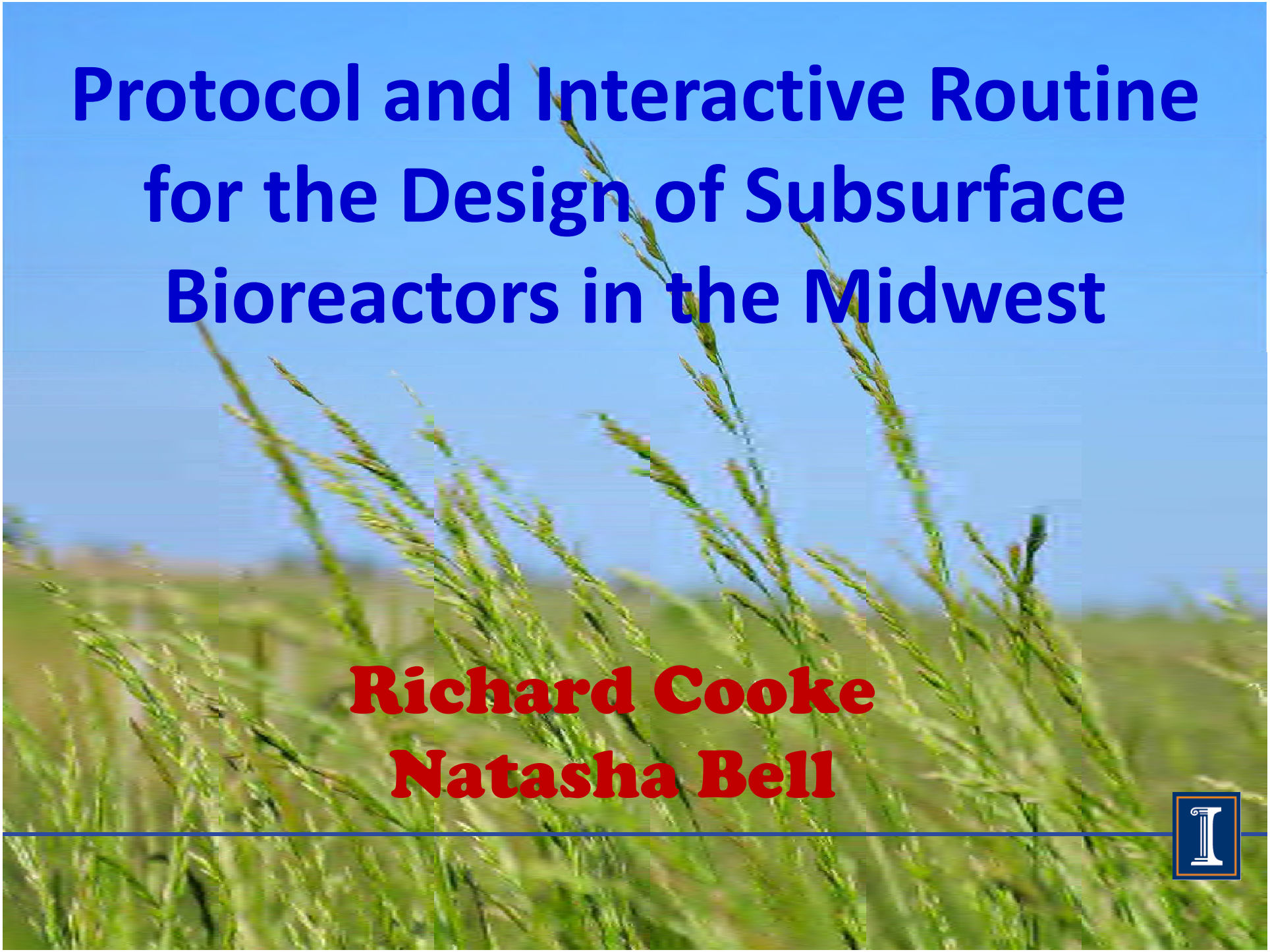
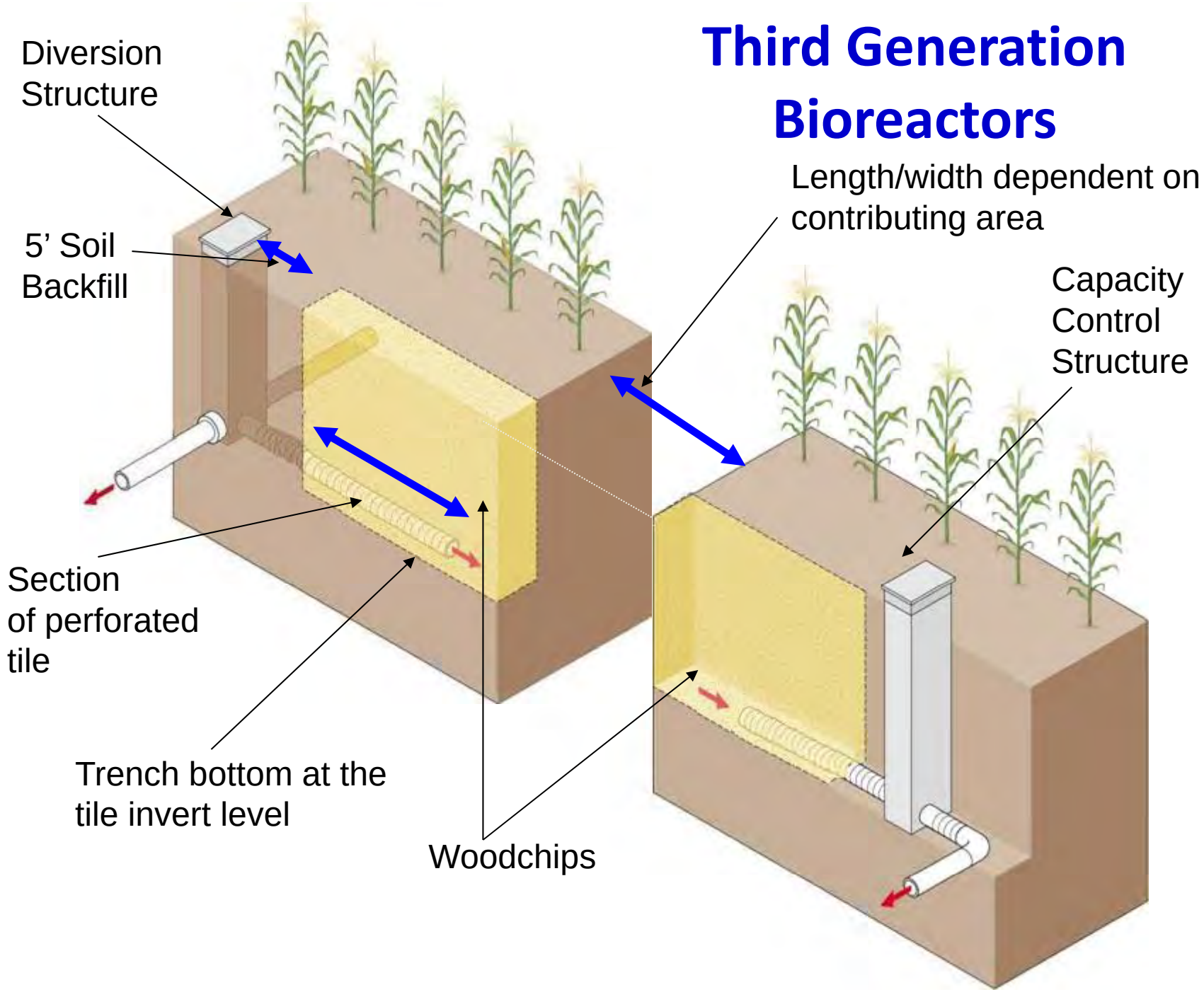
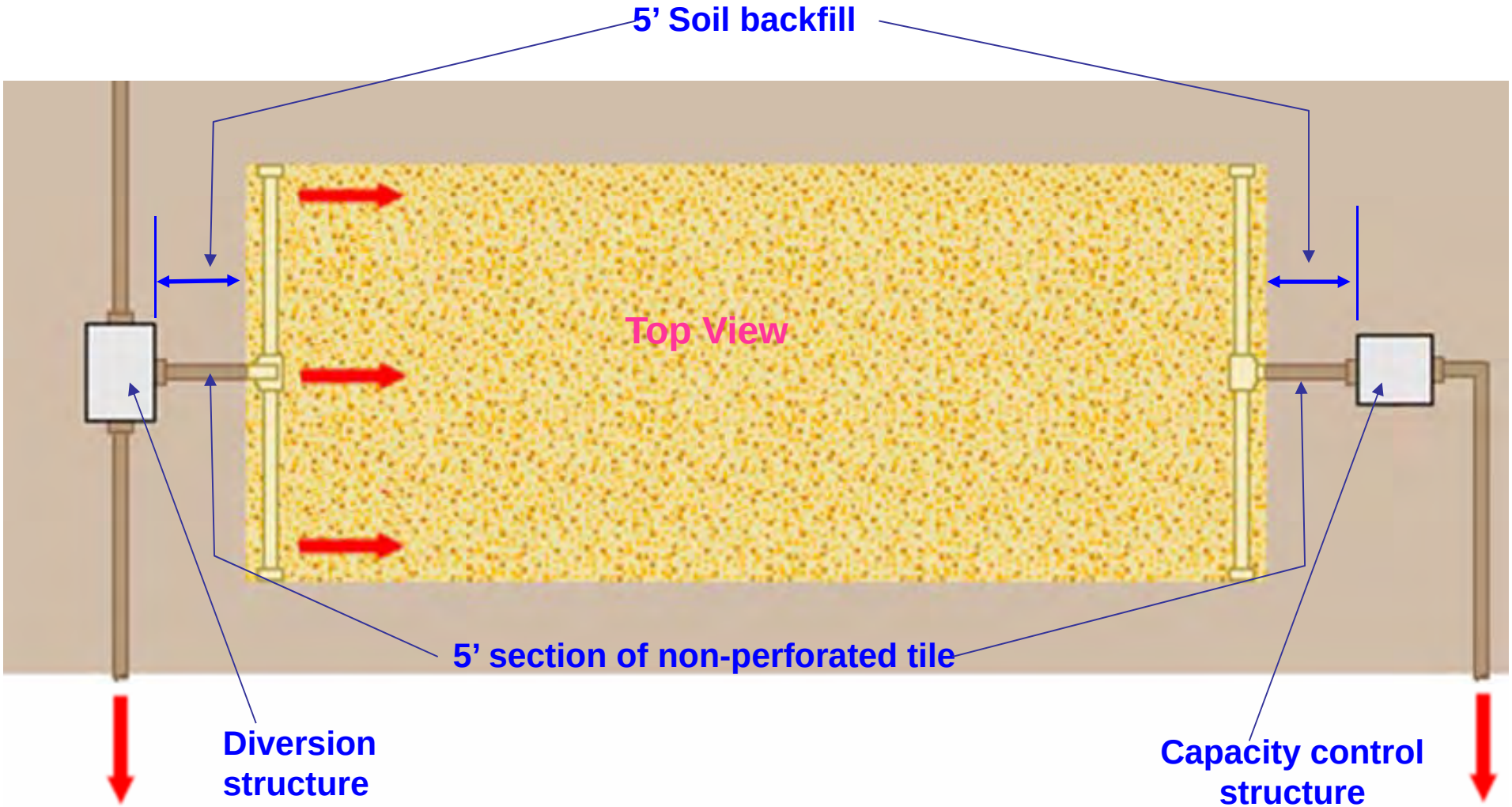
# Protocol and Interactive Routine for the Design of Subsurface Bioreactors in the Midwest

