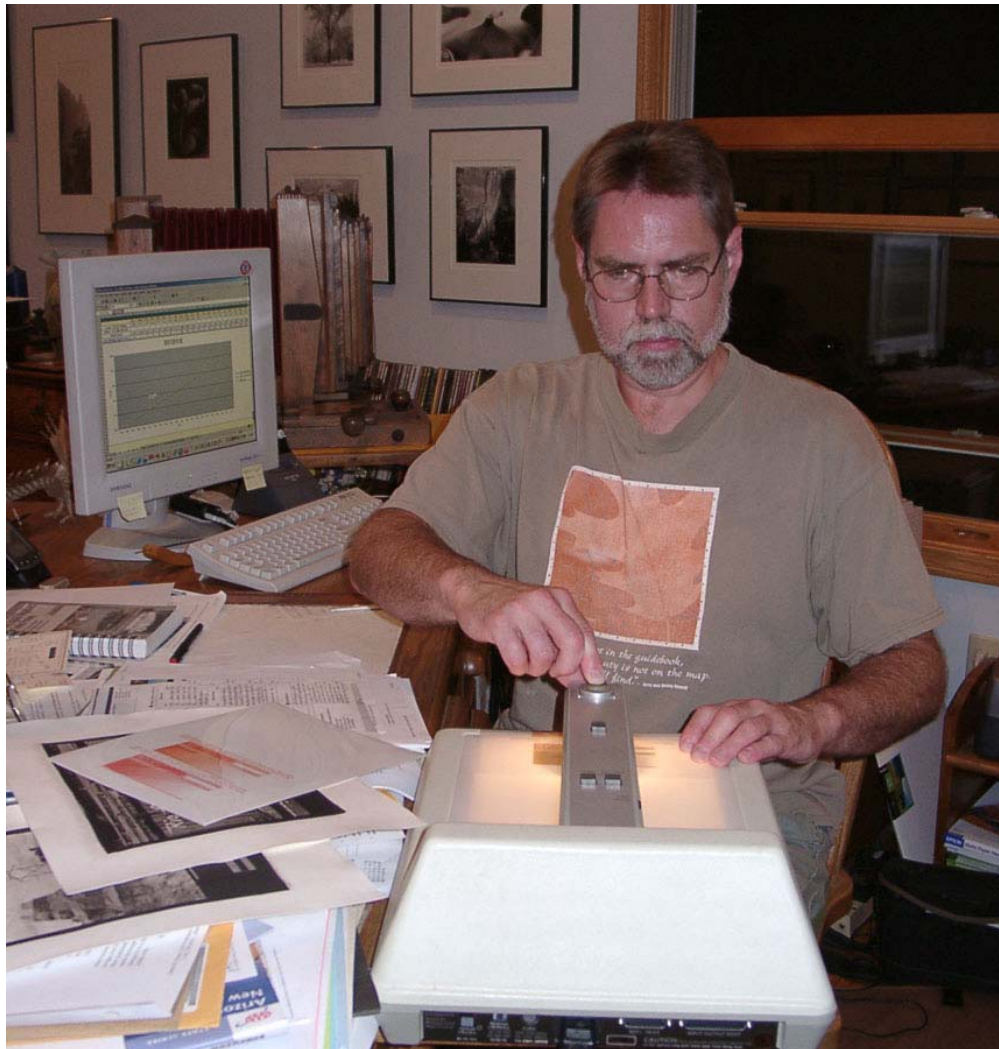
## 4. Print the File on Pictorico OHP

- Allow ink to dry at least until there is no “wet” appearance on the film
- Below are examples of four printed digital step wedge negatives.
- The same sheet of Pictorico is fed through the printer for each wedge.



## 5. Measure the UV Densities of Each Step and Enter the Values into an Excel Spreadsheet

- An x-y chart of the step wedge densities is automatically plotted in Excel

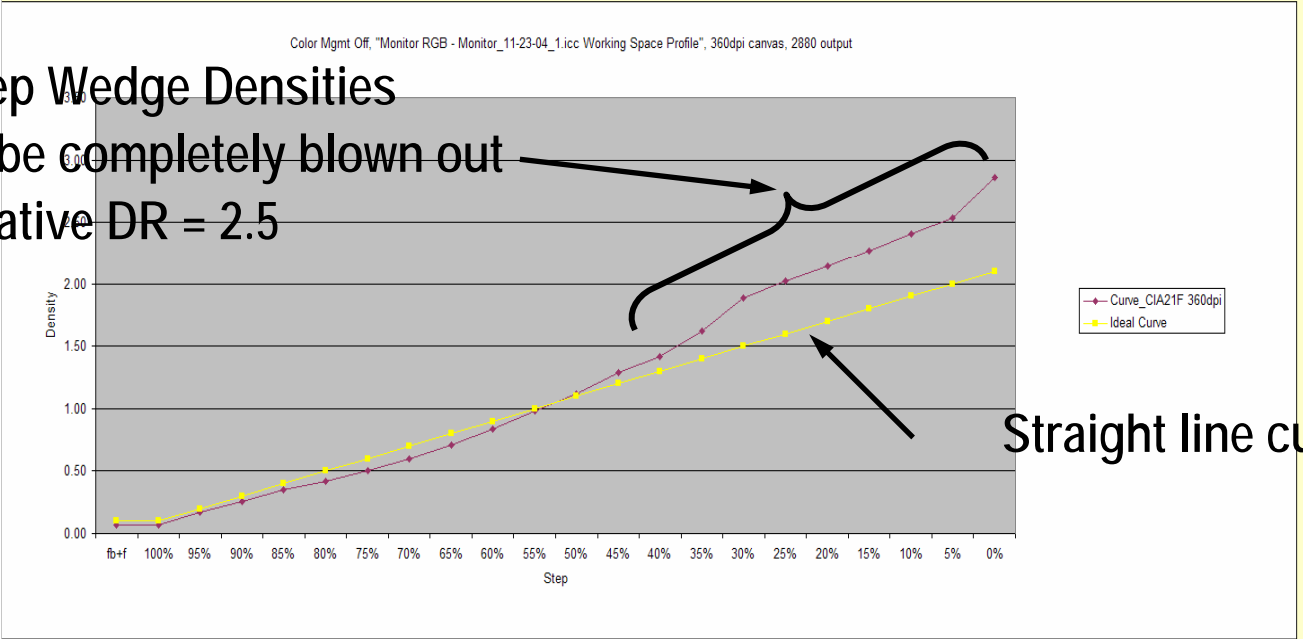


# 6. Compare Step Densities to a Straight Line Density Curve

- Below is a chart plotting densities resulting from a Photoshop curve which is not yet properly calibrated for the working environment.
- The Photoshop curve used for this negative curve was originally calibrated at another local area college illustrating the difference equipment, monitor working space profiles, etc. have on system calibration. It is not even close.

	fb+f	100%	95%	90%	85%	80%	75%	70%	65%	60%	55%	50%	45%	40%	35%	30%	25%	20%	15%	10%	5%	0%
Curve_CIA21F 360dpi	0.07	0.07	0.17	0.25	0.35	0.42	0.50	0.60	0.71	0.84	0.99	1.12	1.29	1.42	1.62	1.88	2.02	2.14	2.27	2.41	2.54	2.86
Ideal Curve	0.10	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	1.00	1.10	1.20	1.30	1.40	1.50	1.60	1.70	1.80	1.90	2.00	2.10
Step Wedge Digital Value	n/a	0	13	26	38	51	64	77	90	102	115	128	141	154	165	178	191	204	217	229	242	255

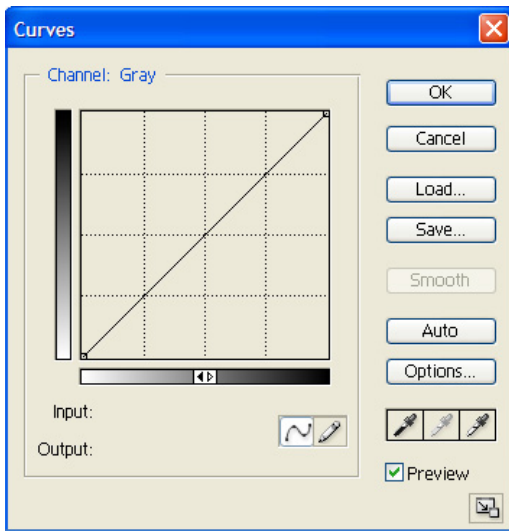
Digital Step Wedge Densities  
 Highlights will be completely blown out  
 Negative DR = 2.5



