Updated: 28 March 2013

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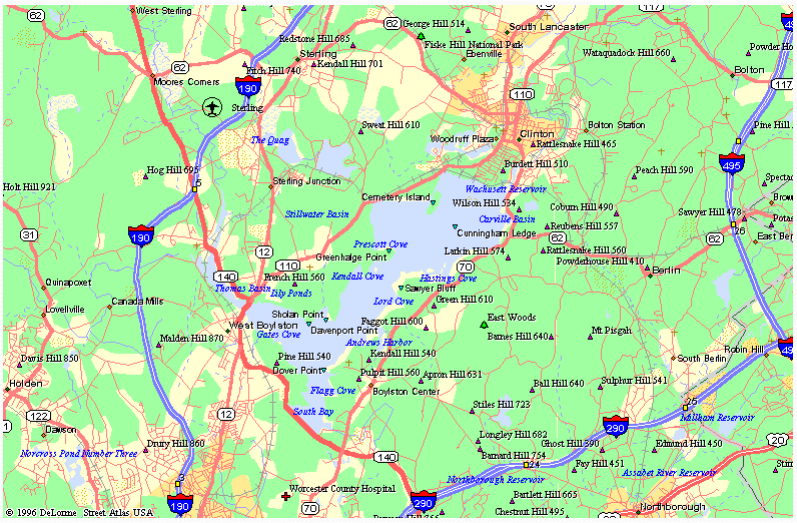
CEE 577: Surface Water Quality Modeling

Lecture #26

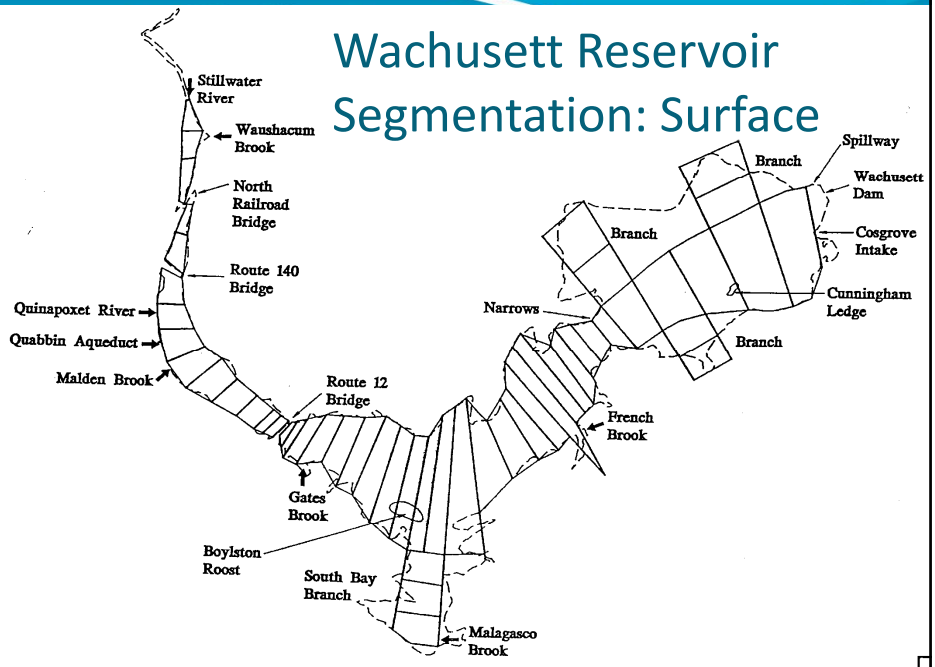
Limnology (cont.): Segmentation and Estimators

(Chapra, L29)

