Spatial interpolation of patterns of sediment deposition in two urban stormwater detention ponds

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Background

- Stormwater ponds improve water quality through sediment trapping

Background

- Patterns of sediment deposition within pond show processes
  - High deposition near inlet
  - Relation to flow path
  - Relation to vegetation
- Total sediment volume is of interest to managers

Objectives

- Map sediment deposition in two ponds
- Compare techniques of spatial interpolation
- Determine volume of sediment in pond
  - Related to thesis question

Site Desctiption—Waldorf Pond

- 142 m2 area, Drains 5.26 ha, TIA 51.7%

Site Description—Valley Pond

- 680 m2 area, Drains 4.98 ha, TIA 50.0%

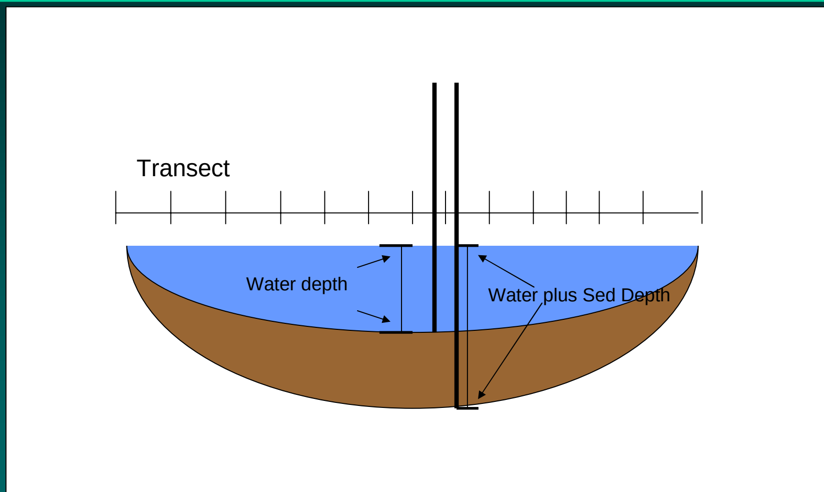
Methods—GPS

- Map pond perimeter with Trimble GeoXT
- Map open water areas with Trimble GeoXT
- Construct transects across ponds
  - GPS end points

Methods—Data Collection

- Every meter along transect
- Survey rod to measure water plus sediment
- Meter stick to measure water depth
  - Adapted from Yousef 1994
- Add additional points not on transects to increase coverage in inaccessible areas