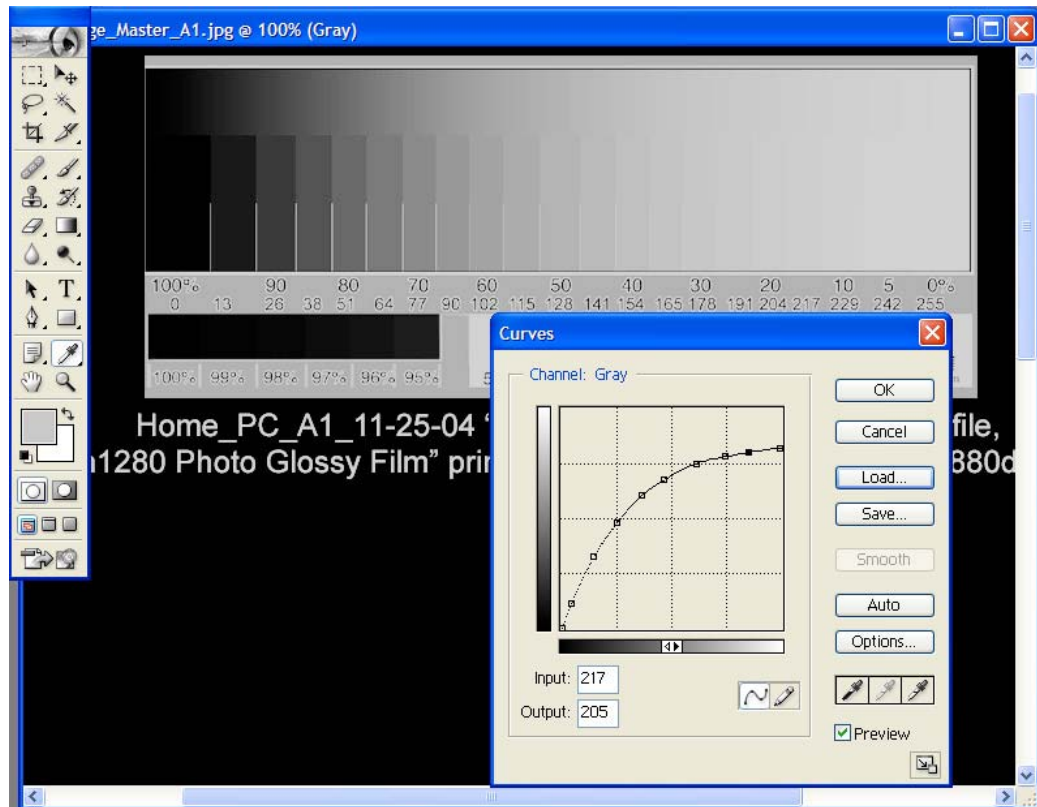
Straight line curve

## 7. Make Adjustments to the Curve

- Use multiple points on the Photoshop Curve for shaping
- Keep the shape smooth to obtain a smooth transition of tones in the resulting digital step wedge densities – no dips or bumps

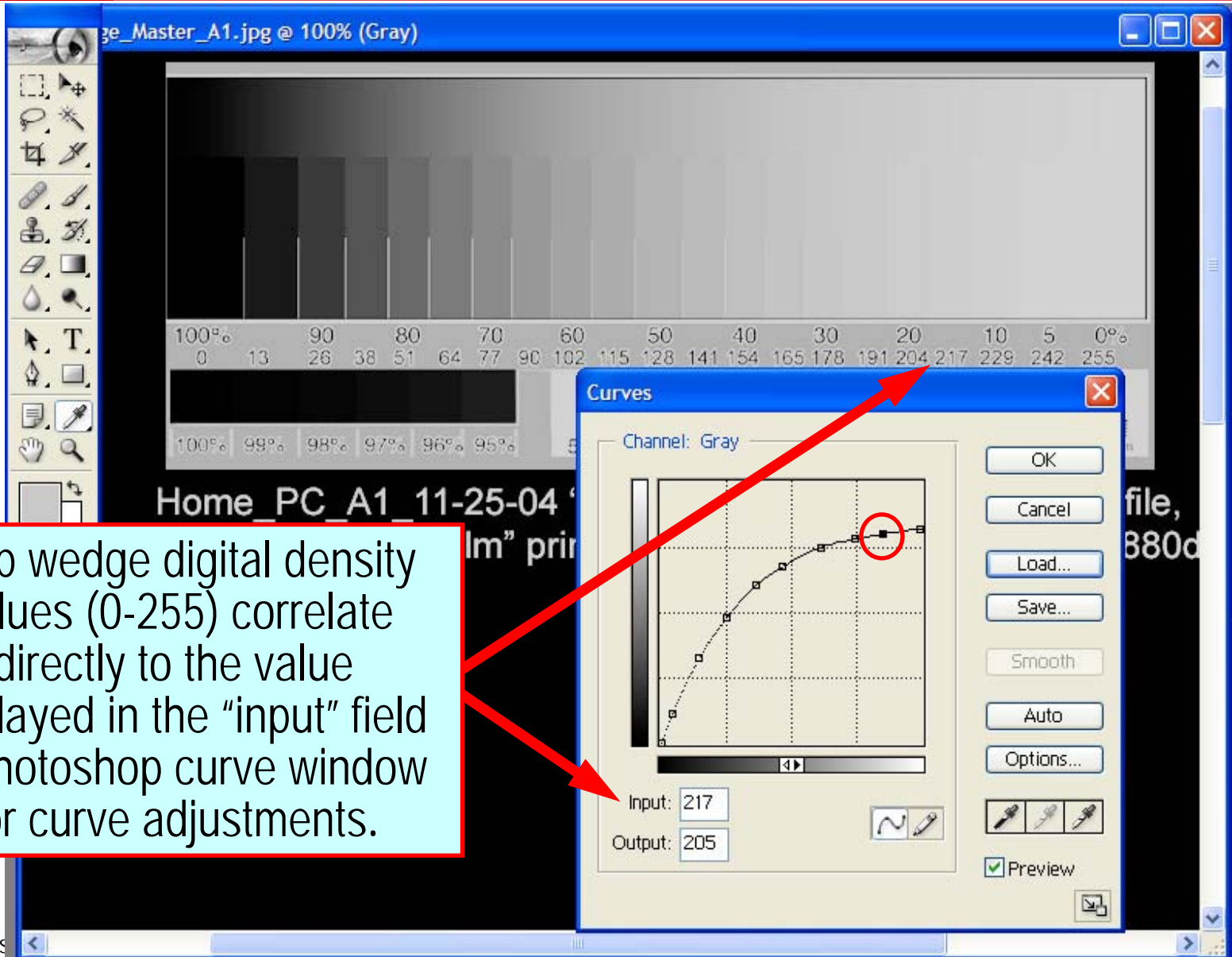


Photoshop Curve with  
no adjustments



Photoshop Calibrated Curve for 0C-45M-100Y-51K

# Correlating Digital Step Wedge Values to Photoshop Curve Values



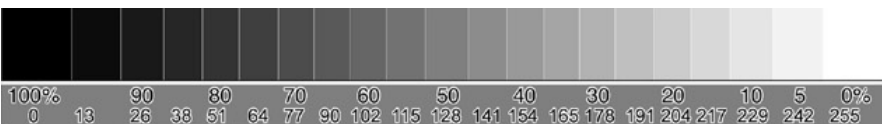
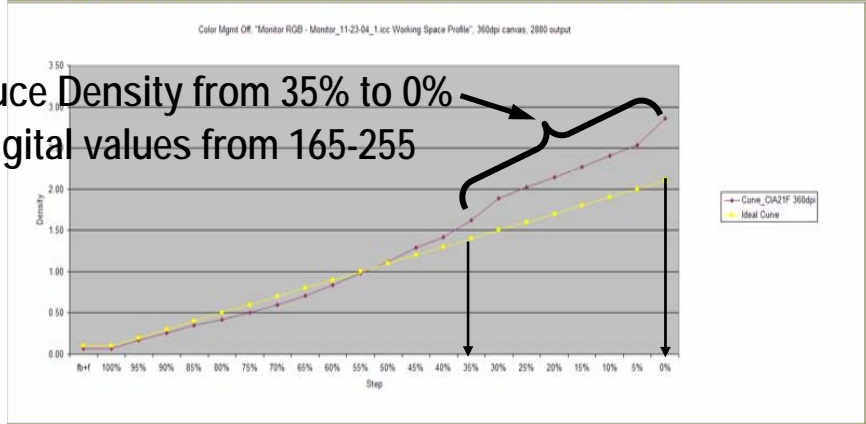
Step wedge digital density values (0-255) correlate directly to the value displayed in the "input" field in Photoshop curve window for curve adjustments.