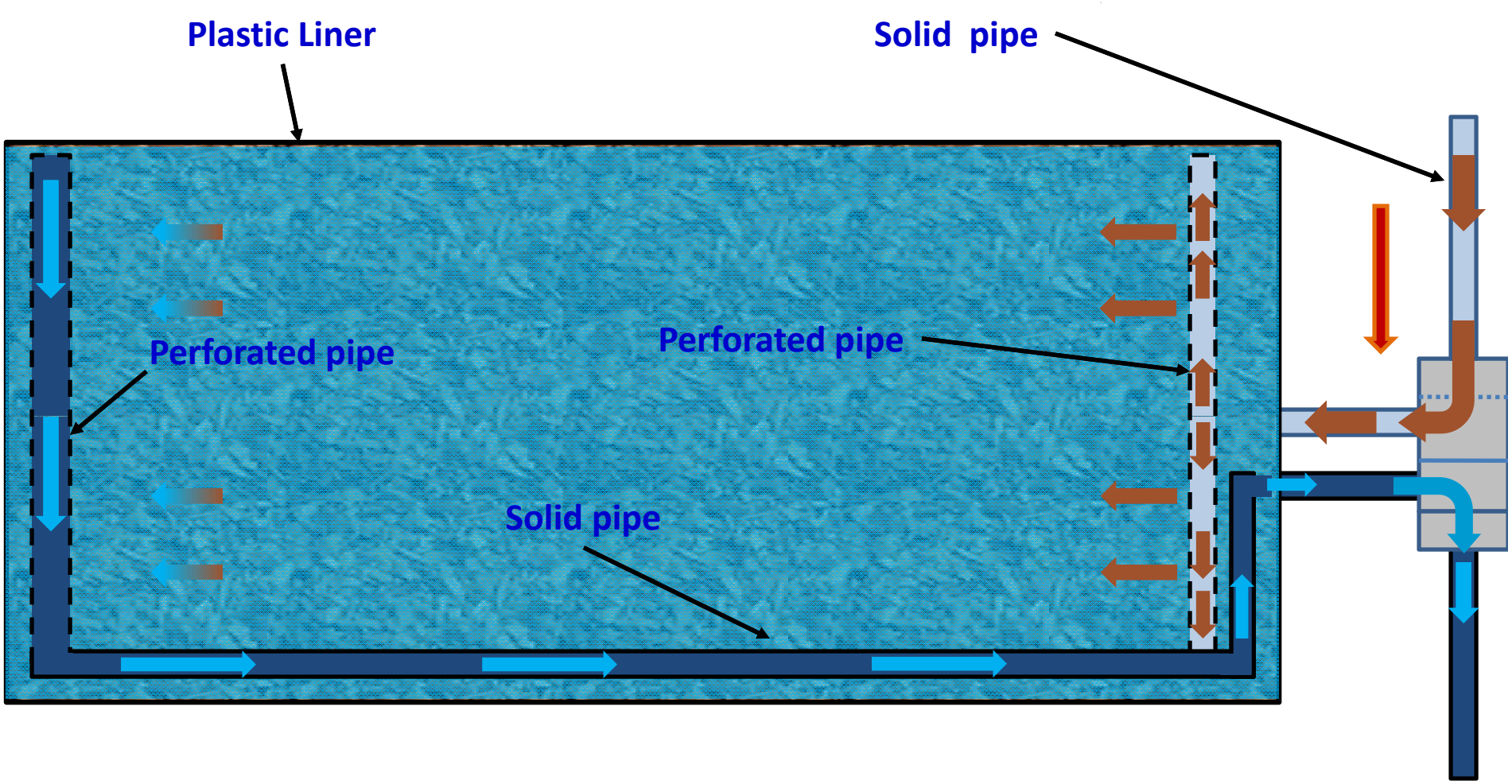


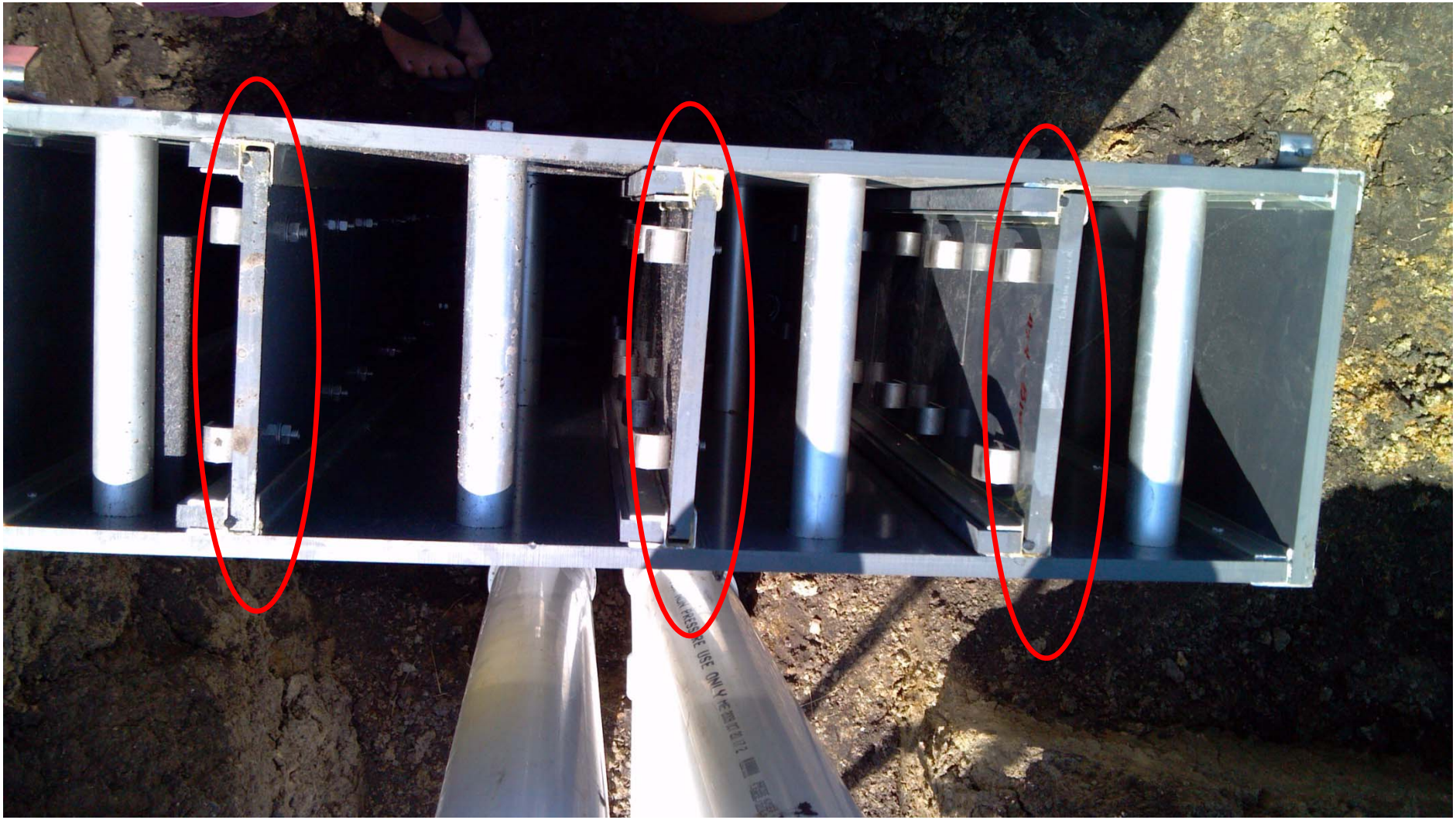
Richard Cooke
Natasha Bell

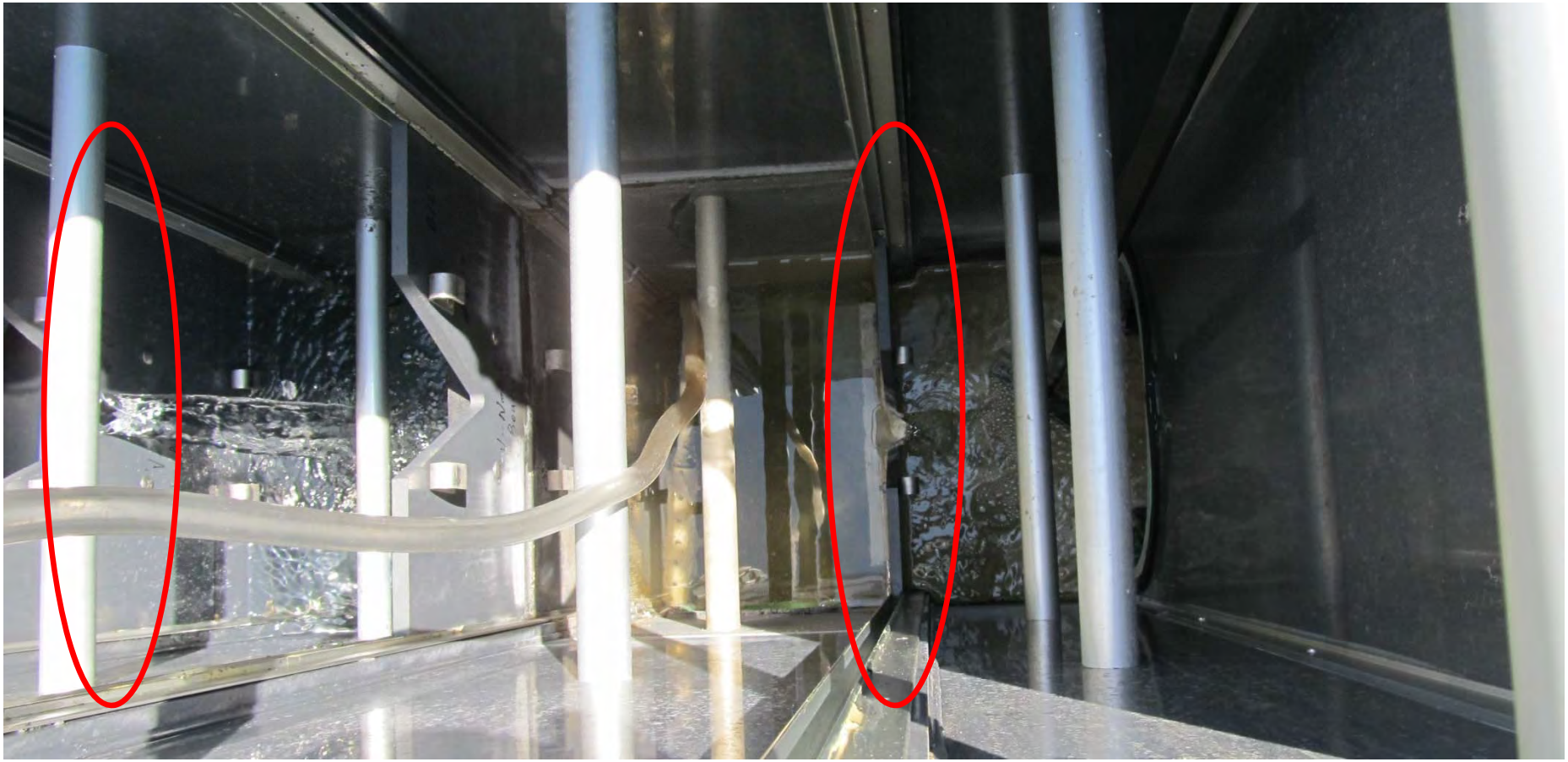
# Third Generation Bioreactors

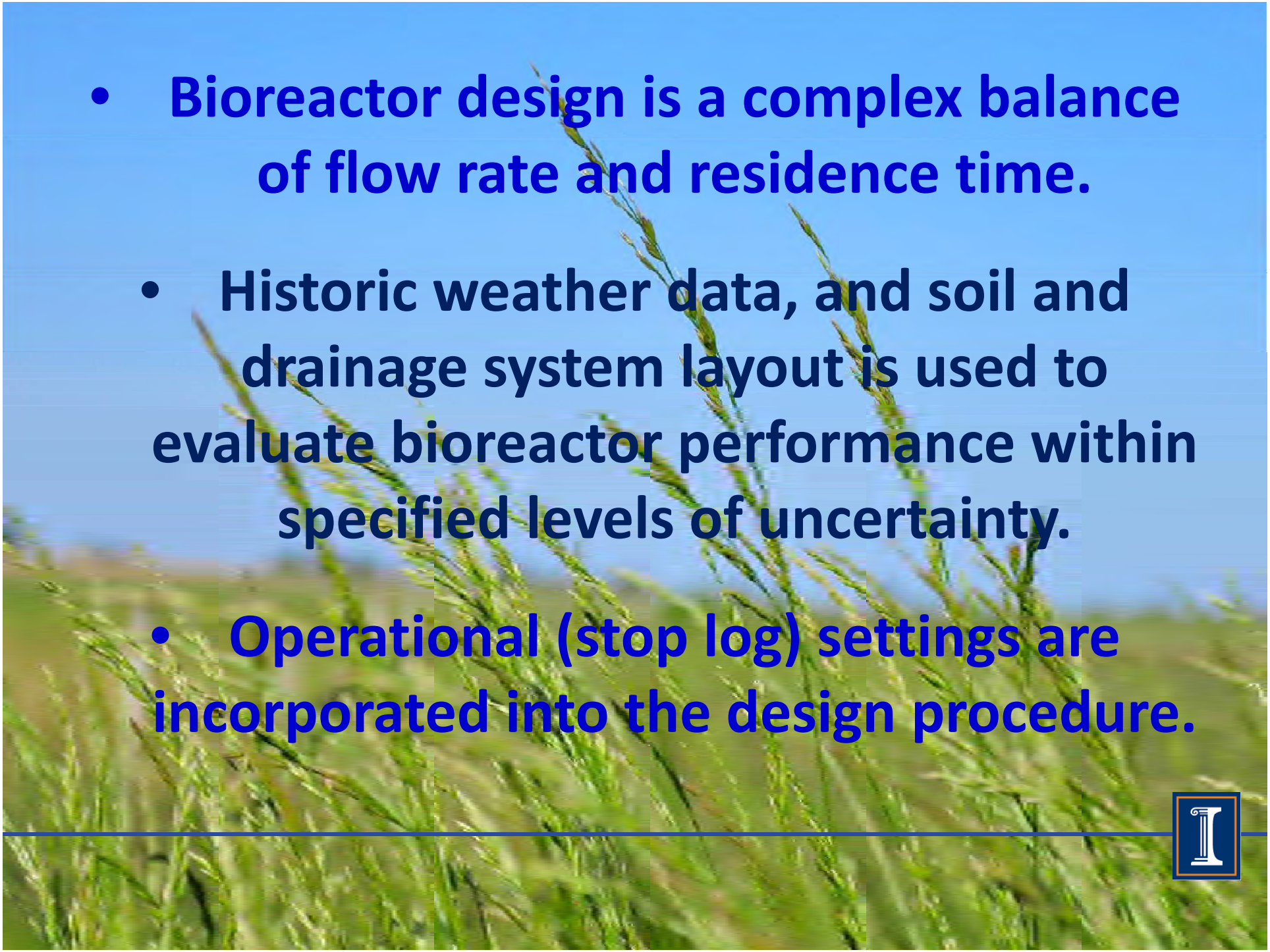






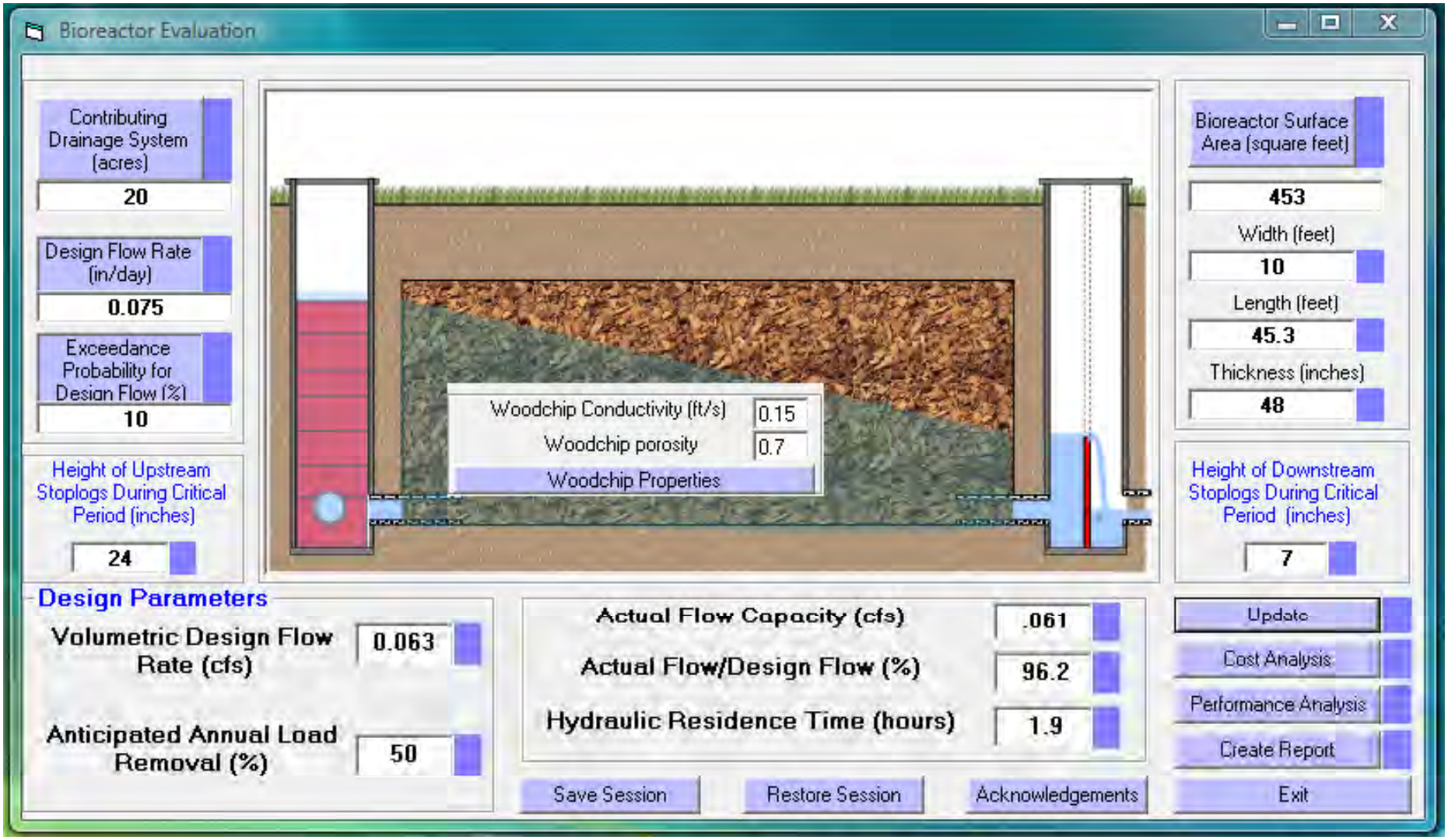


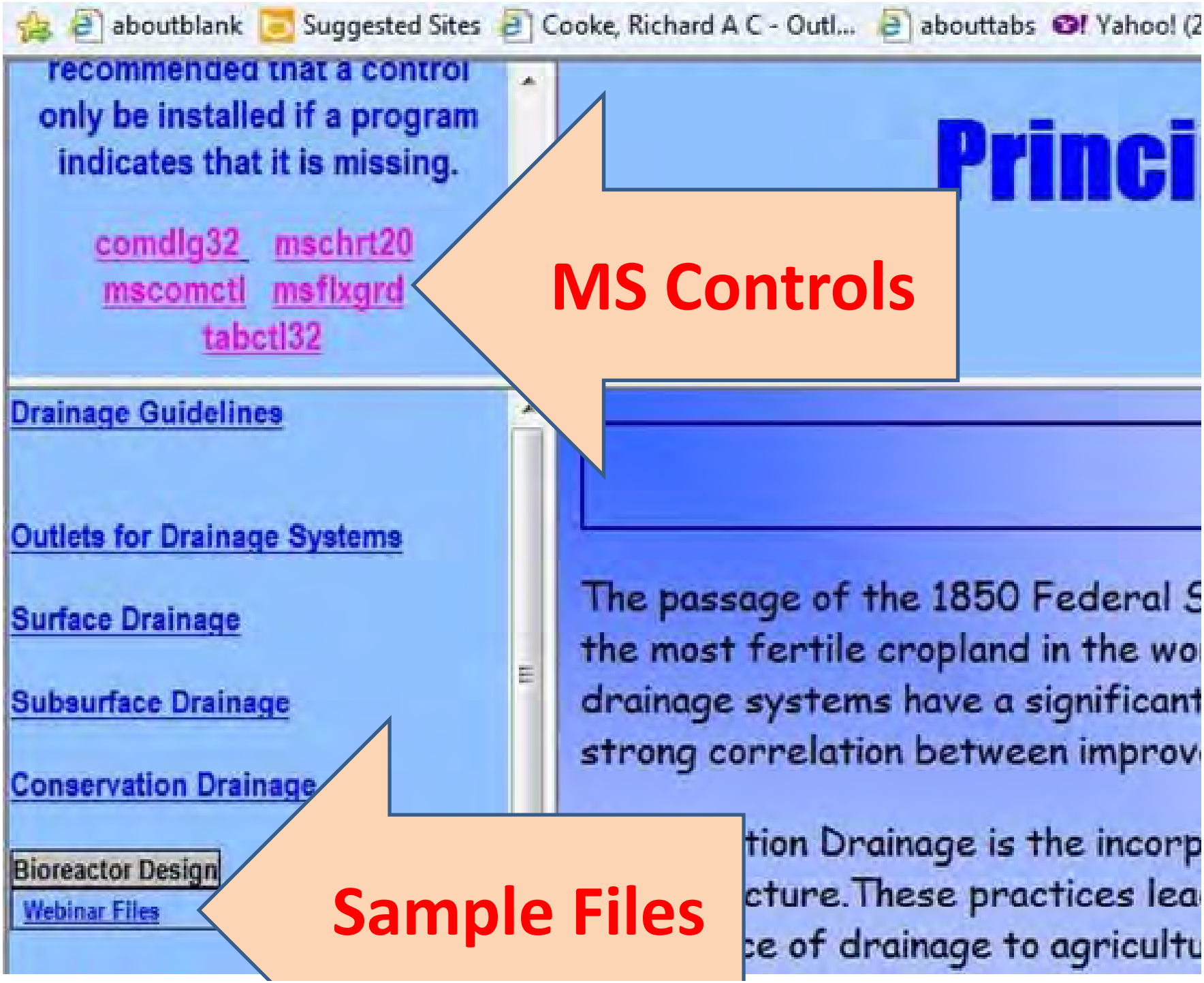


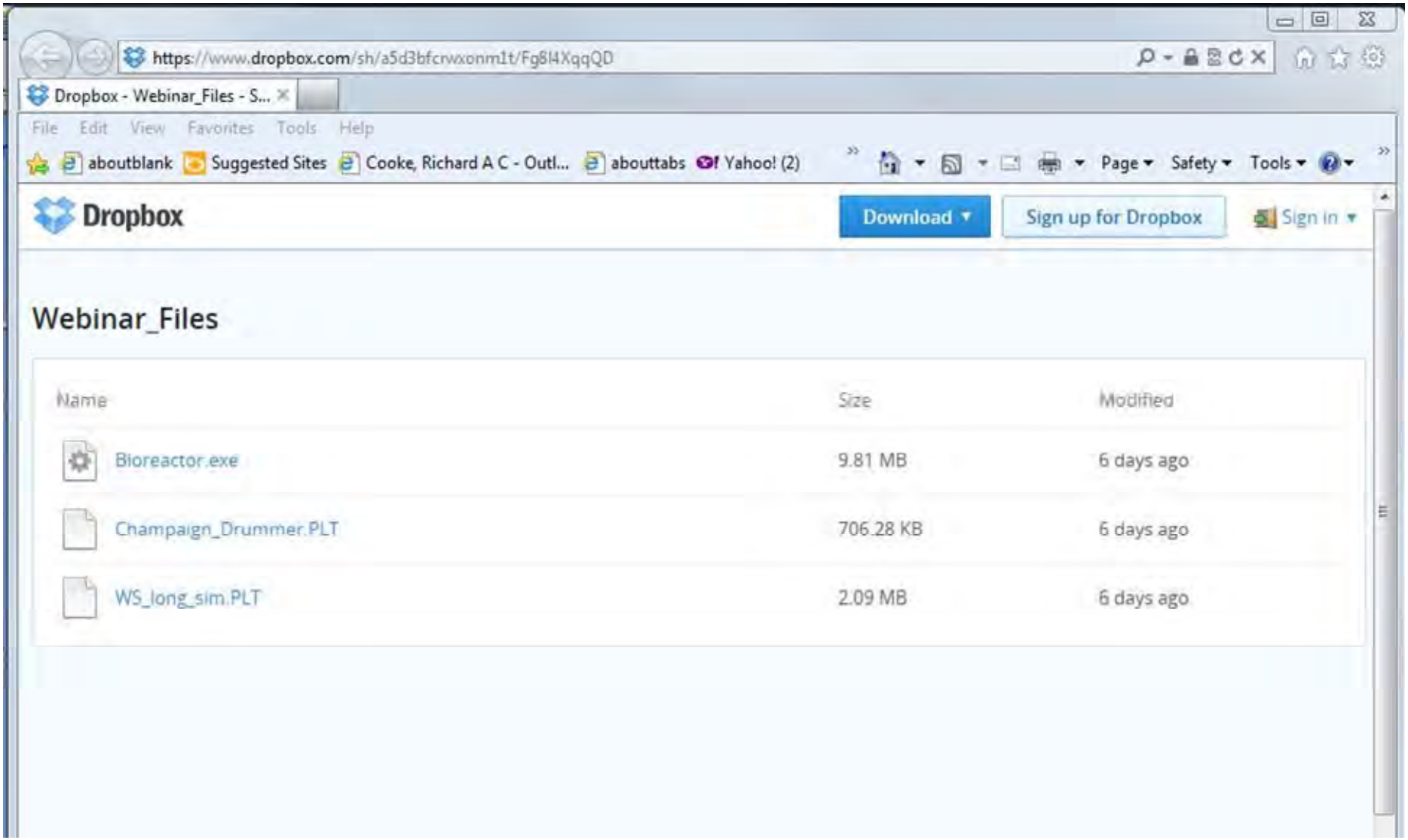


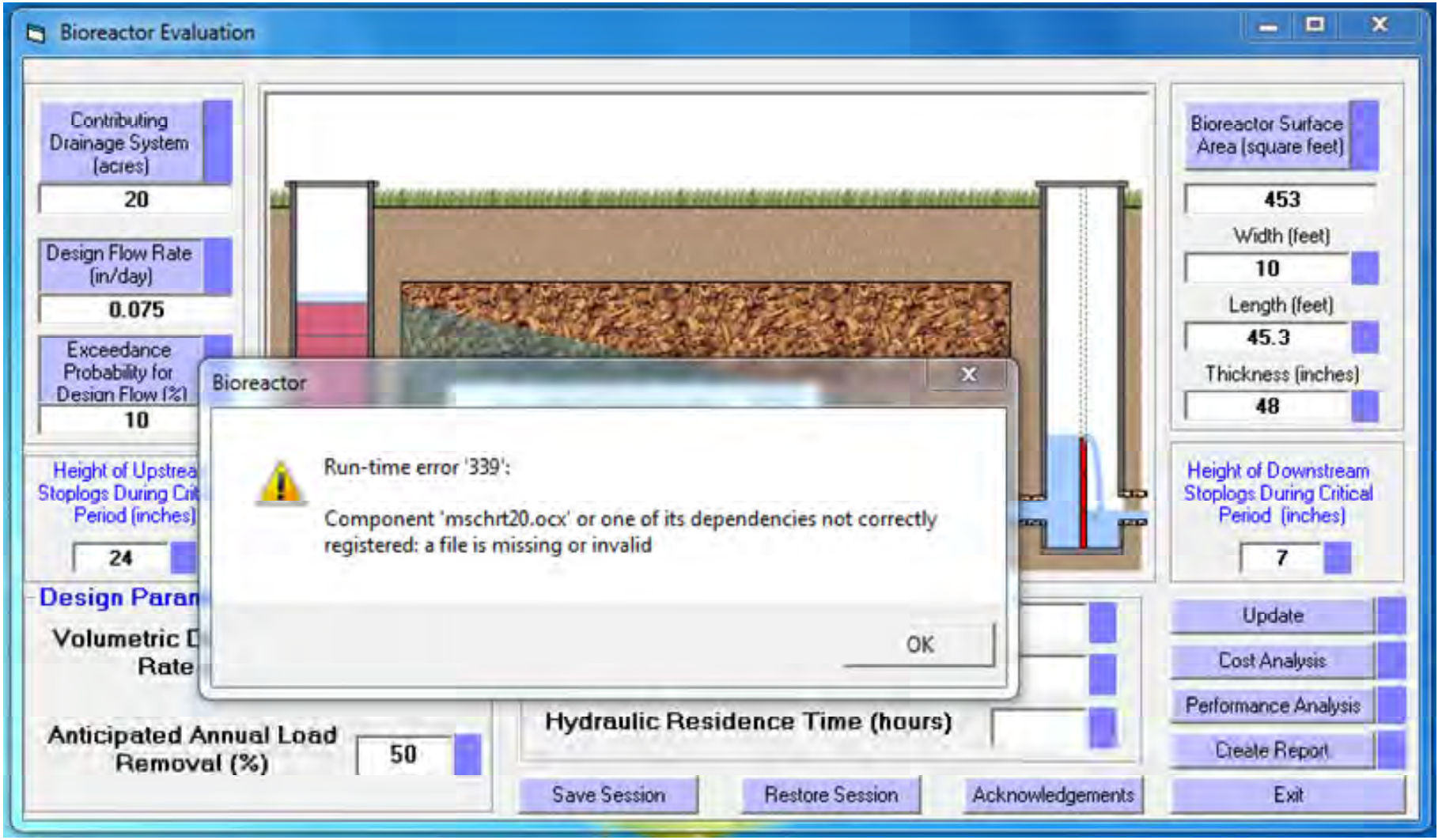
- Bioreactor design is a complex balance of flow rate and residence time.
- Historic weather data, and soil and drainage system layout is used to evaluate bioreactor performance within specified levels of uncertainty.
- Operational (stop log) settings are incorporated into the design procedure.

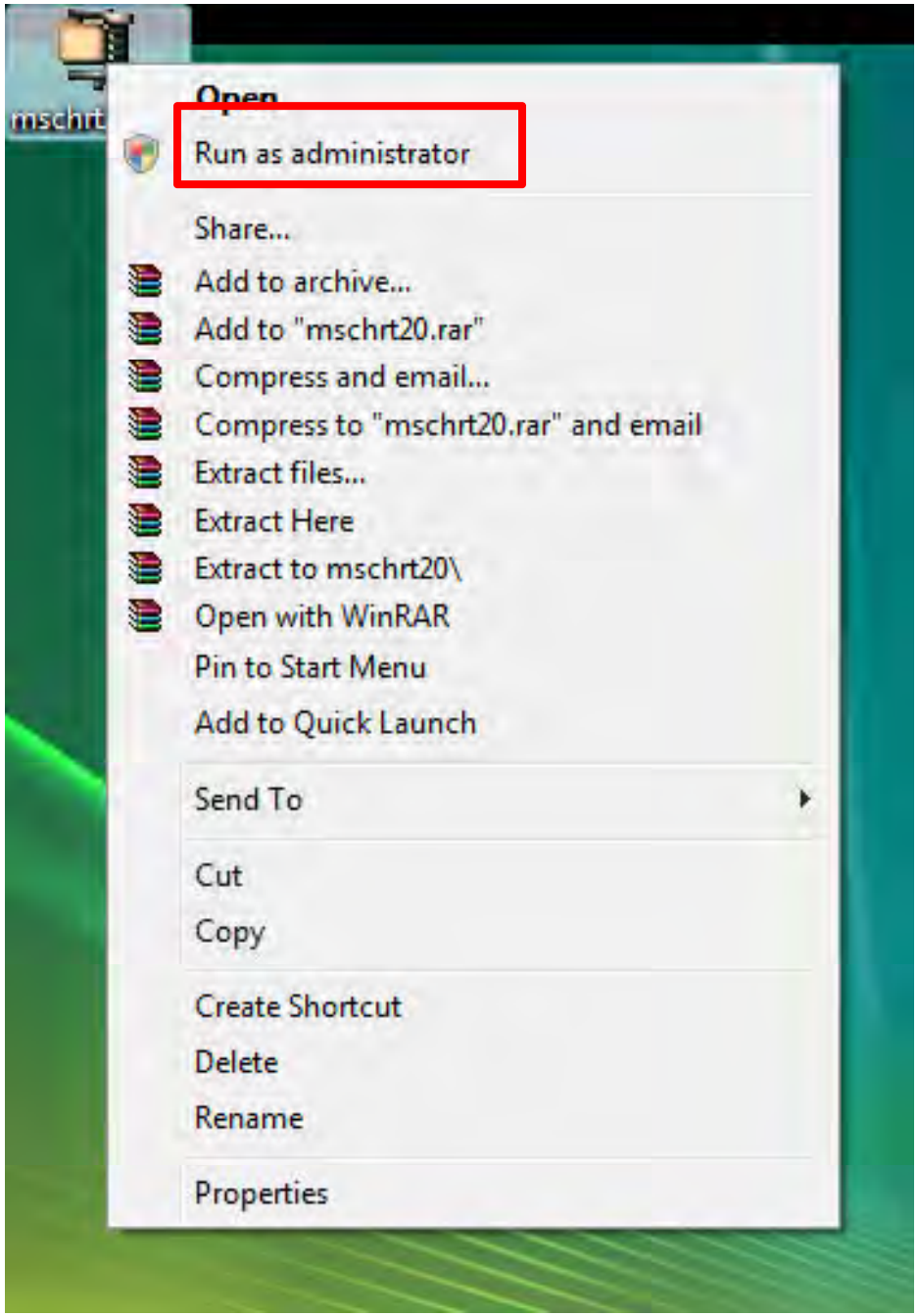
# Main Interface



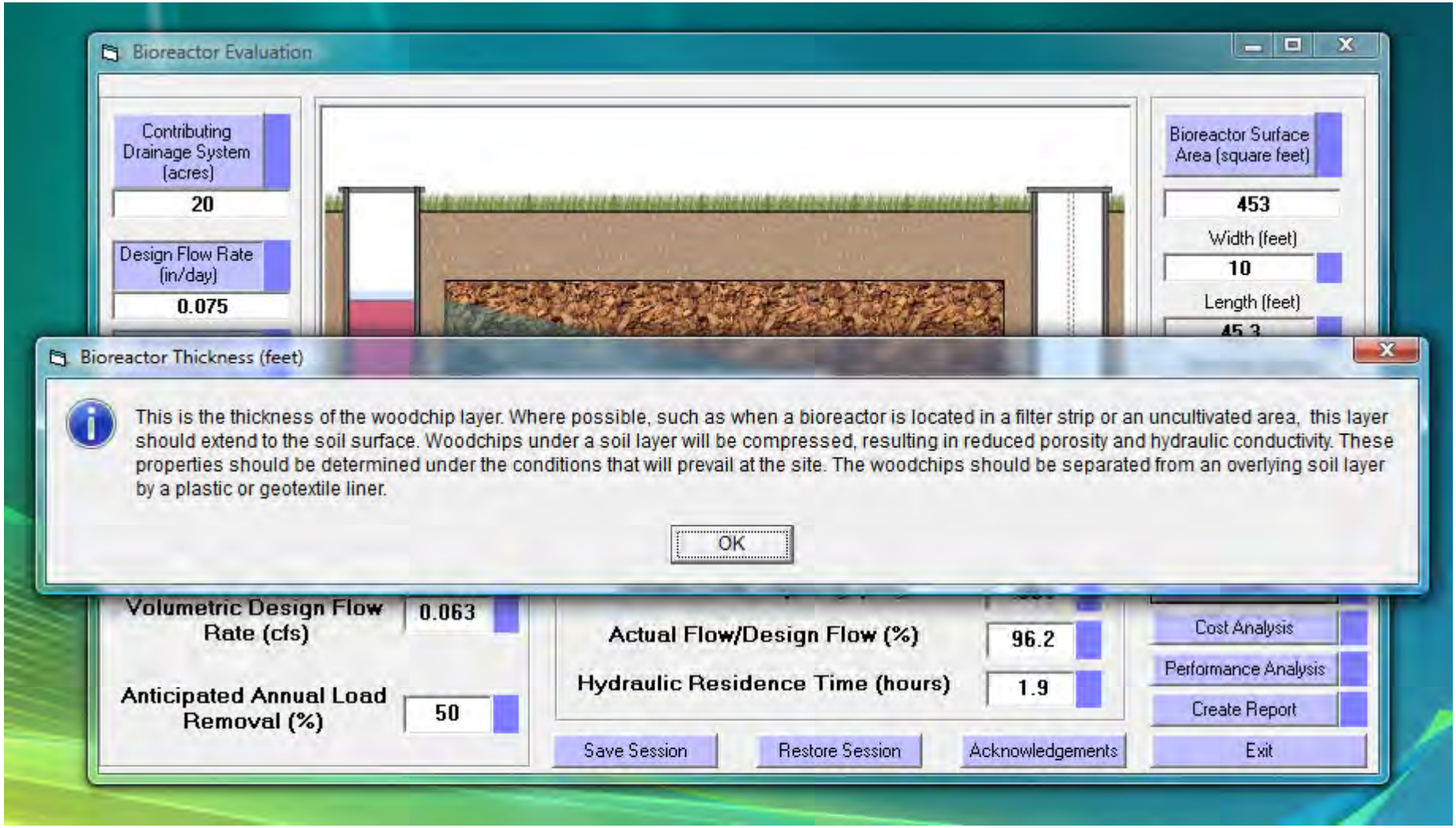



https://www.dropbox.com/sh/a5d3bfcrwxonm1t/Fg8l4XqqQD
Dropbox - Webinar_Files - S...
File Edit View Favorites Tools Help
aboutblank Suggested Sites Cooke, Richard A C - Outl... abouttabs Yahoo! (2)
Page Safety Tools
Dropbox
Download
Sign up for Dropbox
Sign in
Webinar_Files
Name
Size
Modified
Bioreactor.exe
9.81 MB
6 days ago
Champaign_Drummer.PLT
706.28 KB
6 days ago
WS_long_sim.PLT
2.09 MB
6 days ago


Bioreactor Evaluation
Contributing Drainage System (acres)
20
Design Flow Rate (in/day)
0.075
Exceedance Probability for Design Flow (%)
10
Height of Upstrea
Stoplogs During Cri
Period (inches)
24
Design Paran
Volumetric D
Rate
Anticipated Annual Load Removal (%)
50
Bioreactor Surface Area (square feet)
453
Width (feet)
10
Length (feet)
45.3
Thickness (inches)
48
Height of Downstream Stoplogs During Critical Period (inches)
7
Hydraulic Residence Time (hours)
Update
Cost Analysis
Performance Analysis
Create Report
Exit
Save Session
Restore Session
Acknowledgements
Bioreactor
Run-time error '339':
Component 'mschrt20.ocx' or one of its dependencies not correctly registered: a file is missing or invalid
OK