Data Collection



Data Collection

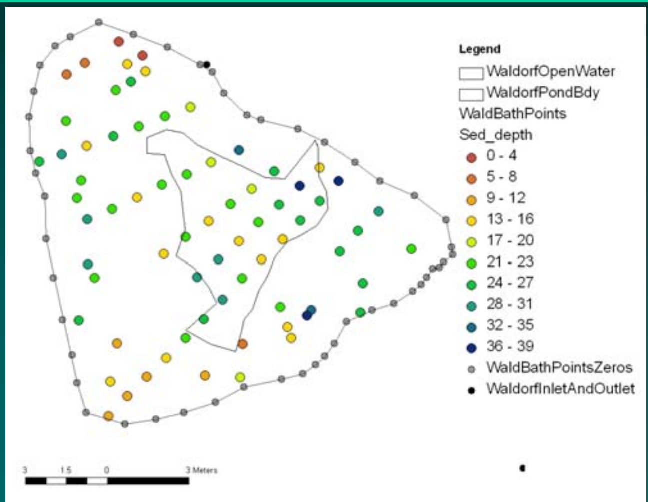
- Mud, Mud, Mud

Photo: K. Cole

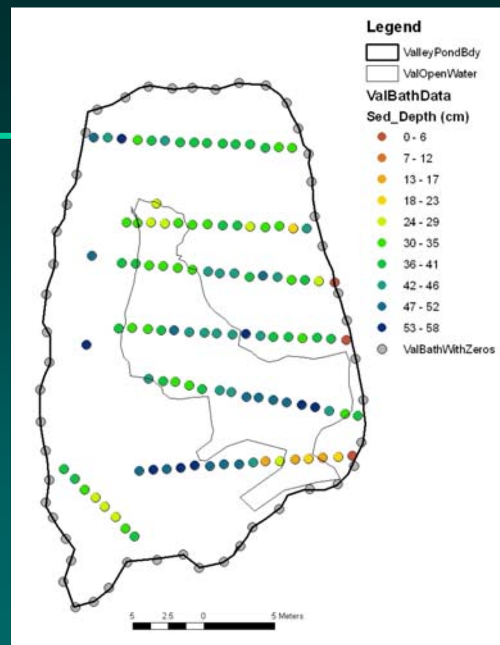
Methods--Mapping

- Differential correction
- Direction-Distance tool to create points in ponds
- Enter water depth and (water plus sediment) depth
- Difference is sediment depth at each point
- Data clean up

Base Map—Waldorf



Base Map--Valley



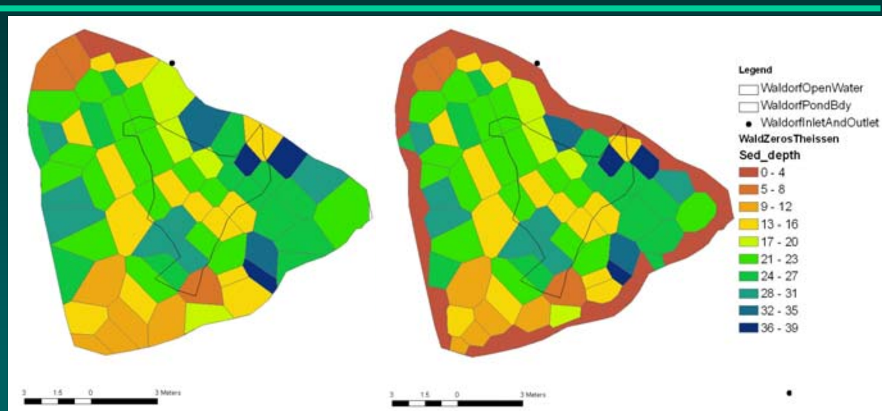
Methods—Spatial interpolation

- Theissen Polygons
- Ordinary Kriging
- TIN
- Compare each with edge zeros and without
  - Create edge zeros by polygon to point, assigning all vertices of edge a zero value

Theissen Polygons

- ESDA—Voronoi map
  - Sediment depth field
  - Clip to pond boundary
  - Export to Geodatabase
  - Sed_Vol (m3) = SUM (Shape Area (ft^2) * Sed_Depth (cm^2) *929 (cm^2/ft^2) / 1000000 (cm^3/m^3))
  - Symbolize with 10 Equal Interval Classes