# Cross-Reference of Density Graph Results, Step Wedge Values, & Photoshop Curve

- Determine steps where adjustment is necessary from Excel chart, translate to digital density input values in Photoshop curve, and make adjustments.

	fb+f	100%	95%	90%	85%	80%	75%	70%	65%	60%	55%	50%	45%	40%	35%	30%	25%	20%	15%	10%	5%	0%
Curve_CIA21F 360dpi	0.07	0.07	0.17	0.25	0.35	0.42	0.50	0.60	0.71	0.84	0.99	1.12	1.29	1.42	1.62	1.88	2.02	2.14	2.27	2.41	2.54	2.86
Ideal Curve	0.10	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	1.00	1.10	1.20	1.30	1.40	1.50	1.60	1.70	1.80	1.90	2.00	2.10
Step Wedge Digital Value	n/a	0	13	26	38	51	64	77	90	102	115	128	141	154	165	178	191	204	217	229	242	255

Reduce Density from 35% to 0%  
Digital values from 165-255



35% = 165 through 0% = 255

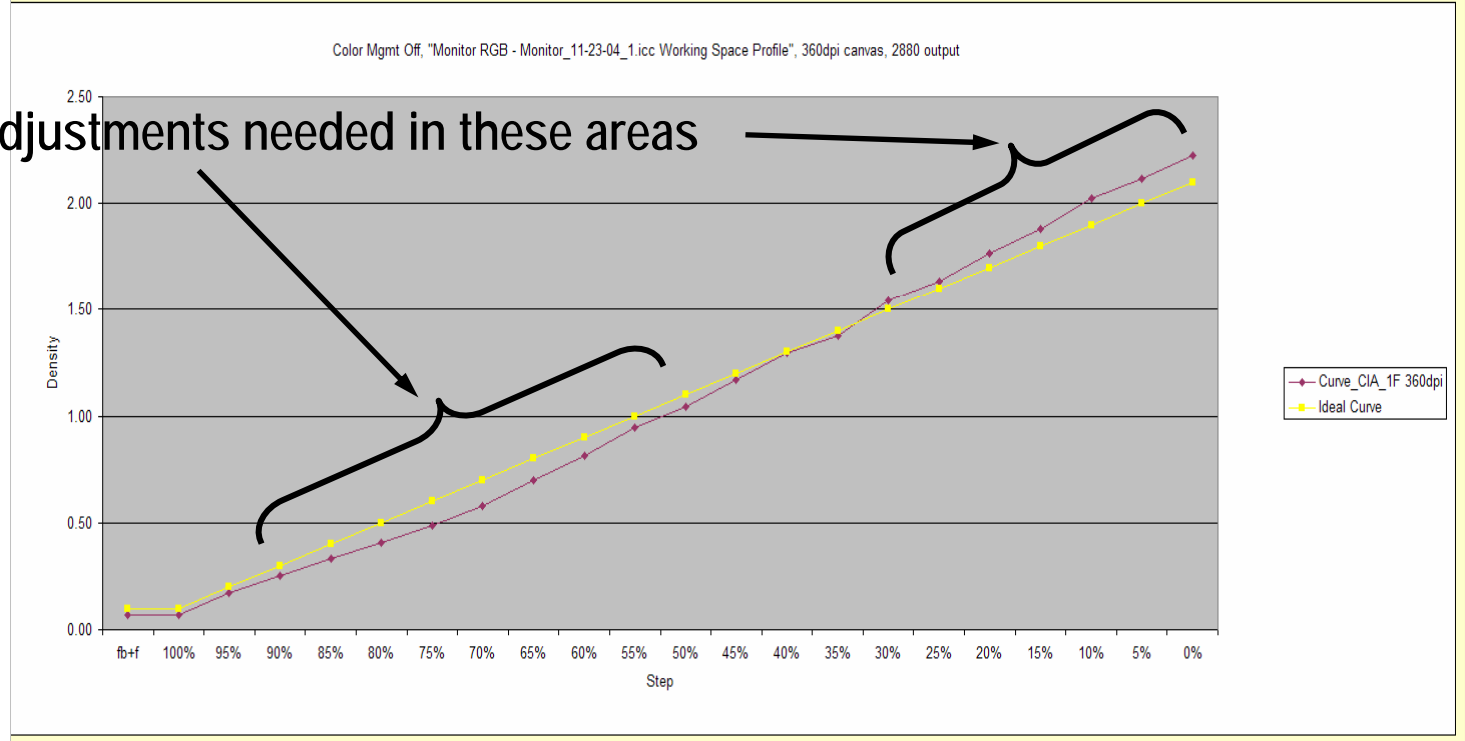
	fb+f	100%	95%	90%	85%	80%	75%	70%	65%	60%	55%	50%	45%	40%	35%	30%	25%	20%	15%	10%	5%	0%
Curve_CIA21F 360dpi	0.07	0.07	0.17	0.25	0.35	0.42	0.50	0.60	0.71	0.84	0.99	1.12	1.29	1.42	1.62	1.88	2.02	2.14	2.27	2.41	2.54	2.86
Ideal Curve	0.10	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	1.00	1.10	1.20	1.30	1.40	1.50	1.60	1.70	1.80	1.90	2.00	2.10
Step Wedge Digital Value	n/a	0	13	26	38	51	64	77	90	102	115	128	141	154	165	178	191	204	217	229	242	255

# Final Adjustments to the Curve

- Adjustments made to the Photoshop curve improve its shape relative to the straight line curve. Minor additional adjustments are necessary.

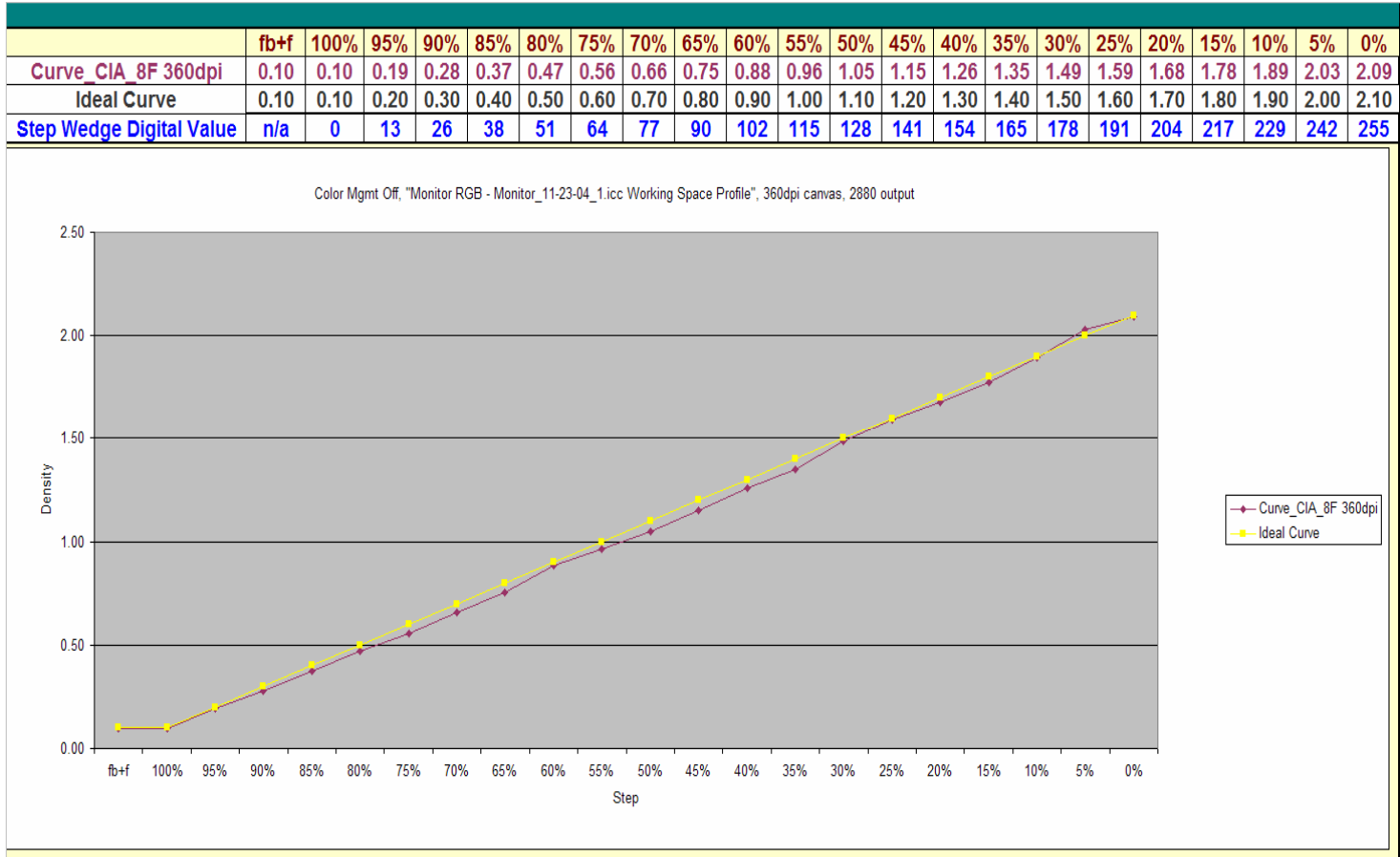
	fb+f	100%	95%	90%	85%	80%	75%	70%	65%	60%	55%	50%	45%	40%	35%	30%	25%	20%	15%	10%	5%	0%
Curve_CIA_1F 360dpi	0.07	0.07	0.17	0.25	0.33	0.41	0.49	0.58	0.70	0.82	0.95	1.04	1.17	1.29	1.37	1.54	1.64	1.77	1.88	2.03	2.12	2.23
Ideal Curve	0.10	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	1.00	1.10	1.20	1.30	1.40	1.50	1.60	1.70	1.80	1.90	2.00	2.10
Step Wedge Digital Value	n/a	0	13	26	38	51	64	77	90	102	115	128	141	154	165	178	191	204	217	229	242	255

