

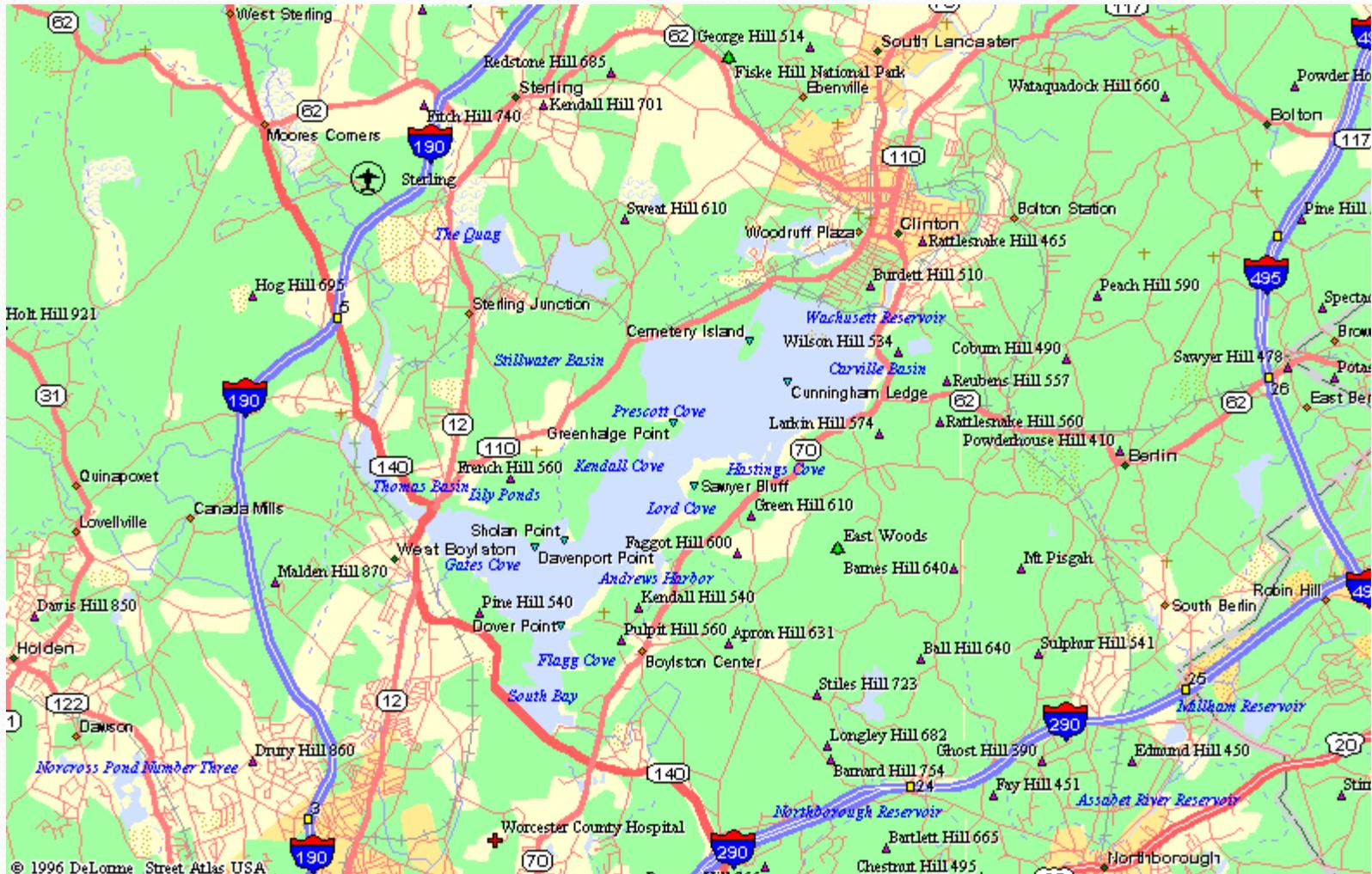
CEE 577: Surface Water Quality Modeling

Lecture #26