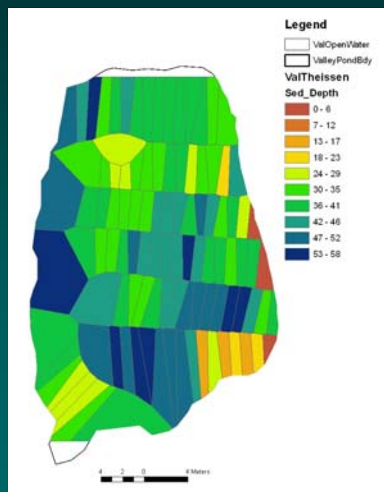
Theissen Results--Waldorf

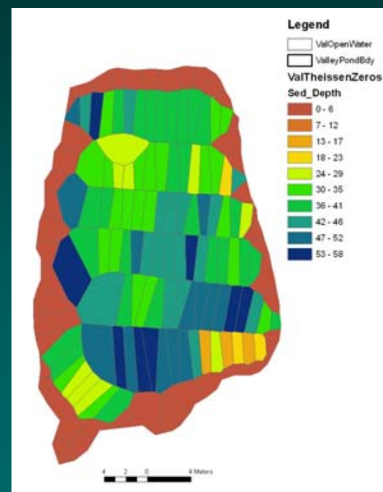


No Zeros: 28.34m^3

Zeros: 23.15 m^3

Theissen Results--Valley





No Zeros: 240 m^3

Zeros: 185.63 m^3

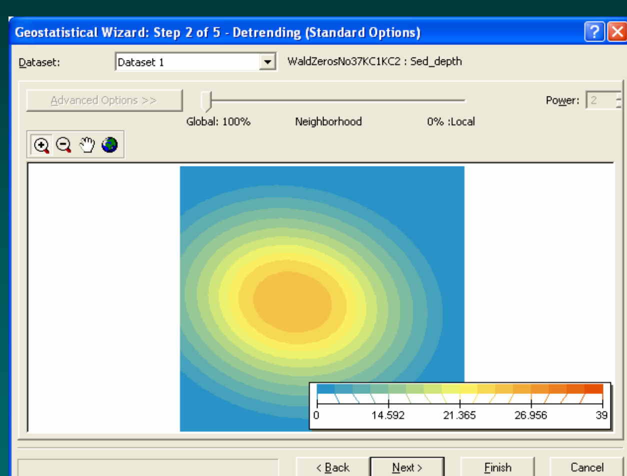
Kriging

- Ordinary Kriging
- Played with parameters to minimize RMSE
- Tradeoffs between minimizing average standard error and RMSE

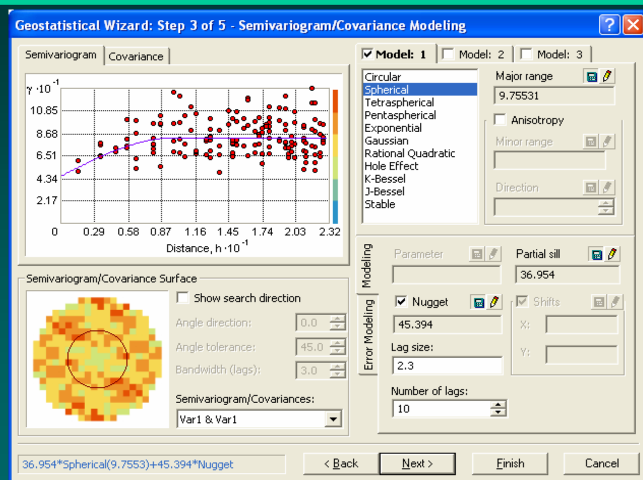
Kriging Volume Calculations

- GA to Raster
- Raster Calculator
  - Value (cm) * Cell area (ft^2) * 929 (cm^2/ft^2) / 1000000 (cm^3/m^3)
- Zonal Statistics Sum on pond boundary
- Same for prediction error
- Construct high and low CI
  - Volume +/- (1.96 * StdErrVol)
- Zonal Statistics Sum to generate 95% CI