Minor adjustments needed in these areas



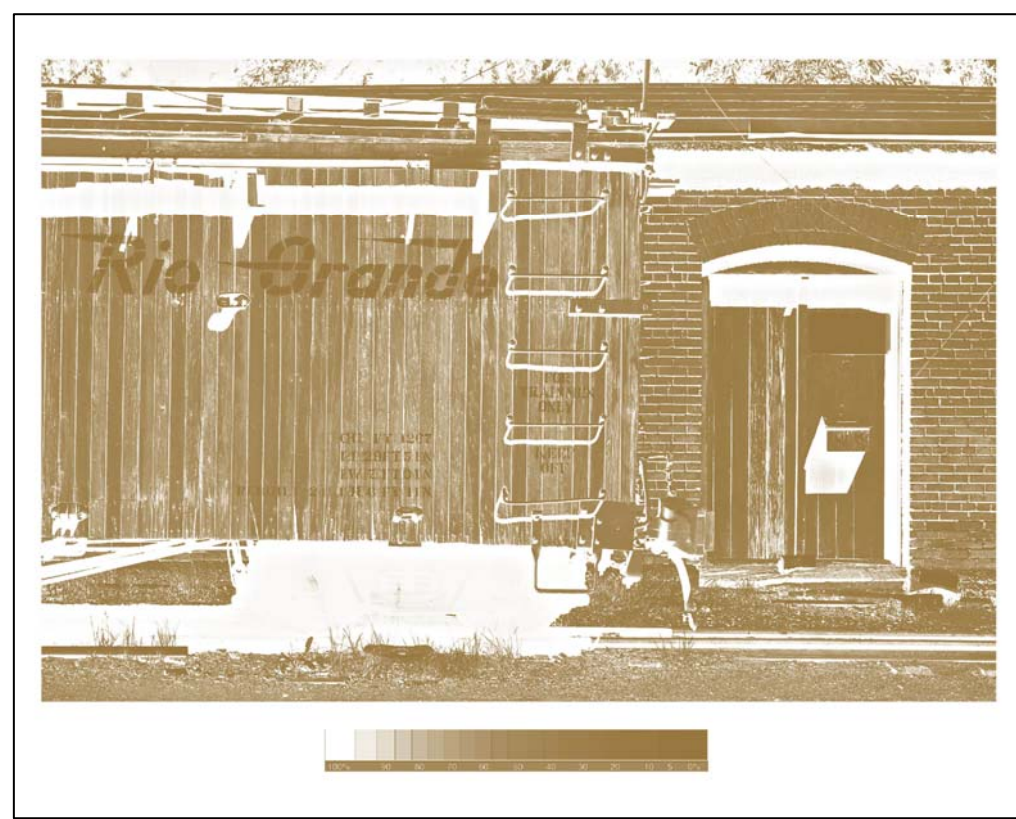
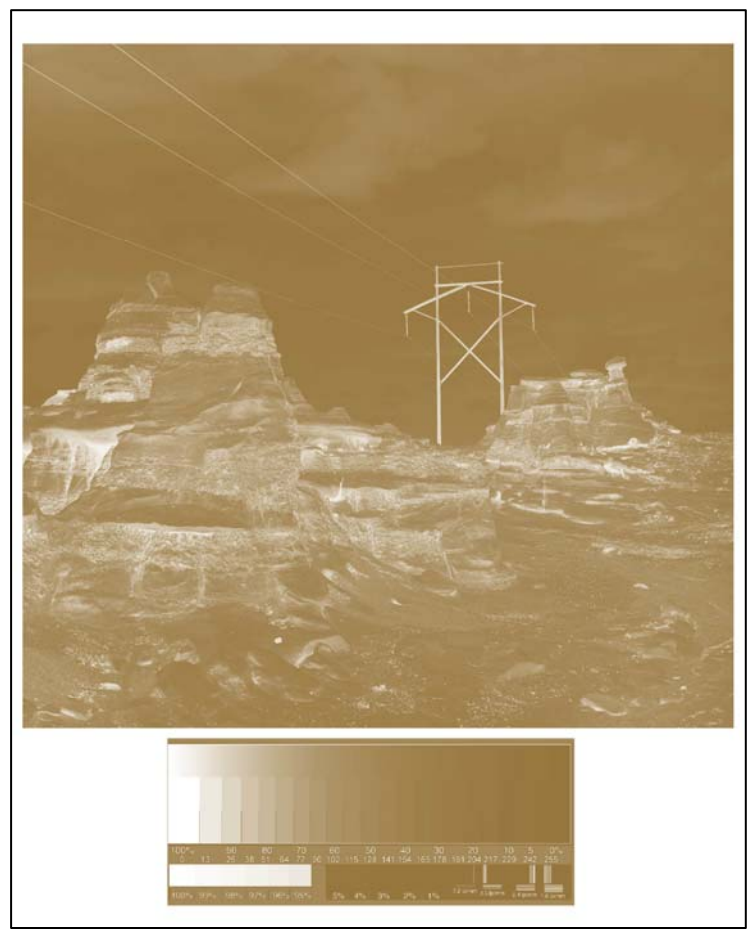
# Calibrated Photoshop Curve

- Digital Step wedge densities from final calibrated Photoshop curve
- Negative DR = 1.9 – ideal for pure palladium



# Image Negatives with Step Wedge Included

- An example of an image negative with a step wedge included in the canvas for initial printing.



# Resulting Print from Negative

- Mixture = 18 drops FeOx – 1 drop NA2 (20%) – 18 drops Pd
- Exposure = 200 units (Olite AL19 commercial point light source)

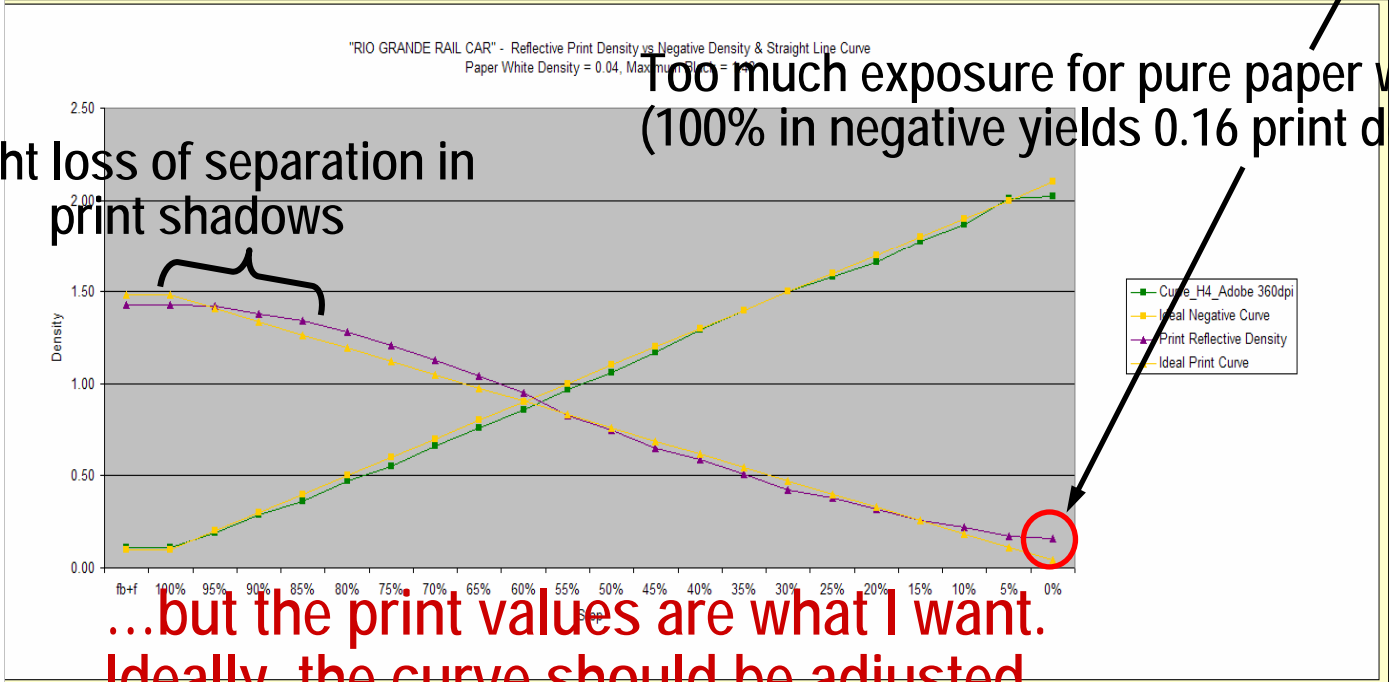


# Reflective Print Density Curve - Rio Grande

- Reflective Print density measured on X-Rite 820TR densitometer
- Paper white density = 0.04 / Maximum black = 1.48 @225 units exposure
- Exposure was 200 units

