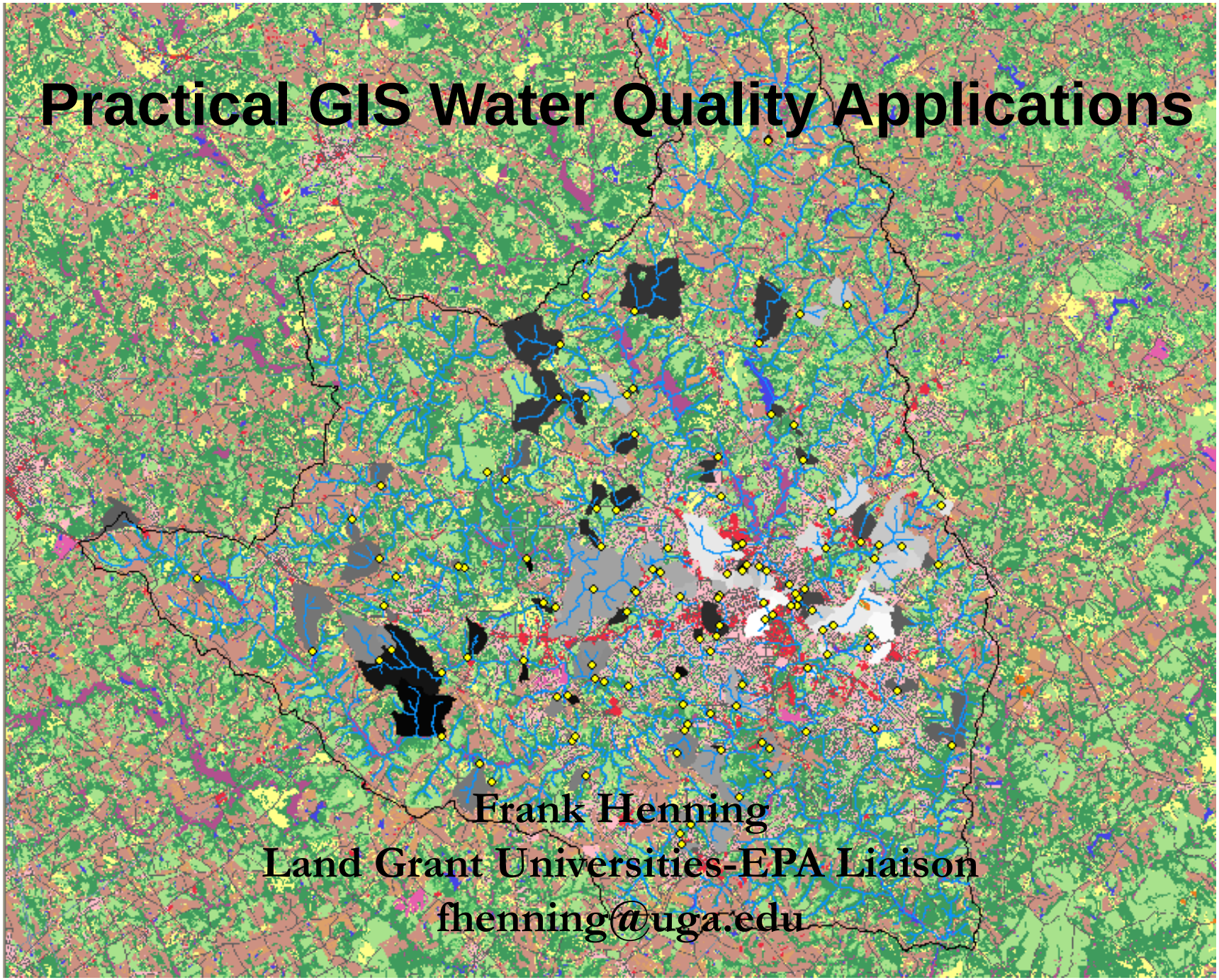
# Practical GIS Water Quality Applications



Frank Henning
Land Grant Universities-EPA Liaison
fhenning@uga.edu

# GIS Clearinghouses

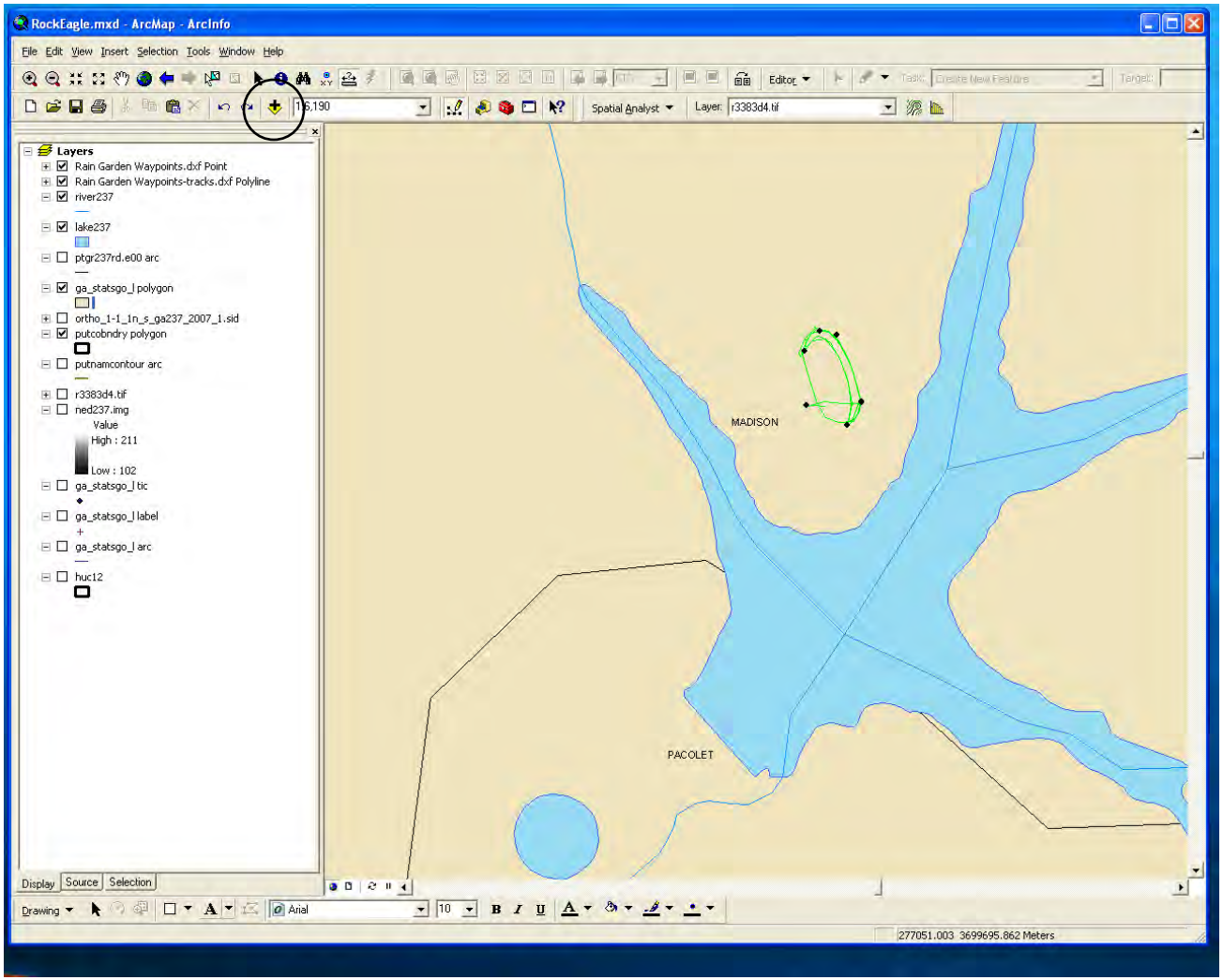



# Simple Bioretention Tools

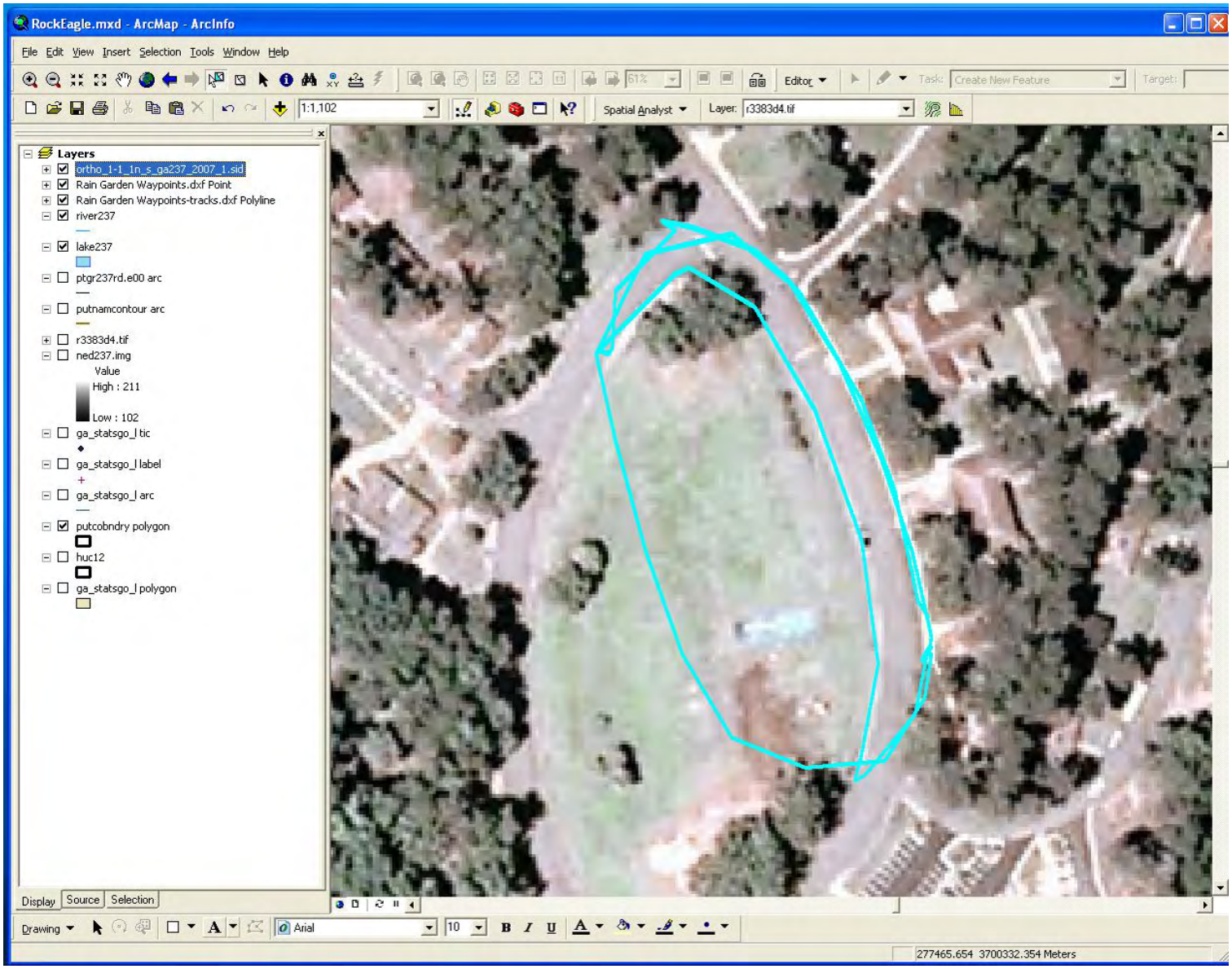
## Add layers

- Waypoints
- Soil
- Photos

- Roads
- Streams
- Lakes
- Boundaries



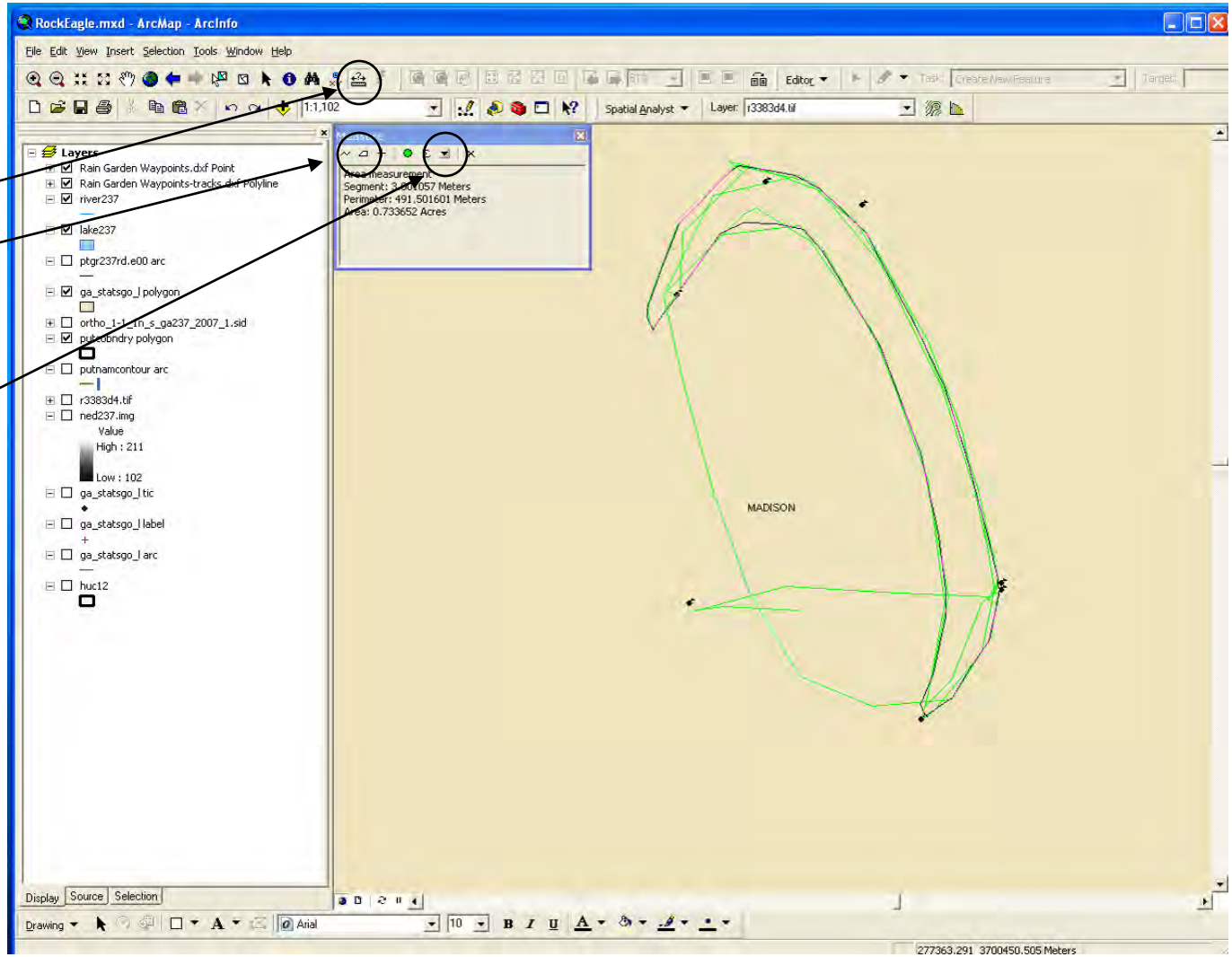
# Aerial Photos



# Area Measurement (impervious, pervious…)

**Measure tool**

- area tool
- distance/area
  - acres, ft…
- click perimeter
  - impervious
  - pervious
  - other