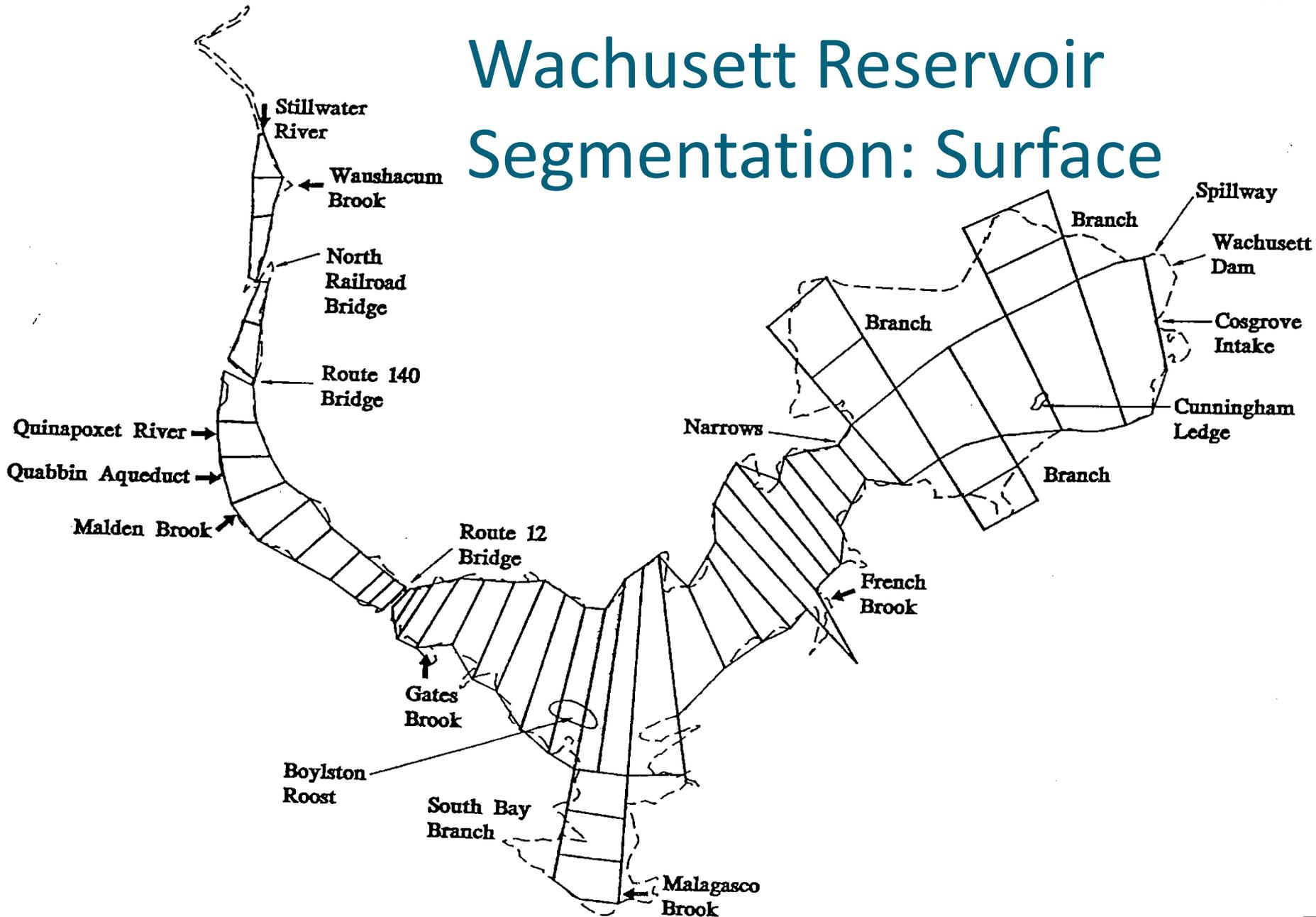
Limnology (cont.): Segmentation and
Estimators

(Chapra, L29)