Wachusett Reservoir

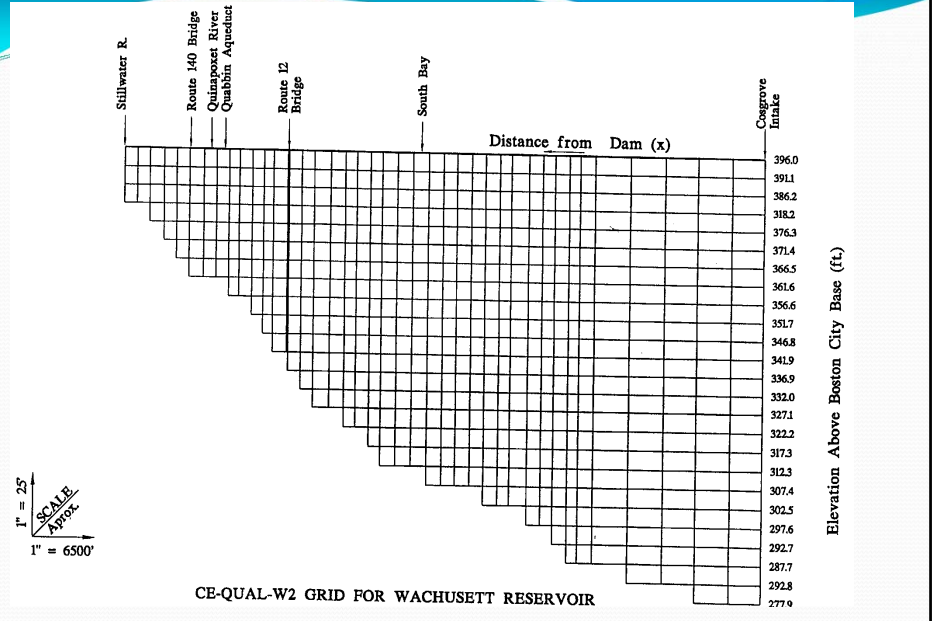


Wachusett Reservoir Segmentation: Surface

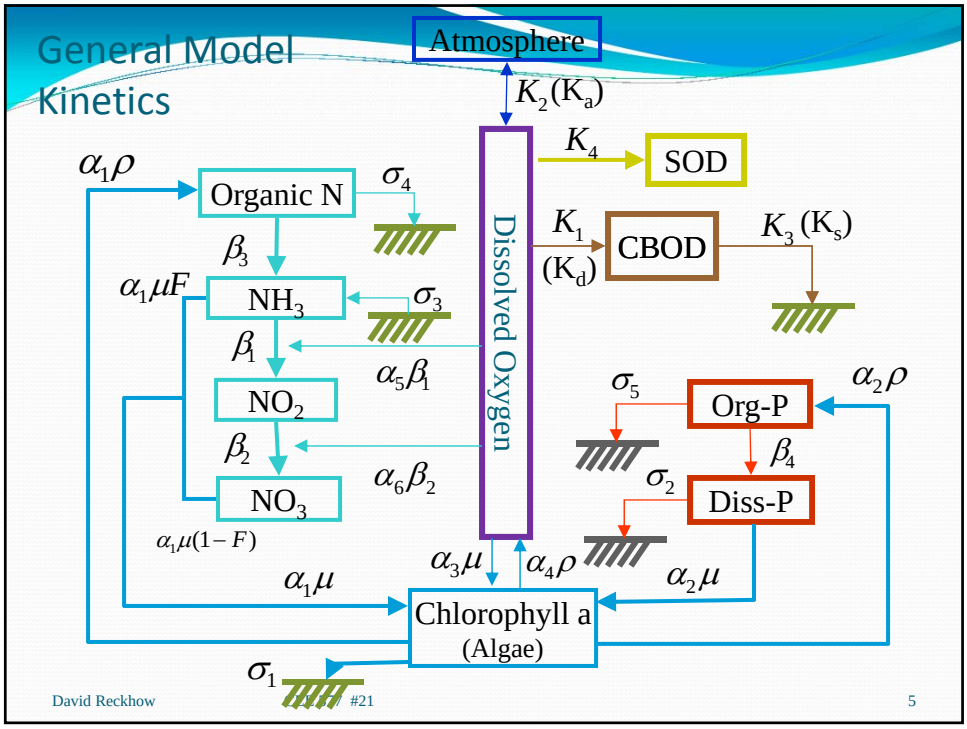


CE-QUAL-W2 SEGMENTS FOR WACHUSETT RESERVOIR

Wachusett Reservoir Segmentation: Depth



CE-QUAL-W2 GRID FOR WACHUSETT RESERVOIR



In-lake Management

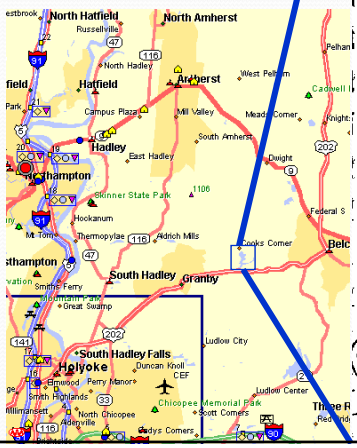
	Technique	Notes
1	Dredging	removal of sediments
2	Macrophyte Harvesting	mechanical removal of plants
3	Biocidal Chemical Treatment	chemicals added to inhibit growth of undesirable plants
4	Water Level Control	flooding or drying of troublesome areas to control growths
5	Hypolimnetic Aeration or Destratification	addition of oxygen, and mixing
6	Hypolimnetic Withdrawal	removal of bottom waters low in oxygen and high in nutrients
7	Bottom Sealing/Sediment Treatment	obstruction of the bottom by physical or chemical means
8	Nitrient Inactivation	chemical precipitation or complexation of dissolved phosphorus, nitrogen, etc.
9	Dilution and Flushing	increase flow to help "flush out" pollutants
10	Biomanipulation or Habitat Management	encouragement of biological interactions to alter ecosystem processes