Kriging—Waldorf with Zeros

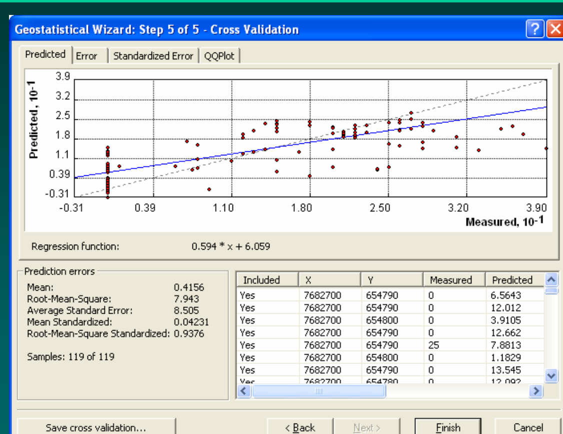


Kriging—Waldorf With Zeros



Kriging Waldorf With Zeros

- RMSE=7.94
- Mean Err=0.4156
- RMS Std Err=0.9376

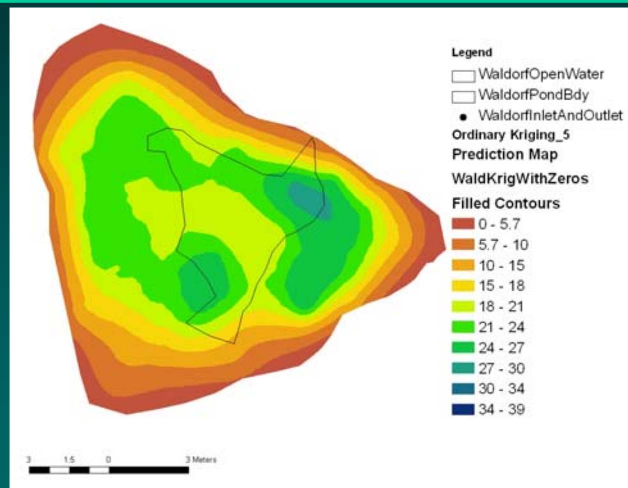


Kriging—Waldorf with Zeros

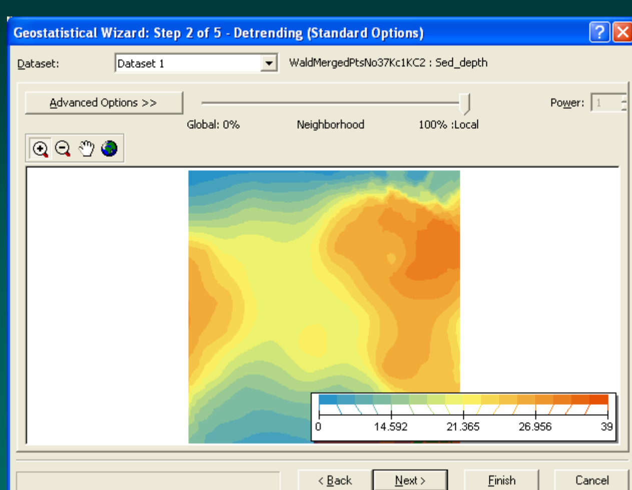
Est Sed Vol:

23.3 m^3

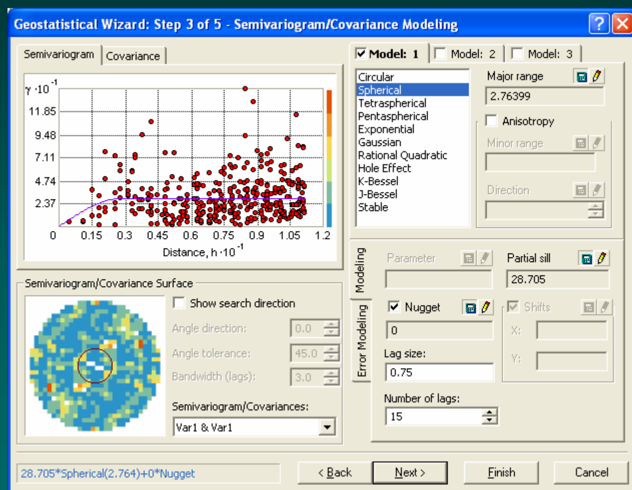
(0.33-46.23)