# Soil Data

## Soil Layer

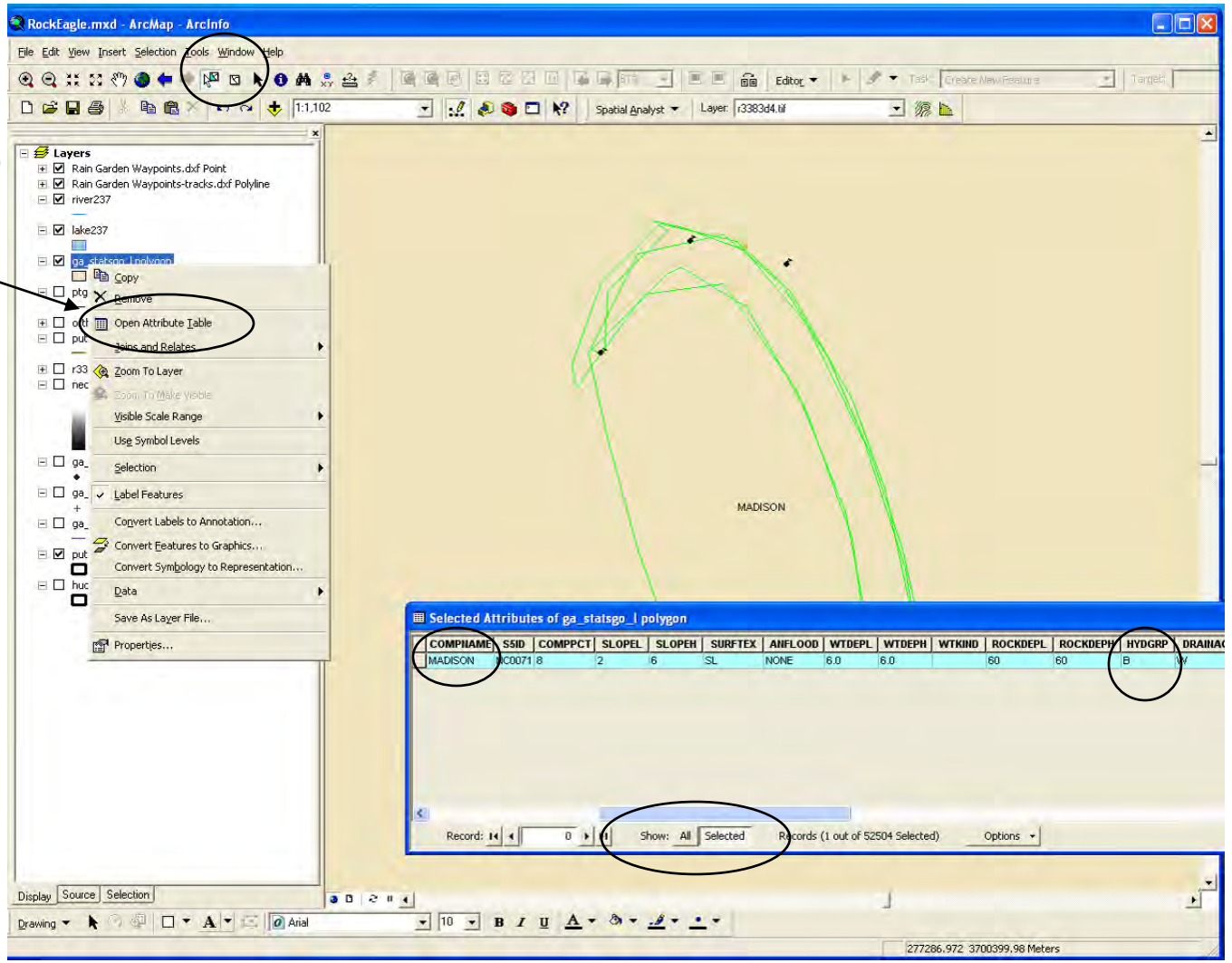
- Rt. click soil layer

> Attribute table

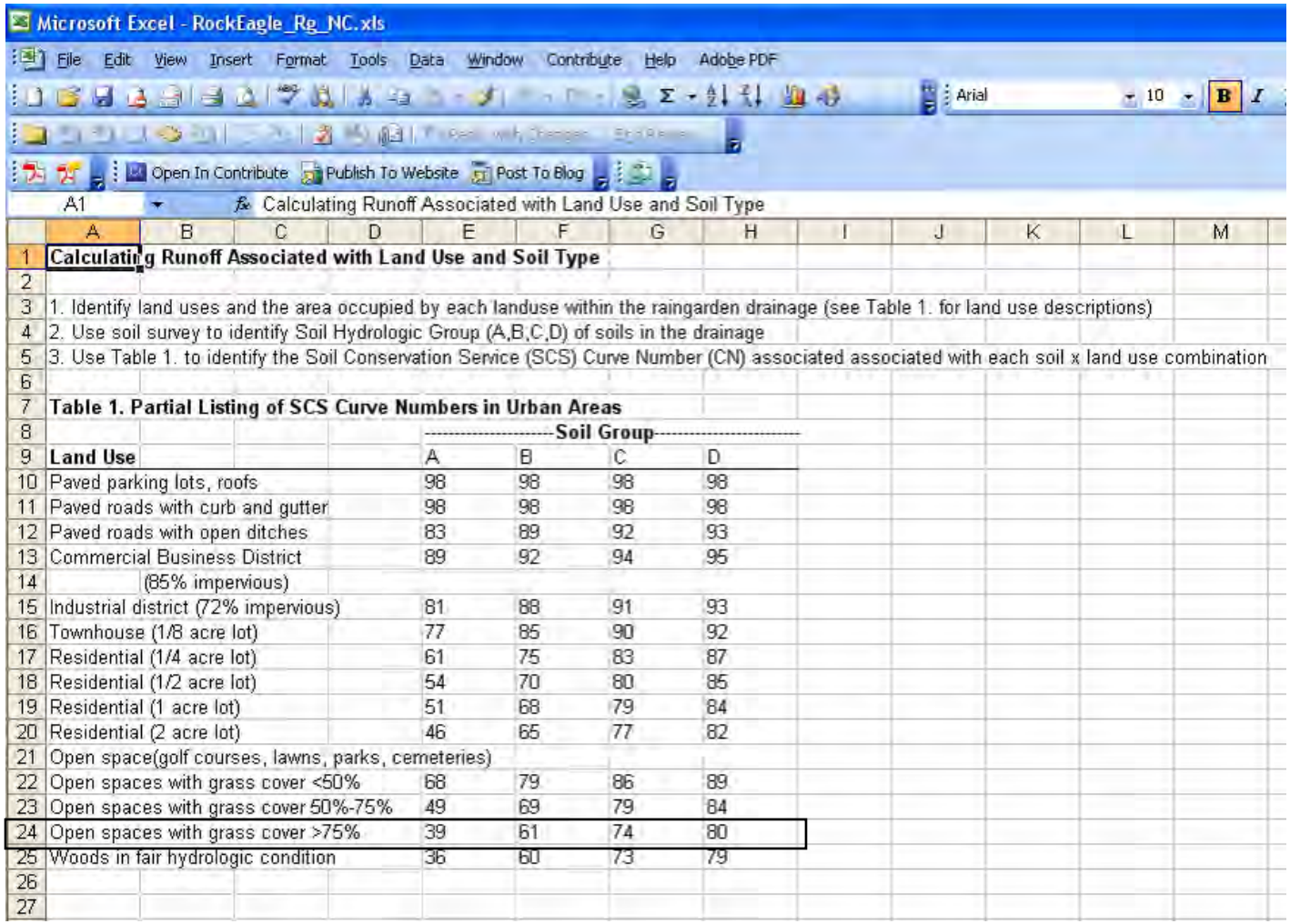
> map feature

> Show – selected

Note soil series & Hydgrp (A,B,C,D)



# Runoff Curve
## Land Use and Soil Group


Microsoft Excel - RockEagle_Rg_NC.xls

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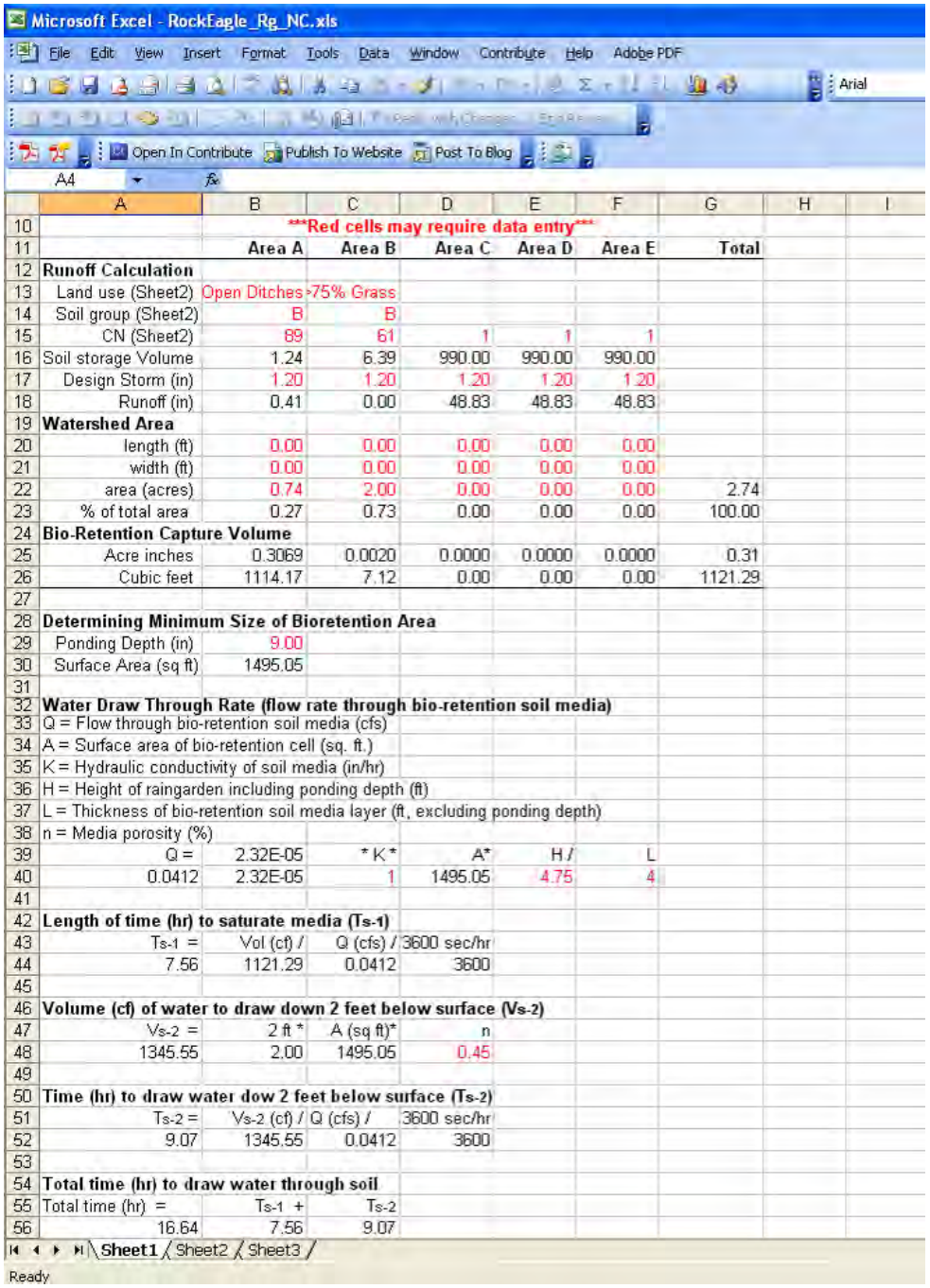
A1 — Calculating Runoff Associated with Land Use and Soil Type

| | A | B | C | D | E | F | G | H | I | J | K | L | M |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | **Calculating Runoff Associated with Land Use and Soil Type** | | | | | | | | | | | | |
| 2 | | | | | | | | | | | | | |
| 3 | 1. Identify land uses and the area occupied by each landuse within the raingarden drainage (see Table 1. for land use descriptions) | | | | | | | | | | | | |
| 4 | 2. Use soil survey to identify Soil Hydrologic Group (A,B,C,D) of soils in the drainage | | | | | | | | | | | | |
| 5 | 3. Use Table 1. to identify the Soil Conservation Service (SCS) Curve Number (CN) associated associated with each soil x land use combination | | | | | | | | | | | | |
| 6 | | | | | | | | | | | | | |
| 7 | **Table 1. Partial Listing of SCS Curve Numbers in Urban Areas** | | | | | | | | | | | | |
| 8 | | | | | ----------**Soil Group**---------- | | | | | | | | |
| 9 | **Land Use** | | | | A | B | C | D | | | | | |
| 10 | Paved parking lots, roofs | | | | 98 | 98 | 98 | 98 | | | | | |
| 11 | Paved roads with curb and gutter | | | | 98 | 98 | 98 | 98 | | | | | |
| 12 | Paved roads with open ditches | | | | 83 | 89 | 92 | 93 | | | | | |
| 13 | Commercial Business District | | | | 89 | 92 | 94 | 95 | | | | | |
| 14 | (85% impervious) | | | | | | | | | | | | |
| 15 | Industrial district (72% impervious) | | | | 81 | 88 | 91 | 93 | | | | | |
| 16 | Townhouse (1/8 acre lot) | | | | 77 | 85 | 90 | 92 | | | | | |
| 17 | Residential (1/4 acre lot) | | | | 61 | 75 | 83 | 87 | | | | | |
| 18 | Residential (1/2 acre lot) | | | | 54 | 70 | 80 | 85 | | | | | |
| 19 | Residential (1 acre lot) | | | | 51 | 68 | 79 | 84 | | | | | |
| 20 | Residential (2 acre lot) | | | | 46 | 65 | 77 | 82 | | | | | |
| 21 | Open space(golf courses, lawns, parks, cemeteries) | | | | | | | | | | | | |
| 22 | Open spaces with grass cover <50% | | | | 68 | 79 | 86 | 89 | | | | | |
| 23 | Open spaces with grass cover 50%-75% | | | | 49 | 69 | 79 | 84 | | | | | |
| 24 | Open spaces with grass cover >75% | | | | 39 | 61 | 74 | 80 | | | | | |
| 25 | Woods in fair hydrologic condition | | | | 36 | 60 | 73 | 79 | | | | | |
| 26 | | | | | | | | | | | | | |
| 27 | | | | | | | | | | | | | |