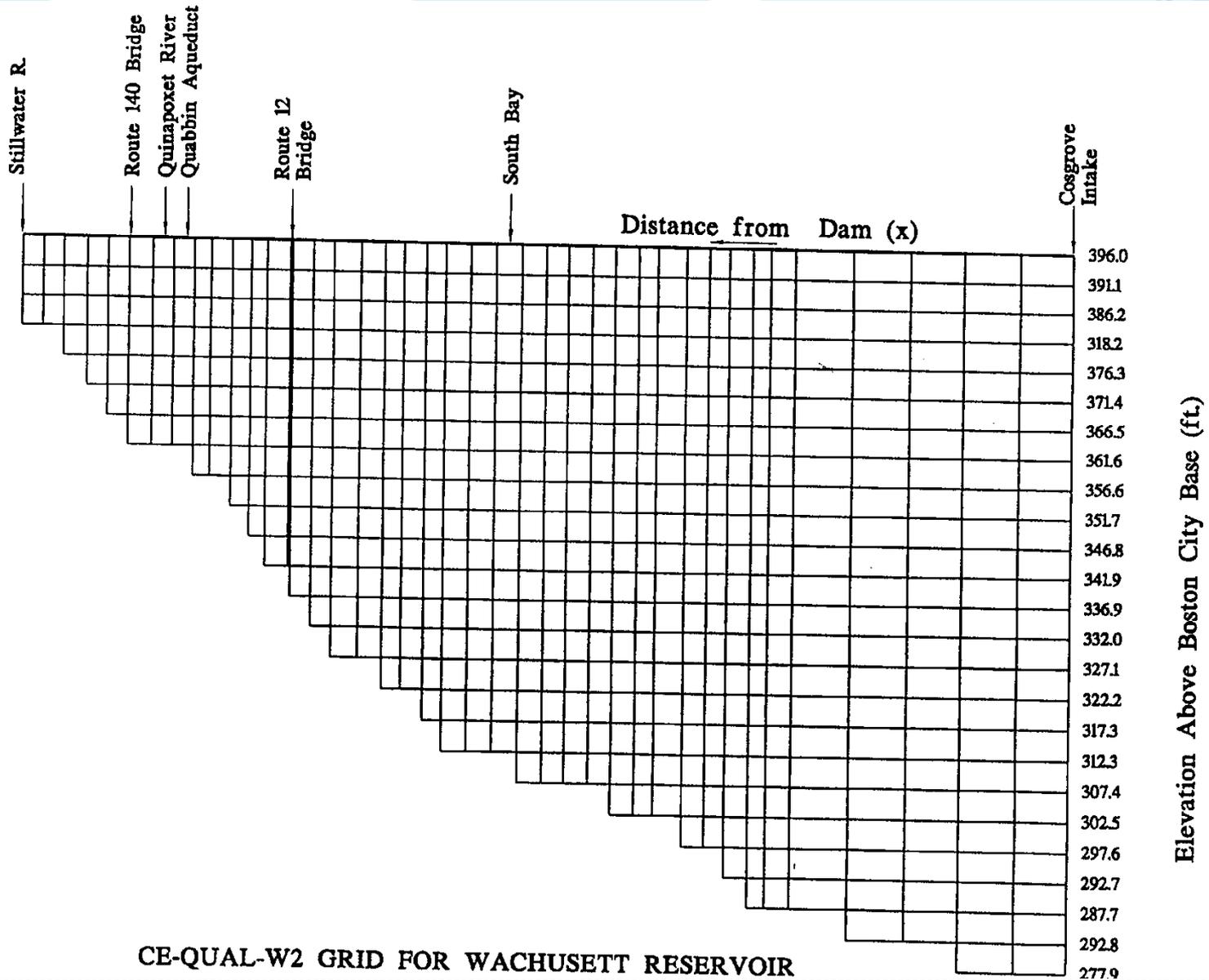
Wachusett Reservoir



Wachusett Reservoir Segmentation: Surface

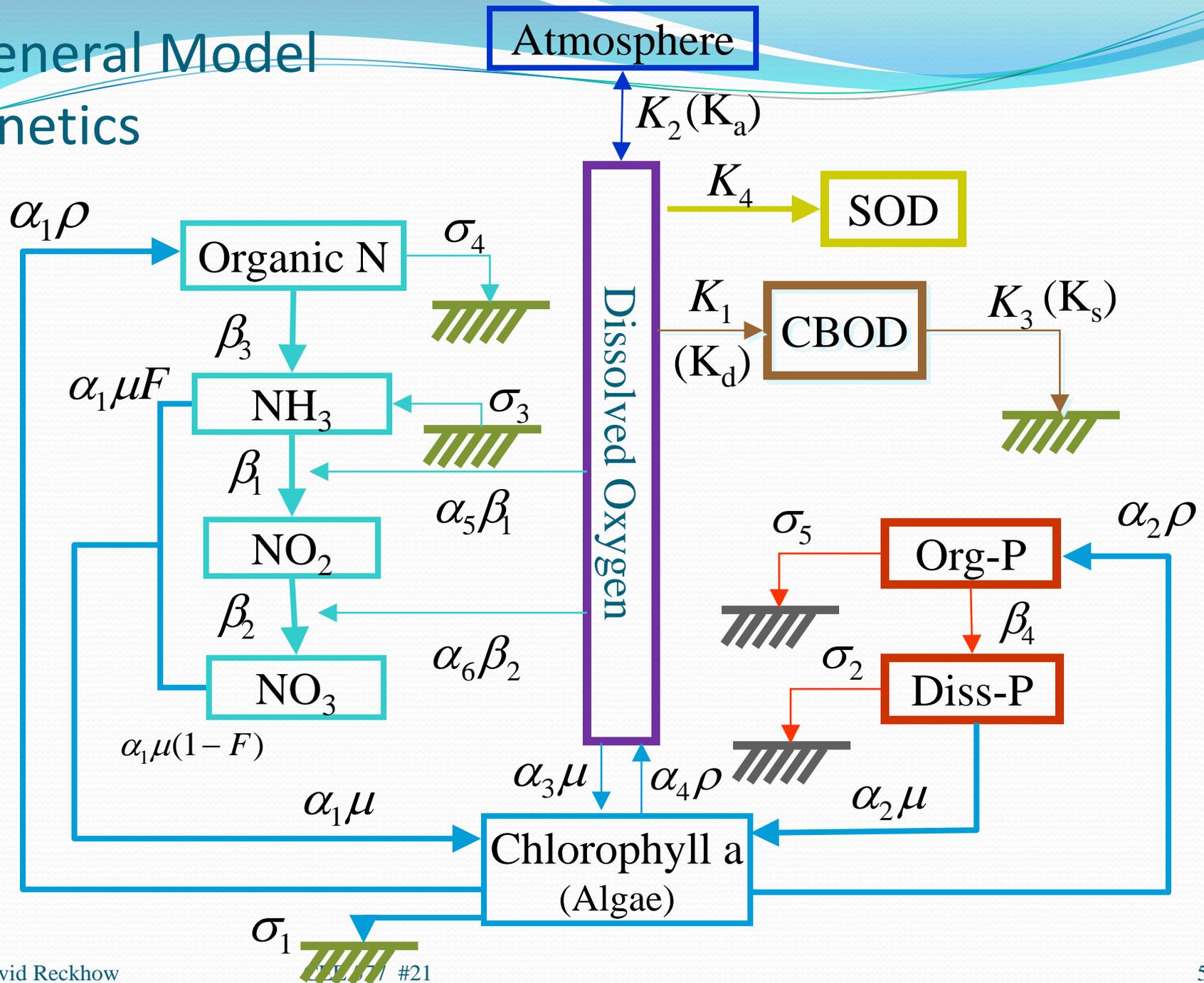


$1'' = 25'$
 SCALE
 APPROX
 $1'' = 6500'$



Wachusett Reservoir Segmentation: Depth

General Model Kinetics



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 Nutrient 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 system
5 Maintenance and Upgrade of On-site Treatment Systems	better operation & performance of home septic systems, etc.
6 Agricultural Best Management Practices	use of improved techniques in forestry, animal crop science
7 Bank and slope stabilization	erosion control to reduce sediment and associated loadings
8 Increased street sweeping	frequent washing and removal of urban runoff 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