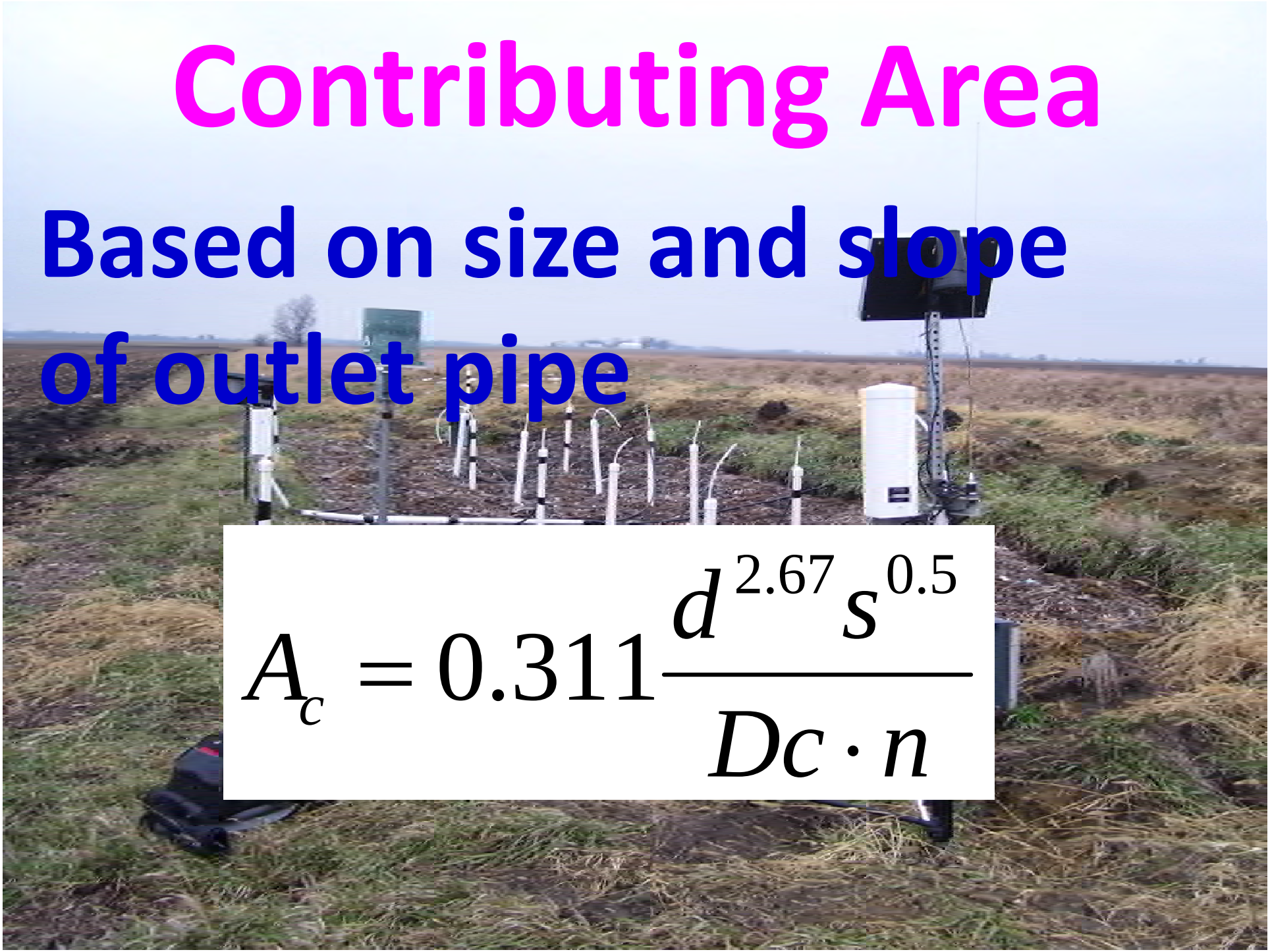

mschrt
Open
Run as administrator
Share...
Add to archive...
Add to "mschrt20.rar"
Compress and email...
Compress to "mschrt20.rar" and email
Extract files...
Extract Here
Extract to mschrt20\
Open with WinRAR
Pin to Start Menu
Add to Quick Launch
Send To
Cut
Copy
Create Shortcut
Delete
Rename
Properties

# Popup Help Screens



# Contributing Area

## Based on size and slope of outlet pipe



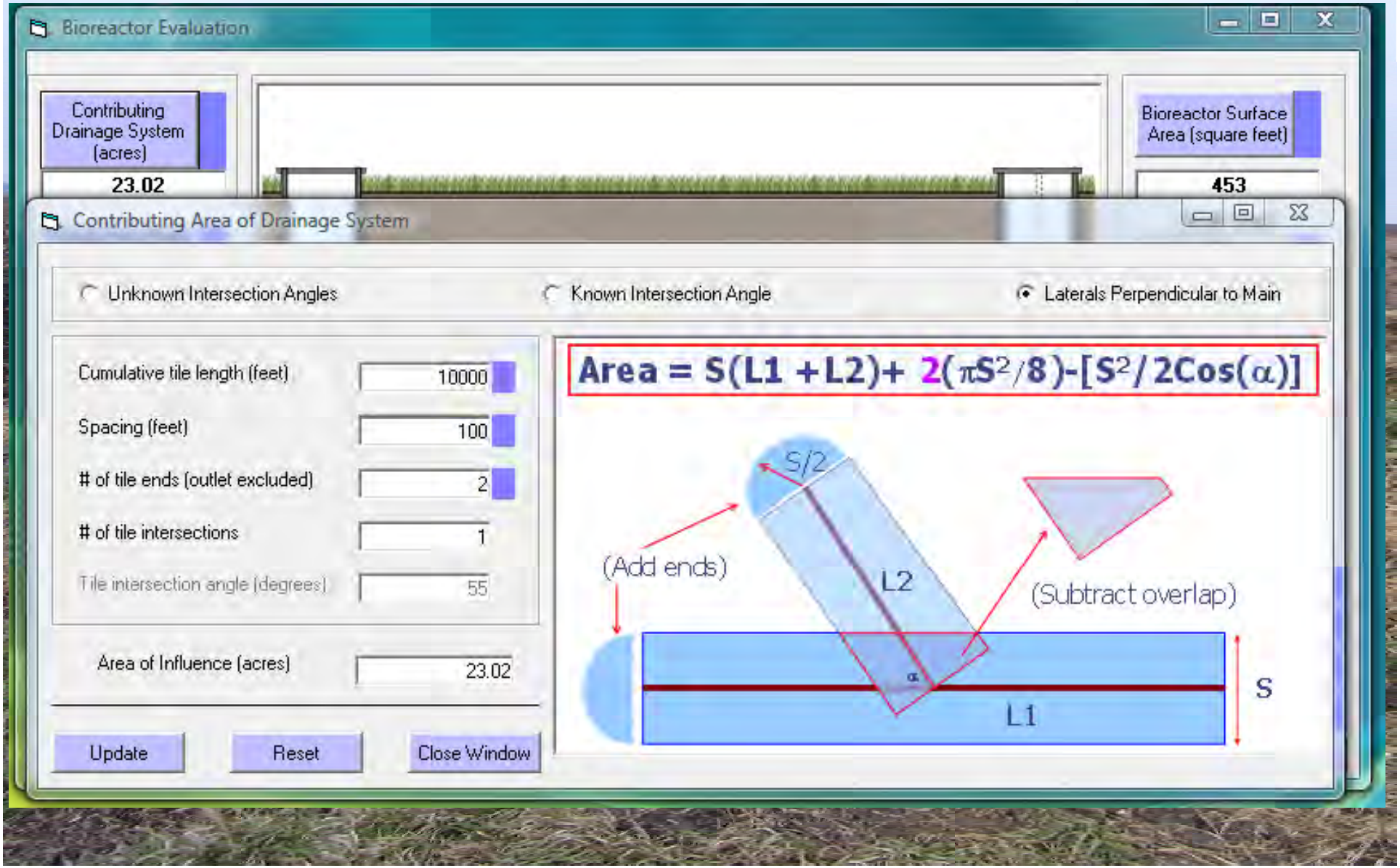
$$A_c = 0.311 \frac{d^{2.67} s^{0.5}}{Dc \cdot n}$$

# Contributing Area

## Based on tile lengths and intersection angles

$$A_c = SL + \left( \frac{\pi E}{8} - \frac{I}{\cos(\alpha)} \right) S^2$$

# Contributing Area



# Woodchip Properties

# Sizing Criteria

- Flow rate
- Residence time
- Performance

# Design Flow Rate

## 10-year, 24 hour drain outflow event

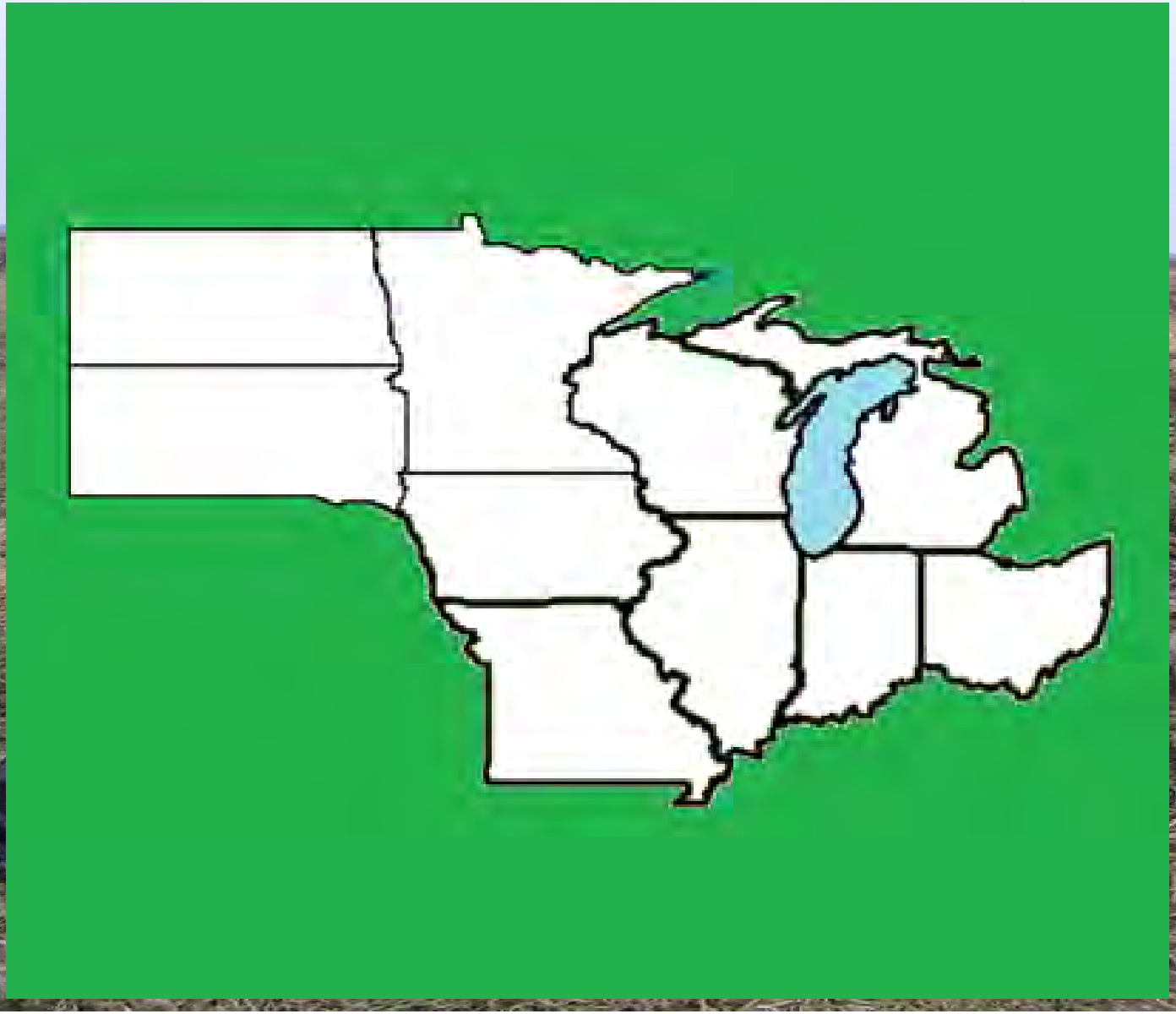
- Grassed waterways (NRCS-412)
- Constructed wetlands (NRCS-656)

# Design Flow Rate

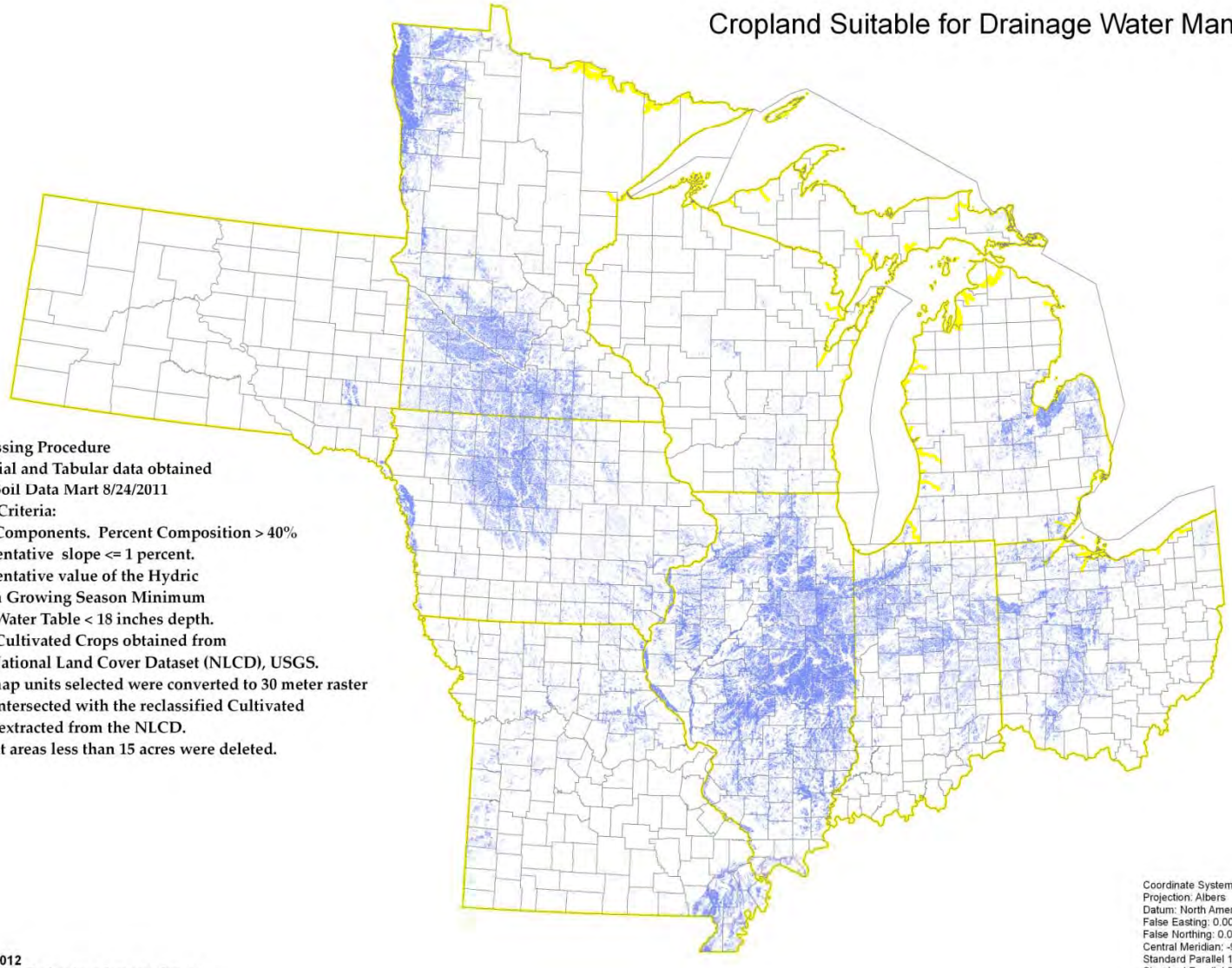
# DRAINMOD Simulations

- Weather
- Soils
- Drainage System Layout

# Midwest Database



# NRCS Midwest DWM States




Illinois 10,289,165 Ac
Indiana 2,752,251 Ac
Iowa 4,076,072 Ac
Missouri 1,844,238 Ac
Michigan 1,259,731 Ac
Minnesota 6,308,982 Ac
Ohio 2,146,231 Ac
South Dakota 228,842 Ac
Wisconsin 309,427 Ac