Watershed Management

	Technique	Notes
1	Zoning/Land Use Planning	Management of land use
2	Stormwater/Wastewater Diversion	re-routing of wastewater flows
3	Detention Basin Use and Maintenance	increase time of travel for polluted waters so natural purification processes act
4	Sanitary Sewers	installation of community-level collection syst
5	Maintenance and Upgrade of On-site Treatment Systems	better operation & performance of home septi systems, etc.
6	Agricultural Best Management Practices	use of improved techniques in forestry, anima crop science
7	Bank and slope stabilization	erosion control to reduce sediment and associ loadings
8	Increased street sweeping	frequent washing and removal of urban runof contaminants
9	Behavioral Modifications	
	a. use of Non-phosphate detergents	eliminates source of P
	b. eliminate garbage grinders	reduces general organic loading
	c. minimize lawn fertilization	reduces nutrient loading
	d. restrict motorboat activity	reduce turbulence and sediment resuspension
	e. eliminate illegal dumping	reduce a wide range of conventional and toxic inputs

David Reckhow

Forge Pond



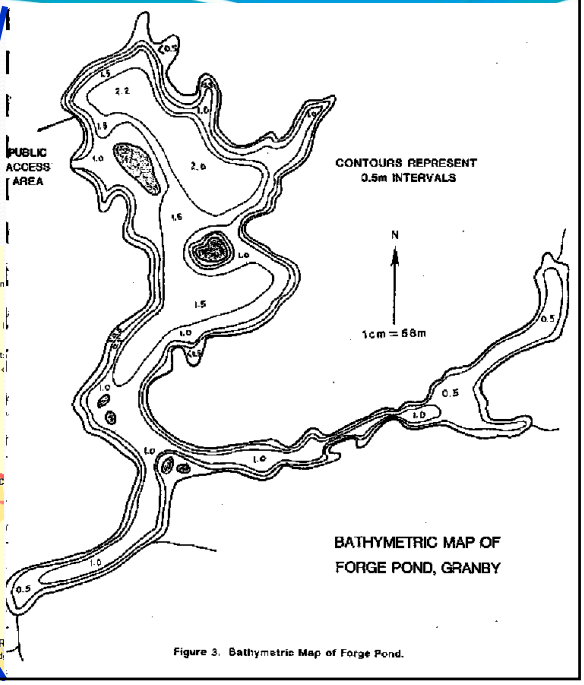


Figure 3. Bathymetric Map of Forge Pond.

Lake Morphometry

- Properties of Wachusett Reservoir & Forge Pond

Property	Symbol	Units	Wachusett	Forge Pond
Volume	V	m^3	$2.5x10^8$	$3.33x10^5$
Lake Surface Area	SA	km^2	15.8	0.303
Watershed Area	DA	km^2	295	37.7
Length	L	km	13.7	1.8
Length of Shoreline	L_s	km	59	5.94
Maximum Width	W	km	1.8	0.45
Mean Width	W	km	1.2	0.12
Maximum Depth	Z_m	m	39	2.2
Mean Depth	Z	m	15.6	0.9
Total Outflow	Q	m^3/s	16	0.5

Order of Magnitude Estimates

- Residence Time
  - T=V/Q
    - if T<100 d, stronger longitudinal gradients, greater productivity
      - partly result of greater sediment and nutrient loads
  - Drainage Area/ Lake Surface Area Ratio

Wachsett 0.5 yr

Forge Pond 7d

18.7

125

Watershed/Lake Area Ratio	Management Approach
< 10	In-lake measures may work by themselves.
10-50	In-lake measures are difficult, but may still work. Watershed management may be needed.
> 50	In-lake measures are infeasible, watershed management is needed.

Order of Magnitude Estimates (cont.)

- Aspect Ratio
  - AR=L/W 11.4 15
    - <4, lateral gradients dominate
      - use 2-d models?
    - >4, longitudinal gradients dominate
      - use 1-d or CSTR models
- Shoreline Development Ratio
  - SDR $= \frac{L_s}{2\sqrt{\pi SA}}$ 4.2 3.0
    - a measure of how dendritic a lake is, indicates potential for littoral productivity
      - =1 for a perfectly circular lake
      - =15 for a highly dendritic lake

Order of Magnitude Estimates (cont.)

- Relative Depth
  - RD= $50 Z_m \sqrt{\pi / SA}$ 0.9 0.35
    - comparison between depth and surface area. As ratio gets smaller there is a greater potential for wind to disrupt thermal stratification
- Areal Erosion
  - AR= $1090 \frac{\sqrt{SA}}{Z} \exp\left(\frac{Z}{\sqrt{SA}}\right)$

Chemical Assessment

- N/P Ratio
  - Nitrogen limited: <13:1
  - Algal cells ~ 16:1
  - Phosphorus limited >20:1

0.714/0.113 ~ 6/1

- To next lecture