Within 0.05 of maximum black

	fb+f	100%	95%	90%	85%	80%	75%	70%	65%	60%	55%	50%	45%	40%	35%	30%	25%	20%	15%	10%	5%	0%
Curve_H4_Adobe 360dpi	0.11	0.11	0.19	0.29	0.36	0.47	0.55	0.66	0.76	0.86	0.97	1.06	1.17	1.29	1.40	1.50	1.58	1.66	1.78	1.87	2.01	2.02
Ideal Negative Curve	0.10	0.10	0.30	0.40	0.50	0.60	0.70	0.80	0.90	1.00	1.10	1.20	1.30	1.40	1.50	1.60	1.70	1.80	1.90	2.00	2.10	2.10
Print Reflective Density	1.48	1.43	1.42	1.38	1.34	1.28	1.21	1.13	1.04	0.95	0.83	0.75	0.65	0.59	0.51	0.42	0.38	0.32	0.26	0.22	0.17	0.16
Ideal Print Curve	1.48	1.48	1.41	1.34	1.26	1.19	1.12	1.05	0.98	0.90	0.83	0.76	0.69	0.62	0.54	0.47	0.40	0.33	0.26	0.18	0.11	0.04
Step Wedge Digital Value	n/a	0	13	26	38	51	64	77	90	102	115	128	141	154	165	178	191	204	217	229	242	255



Too much exposure for pure paper white (0.04) (100% in negative yields 0.16 print density)

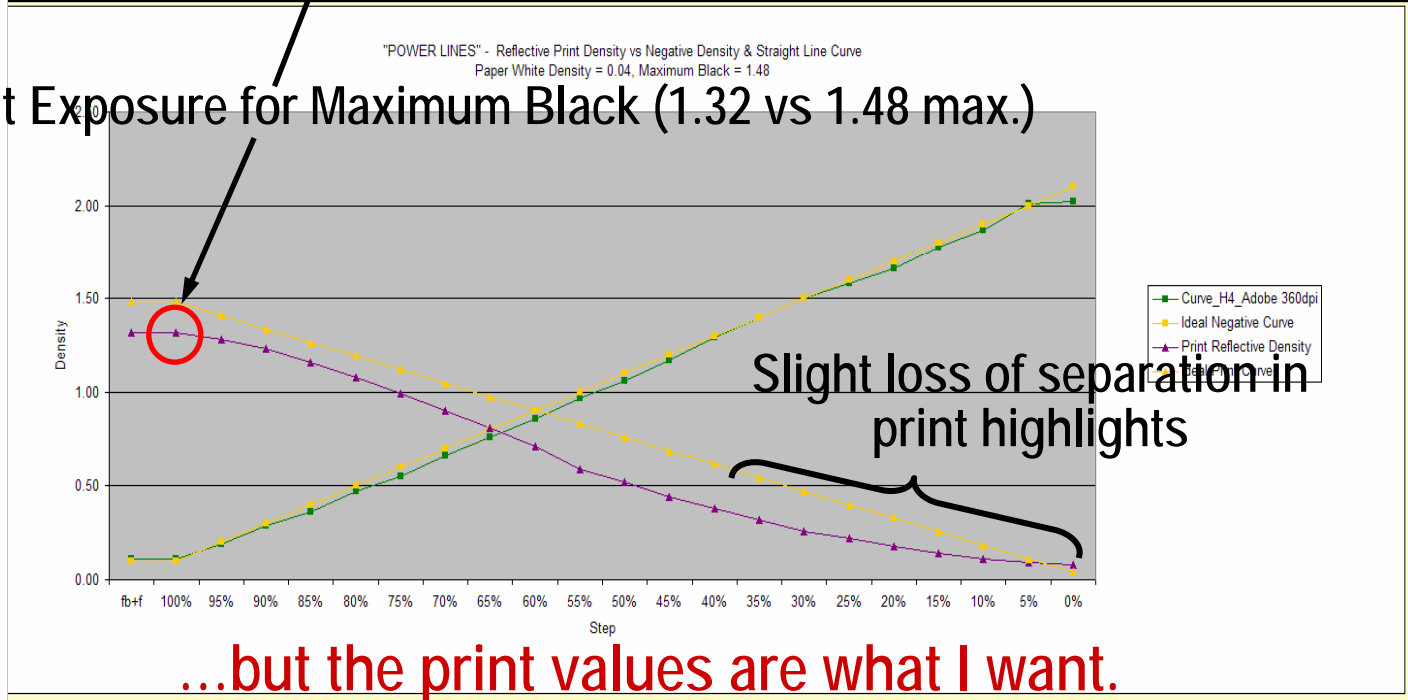
Slight loss of separation in print shadows

...but the print values are what I want. Ideally, the curve should be adjusted.

# Reflective Print Density Curve - Power Lines

- Paper white density = 0.04 / Maximum black = 1.48 @225 units exposure
- Exposure was 175 units – insufficient for maximum black and resulting in lower separation in print highlights (better for this image!)

	fb+f	100%	95%	90%	85%	80%	75%	70%	65%	60%	55%	50%	45%	40%	35%	30%	25%	20%	15%	10%	5%	0%
Curve_H4_Adobe 360dpi	0.11	0.11	0.19	0.29	0.36	0.47	0.55	0.66	0.76	0.86	0.97	1.06	1.17	1.29	1.40	1.50	1.58	1.66	1.78	1.87	2.01	2.02
Ideal Negative Curve	0.10	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	1.00	1.10	1.20	1.30	1.40	1.50	1.60	1.70	1.80	1.90	2.00	2.10
Print Reflective Density	1.32	1.32	1.28	1.23	1.16	1.08	0.99	0.90	0.81	0.71	0.59	0.52	0.44	0.38	0.32	0.26	0.22	0.18	0.14	0.11	0.09	0.08
Ideal Print Curve	1.48	1.48	1.41	1.34	1.26	1.19	1.12	1.05	0.98	0.90	0.83	0.76	0.69	0.62	0.54	0.47	0.40	0.33	0.26	0.18	0.11	0.04
Step Wedge Digital Value	n/a	0	13	26	38	51	64	77	90	102	115	128	141	154	165	178	191	204	217	229	242	255



# Negative Density - Epson 2200 Burkholder

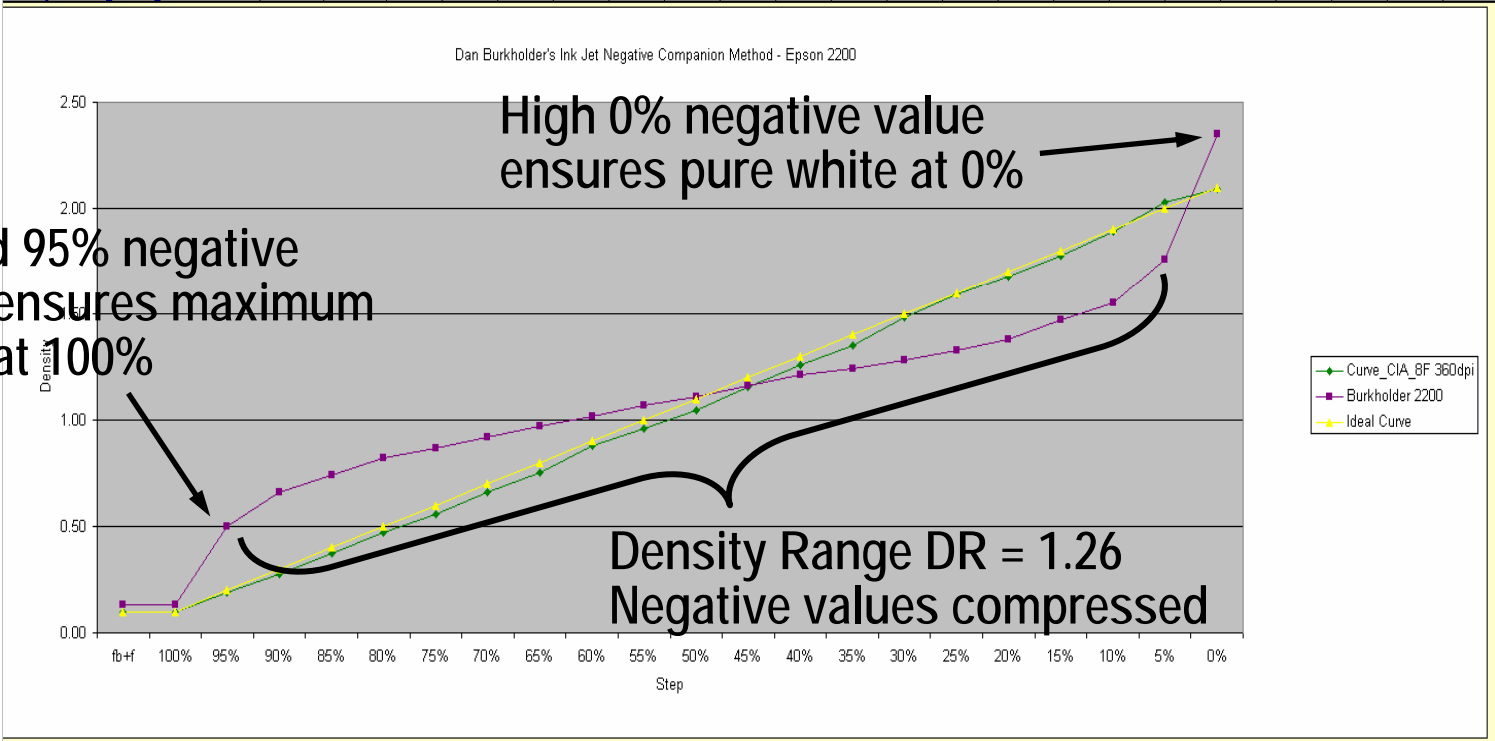
- UV negative density using Dan Burkholder's Ink Jet Negative Companion template on an Epson 2200 (generated by David Thum)