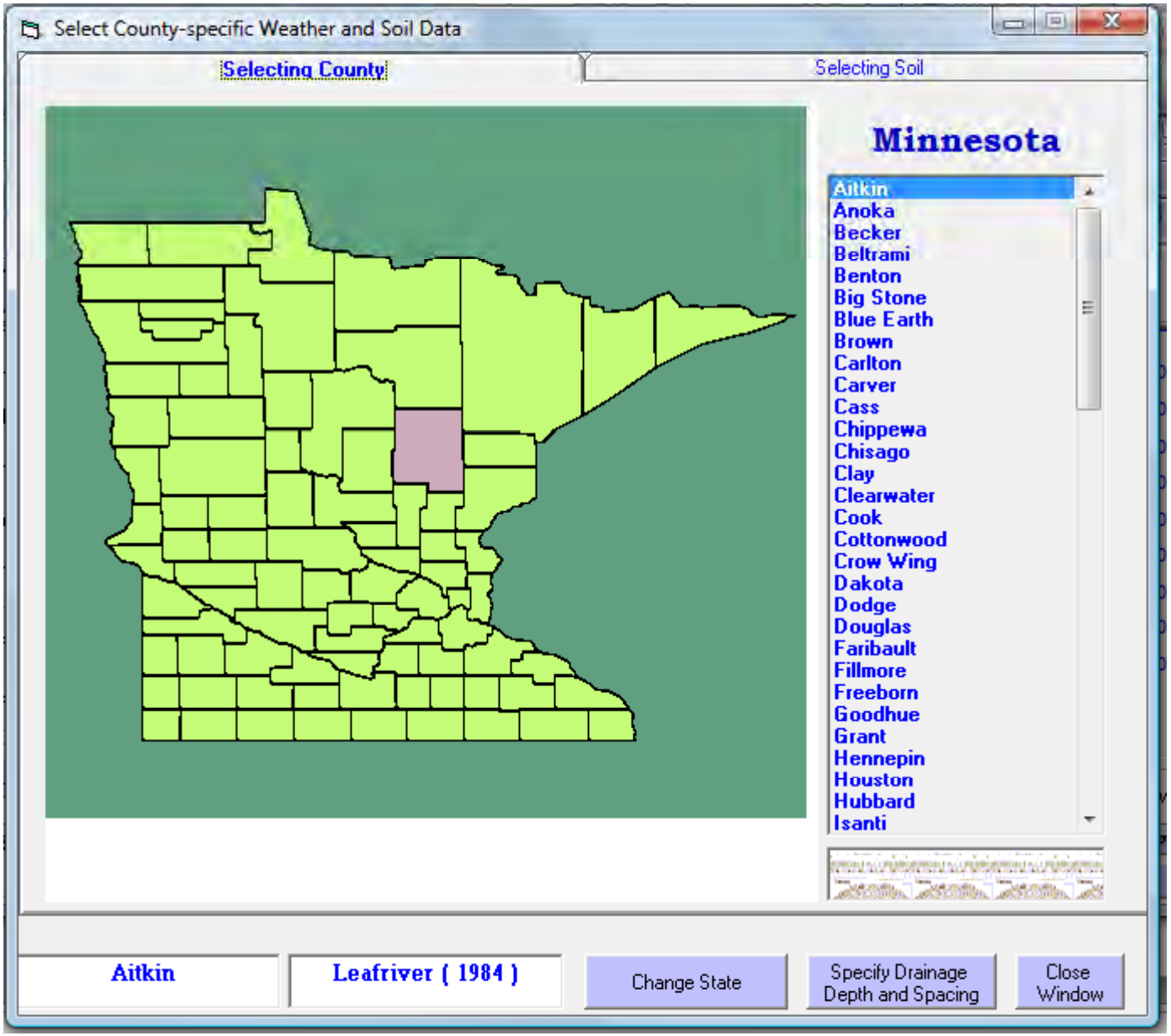
Geoprocessing Procedure
Soils Spatial and Tabular data obtained
from the Soil Data Mart 8/24/2011
Selection Criteria:
1. Major Components. Percent Composition > 40%
2. Representative slope <= 1 percent.
3. Representative value of the Hydric
Definition Growing Season Minimum
Depth of Water Table < 18 inches depth.
Extent of Cultivated Crops obtained from
the 2006 National Land Cover Dataset (NLCD), USGS.
The soil map units selected were converted to 30 meter raster
data and intersected with the reclassified Cultivated
Cropland extracted from the NLCD.
Coincident areas less than 15 acres were deleted.

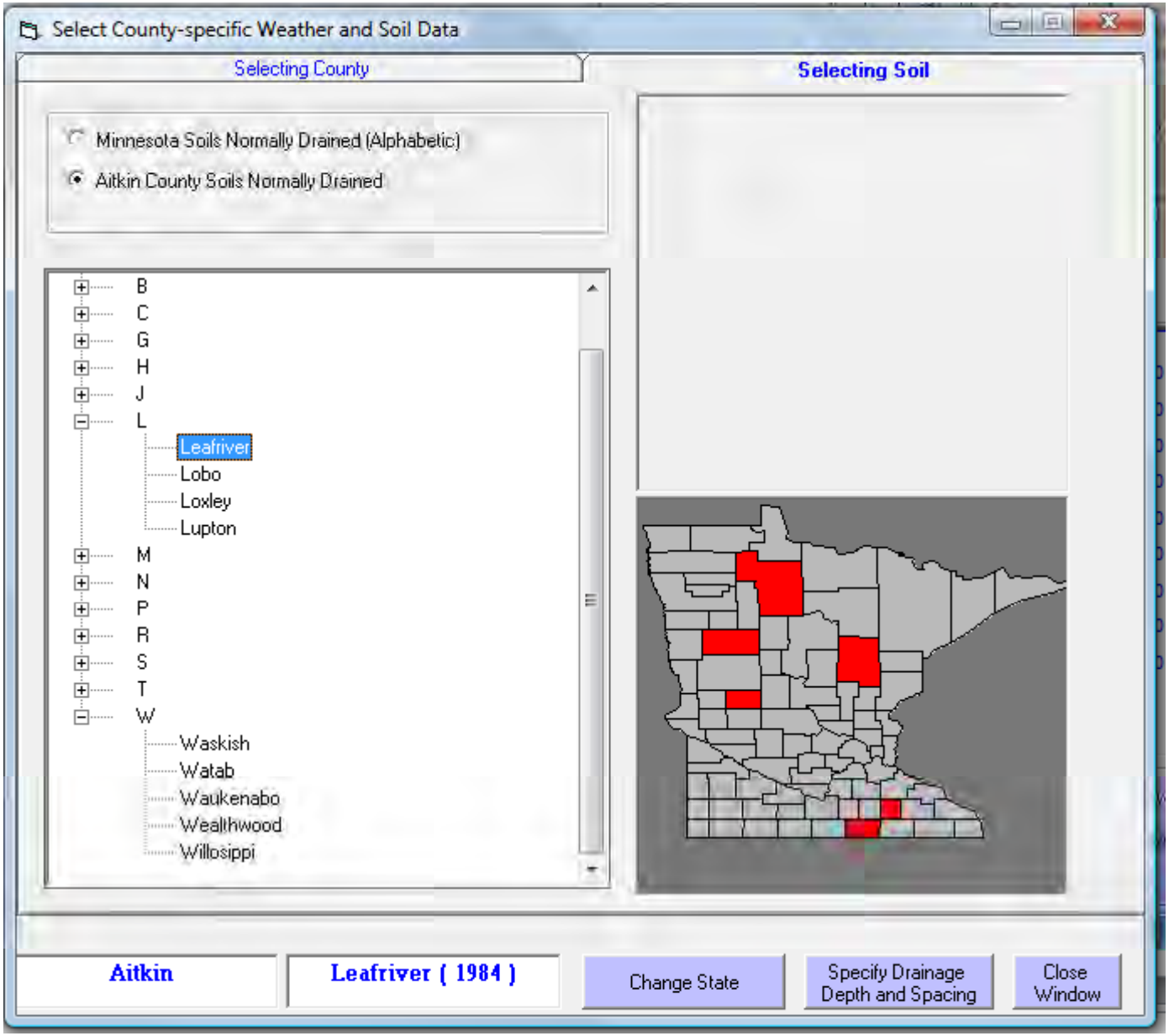
Coordinate System: USA Contiguous Albers Equal Area Conic USGS version
Projection: Albers
Datum: North American 1983
False Easting: 0.0000
False Northing: 0.0000
Central Meridian: -96.0000
Standard Parallel 1: 29.5000
Standard Parallel 2: 45.5000
Latitude Of Origin: 23.0000
Units: Meter

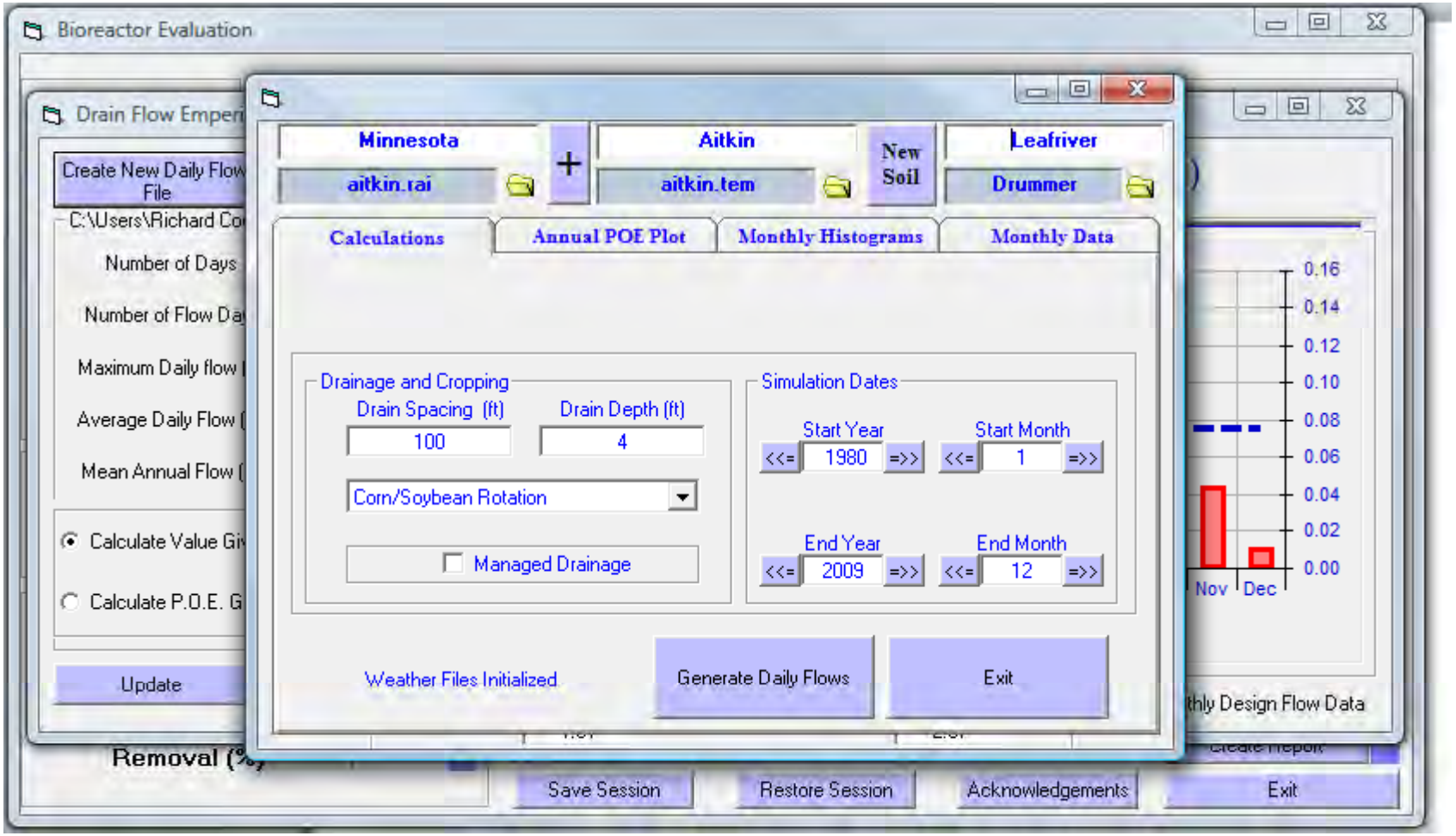
1:6,000,000

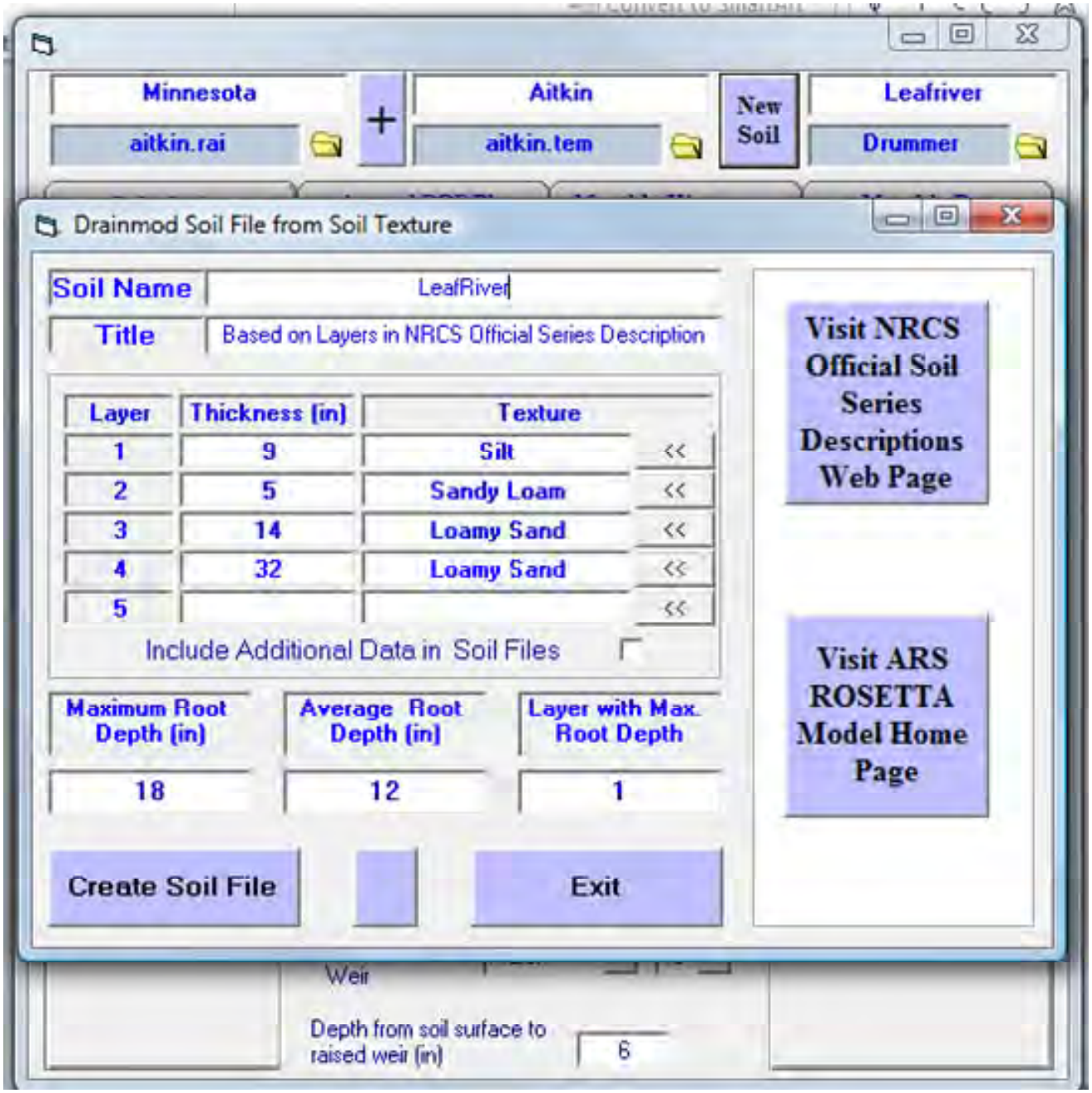
February 1, 2012
Central National Technology Support Center
Fort Worth, TX Map 2012- 41


Select a state then click Continue
Illinois
Indiana
Iowa
Michigan
Minnesota
Missouri
North Dakota
Ohio
South Dakota
Wisconsin
Other Location
Continue