Kriging Waldorf—No Zeros



Kriging Waldorf No Zeros

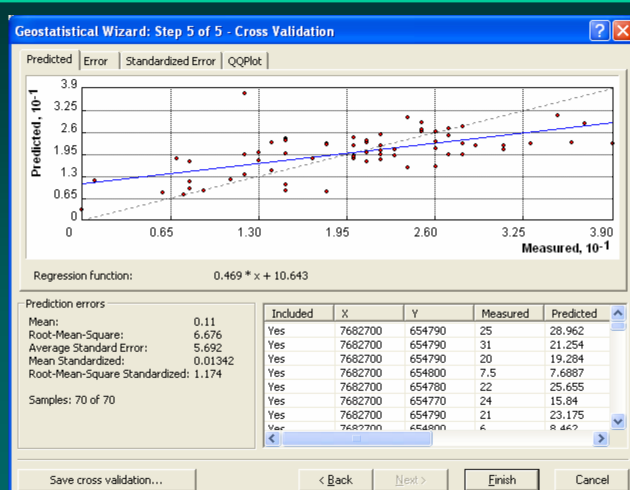


Kriging Waldorf No Zeros

RSME=6.676

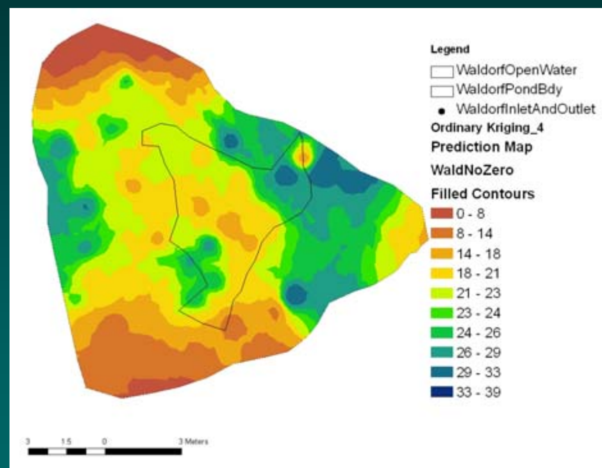
Avg StErr=5.692

RMS StErr=1.174

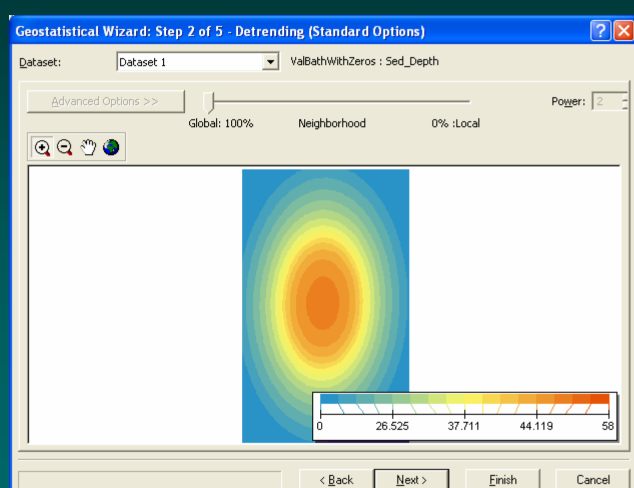


Kriging—No Zeros

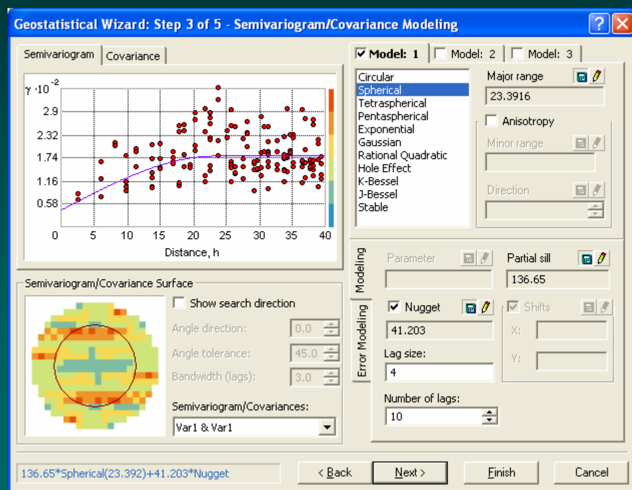
- Est Sed Vol: 24.87 m^3 (0.717-49.02)