	fb+f	100%	95%	90%	85%	80%	75%	70%	65%	60%	55%	50%	45%	40%	35%	30%	25%	20%	15%	10%	5%	0%
Curve_CIA_8F 360dpi	0.10	0.10	0.19	0.28	0.37	0.47	0.56	0.66	0.75	0.88	0.96	1.05	1.15	1.26	1.35	1.49	1.59	1.68	1.78	1.89	2.03	2.09
Burkholder 2200	0.13	0.13	0.50	0.66	0.74	0.82	0.87	0.92	0.97	1.02	1.07	1.11	1.16	1.21	1.24	1.28	1.33	1.38	1.47	1.55	1.76	2.35
Ideal Curve	0.10	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	1.00	1.10	1.20	1.30	1.40	1.50	1.60	1.70	1.80	1.90	2.00	2.10
Step Wedge Digital Value	n/a	0	13	26	38	51	64	77	90	102	115	128	141	154	165	178	191	204	217	229	242	255

Raised 95% negative value ensures maximum black at 100%

High 0% negative value ensures pure white at 0%

Density Range DR = 1.26  
Negative values compressed



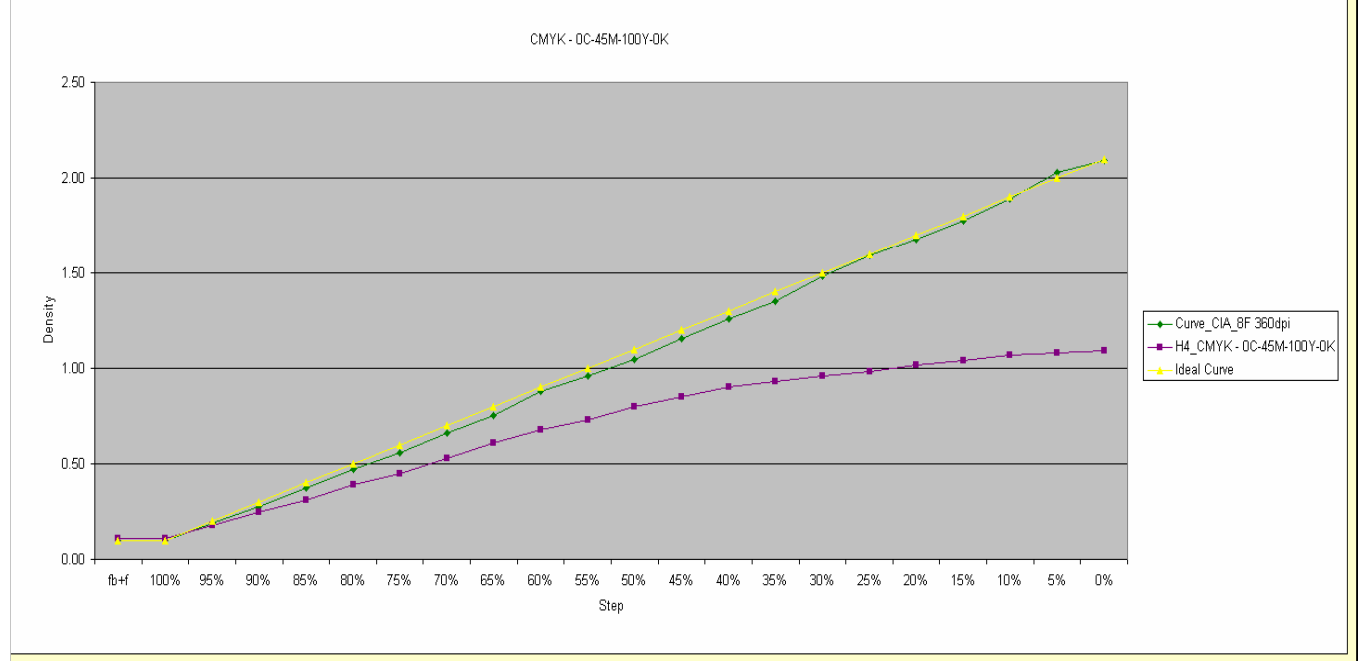
# Observations from Burkholder Negative

- Dan's negative compresses the density range with a value of  $DR=1.26$  (from 5%-95%) meaning a little more contrast agent will be needed to re-expand it slightly
- By using an 'S'-shaped curve, a slightly longer exposure is required for the shadow areas which normally would tend to make the highlights a little muddy. But the latter is compensated for by increasing the contrast agent.
- By tailing up the top end of the curve, a pure paper white is almost guaranteed in any area that is at 0% (255 value in Photoshop).
- I've learned from reading the reflective print densities of my prints that to get a full range print, a straight-line curve results in an exposure time below the threshold necessary to obtain a maximum black. It is not obvious to the eye but does show up in the reflective print densities.
- Consequently, I'll make adjustments to my curve to be somewhere in between Dan's and my current straight-line curve.

# Color Experiments in Digital Negatives

- Experimented with the CMYK colors to determine effects on resulting negative densities
- Removed Black: 0C-45M-100Y-0K
- Conclusion: Some Black is required to produce sufficient negative density

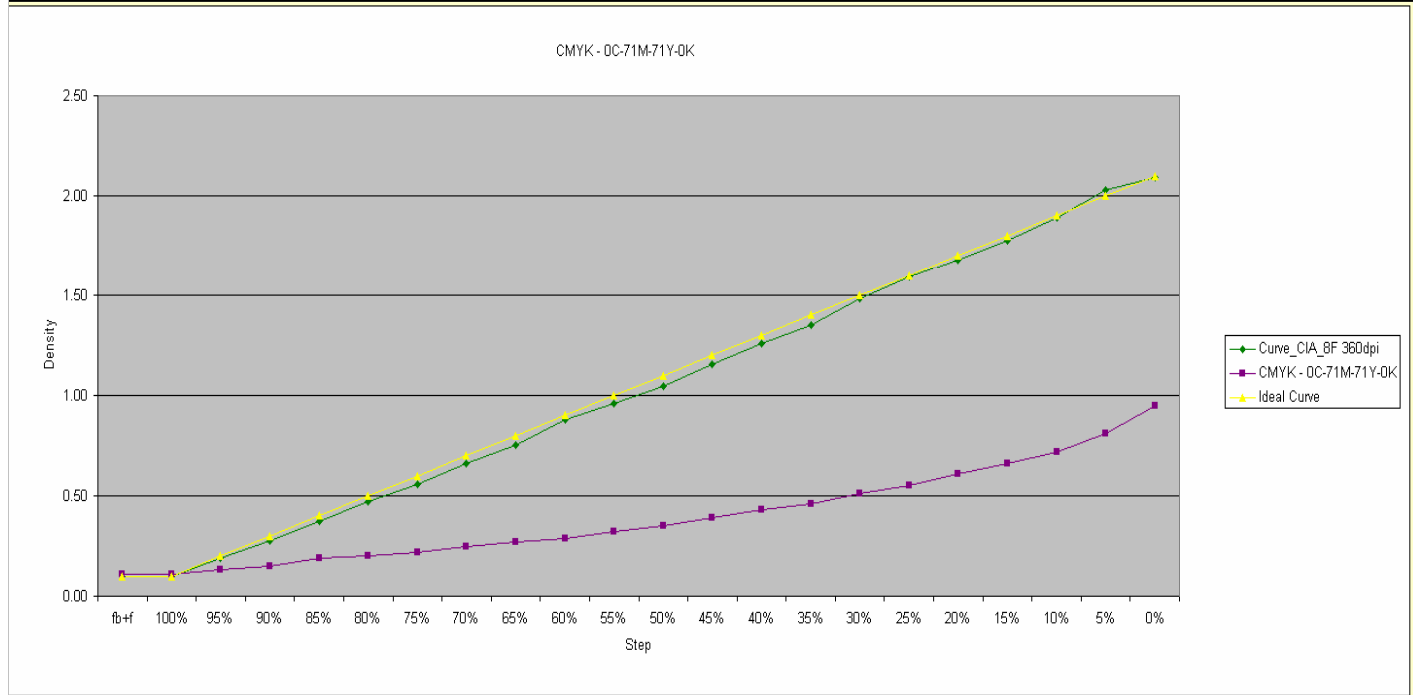
	fb+f	100%	95%	90%	85%	80%	75%	70%	65%	60%	55%	50%	45%	40%	35%	30%	25%	20%	15%	10%	5%	0%
Curve_CIA_8F 360dpi	0.10	0.10	0.19	0.28	0.37	0.47	0.56	0.66	0.75	0.88	0.96	1.05	1.15	1.26	1.35	1.49	1.59	1.68	1.78	1.89	2.03	2.09
H4_CMYK - 0C-45M-100Y-0K	0.11	0.11	0.18	0.25	0.31	0.39	0.45	0.53	0.61	0.68	0.73	0.80	0.85	0.90	0.93	0.96	0.98	1.02	1.04	1.07	1.08	1.09
Ideal Curve	0.10	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	1.00	1.10	1.20	1.30	1.40	1.50	1.60	1.70	1.80	1.90	2.00	2.10
Step Wedge Digital Value	n/a	0	13	26	38	51	64	77	90	102	115	128	141	154	165	178	191	204	217	229	242	255