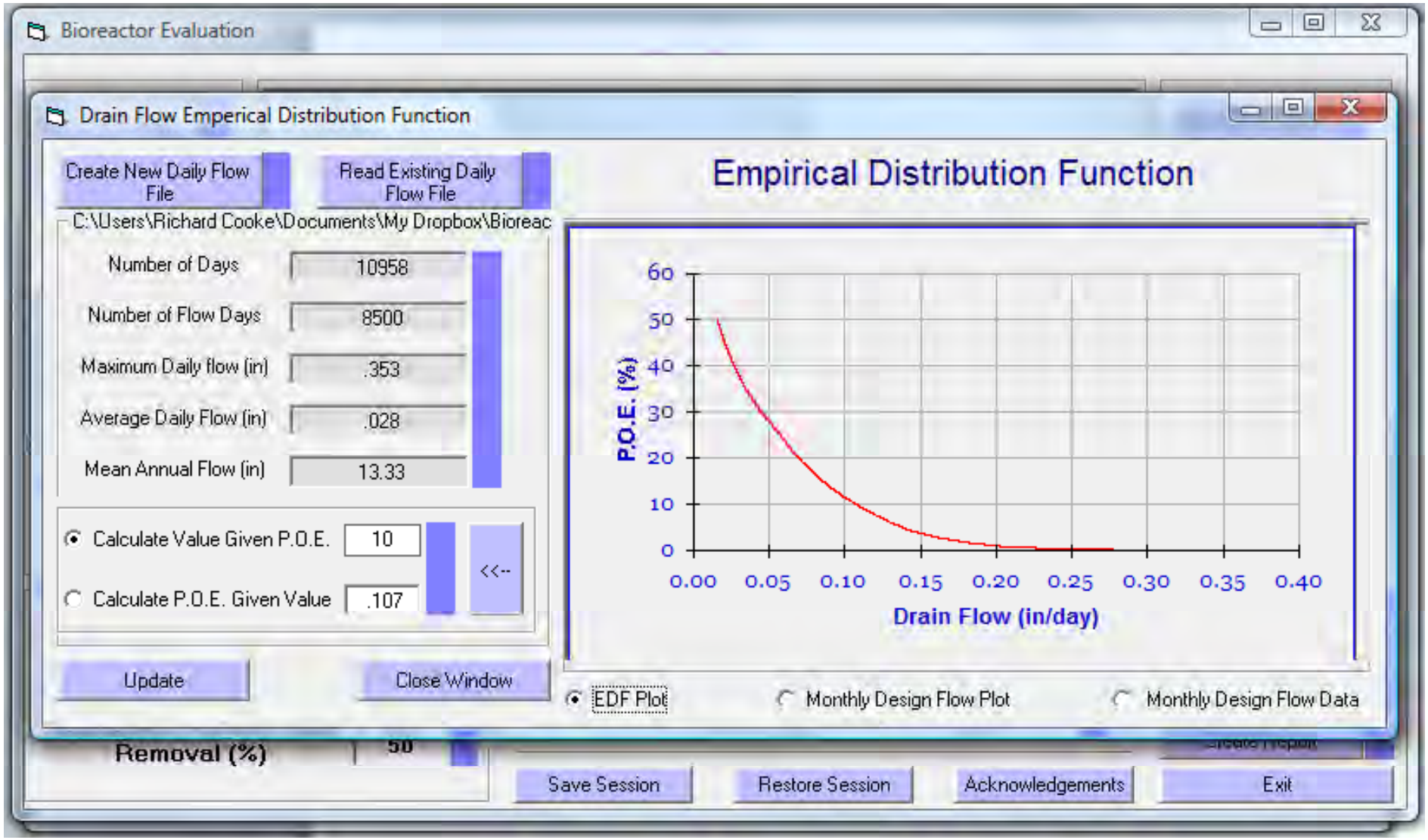

Select County-specific Weather and Soil Data
Selecting County
Selecting Soil
Minnesota
Aitkin
Anoka
Becker
Beltrami
Benton
Big Stone
Blue Earth
Brown
Carlton
Carver
Cass
Chippewa
Chisago
Clay
Clearwater
Cook
Cottonwood
Crow Wing
Dakota
Dodge
Douglas
Faribault
Fillmore
Freeborn
Goodhue
Grant
Hennepin
Houston
Hubbard
Isanti
Aitkin
Leafriver ( 1984 )
Change State
Specify Drainage Depth and Spacing
Close Window


Select County-specific Weather and Soil Data
Selecting County
Selecting Soil
Minnesota Soils Normally Drained (Alphabetic)
Aitkin County Soils Normally Drained
B
C
G
H
J
L
Leafriver
Lobo
Loxley
Lupton
M
N
P
R
S
T
W
Waskish
Watab
Waukenabo
Wealthwood
Willosippi
Aitkin
Leafriver ( 1984 )
Change State
Specify Drainage Depth and Spacing
Close Window

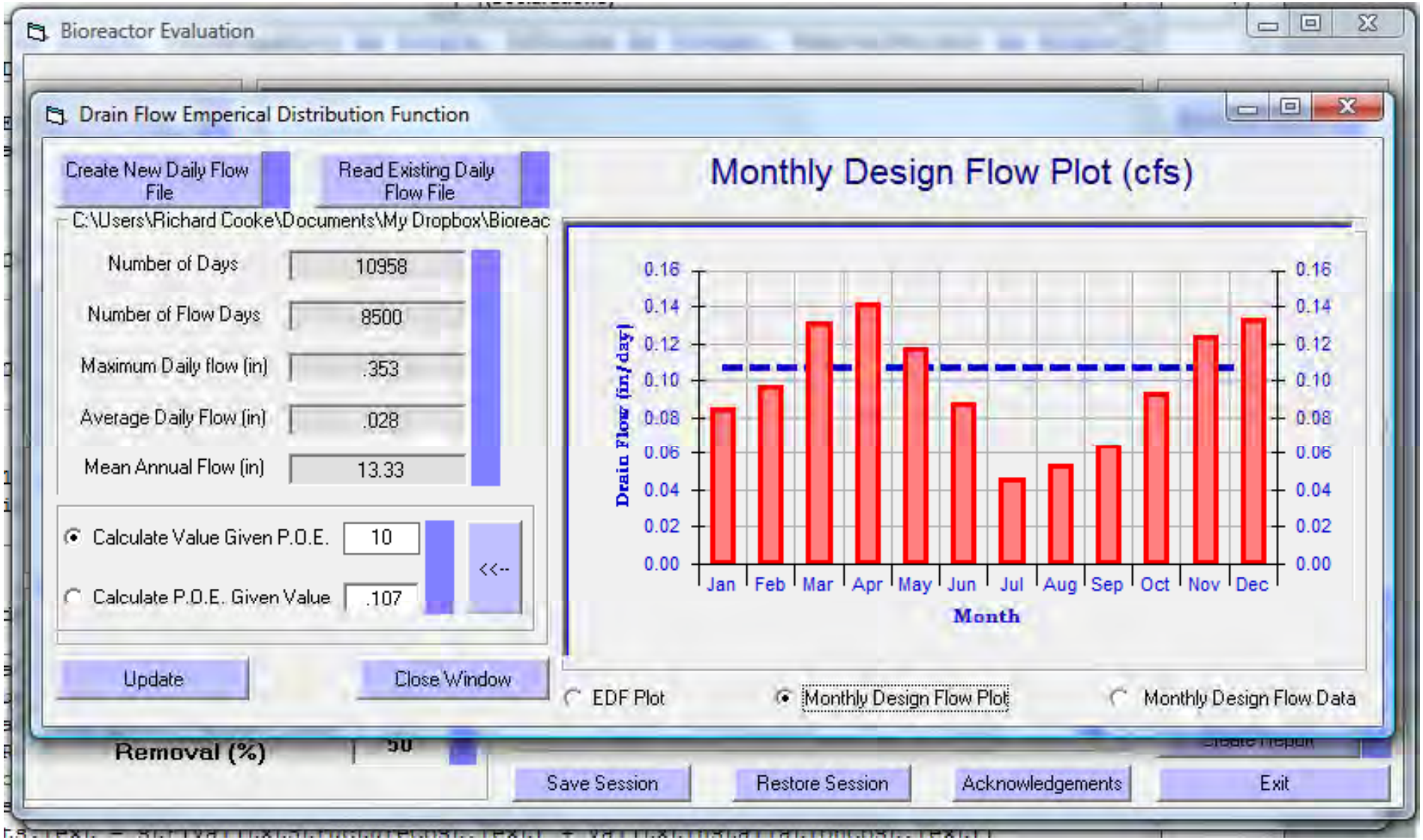

Bioreactor Evaluation
Drain Flow Emperi
Create New Daily Flow File
C:\Users\Richard Co
Number of Days
Number of Flow Da
Maximum Daily flow
Average Daily Flow
Mean Annual Flow
Calculate Value Gi
Calculate P.O.E. G
Update
Removal (%)
Minnesota
aitkin.rai
+
Aitkin
aitkin.tem
New Soil
Leafriver
Drummer
Calculations
Annual POE Plot
Monthly Histograms
Monthly Data
Drainage and Cropping
Drain Spacing (ft)
100
Drain Depth (ft)
4
Corn/Soybean Rotation
Managed Drainage
Simulation Dates
Start Year
<<=
1980
=>>
Start Month
<<=
1
=>>
End Year
<<=
2009
=>>
End Month
<<=
12
=>>
Weather Files Initialized
Generate Daily Flows
Exit
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
Nov
Dec
thly Design Flow Data
Save Session
Restore Session
Acknowledgements
Exit


Minnesota
aitkin.rai
Aitkin
aitkin.tem
New Soil
Leafriver
Drummer
Drainmod Soil File from Soil Texture
Soil Name
LeafRiver
Title
Based on Layers in NRCS Official Series Description
Layer
Thickness (in)
Texture
1
9
Silt
2
5
Sandy Loam
3
14
Loamy Sand
4
32
Loamy Sand
5
Include Additional Data in Soil Files
Maximum Root Depth (in)
Average Root Depth (in)
Layer with Max. Root Depth
18
12
1
Create Soil File
Exit
Visit NRCS Official Soil Series Descriptions Web Page
Visit ARS ROSETTA Model Home Page
Weir
Depth from soil surface to raised weir (in)
6