Kriging—Valley with Zeros



Kriging—Valley with Zeros

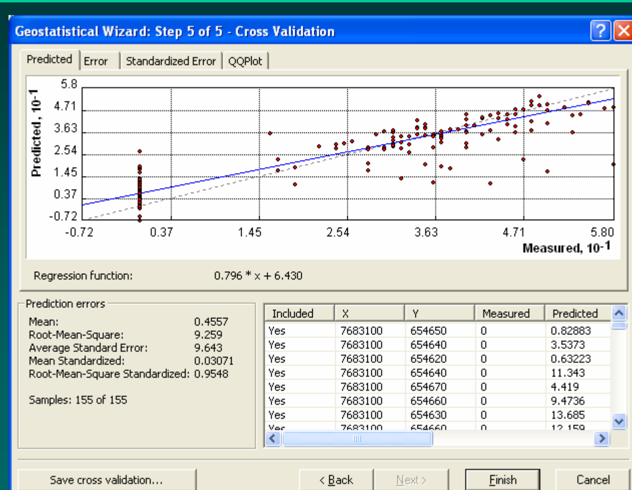


Kriging—Valley with Zeros

RMSE=9.259

Avg StErr=9.643

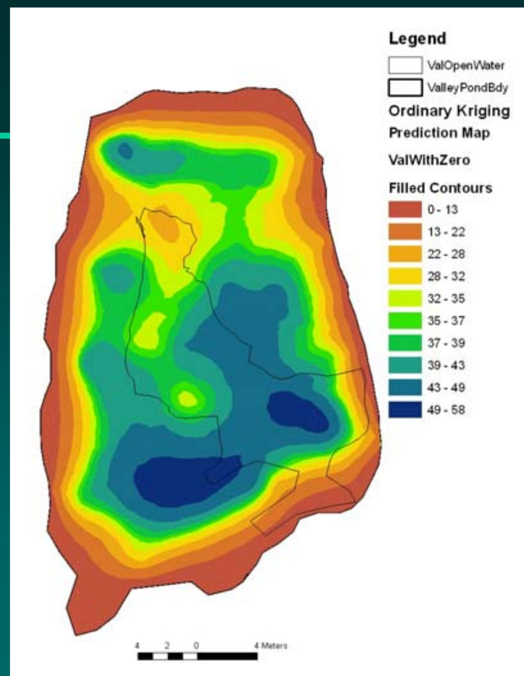
RMS StErr=0.9548



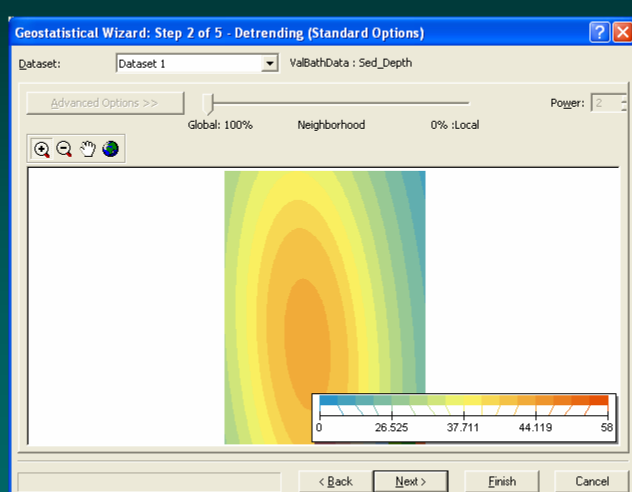
Kriging

Sed Vol: 193.63 m^3

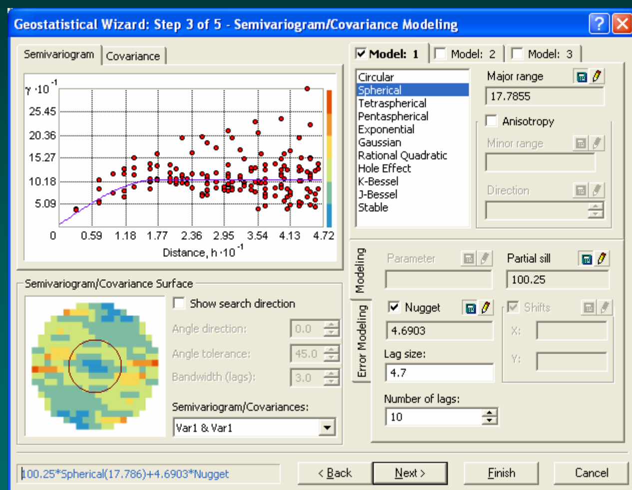
(72.3-334.79)