# Color Experiments in Digital Negatives

- Burkholder paint bucket color of 0C-71M-71Y-0K with color table method
- Conclusion: Insufficient spectral density to produce a good negative without the density of the image itself.

	fb+f	100%	95%	90%	85%	80%	75%	70%	65%	60%	55%	50%	45%	40%	35%	30%	25%	20%	15%	10%	5%	0%
Curve_CIA_8F 360dpi	0.10	0.10	0.19	0.28	0.37	0.47	0.56	0.66	0.75	0.88	0.96	1.05	1.15	1.26	1.35	1.49	1.59	1.68	1.78	1.89	2.03	2.09
CMYK - 0C-71M-71Y-0K	0.11	0.11	0.13	0.15	0.19	0.20	0.22	0.25	0.27	0.29	0.32	0.35	0.39	0.43	0.46	0.51	0.55	0.61	0.66	0.72	0.81	0.95
Ideal Curve	0.10	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	1.00	1.10	1.20	1.30	1.40	1.50	1.60	1.70	1.80	1.90	2.00	2.10
Step Wedge Digital Value	n/a	0	13	26	38	51	64	77	90	102	115	128	141	154	165	178	191	204	217	229	242	255



# Advantages of Using a UV Densitometer

- Quick calibration of the curve for any situation or system configuration
- Extremely consistent, repeatable results
- Can use any combination of color management settings, monitor and material profiles, printer types or method for making digital negatives
  - Works for colorized negatives using methods such as paint bucket fill, color table, etc.
  - Works for non-colorized negatives
- Since the curve is calibrated for a full range file with image tone values from 0-255, exactly the same mixture of the sensitizer is used for all prints. Rarely does the amount of NA2 change.
- No math or logarithms required – print the step wedge, measure step wedge densities with the densitometer, enter values in Excel spreadsheet (negative density curve is plotted automatically), make adjustments to the Photoshop curve, repeat until calibration complete

# Disadvantages of Using a UV Densitometer

- This method is not for everyone.
- Most people do not have a UV densitometer or care to work with one.
- Since the curve is calibrated for a full range file with image tone values from 0-255, the exact same mixture of coating chemistry is used for all prints. Rarely does the amount of NA2 change and **therefore students don't really learn how to adjust contrast in the coating chemistry.**

# Lessons Learned

- Ink manufacturers do not test or design the ink for UV transmissive characteristics – They design and test for the visible spectrum of color
- When manufacturers move production to a different country, the UV characteristics of the ink can change drastically e.g. Epson 1280 color cartridge production was moved from Mexico to China while I was developing this method of calibration. Latest cartridges are from Japan.
- Ink batches vary in their UV response characteristics – Buy ink cartridges in batches
- Re-check calibration after installing a new ink cartridge
- With a completely calibrated system, the quality of the final image is dependent solely on the Photoshop skills of the user and where tonal values are placed in the range from 0-255.
- Tonal distribution varies widely with “canned” curves provided in commercially available software packages. They are only a starting point.

## Lessons Learned (cont.)

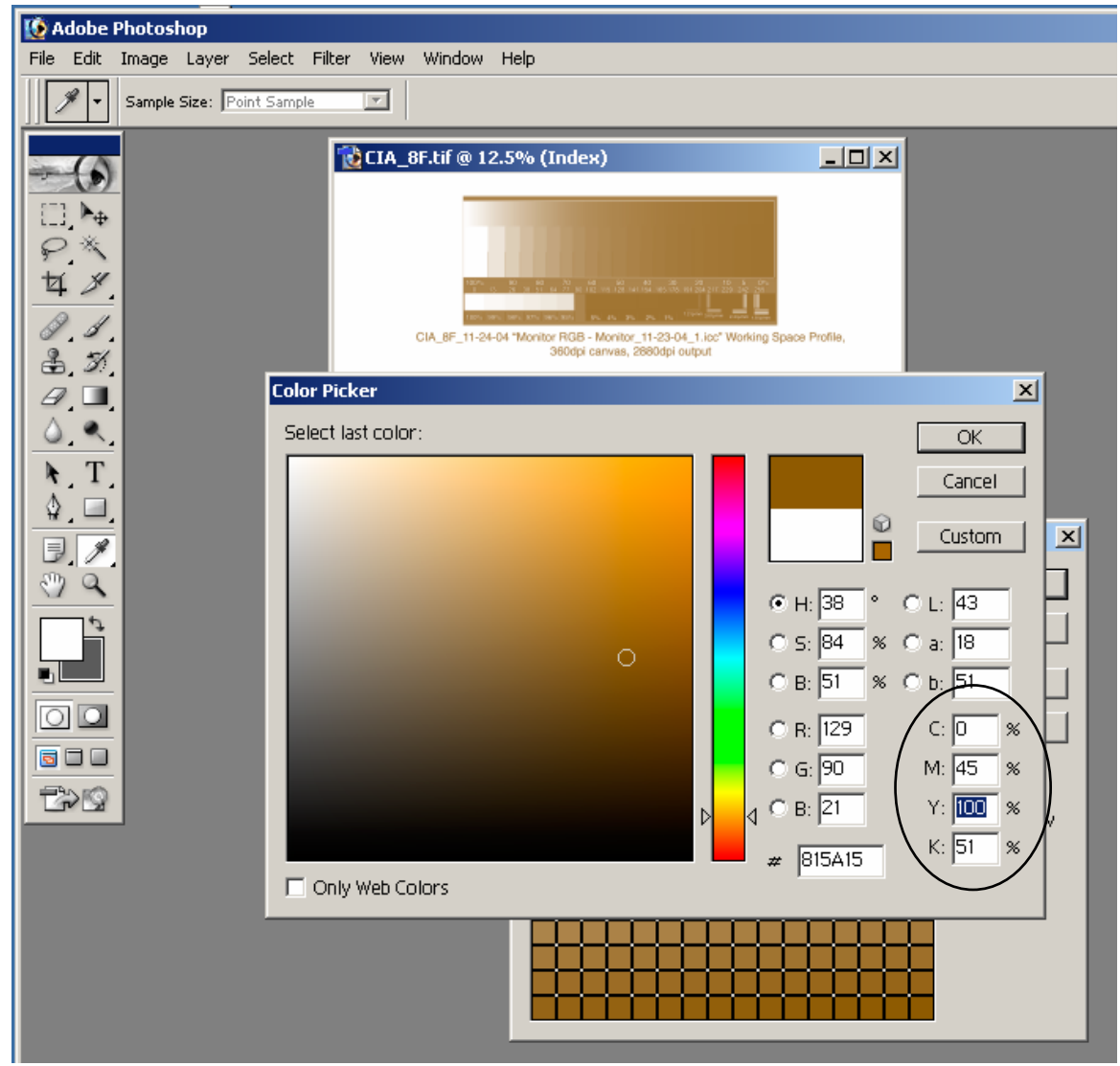
- Very minute adjustments in the Photoshop calibration curve in the highlight area can result in very large changes in negative density
- Most adjustments and difficulty in the Photoshop calibration curve is in the print highlight portions of the curve.
- UV density decreases as the ink dries - "digital dry-down"
- Pictorico material can vary from batch to batch – up to a third of a stop in range. When calibrating a curve, use Pictorico material from the same production batch.
- An ink cartridge and printer combination may exhibit "drift" in the calibration after a few weeks or months so re-calibration may be required even when using the same ink cartridge

# A Pleasant Surprise

- When using a colorized negative method (e.g. color table) changing the saturation of Yellow in the CMYK settings can raise or lower the density range of the entire curve linearly.
  - Allows adaptation for reducing the entire density range of an image without having to modify the file contrast or other characteristics of the image
  - Useful for adapting an existing curve to other alternative processes e.g. cyanotype, van Dyke brown, etc. which have different density range requirements than platinum/palladium
- If using RGB mode increasing/decreasing green content has a similar effect but not as great as the same amount of yellow.
- Examples follow...