# Bioretention Size Calculations

- Curve number
- Soil group
- Drainage areas



Microsoft Excel - RockEagle_Rg_NC.xls

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A4

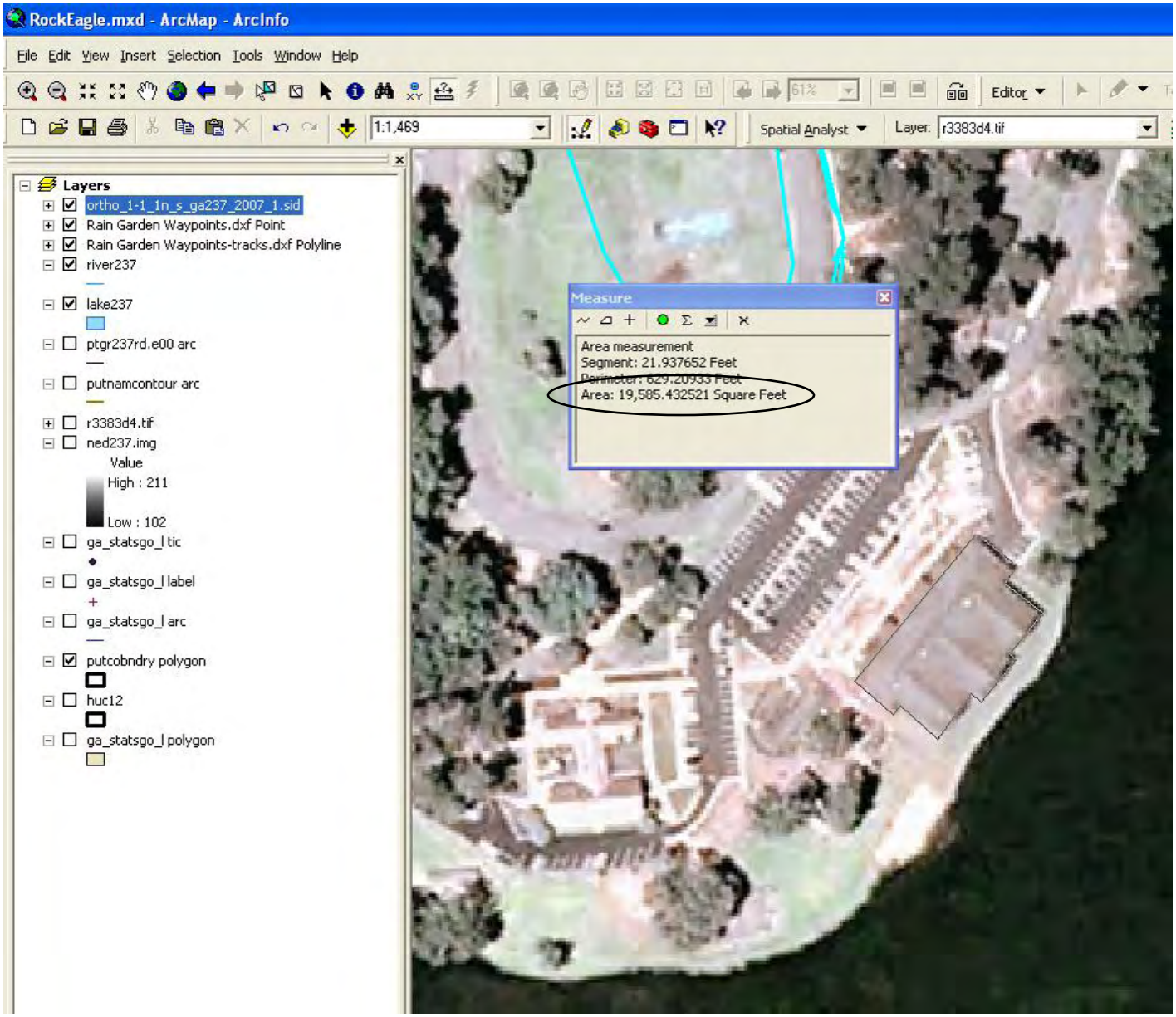
| | A | B | C | D | E | F | G | H | I |
|---|---|---|---|---|---|---|---|---|---|
| 10 | | ***Red cells may require data entry*** | | | | | | | |
| 11 | | Area A | Area B | Area C | Area D | Area E | Total | | |
| 12 | **Runoff Calculation** | | | | | | | | |
| 13 | Land use (Sheet2) | Open Ditches | >75% Grass | | | | | | |
| 14 | Soil group (Sheet2) | B | B | | | | | | |
| 15 | CN (Sheet2) | 89 | 61 | 1 | 1 | 1 | | | |
| 16 | Soil storage Volume | 1.24 | 6.39 | 990.00 | 990.00 | 990.00 | | | |
| 17 | Design Storm (in) | 1.20 | 1.20 | 1.20 | 1.20 | 1.20 | | | |
| 18 | Runoff (in) | 0.41 | 0.00 | 48.83 | 48.83 | 48.83 | | | |
| 19 | **Watershed Area** | | | | | | | | |
| 20 | length (ft) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | |
| 21 | width (ft) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | |
| 22 | area (acres) | 0.74 | 2.00 | 0.00 | 0.00 | 0.00 | 2.74 | | |
| 23 | % of total area | 0.27 | 0.73 | 0.00 | 0.00 | 0.00 | 100.00 | | |
| 24 | **Bio-Retention Capture Volume** | | | | | | | | |
| 25 | Acre inches | 0.3069 | 0.0020 | 0.0000 | 0.0000 | 0.0000 | 0.31 | | |
| 26 | Cubic feet | 1114.17 | 7.12 | 0.00 | 0.00 | 0.00 | 1121.29 | | |
| 27 | | | | | | | | | |
| 28 | **Determining Minimum Size of Bioretention Area** | | | | | | | | |
| 29 | Ponding Depth (in) | 9.00 | | | | | | | |
| 30 | Surface Area (sq ft) | 1495.05 | | | | | | | |
| 31 | | | | | | | | | |
| 32 | **Water Draw Through Rate (flow rate through bio-retention soil media)** | | | | | | | | |
| 33 | Q = Flow through bio-retention soil media (cfs) | | | | | | | | |
| 34 | A = Surface area of bio-retention cell (sq. ft.) | | | | | | | | |
| 35 | K = Hydraulic conductivity of soil media (in/hr) | | | | | | | | |
| 36 | H = Height of raingarden including ponding depth (ft) | | | | | | | | |
| 37 | L = Thickness of bio-retention soil media layer (ft, excluding ponding depth) | | | | | | | | |
| 38 | n = Media porosity (%) | | | | | | | | |
| 39 | Q = | 2.32E-05 | * K * | A* | H / | L | | | |
| 40 | 0.0412 | 2.32E-05 | 1 | 1495.05 | 4.75 | 4 | | | |
| 41 | | | | | | | | | |
| 42 | **Length of time (hr) to saturate media (Ts-1)** | | | | | | | | |
| 43 | Ts-1 = | Vol (cf) / | Q (cfs) / | 3600 sec/hr | | | | | |
| 44 | 7.56 | 1121.29 | 0.0412 | 3600 | | | | | |
| 45 | | | | | | | | | |
| 46 | **Volume (cf) of water to draw down 2 feet below surface (Vs-2)** | | | | | | | | |
| 47 | Vs-2 = | 2 ft * | A (sq ft)* | n | | | | | |
| 48 | 1345.55 | 2.00 | 1495.05 | 0.45 | | | | | |
| 49 | | | | | | | | | |
| 50 | **Time (hr) to draw water dow 2 feet below surface (Ts-2)** | | | | | | | | |
| 51 | Ts-2 = | Vs-2 (cf) / | Q (cfs) / | 3600 sec/hr | | | | | |
| 52 | 9.07 | 1345.55 | 0.0412 | 3600 | | | | | |
| 53 | | | | | | | | | |
| 54 | **Total time (hr) to draw water through soil** | | | | | | | | |
| 55 | Total time (hr) = | Ts-1 + | Ts-2 | | | | | | |
| 56 | 16.64 | 7.56 | 9.07 | | | | | | |

Sheet1 / Sheet2 / Sheet3 /

Ready

# Rainfall Harvesting

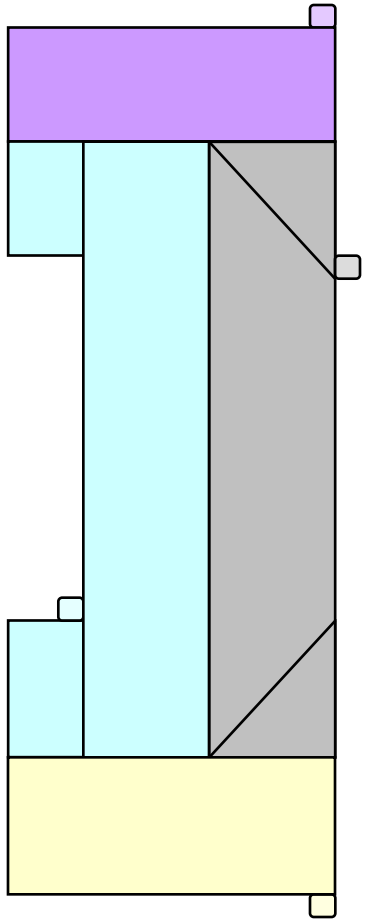
# Rain Harvesting Catchment Areas



# 2007 Rain Harvest Potential - Athens, GA

| Month | Inches | Gal/ft$^2$ | Roof ft$^2$ | Harvest estimate (gal.) |
|---|---|---|---|---|
| April | 1.8 | 0.6 | 19500 | 21060 |
| May | 0.55 | 0.6 | | |
| June | 2.23 | 0.6 | | |
| July | 3.04 | 0.6 | | |
| August | 1.31 | 0.6 | | |
| September | 2.15 | 0.6 | | |
| October | 1.61 | 0.6 | | |
| November | 2.12 | 0.6 | | |

**Roof Drainages**



## Roof Area Calculation

| Catchment | Length (ft) | Width (ft) | Area (ft$^2$) |
|---|---|---|---|
| 1. | | | 19500 |
| 2. | | | |
| 3. | | | |
| 4. | | | |
| 5. | | | |

# Watersheds, & Water Quality

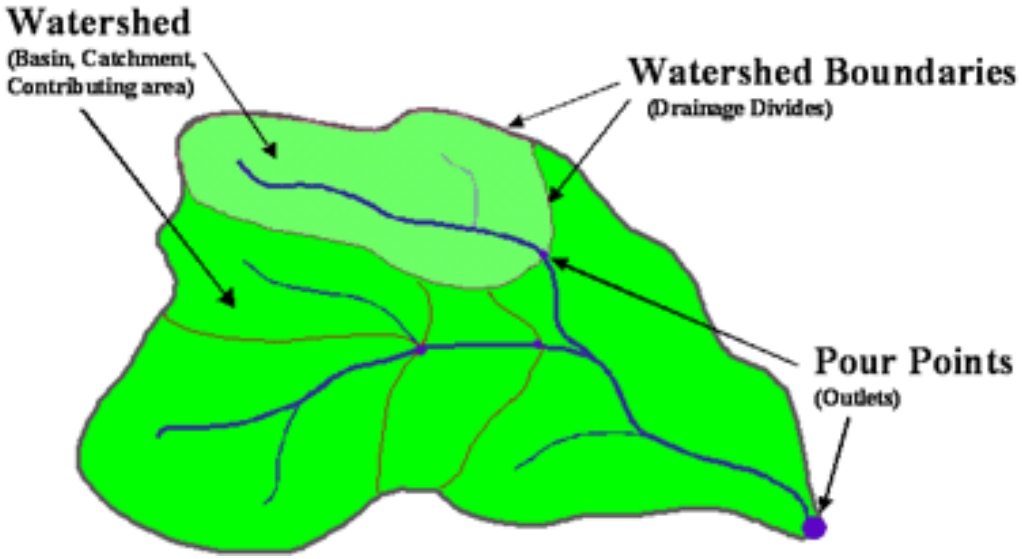
http://courses.washington.edu/esrm590/lessons/hydrology/index.html