Forge Pond

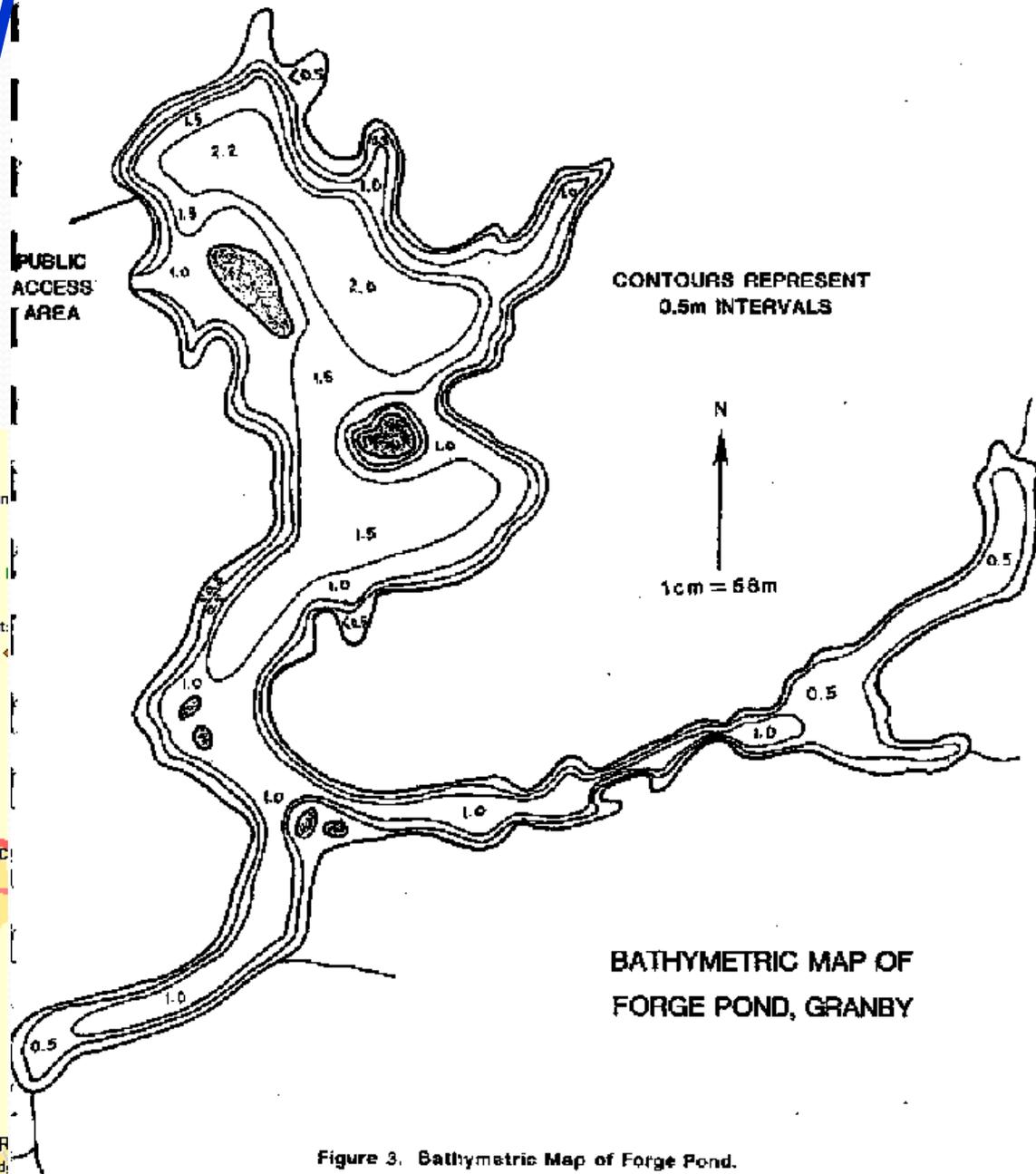
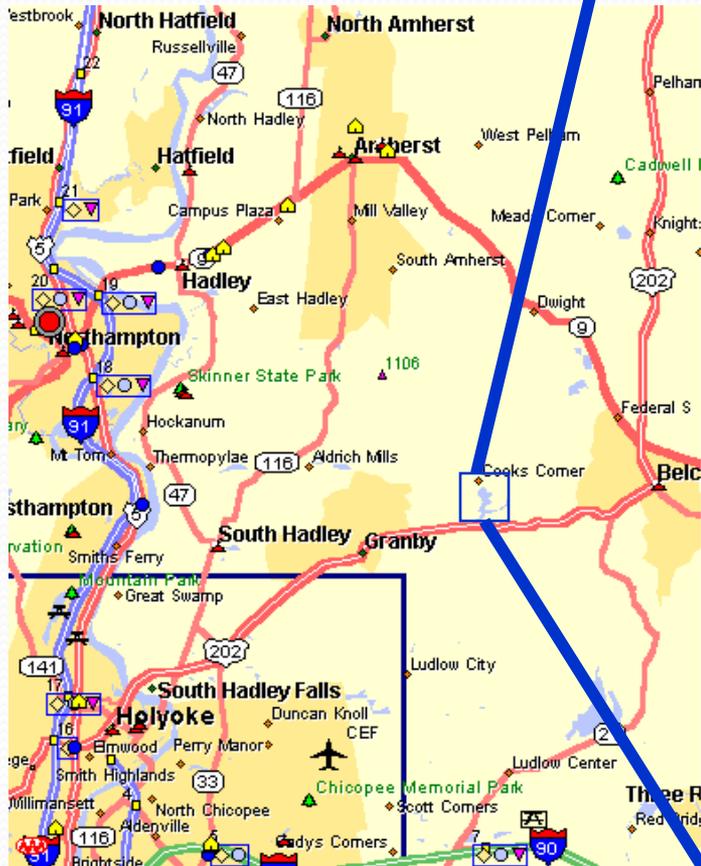


Figure 3. Bathymetric Map of Forge Pond.

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

Wachusett
0.5 yr

Forge Pond
7d

- $T=V/Q$

- if $T < 100$ d, stronger longitudinal gradients, greater productivity

- partly result of greater sediment and nutrient loads

- Drainage Area/ Lake Surface Area Ratio

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

- $RD = 50Z_m \sqrt{\pi / SA}$

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