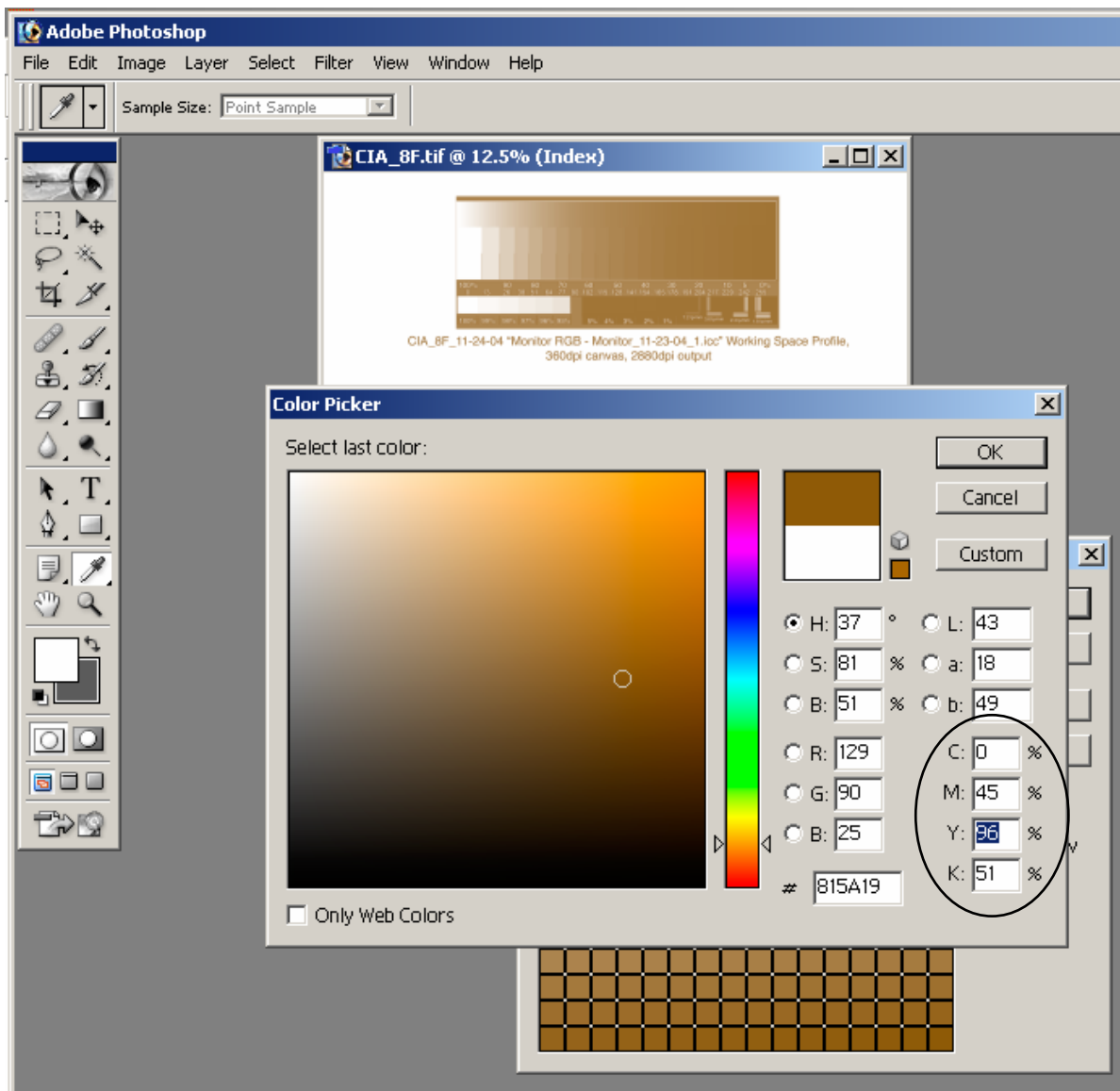
# Normal Color Table Settings for Palladium

- Indexed Color / Color Table Method for colorized digital negatives
- CMYK values for Last Color set to: C0-45M-100Y-51K



# Reducing Density Range with 'Y' Adjustment

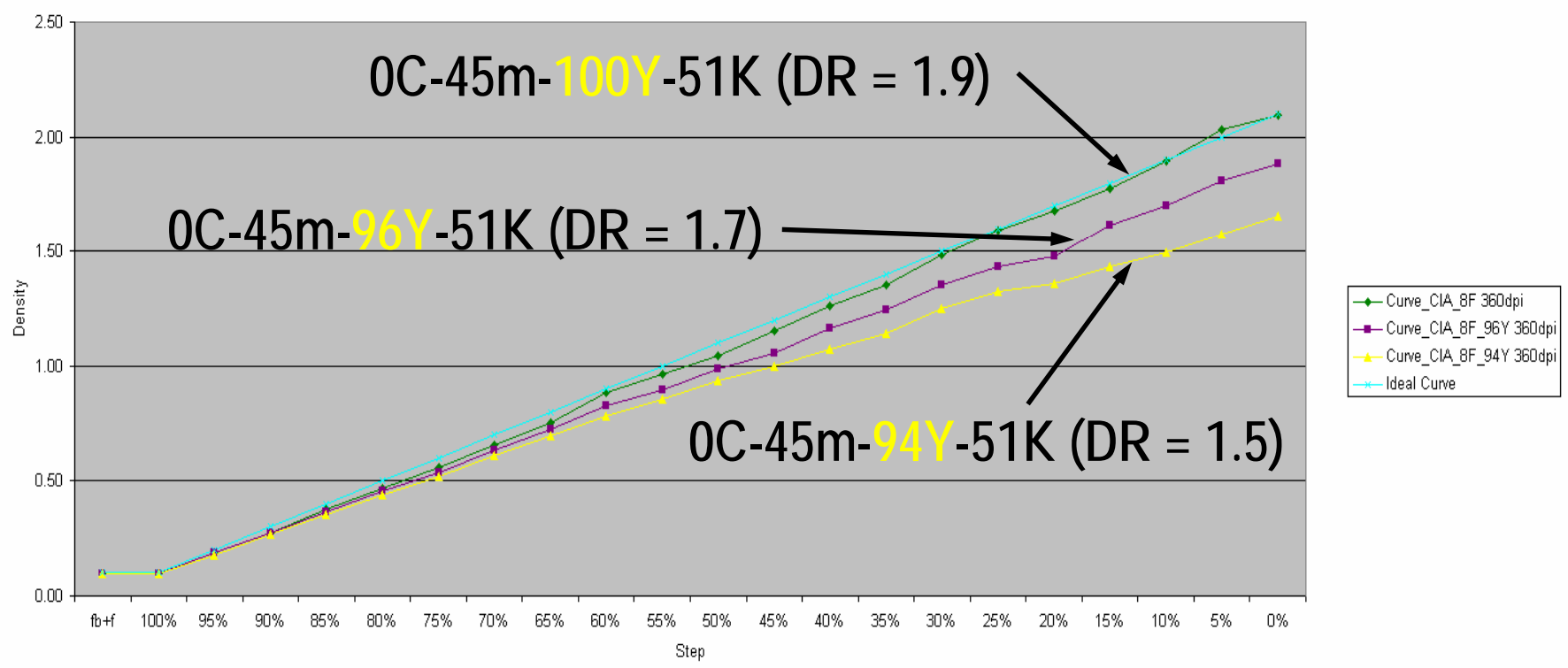
- CMYK values for Last Color set to: C0-45M-96Y-51K



# Resulting Density Range with 'Y' Adjustment

	fb+f	100%	95%	90%	85%	80%	75%	70%	65%	60%	55%	50%	45%	40%	35%	30%	25%	20%	15%	10%	5%	0%
Curve_CIA_8F_360dpi	0.10	0.10	0.19	0.28	0.37	0.47	0.56	0.66	0.75	0.88	0.96	1.05	1.15	1.26	1.35	1.49	1.59	1.68	1.78	1.89	2.03	2.09
Curve_CIA_8F_96Y_360dpi	0.10	0.10	0.19	0.27	0.37	0.46	0.54	0.63	0.72	0.83	0.90	0.99	1.06	1.17	1.25	1.36	1.43	1.48	1.61	1.70	1.81	1.88
Curve_CIA_8F_94Y_360dpi	0.10	0.10	0.18	0.27	0.36	0.44	0.52	0.61	0.70	0.78	0.86	0.94	1.00	1.08	1.14	1.25	1.32	1.36	1.43	1.50	1.57	1.65
Ideal Curve	0.10	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	1.00	1.10	1.20	1.30	1.40	1.50	1.60	1.70	1.80	1.90	2.00	2.10

Color Mgmt Off, "Monitor RGB - Monitor\_11-23-04\_1.icc Working Space Profile", 360dpi canvas, 2880 output



# Summary

- This method is based on common principles of color filtration and absorption characteristics for varying frequencies of light
- With practice, a Photoshop curve can be calibrated in 5-6 iterations in a couple hours
- Once the system has been calibrated, it is best to make negatives immediately since calibration “drift” may result after a week or more especially if the printer is not used extensively.