**http://webhelp.esri.com/arcgisdesktop/9.2/index.cfm?TopicName=Understanding_drainage_systems**

## Layers

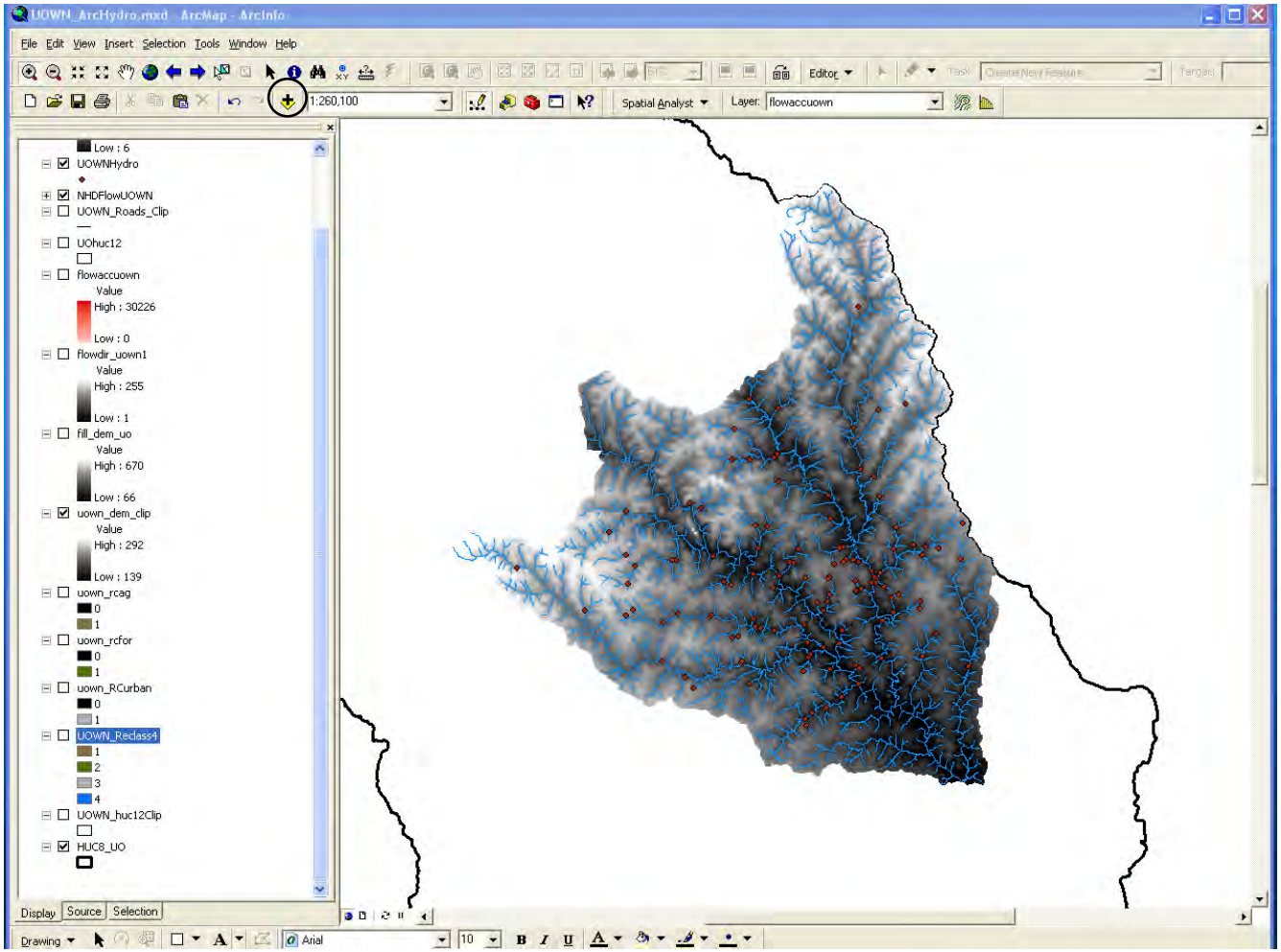
- DEM
- Pour points

- Streams
- Roads
- HUC Watersheds
- Other boundaries



# Delineate Subwatersheds

## - Add DEM, Streams, Pour Points Layers



# UOWN Volunteer-Collected Data

## April 8, 2006 & April 14, 2007

| 1 | River Rendezvous results, April 14, 2007, Upper Oconee Watershed Network | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | Watershed | I.D. | Site Description | [b]Visual | [a]Biol | Cond (H) | Turb | PO4 | NO3 | DO | T | pH | Fecal[c] | [d]E coli | [d]Entero | [d]Total Col | [e]E coli | SRP[f] |
| 61 | NORO | 502 | (Q) Barber Creek at Barber St. | | | **183.3** | 6.4 | | | | | 6.9 | | **855** | 262 | 24,192 | 4 | 20 |
| 62 | NORO | 503 | (Q) Trail Creek at Dudl | 37 | 20 | 47.9 | 13.4 | | | | | | | 399 | 63 | 6,131 | **6** | |
| 63 | NORO | 504 | Trail Creek Trib., Branc | 27 | | **95.5** | 2.6 | | | | | 6.9 | | 131 | 116 | 7,701 | 0 | 30 |
| 64 | NORO | 505 | (TMDL) Carvers Branch | 37 | | 76.7 | 12.0 | | | | | 7.0 | | 52 | 97 | 1,658 | 1 | 290 |
| 65 | NORO | 506 | (Q) Barber Creek at Nantahala | | | **90.3** | 8.0 | | | | | 7.1 | | **882** | 3,282 | 24,192 | **6** | 60 |
| 66 | NORO | 510 | (Q) North Oconee at Dudley Park | | | 54.6 | 14.4 | | | | | 6.9 | | 158 | 30 | 6,488 | 1 | 40 |
| 67 | NORO | 512 | (TMDL) East Fork Trail | 39 | | 56.2 | 13.4 | | | | | 6.7 | | | | | | 150 |
| 68 | NORO | 513 | (TMDL) W Fork Trail C | 39 | | 49.7 | 11.1 | | | | | 6.7 | | | | | 2 | |
| 69 | NORO | 514 | (TMDL) West Fork Trai | 45 | | 53.1 | 12.4 | | | | | 6.8 | | | | | 0 | |

**<u>Physical/Chemical</u>**

Conductivity

Turbidity

Nutrients

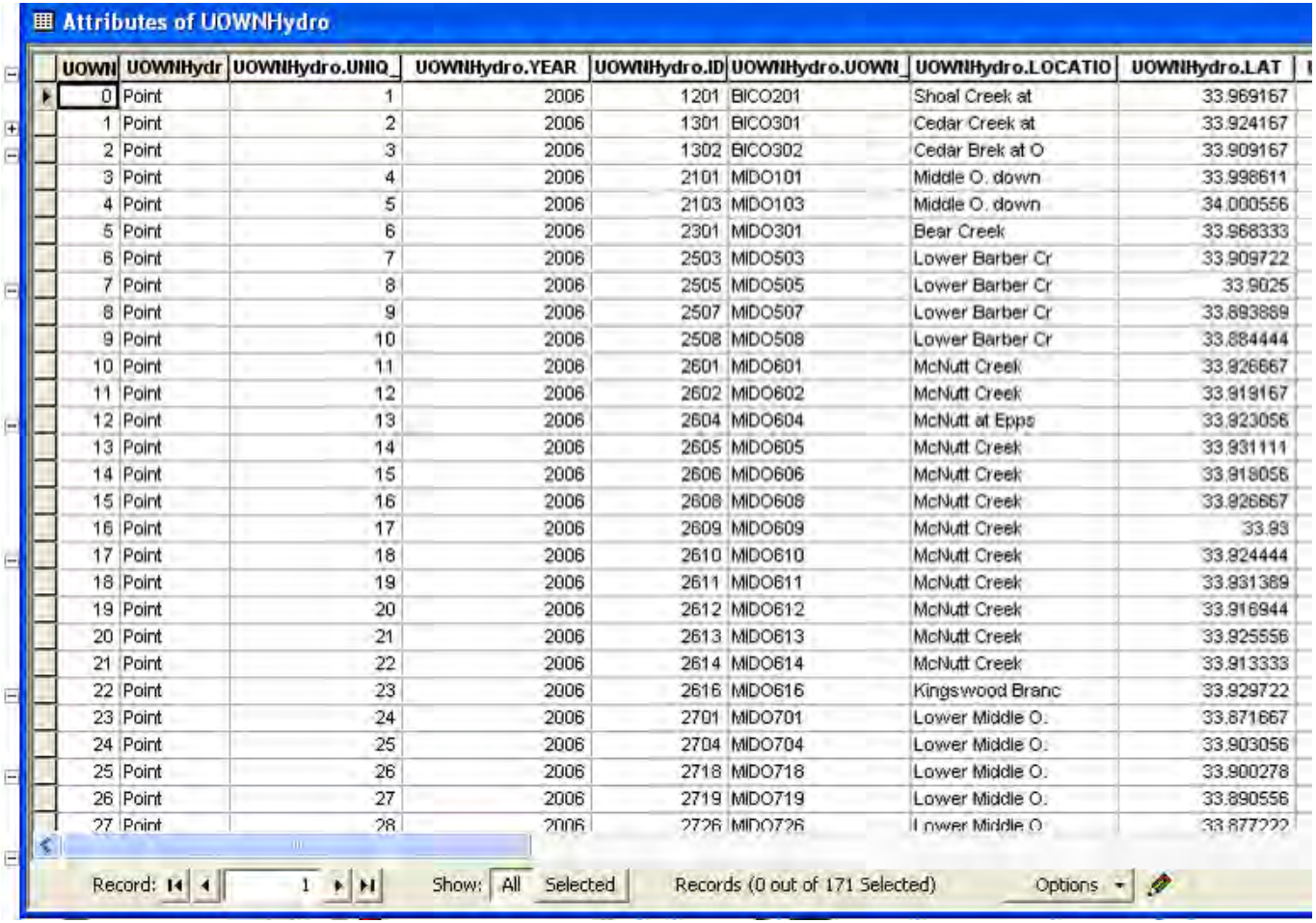
**<u>Habitat/Biological</u>**

Visual analysis

Macroinvertebrate

Bacteria indicators

Be sure your pour points Have unique ID numbers, other data is optional



Attributes of UOWNHydro

| UOWN | UOWNHydr | UOWNHydro.UNIQ_ | UOWNHydro.YEAR | UOWNHydro.ID | UOWNHydro.UOWN_ | UOWNHydro.LOCATIO | UOWNHydro.LAT |
|---|---|---|---|---|---|---|---|
| 0 | Point | 1 | 2006 | 1201 | BICO201 | Shoal Creek at | 33.969167 |
| 1 | Point | 2 | 2006 | 1301 | BICO301 | Cedar Creek at | 33.924167 |
| 2 | Point | 3 | 2006 | 1302 | BICO302 | Cedar Brek at O | 33.909167 |
| 3 | Point | 4 | 2006 | 2101 | MIDO101 | Middle O. down | 33.998611 |
| 4 | Point | 5 | 2006 | 2103 | MIDO103 | Middle O. down | 34.000556 |
| 5 | Point | 6 | 2006 | 2301 | MIDO301 | Bear Creek | 33.968333 |
| 6 | Point | 7 | 2006 | 2503 | MIDO503 | Lower Barber Cr | 33.909722 |
| 7 | Point | 8 | 2006 | 2505 | MIDO505 | Lower Barber Cr | 33.9025 |
| 8 | Point | 9 | 2006 | 2507 | MIDO507 | Lower Barber Cr | 33.893889 |
| 9 | Point | 10 | 2006 | 2508 | MIDO508 | Lower Barber Cr | 33.884444 |
| 10 | Point | 11 | 2006 | 2601 | MIDO601 | McNutt Creek | 33.926667 |
| 11 | Point | 12 | 2006 | 2602 | MIDO602 | McNutt Creek | 33.919167 |
| 12 | Point | 13 | 2006 | 2604 | MIDO604 | McNutt at Epps | 33.923056 |
| 13 | Point | 14 | 2006 | 2605 | MIDO605 | McNutt Creek | 33.931111 |
| 14 | Point | 15 | 2006 | 2606 | MIDO606 | McNutt Creek | 33.919056 |
| 15 | Point | 16 | 2006 | 2608 | MIDO608 | McNutt Creek | 33.926667 |
| 16 | Point | 17 | 2006 | 2609 | MIDO609 | McNutt Creek | 33.93 |
| 17 | Point | 18 | 2006 | 2610 | MIDO610 | McNutt Creek | 33.924444 |
| 18 | Point | 19 | 2006 | 2611 | MIDO611 | McNutt Creek | 33.931389 |
| 19 | Point | 20 | 2006 | 2612 | MIDO612 | McNutt Creek | 33.916944 |
| 20 | Point | 21 | 2006 | 2613 | MIDO613 | McNutt Creek | 33.925556 |
| 21 | Point | 22 | 2006 | 2614 | MIDO614 | McNutt Creek | 33.913333 |
| 22 | Point | 23 | 2006 | 2616 | MIDO616 | Kingswood Branc | 33.929722 |
| 23 | Point | 24 | 2006 | 2701 | MIDO701 | Lower Middle O. | 33.871667 |
| 24 | Point | 25 | 2006 | 2704 | MIDO704 | Lower Middle O. | 33.903056 |
| 25 | Point | 26 | 2006 | 2718 | MIDO718 | Lower Middle O. | 33.900278 |
| 26 | Point | 27 | 2006 | 2719 | MIDO719 | Lower Middle O. | 33.890556 |
| 27 | Point | 28 | 2006 | 2726 | MIDO726 | Lower Middle O | 33.877222 |