Kriging—Valley no Zeros

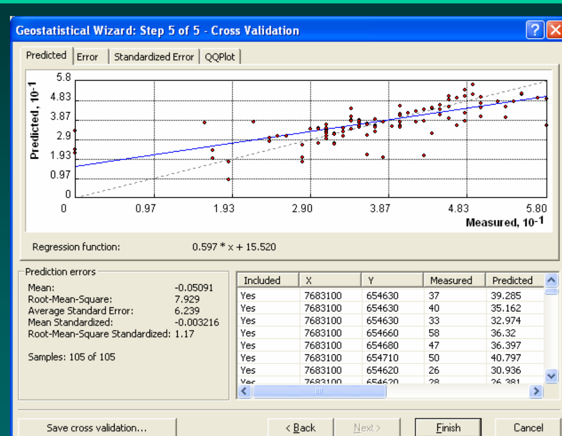


Kriging Valley No Zeros



Kriging Valley No Zeros

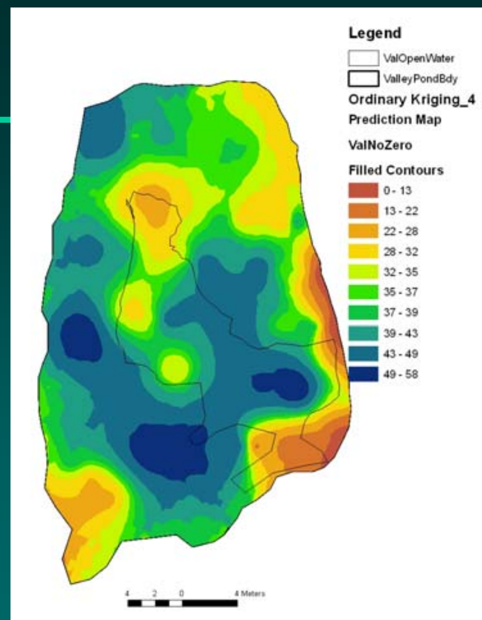
- RMSE=7.929
- AvgStErr=6.239
- RMS StErr=1.17



Kriging No Zero

Sed Vol: 239.62m^3

(144.07-335.17)



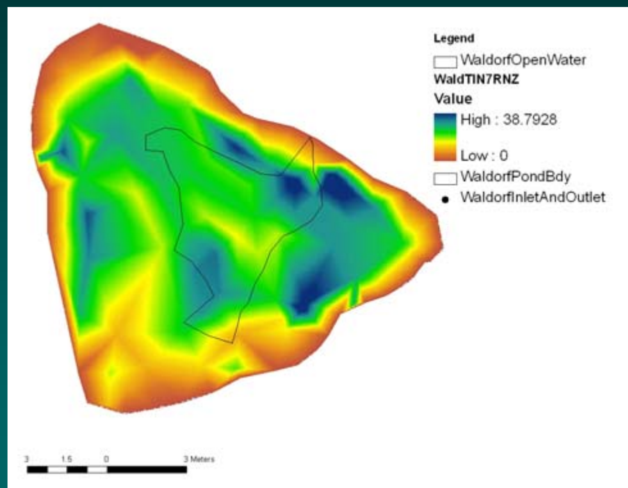
TIN volume

- Create TIN
- Mass points—Sed_depth
- Break line—Pond Boundary
- 3D Analyst—TIN Volume
- Units conversions

TIN--Waldorf

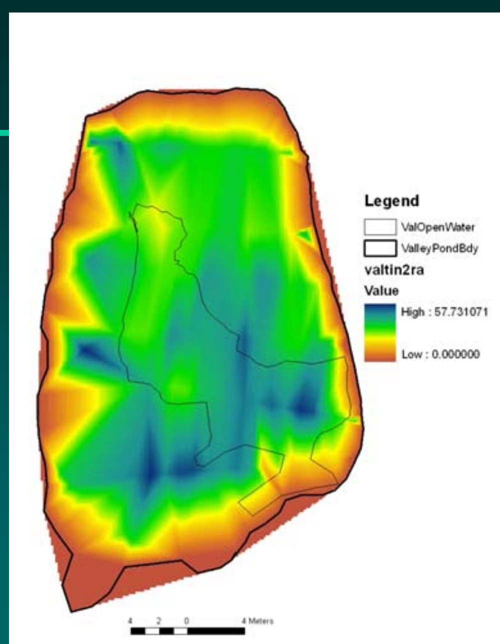
Sed Vol:

23.03m^3



TIN--Valley

Sed Vol: 187.9 m^3



Results Summary--Waldorf

m^3 sediment	With Zeros	Without Zeros
Theissen Polygons	23.15	28.34
Ordinary Kriging	23.3 (0.33-46.23)	24.87 (0.717-49.02)
TIN		23.03

Results Summary--Valley

m^3 sediment	With Zeros	Without Zeros
Theissen Polygons	185.63	240
Ordinary Kriging	193.63 (74.8-312.47)	239.62 (144.07-335.17)
TIN		187.9

Conclusions

- TINs agreed well with Theissen polygons with zeros
- Kriging makes the best maps
- Errors associated with kriging can be large

Conclusions

- My favorite method:

TIN!

References and Acknowledgements

- Yousef Y. A., T. Hvitved-Jacobsen, J. Sloat, and W. Lindeman. 1994. Sediment Accumulation in Detention or Retention Ponds. Science of the Total Environment **147**:451-456

- Thanks to Kelly Cole for field assistance
- Thanks to Clackamas County Water Environment Services for permission to use the ponds