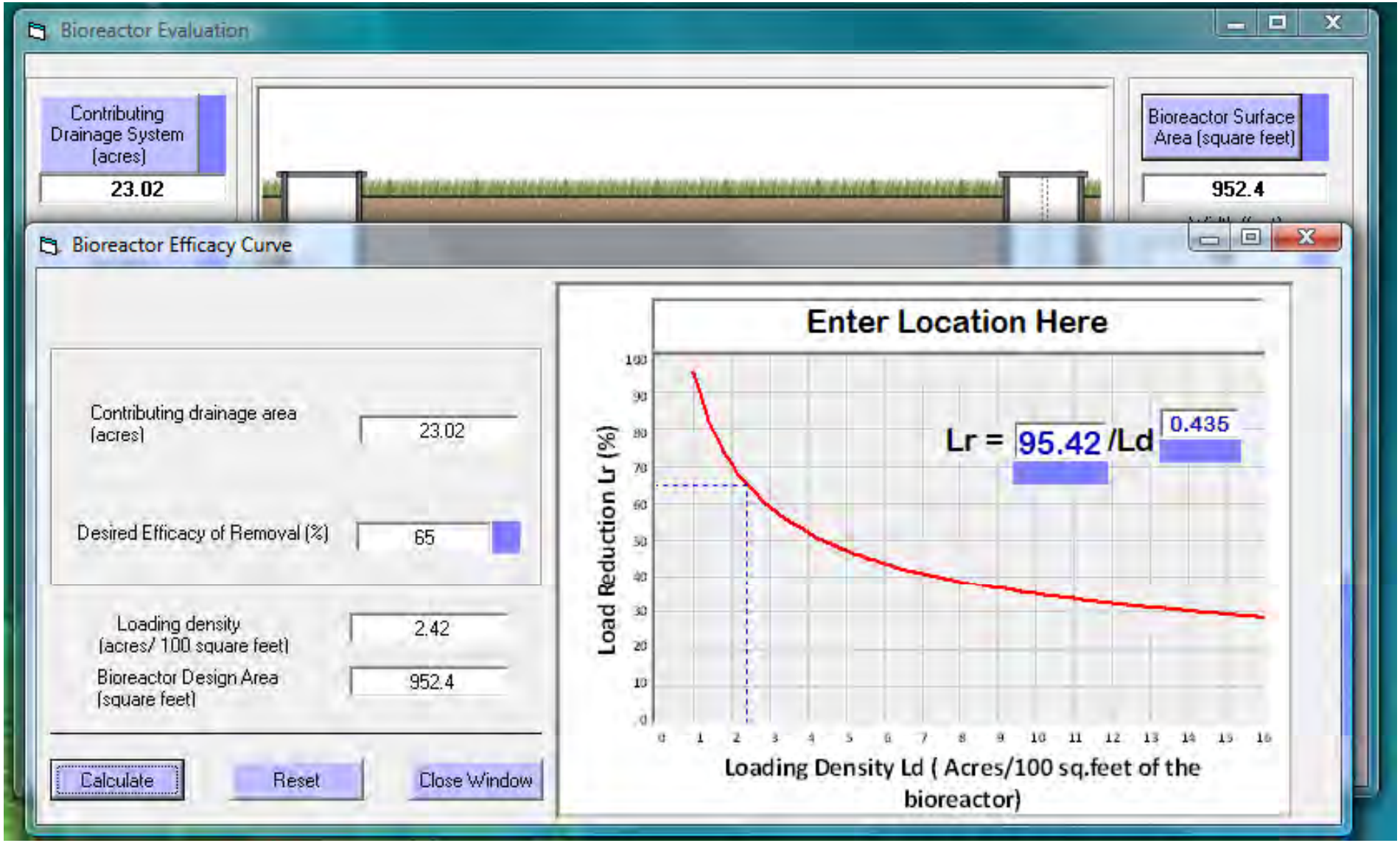
# EDF for Daily Flow



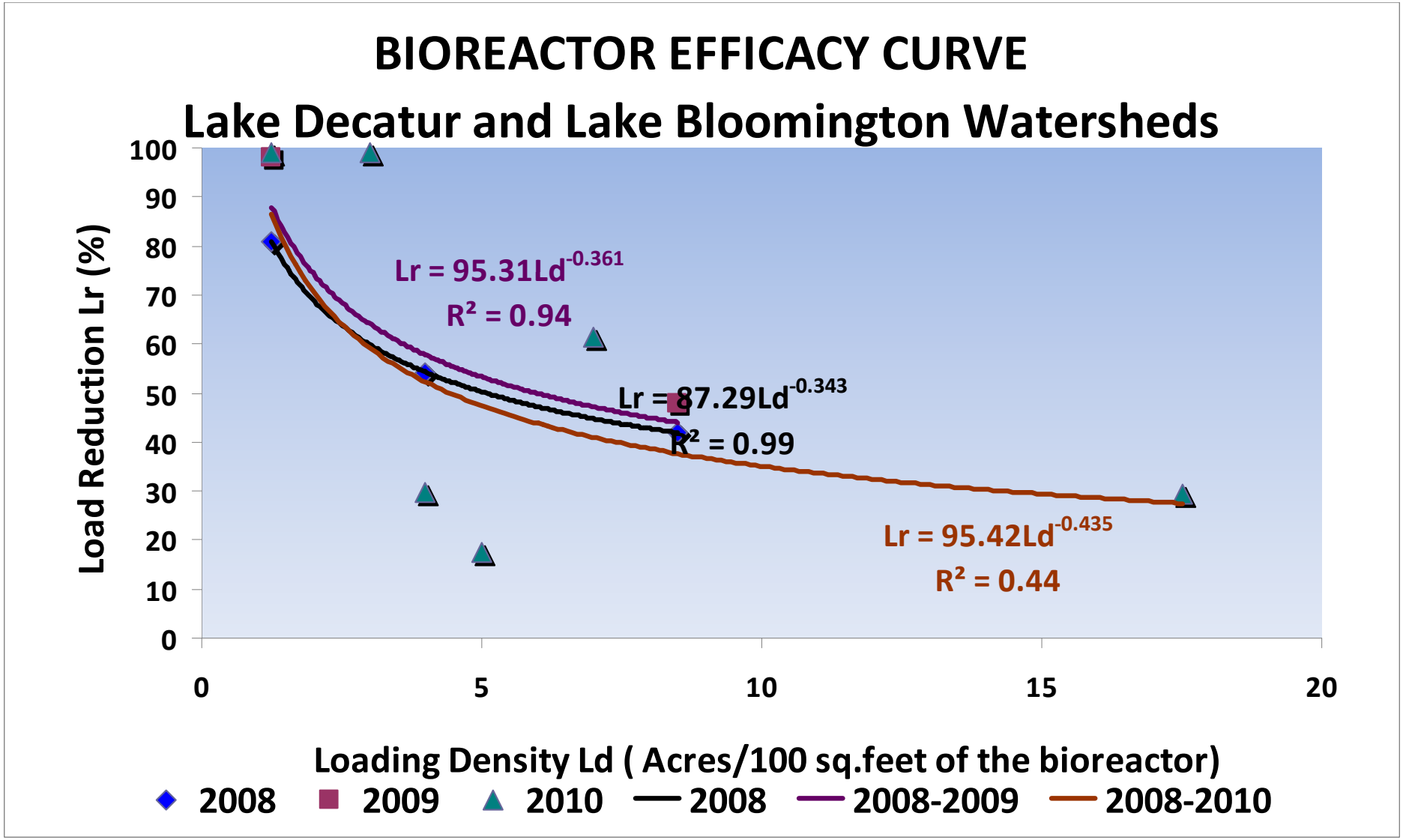
# Monthly Design Flows



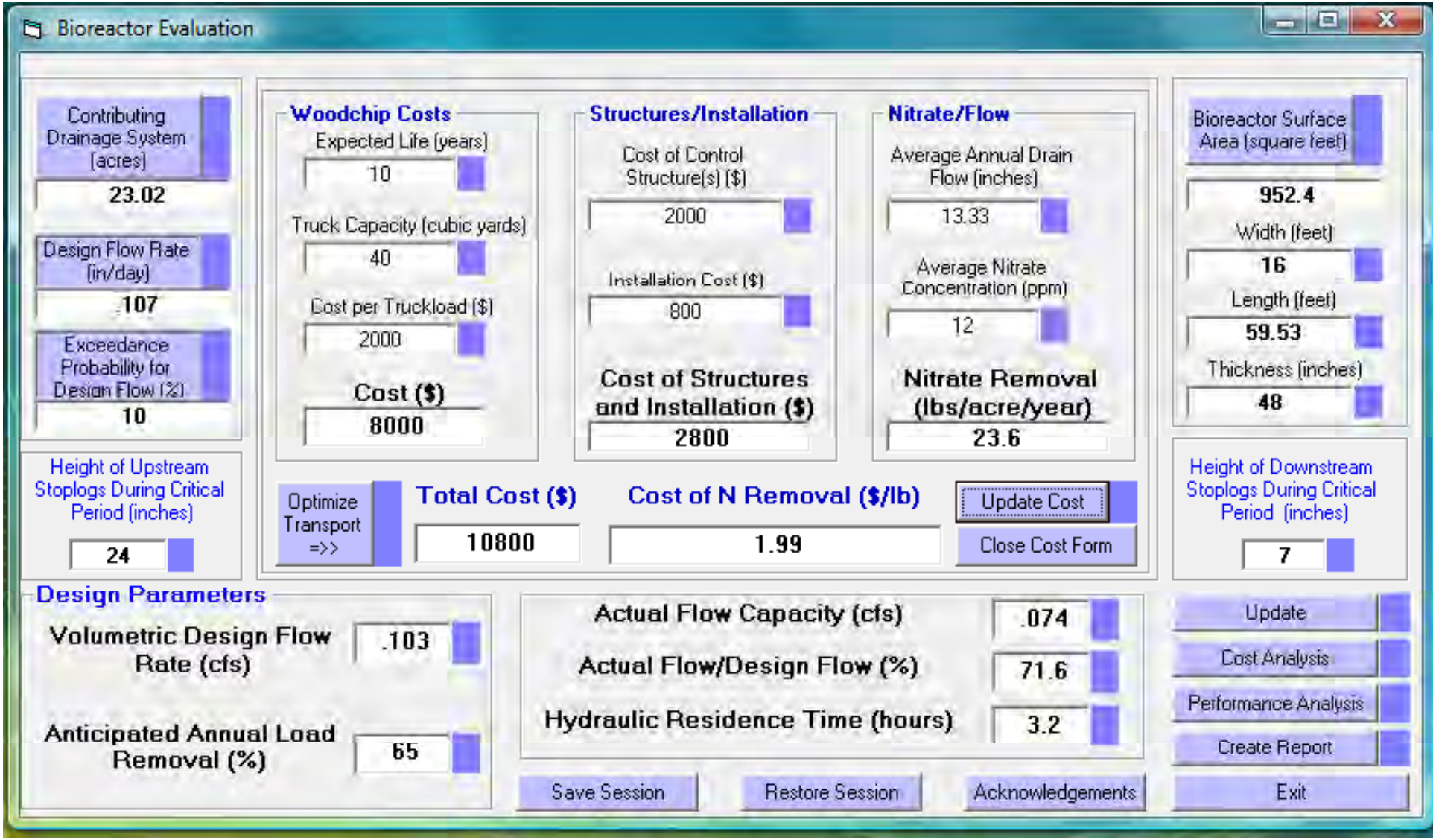
# Performance Curve



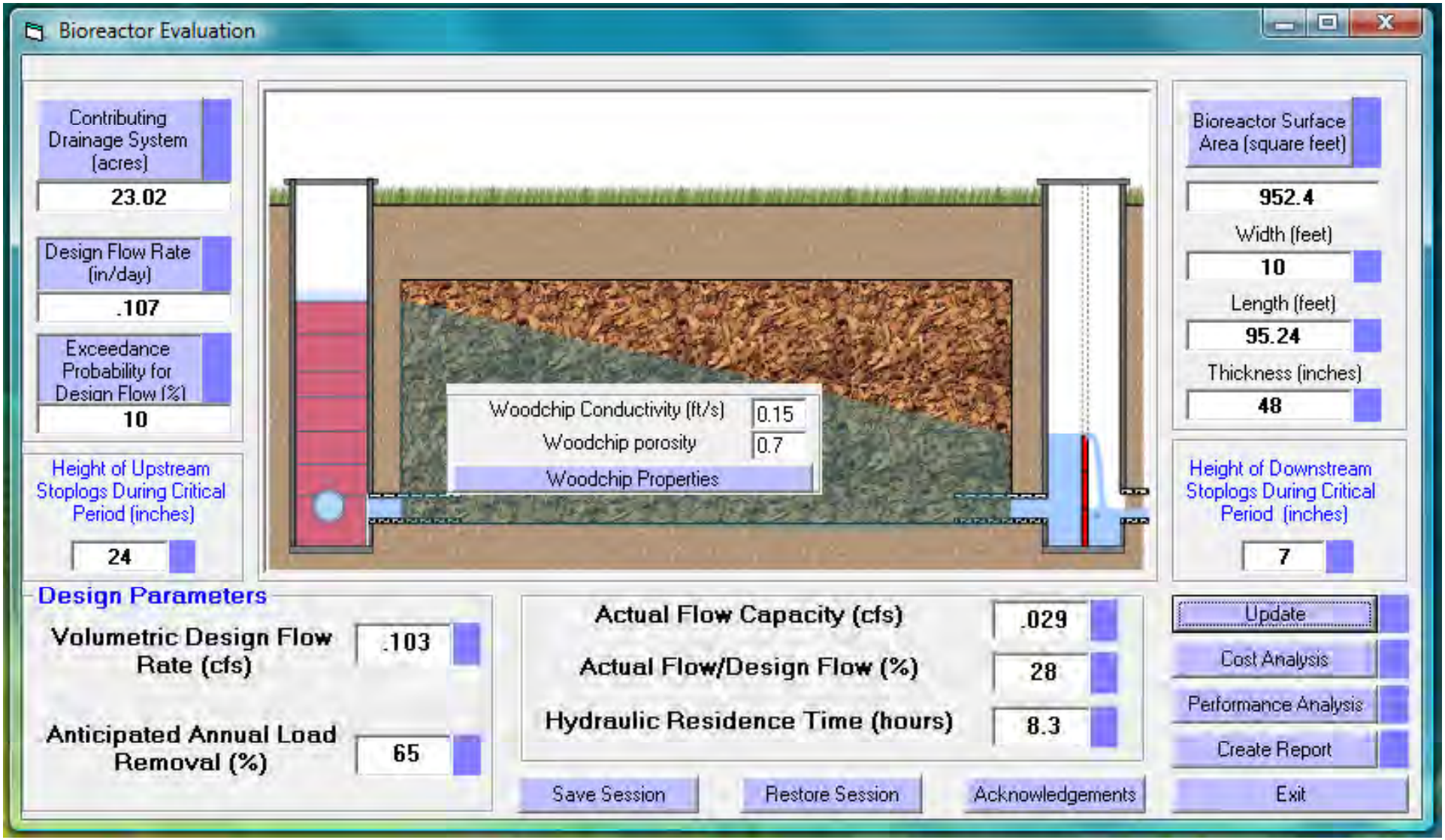
# Illinois Performance Curve



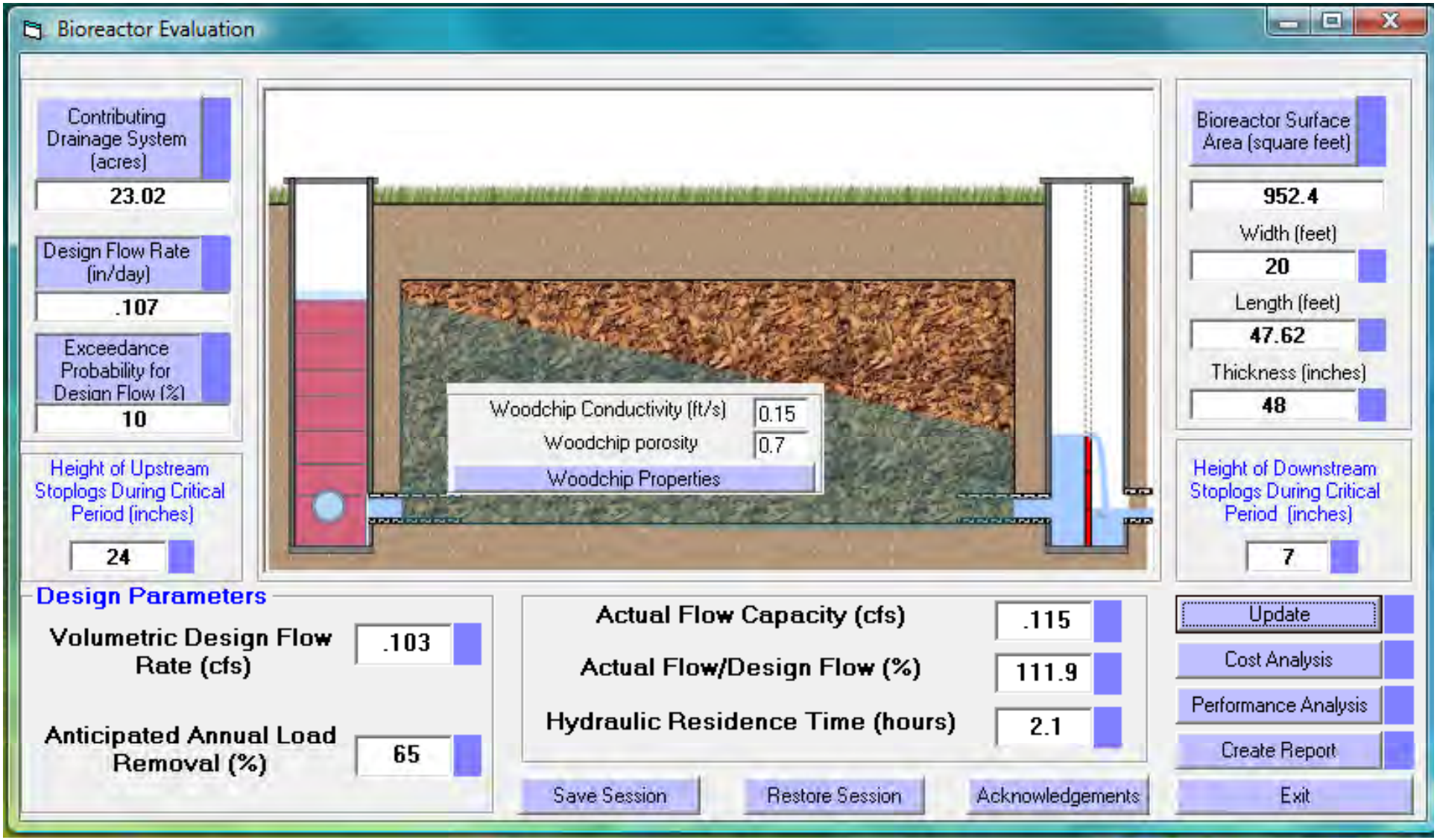
# Cost Analysis



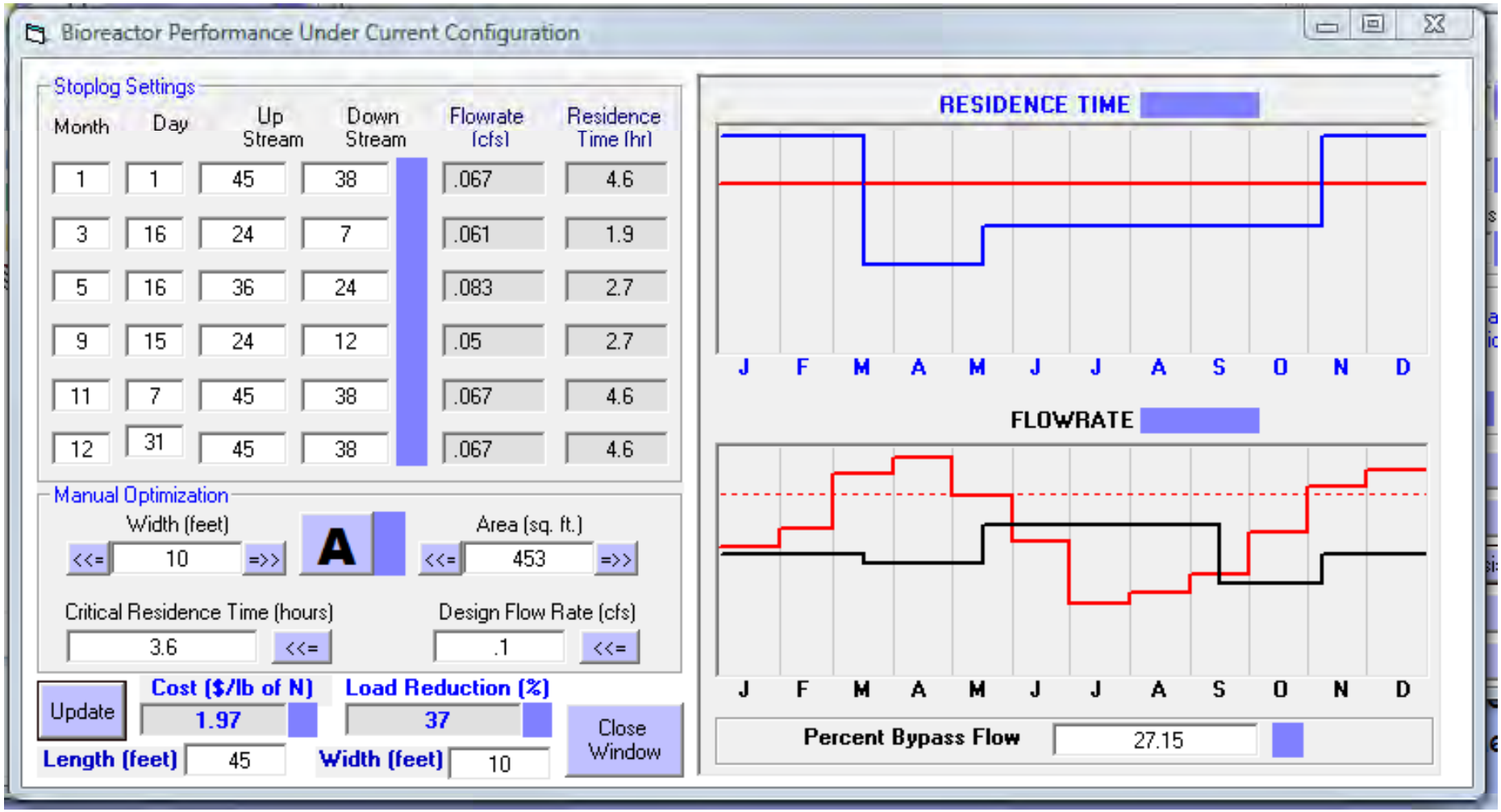