Record: 1 Show: All Selected Records (0 out of 171 Selected) Options

# Turn on Statistical Analyst & Editor Tools

## Stat Analyst

>Tools

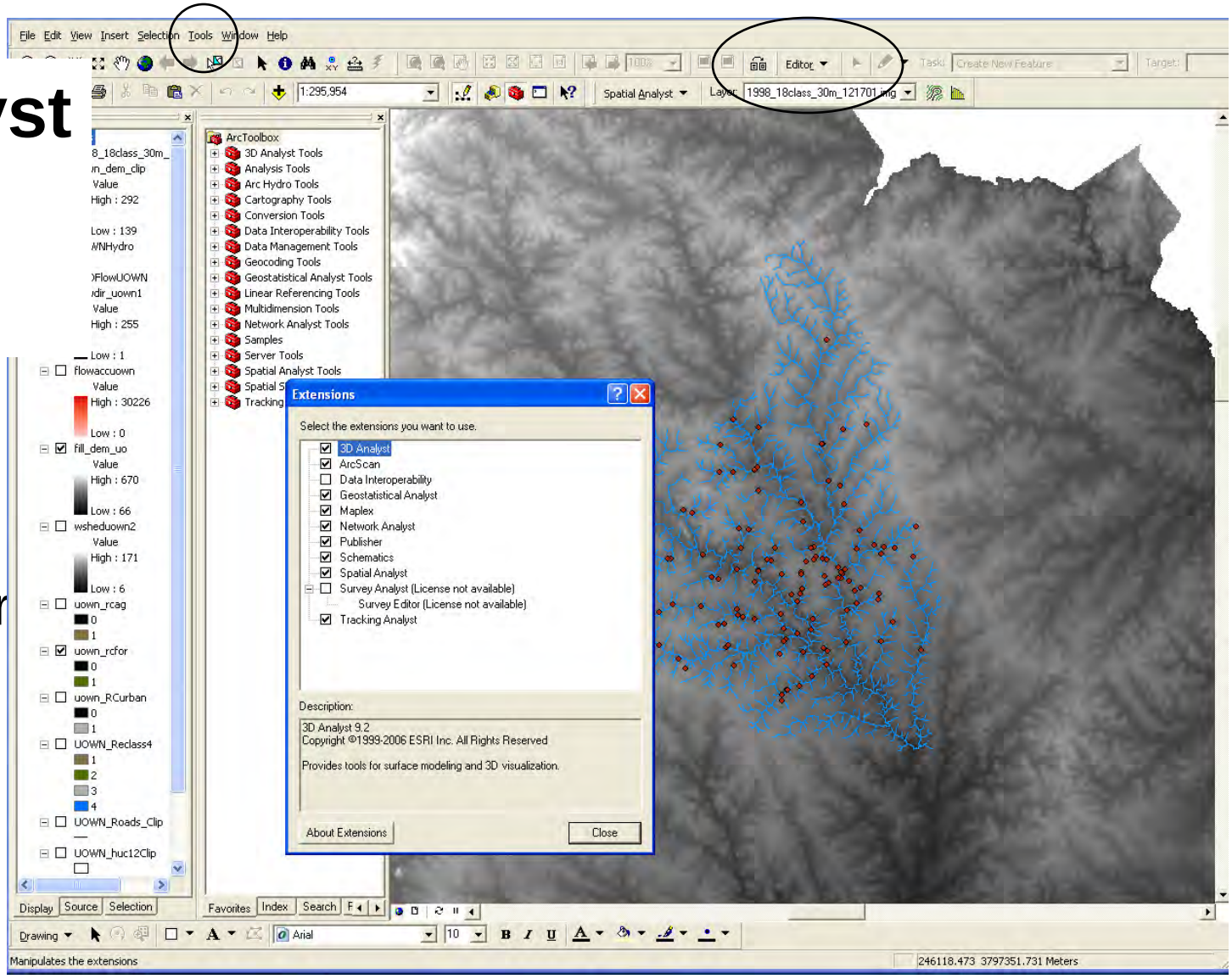
>Extensions

>Check boxes

## Editor

>Tools

>Editor toolbar

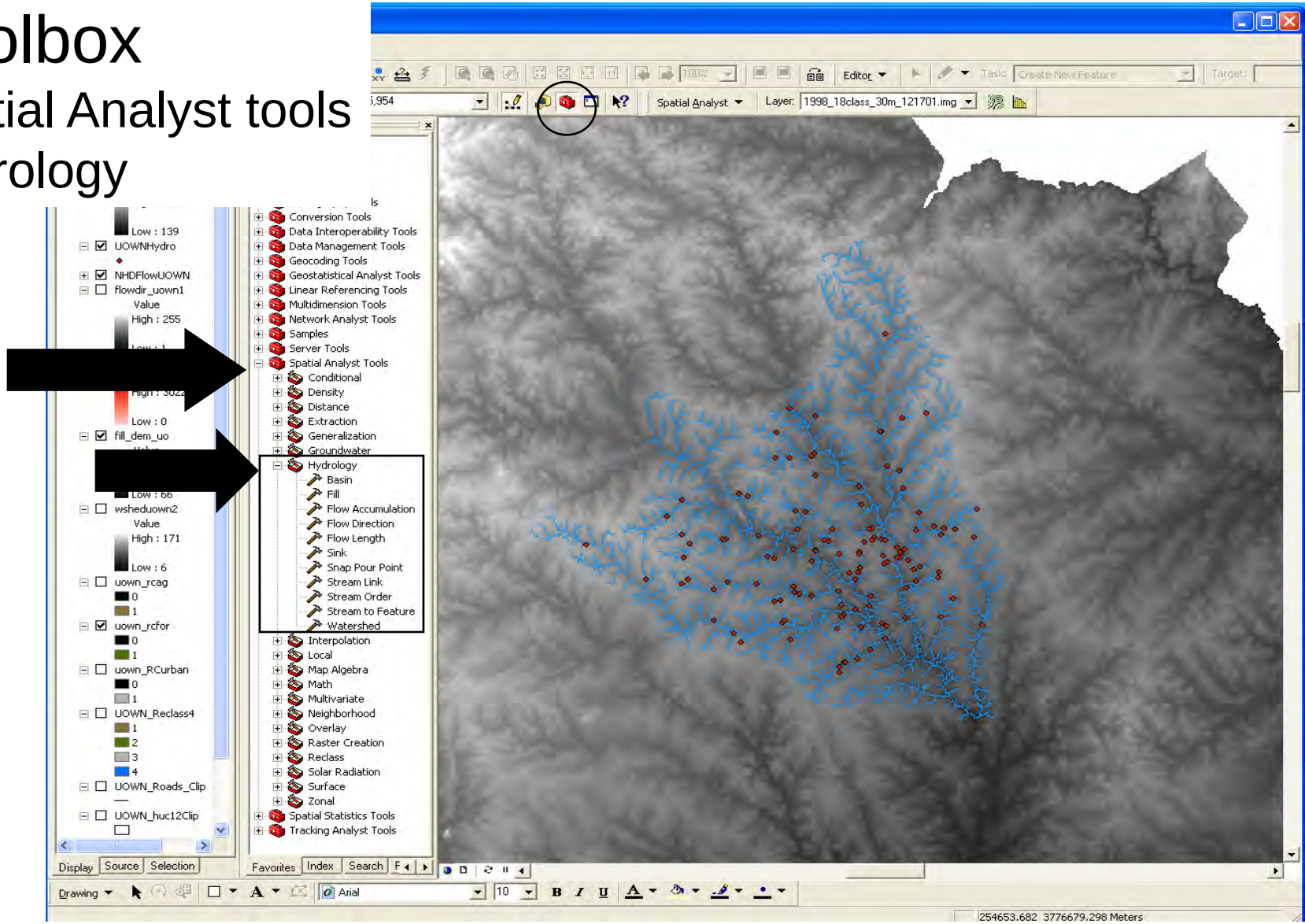


# Open Hydrology Tools

>Toolbox

>Spatial Analyst tools

>Hydrology

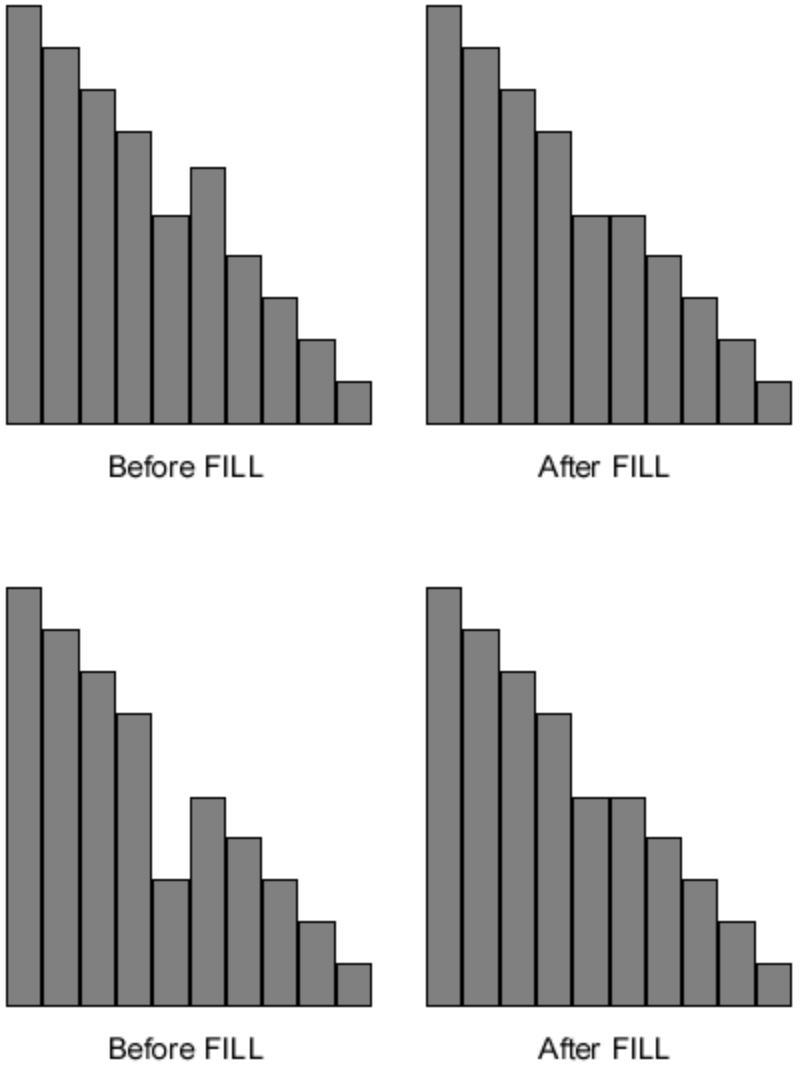


# Watershed Delineation

## Step #1 - Fill Sinks

>Arc Toolbox
>Spatial Analyst Tools
>Hydrology Tools
>Fill Sinks

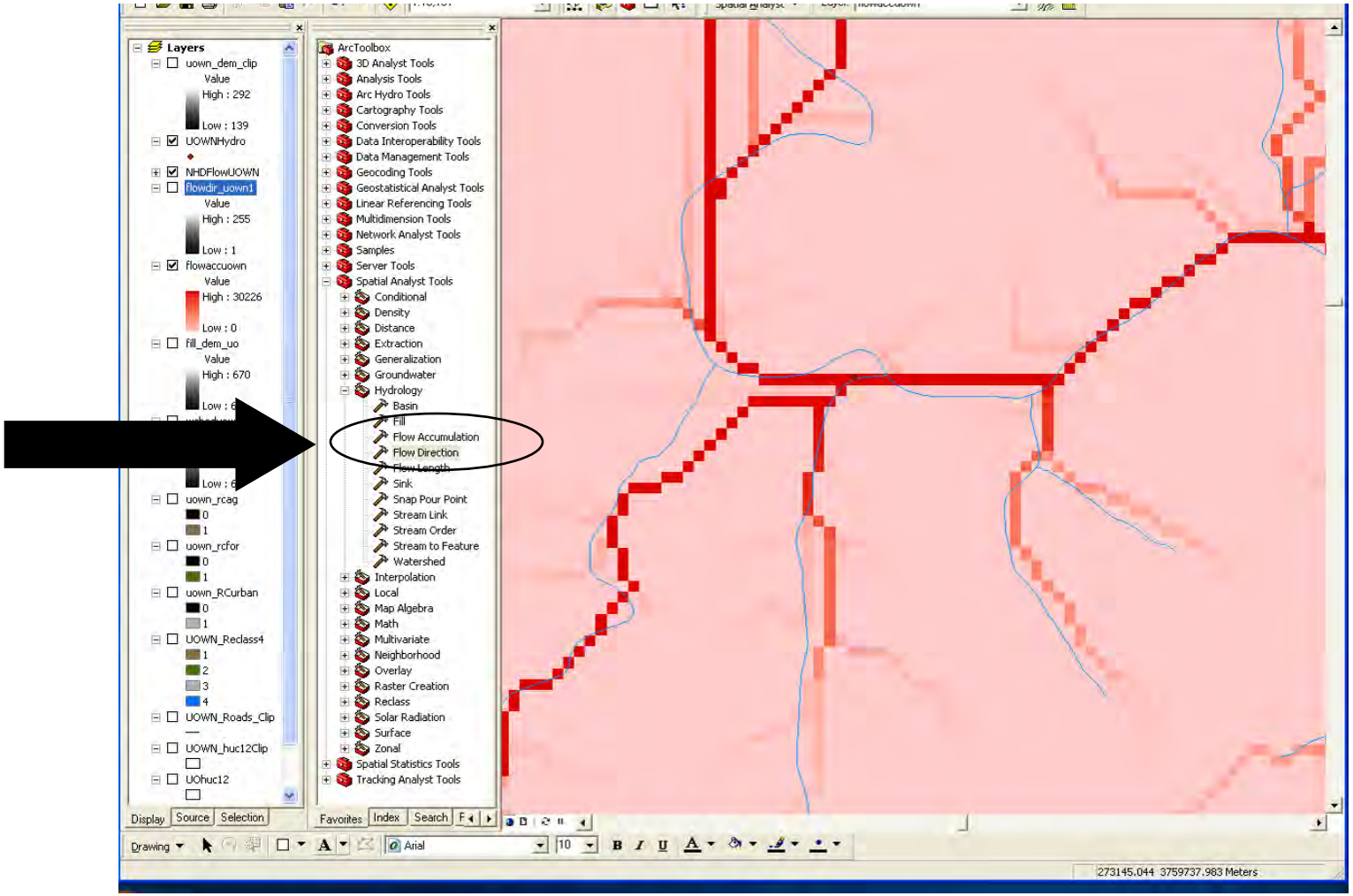
*Creates a new DEM



# Watershed Delineation

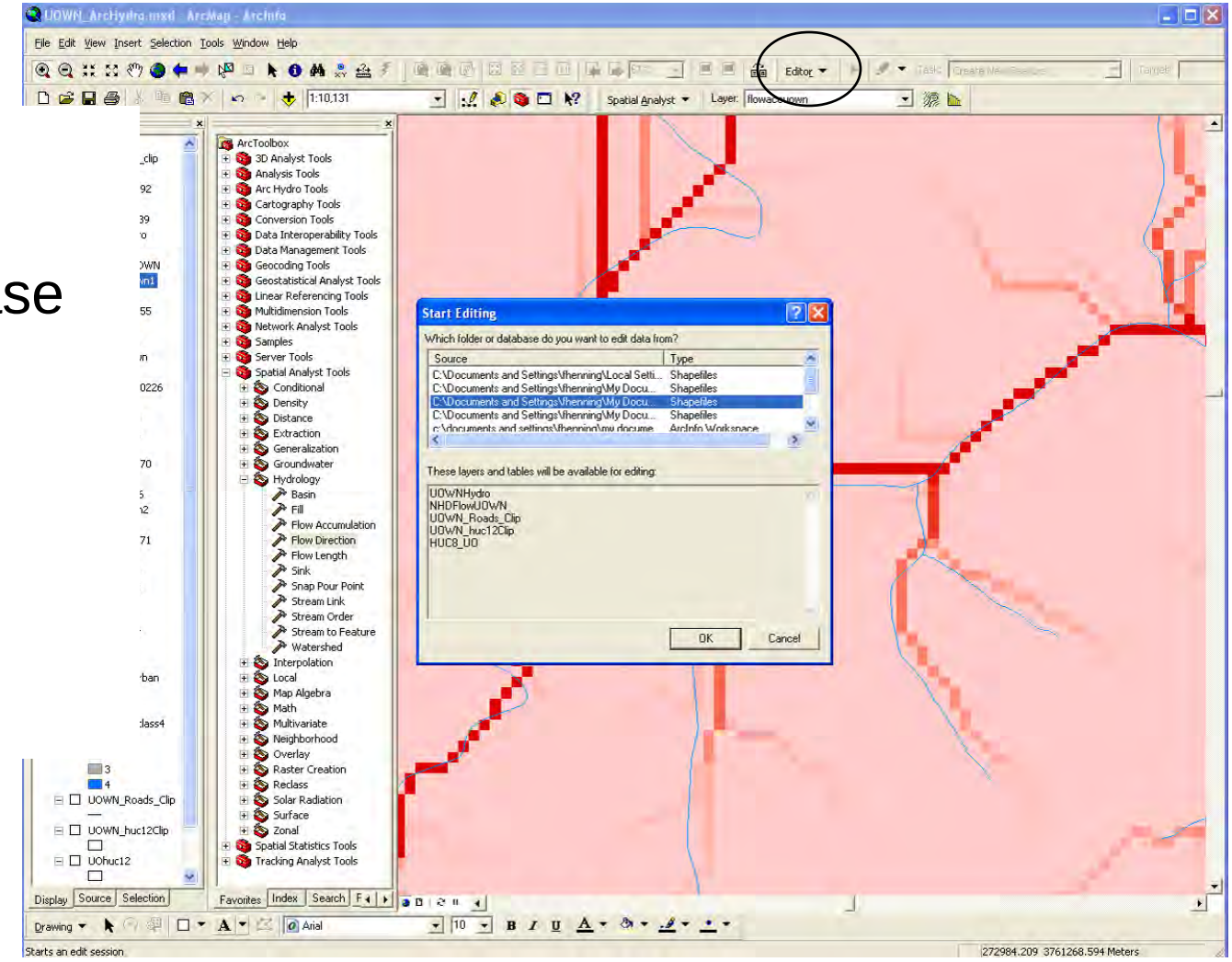
#2. Flow Direction (use DEM with sinks filled)

#3. Flow Accumulation



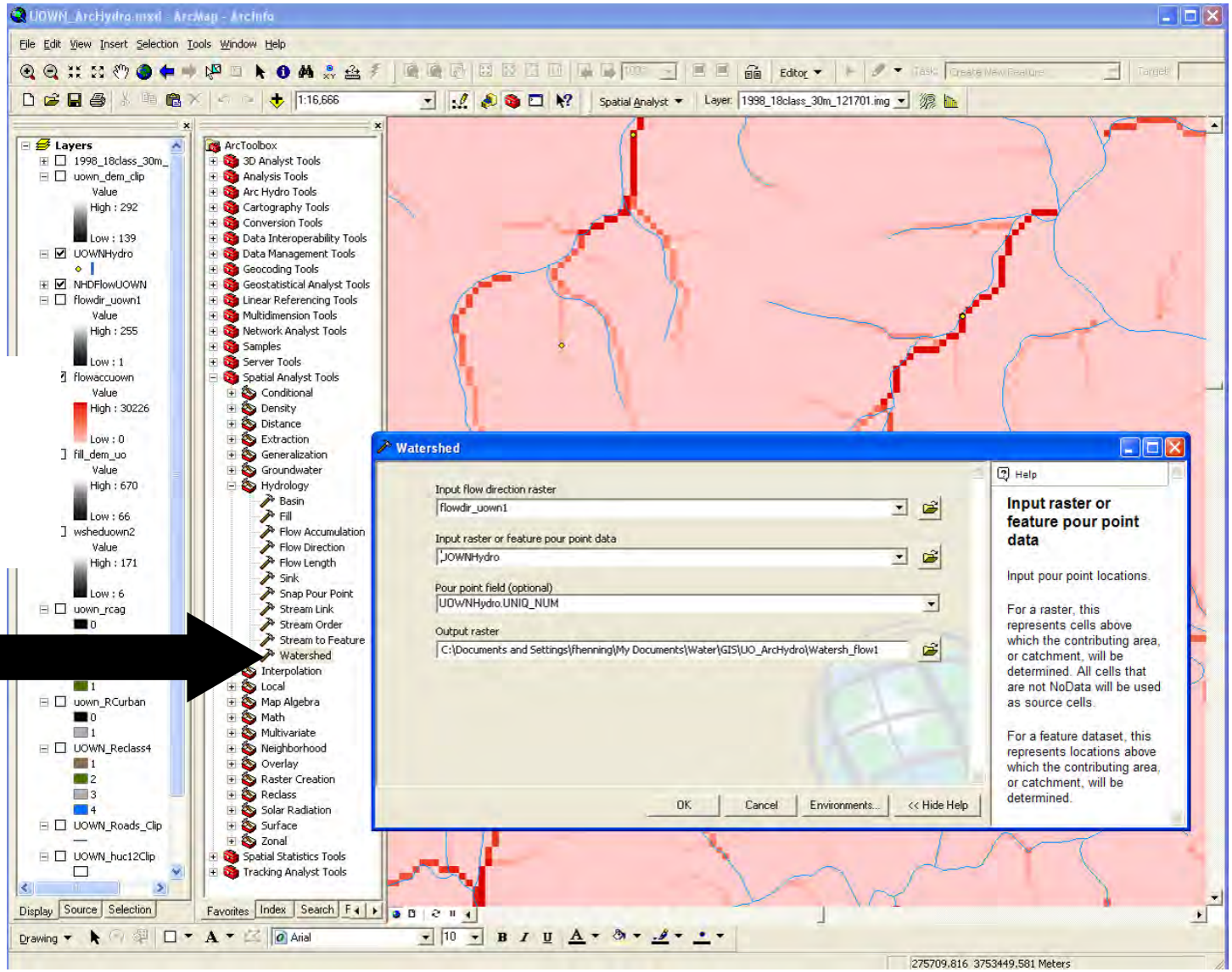
# Magnify Flow Accumulation layer & Move Pour points to Flow Accumulation lines

**Editor**
>Start editing
>Choose database
>Choose layer
>Start editing
>Use mouse to move points
>Editor
>Save edits

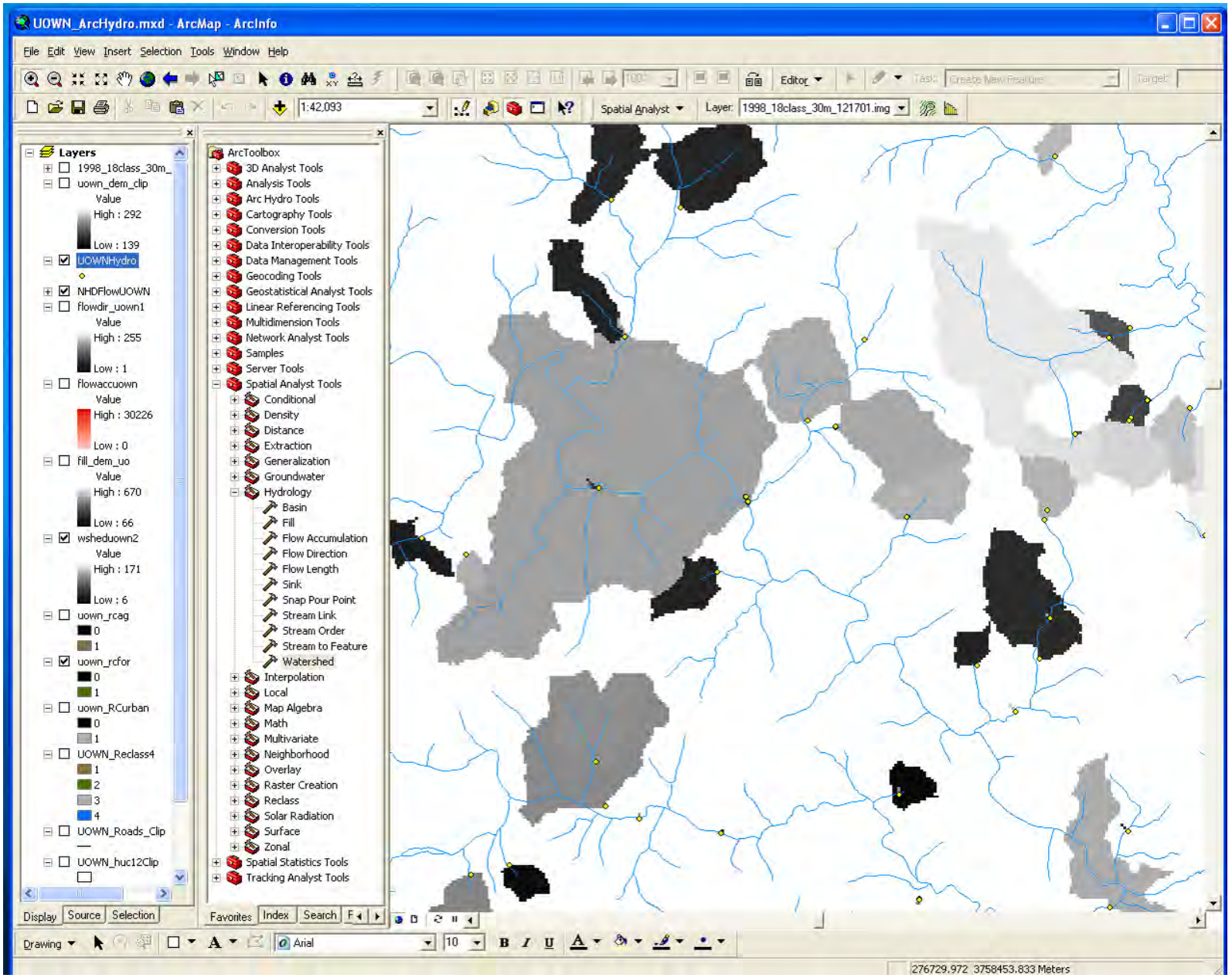


# Watershed – create watersheds

**Watershed**
>Flow dir
>Point data

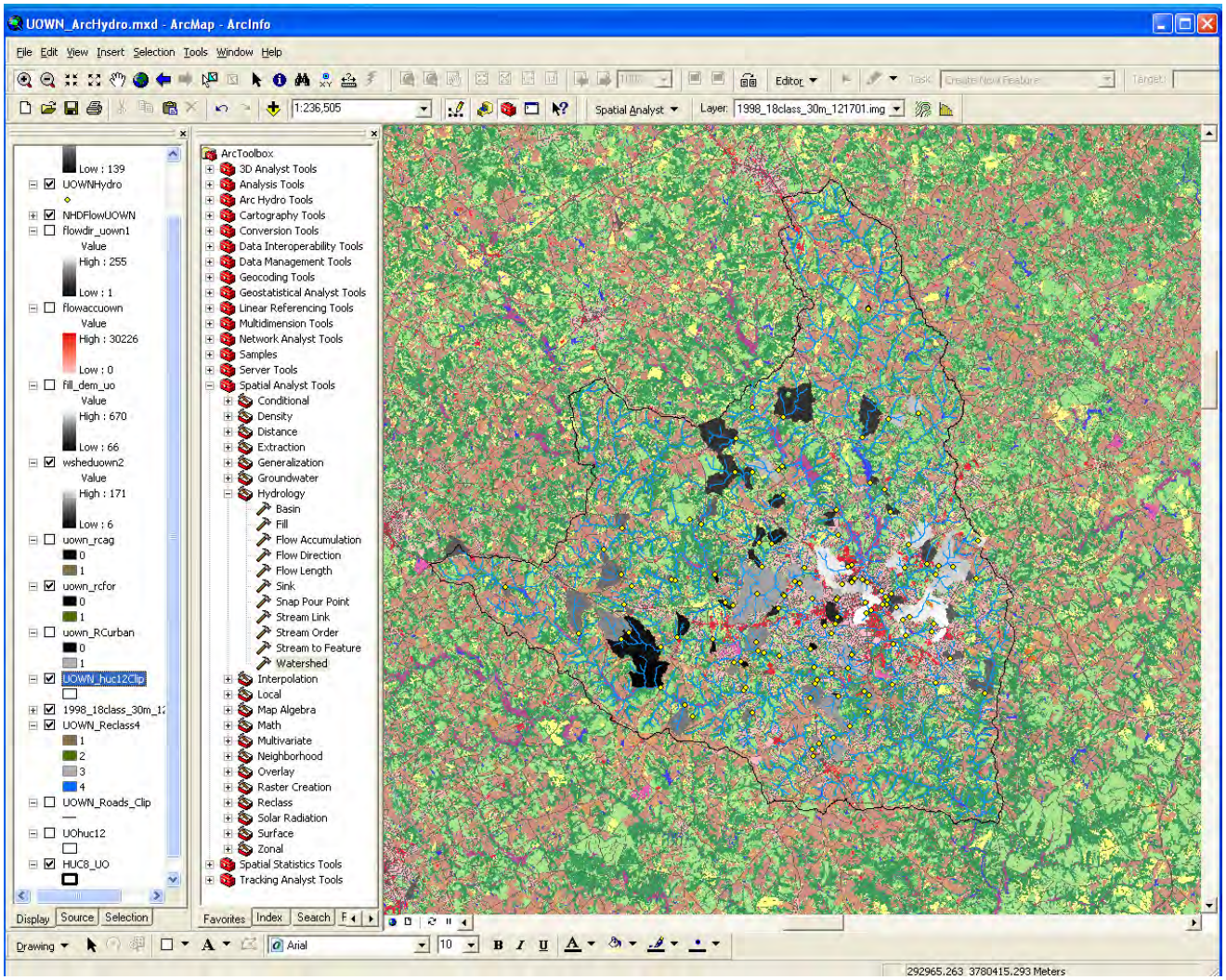


# New Subwatersheds



# Associate Watersheds & Land Cover

>Add Land Cover layer (many LCs)

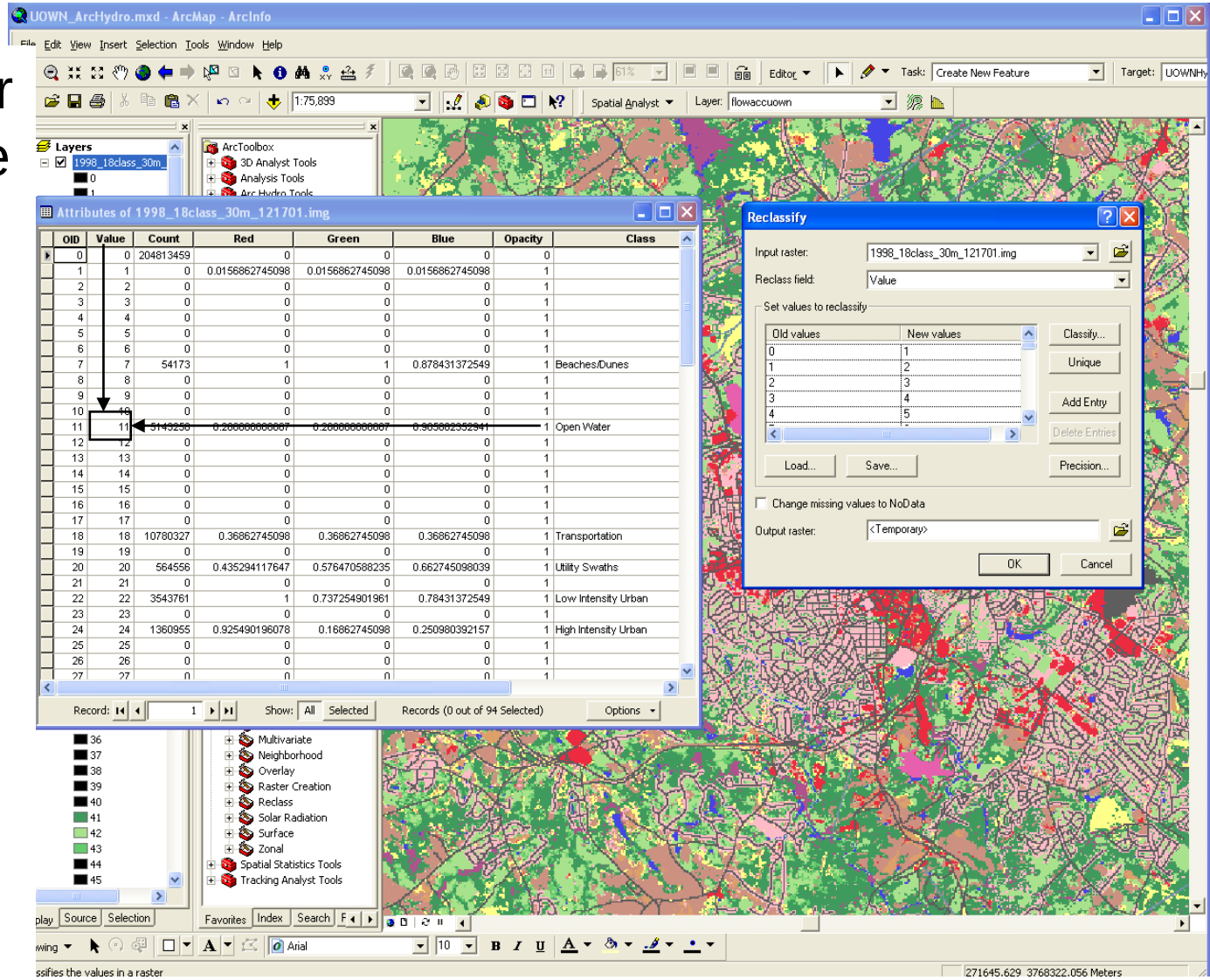


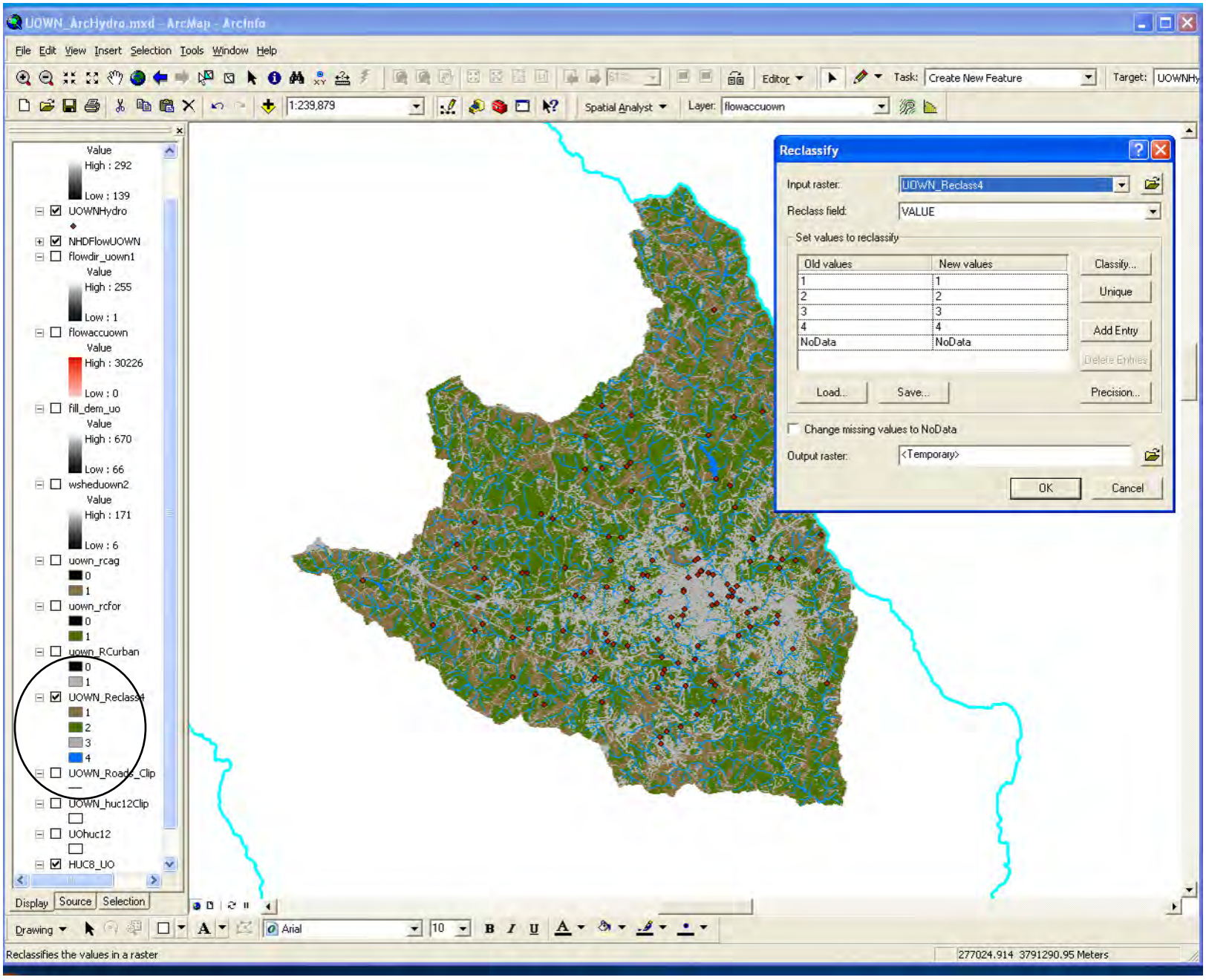
# Reclassify Land Cover Data

>Rt. Click LC layer
>Open attrib. table
(look at LC #'s)

**Spatial Analyst**
>Reclassify
>Land use layer

Combine Classes
1. Ag (73,80,83)
2. For (41,42,43)
3. Urb (24,25)
4. Water (11,92)



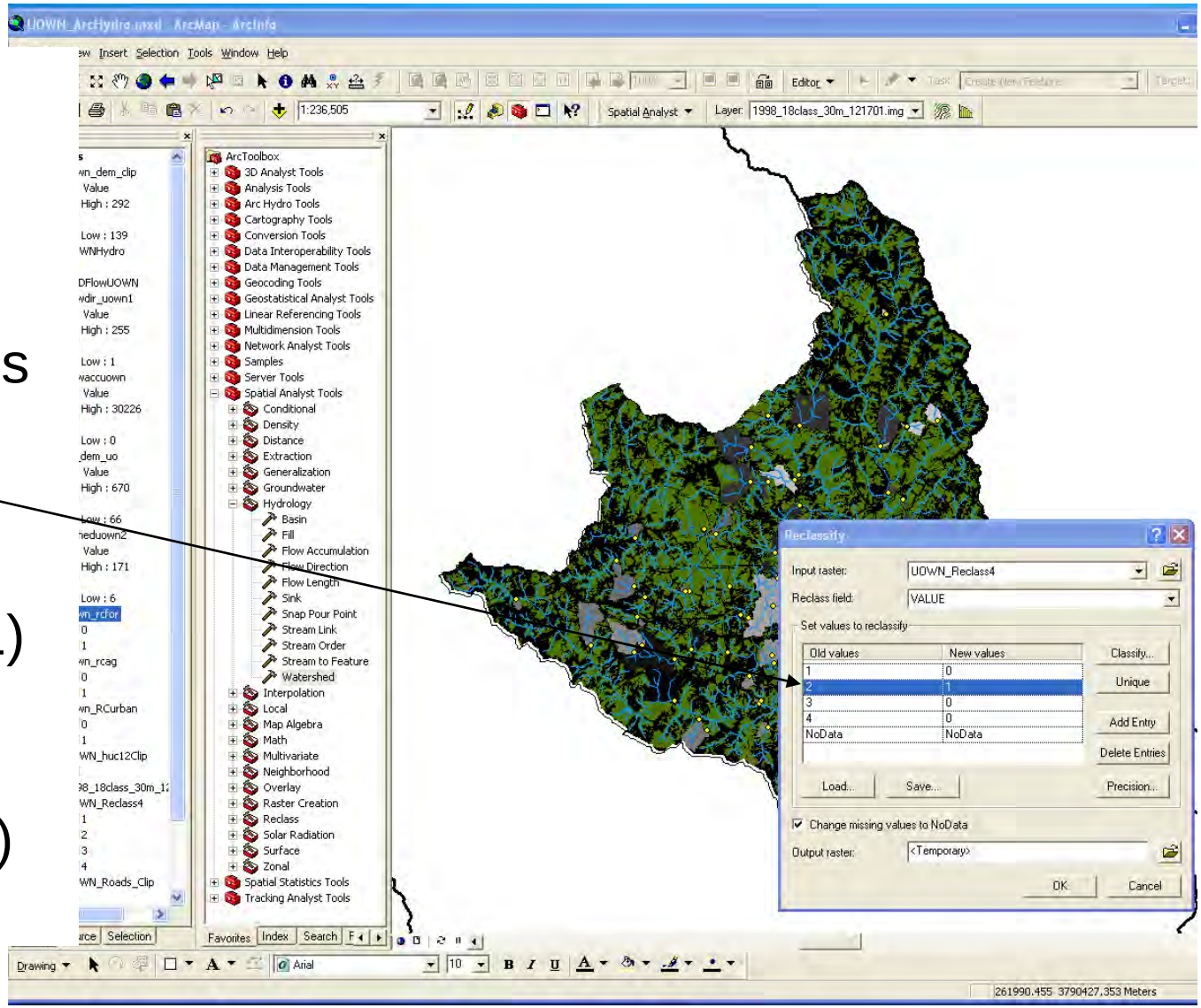

UOWN_ArcHydro.mxd - ArcMap - ArcInfo
File Edit View Insert Selection Tools Window Help
Editor
Task: Create New Feature
Target: UOWNHy
1:239,879
Spatial Analyst
Layer: flowaccuown
Value
High : 292
Low : 139
UOWNHydro
NHDFlowUOWN
flowdir_uown1
Value
High : 255
Low : 1
flowaccuown
Value
High : 30226
Low : 0
fill_dem_uo
Value
High : 670
Low : 66
wsheduown2
Value
High : 171
Low : 6
uown_rcag
0
1
uown_rcfor
0
1
uown_RCurban
0
1
UOWN_Reclass4
1
2
3
4
UOWN_Roads_Clip
UOWN_huc12Clip
UOhuc12
HUC8_UO
Display
Source
Selection
Reclassify
Input raster:
UOWN_Reclass4
Reclass field:
VALUE
Set values to reclassify
Old values
New values
1
1
2
2
3
3
4
4
NoData
NoData
Classify...
Unique
Add Entry
Delete Entries
Load...
Save...
Precision...
Change missing values to NoData
Output raster:
<Temporary>
OK
Cancel
Drawing
Arial
10
Reclassifies the values in a raster
277024.914 3791290.95 Meters

# Reclassify each individual land use

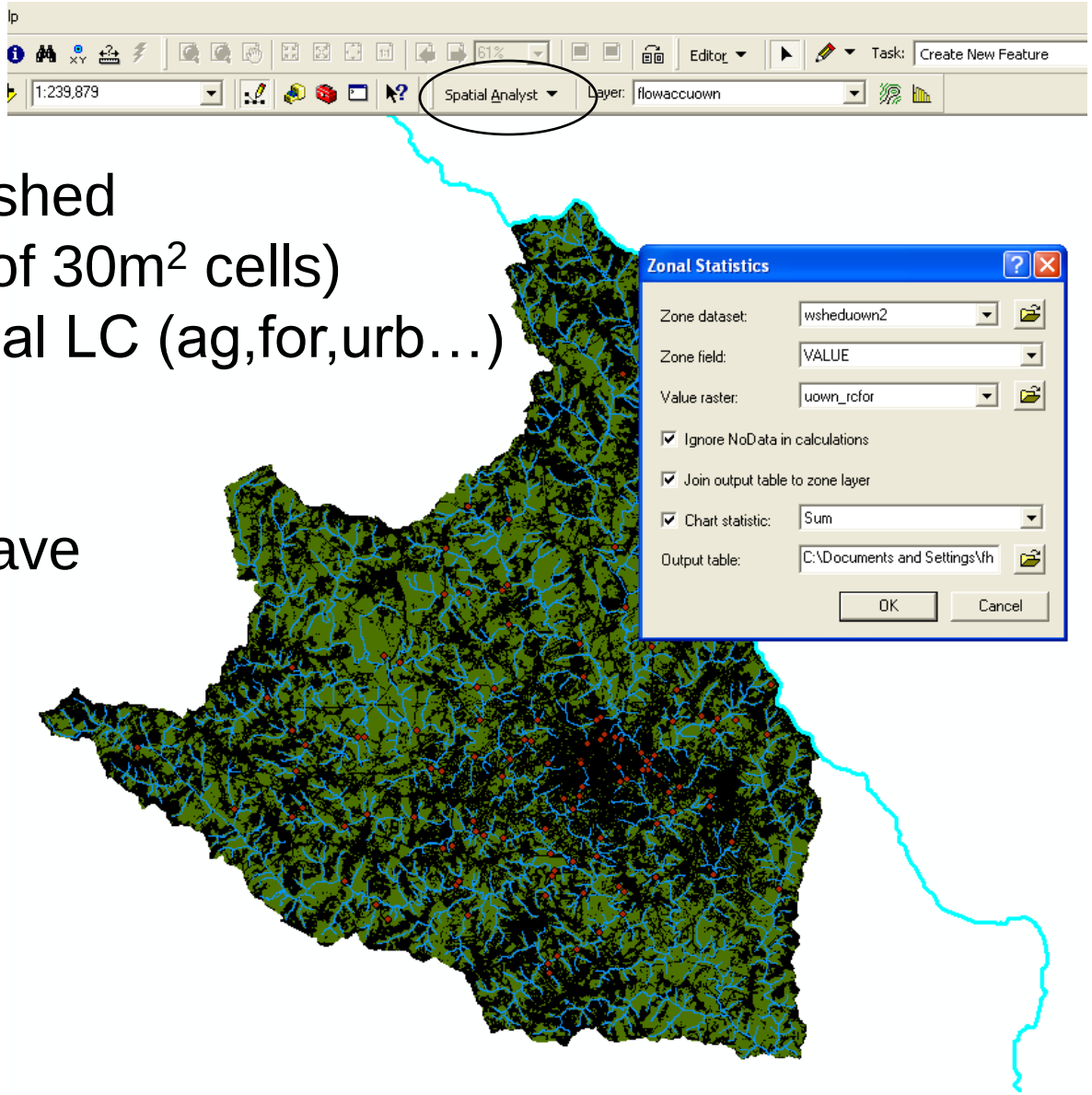
**Spatial Analyst**
>Reclassify
>Land use layer

Combine Classes
1. Ag (1,0,0,0)
2. For (0,1,0,0)
3. Urb (0,0,1,0)
4. Water (0,0,0,1)

Save 4 layers
(ag, for, urb, wat)



# Spatial Analyst, Zonal Statistics




Zone dataset – watershed
Zone field – value (# of 30m$^2$ cells)
Zone raster – individual LC (ag,for,urb…)
Check boxes
Chart statistic – sum
Output – name and save

# Count = the number of 900m$^2$ cells

| | A | B | C | D | E | F | G |
|---|---|---|---|---|---|---|---|
| 1 | Agriculture Landuse Data | | | | Water Quality Data goes here | | |
| 2 | VALUE | COUNT | AREA | | | | |
| 3 | 6 | 123 | 110700 | | | | |

900m$^2$ * 2 cells = 1800m$^2$ of agriculture

| | | | |
|---|---|---|---|
| 7 | 12 | 185 | 166500 |
| 8 | 13 | 2 | 1800 |
| 9 | 14 | 289 | 260100 |
| 10 | 19 | 937 | 843300 |

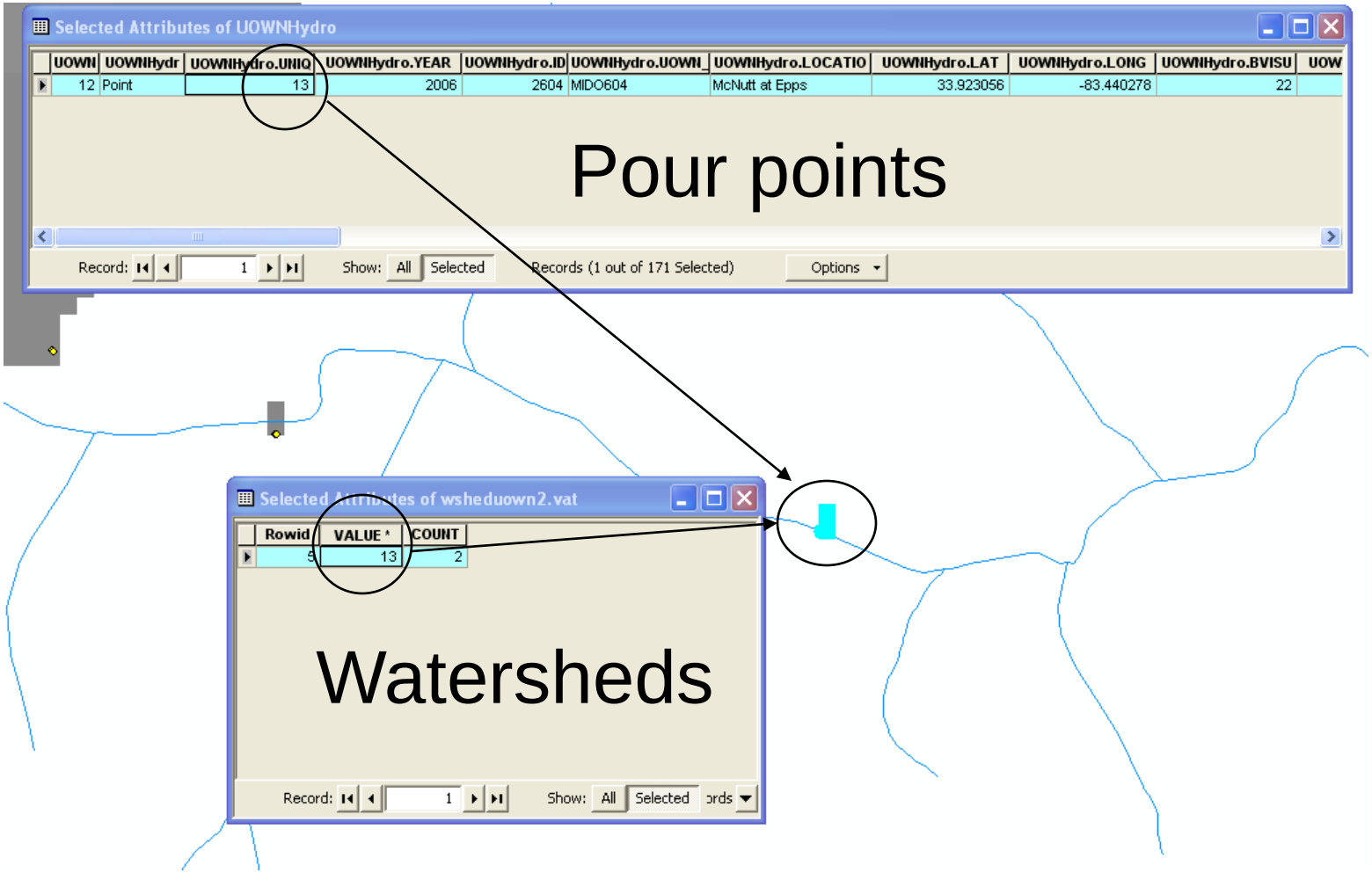

Watershed = 2 cells,1800m$^2$

A1 VALUE

| | A | B | C | D |
|---|---|---|---|---|
| 1 | VALUE | COUNT | | |
| 2 | 6 | 123 | | |
| 3 | 7 | 5 | | |
| 4 | 8 | 4456 | | |
| 5 | 11 | 226 | | |
| 6 | 12 | 185 | | |
| 7 | 13 | 2 | | |
| 8 | 14 | 289 | | |
| 9 | 19 | 937 | | |

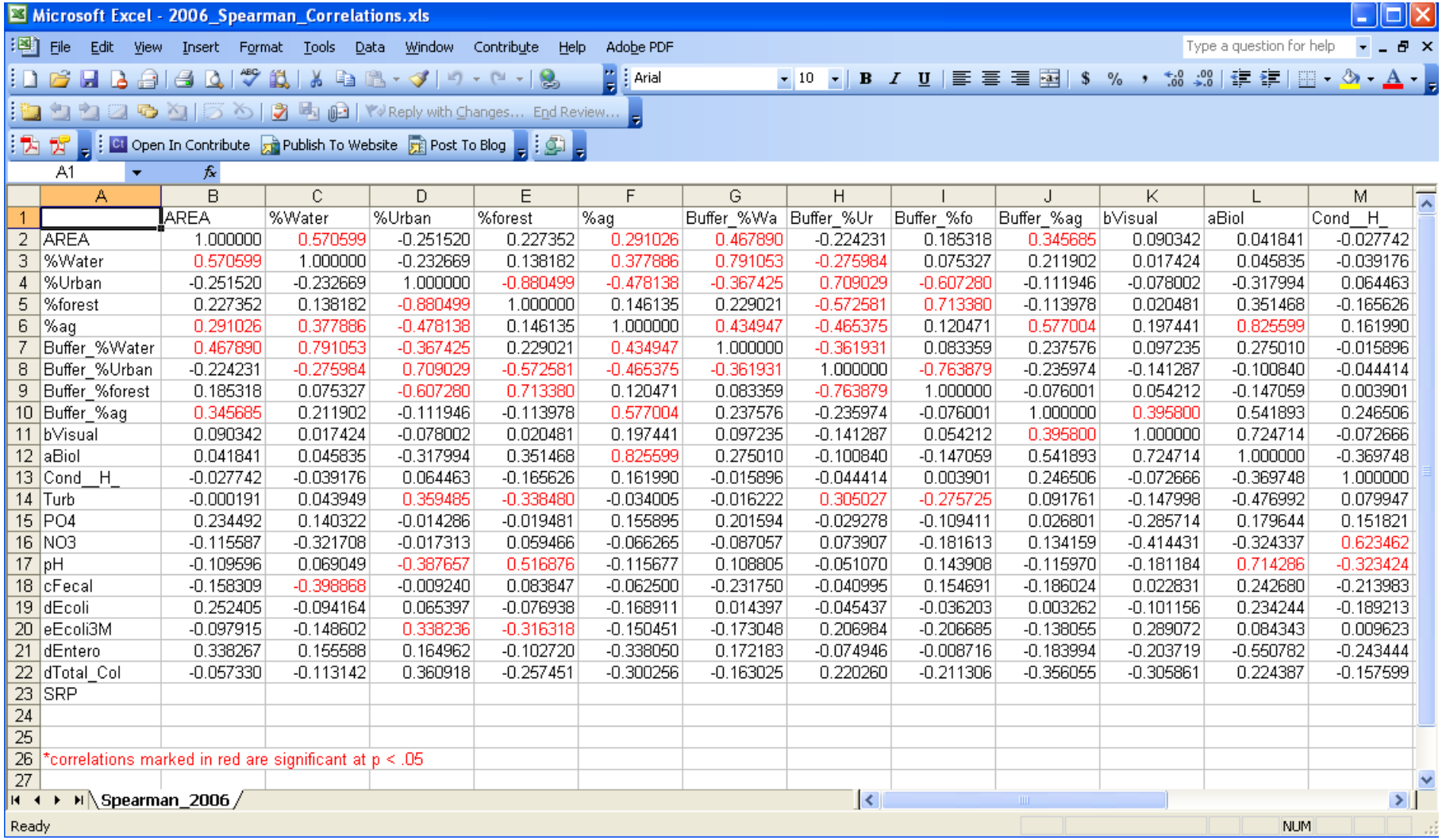
WS13 = 100% Ag

# Watershed Value = Pour Pont Unique ID # with assoc. WQ data



# Interpretation

## Correlation, or other analysis between Land cover & Water Quality



Microsoft Excel - 2006_Spearman_Correlations.xls

| | A | B | C | D | E | F | G | H | I | J | K | L | M |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | AREA | %Water | %Urban | %forest | %ag | Buffer_%Wa | Buffer_%Ur | Buffer_%fo | Buffer_%ag | bVisual | aBiol | Cond__H_ |
| 2 | AREA | 1.000000 | 0.570599 | -0.251520 | 0.227352 | 0.291026 | 0.467890 | -0.224231 | 0.185318 | 0.345685 | 0.090342 | 0.041841 | -0.027742 |
| 3 | %Water | 0.570599 | 1.000000 | -0.232669 | 0.138182 | 0.377886 | 0.791053 | -0.275984 | 0.075327 | 0.211902 | 0.017424 | 0.045835 | -0.039176 |
| 4 | %Urban | -0.251520 | -0.232669 | 1.000000 | -0.880499 | -0.478138 | -0.367425 | 0.709029 | -0.607280 | -0.111946 | -0.078002 | -0.317994 | 0.064463 |
| 5 | %forest | 0.227352 | 0.138182 | -0.880499 | 1.000000 | 0.146135 | 0.229021 | -0.572581 | 0.713380 | -0.113978 | 0.020481 | 0.351468 | -0.165626 |
| 6 | %ag | 0.291026 | 0.377886 | -0.478138 | 0.146135 | 1.000000 | 0.434947 | -0.465375 | 0.120471 | 0.577004 | 0.197441 | 0.825599 | 0.161990 |
| 7 | Buffer_%Water | 0.467890 | 0.791053 | -0.367425 | 0.229021 | 0.434947 | 1.000000 | -0.361931 | 0.083359 | 0.237576 | 0.097235 | 0.275010 | -0.015896 |
| 8 | Buffer_%Urban | -0.224231 | -0.275984 | 0.709029 | -0.572581 | -0.465375 | -0.361931 | 1.000000 | -0.763879 | -0.235974 | -0.141287 | -0.100840 | -0.044414 |
| 9 | Buffer_%forest | 0.185318 | 0.075327 | -0.607280 | 0.713380 | 0.120471 | 0.083359 | -0.763879 | 1.000000 | -0.076001 | 0.054212 | -0.147059 | 0.003901 |
| 10 | Buffer_%ag | 0.345685 | 0.211902 | -0.111946 | -0.113978 | 0.577004 | 0.237576 | -0.235974 | -0.076001 | 1.000000 | 0.395800 | 0.541893 | 0.246506 |
| 11 | bVisual | 0.090342 | 0.017424 | -0.078002 | 0.020481 | 0.197441 | 0.097235 | -0.141287 | 0.054212 | 0.395800 | 1.000000 | 0.724714 | -0.072666 |
| 12 | aBiol | 0.041841 | 0.045835 | -0.317994 | 0.351468 | 0.825599 | 0.275010 | -0.100840 | -0.147059 | 0.541893 | 0.724714 | 1.000000 | -0.369748 |
| 13 | Cond__H_ | -0.027742 | -0.039176 | 0.064463 | -0.165626 | 0.161990 | -0.015896 | -0.044414 | 0.003901 | 0.246506 | -0.072666 | -0.369748 | 1.000000 |
| 14 | Turb | -0.000191 | 0.043949 | 0.359485 | -0.338480 | -0.034005 | -0.016222 | 0.305027 | -0.275725 | 0.091761 | -0.147998 | -0.476992 | 0.079947 |
| 15 | PO4 | 0.234492 | 0.140322 | -0.014286 | -0.019481 | 0.155895 | 0.201594 | -0.029278 | -0.109411 | 0.026801 | -0.285714 | 0.179644 | 0.151821 |
| 16 | NO3 | -0.115587 | -0.321708 | -0.017313 | 0.059466 | -0.066265 | -0.087057 | 0.073907 | -0.181613 | 0.134159 | -0.414431 | -0.324337 | 0.623462 |
| 17 | pH | -0.109596 | 0.069049 | -0.387657 | 0.516876 | -0.115677 | 0.108805 | -0.051070 | 0.143908 | -0.115970 | -0.181184 | 0.714286 | -0.323424 |
| 18 | cFecal | -0.158309 | -0.398868 | -0.009240 | 0.083847 | -0.062500 | -0.231750 | -0.040995 | 0.154691 | -0.186024 | 0.022831 | 0.242680 | -0.213983 |
| 19 | dEcoli | 0.252405 | -0.094164 | 0.065397 | -0.076938 | -0.168911 | 0.014397 | -0.045437 | -0.036203 | 0.003262 | -0.101156 | 0.234244 | -0.189213 |
| 20 | eEcoli3M | -0.097915 | -0.148602 | 0.338236 | -0.316318 | -0.150451 | -0.173048 | 0.206984 | -0.206685 | -0.138055 | 0.289072 | 0.084343 | 0.009623 |
| 21 | dEntero | 0.338267 | 0.155588 | 0.164962 | -0.102720 | -0.338050 | 0.172183 | -0.074946 | -0.008716 | -0.183994 | -0.203719 | -0.550782 | -0.243444 |
| 22 | dTotal_Col | -0.057330 | -0.113142 | 0.360918 | -0.257451 | -0.300256 | -0.163025 | 0.220260 | -0.211306 | -0.356055 | -0.305861 | 0.224387 | -0.157599 |
| 23 | SRP | | | | | | | | | | | | |
| 24 | | | | | | | | | | | | | |
| 25 | | | | | | | | | | | | | |
| 26 | *correlations marked in red are significant at p < .05 | | | | | | | | | | | | |
| 27 | | | | | | | | | | | | | |

Spearman_2006

Ready

NUM

# Mixed Forest &Water Quality

| Variable 1 | Variable 2 | Correlations |
|---|---|---|
| Visual | % Forest | 0.21 (n=62) |
| Macros | % Forest | 0.53 (n=13) |
| Total coliform | % Forest | -0.41* (n=33) |
| **$H_2O$ Quality** | **Mixed Forest** | **Positive** |

* Pearson's correlations significant at $p \leq 0.05$

# Agricultural Land Use & Water Quality

| Variable 1 | Variable 2 | Correlations |
|---|---|---|
| Visual | % Agriculture | 0.35 (n=62)* |
| Macros | % Agriculture | 0.64 (n=17)* |
| Total Coliform | % Agriculture | -0.28 (n=33) |
| $NO_3$ | % Agriculture | 0.27 (n=24) |
| SRP | %Agriculture | 0.33 (n=23) |

* Pearson's correlations significant at $p \leq 0.05$

# Urban Land Use & Water Quality

| Variable 1 | Variable 2 | Correlations |
|---|---|---|
| Visual | % Urban | -0.34 (n=62)* |
| Macros | % Urban | -0.68 (n=13)* |
| Total Coliform | %Urban | 0.44 (n=33)* |
| $H_2O$ Quality | Urbanization | Negative |

*Pearson's correlations significant at $p \leq 0.05$

**Frank Henning**
**Land Grant Universities-EPA Liaison**
**fhenning@uga.edu**