# Length/Width Effects



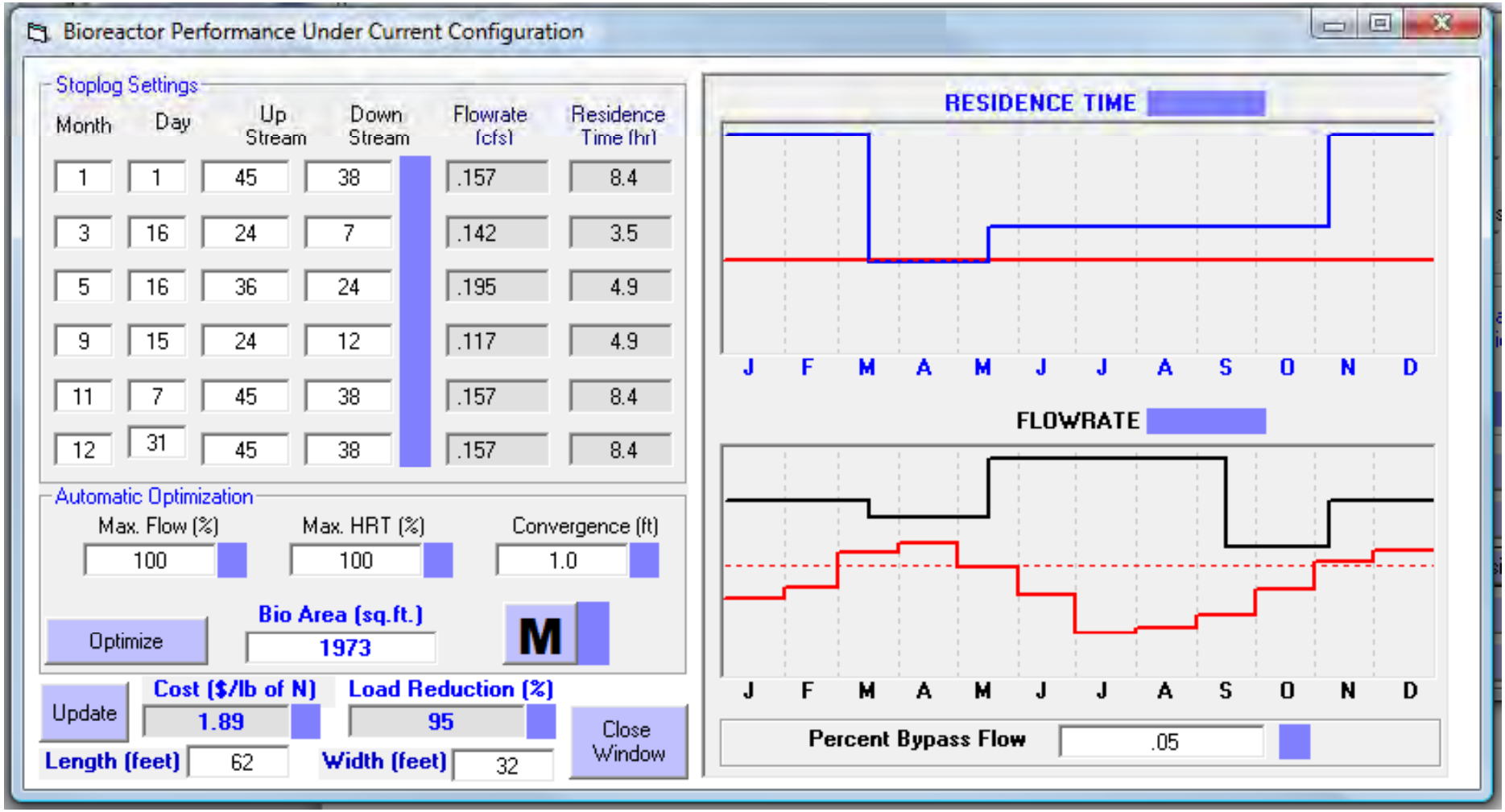
# Length/Width Effects



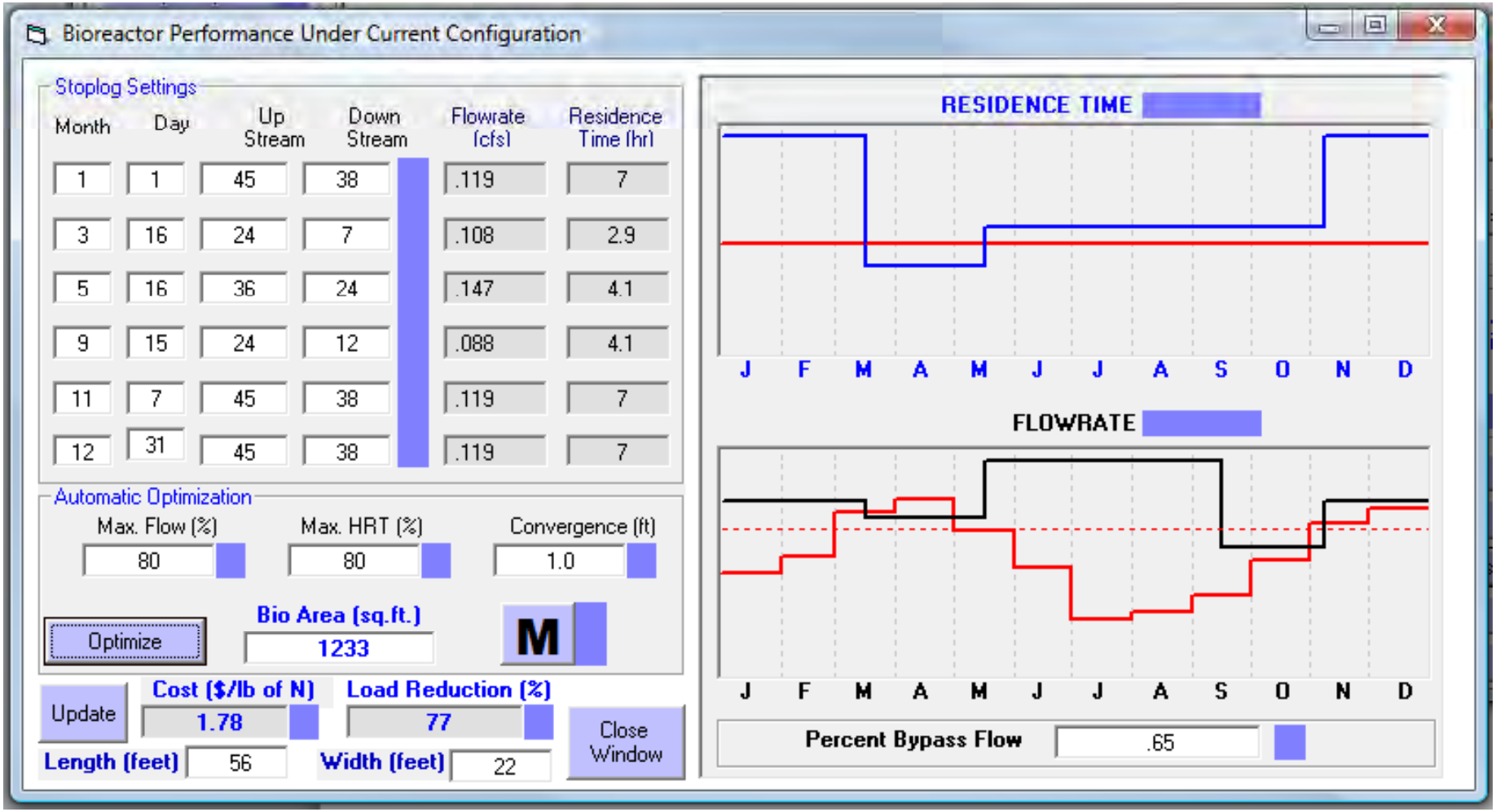
# Manual Optimization



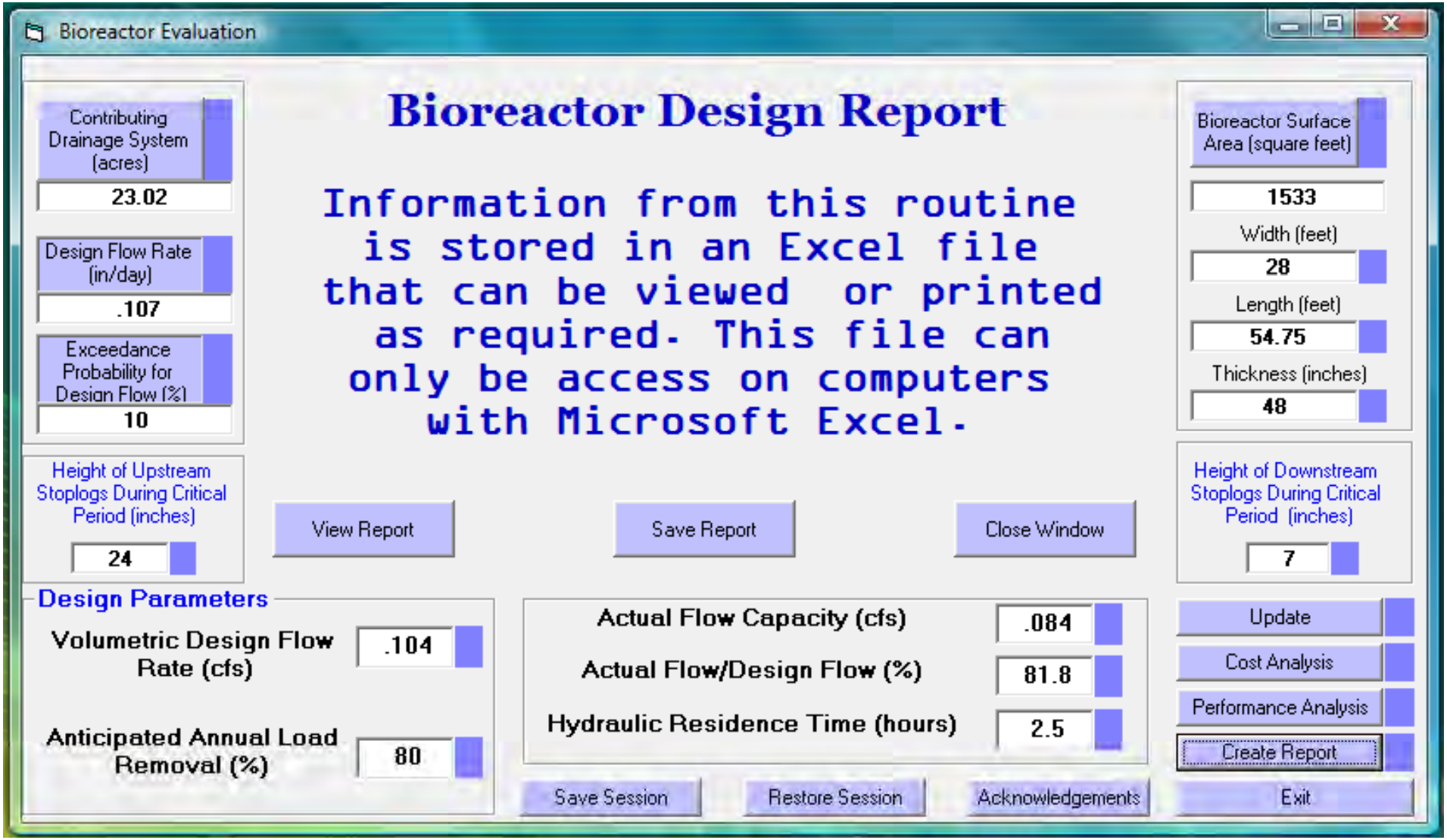
# Automatic Optimization



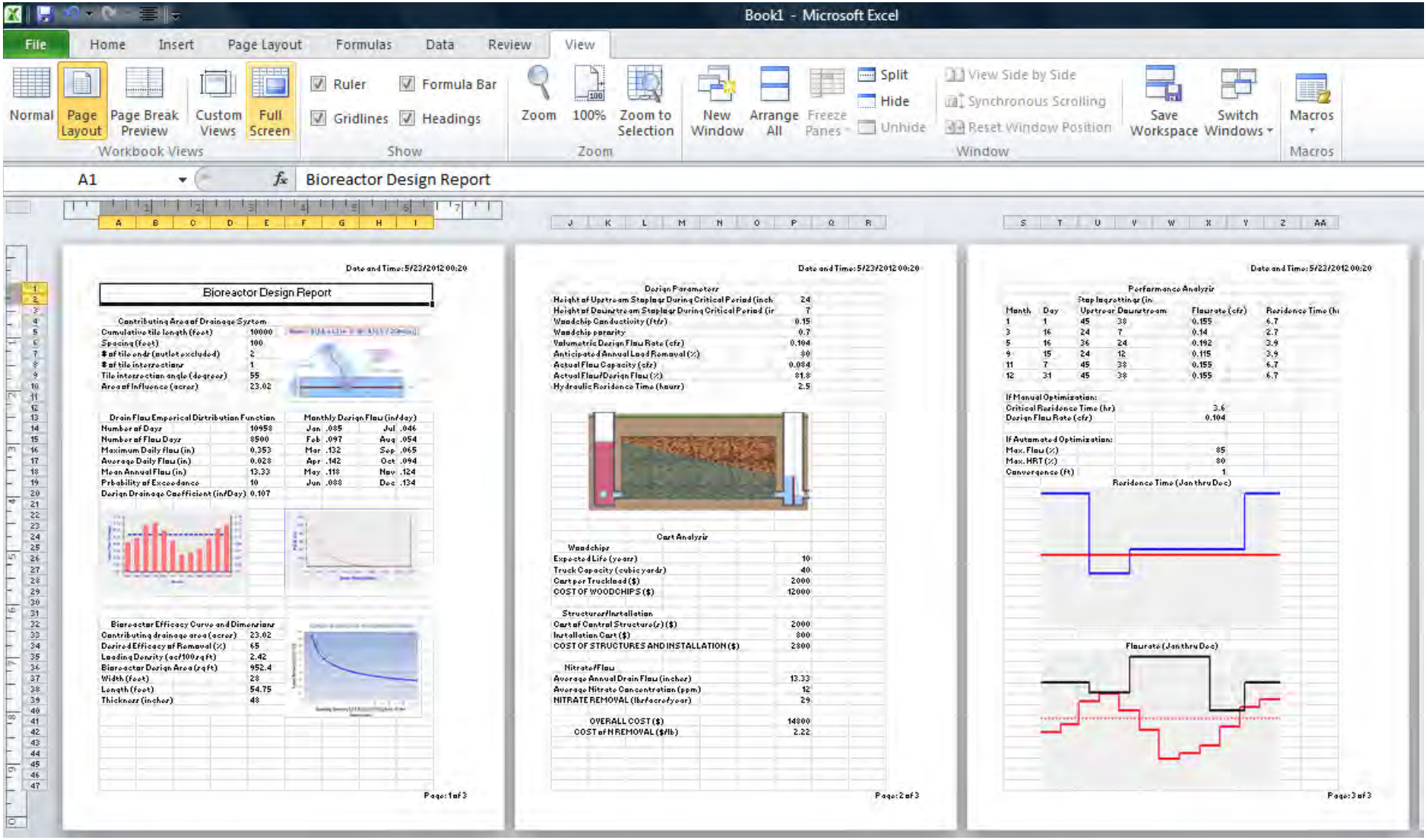
# Incorporating Performance



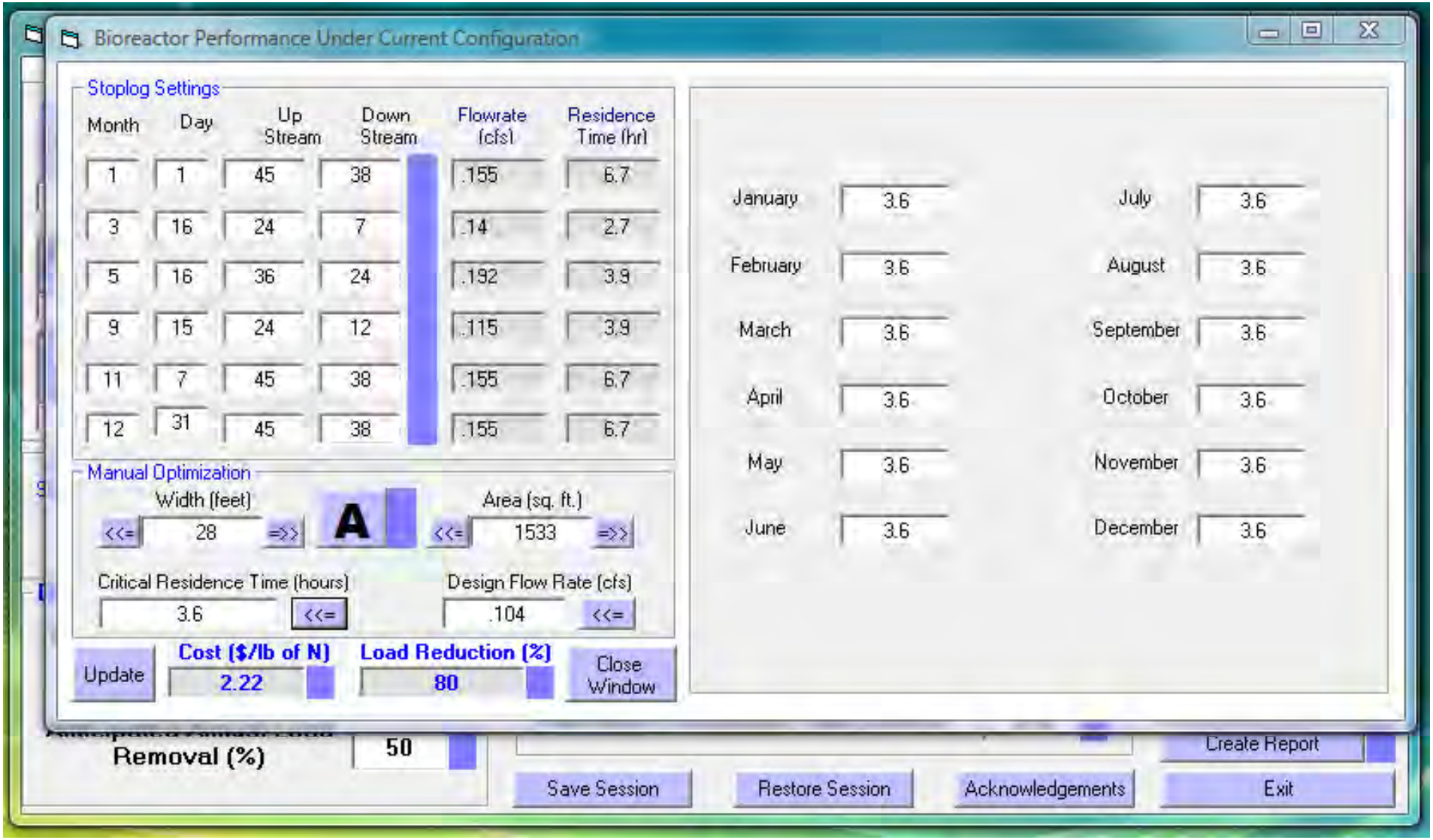
# Report Generation

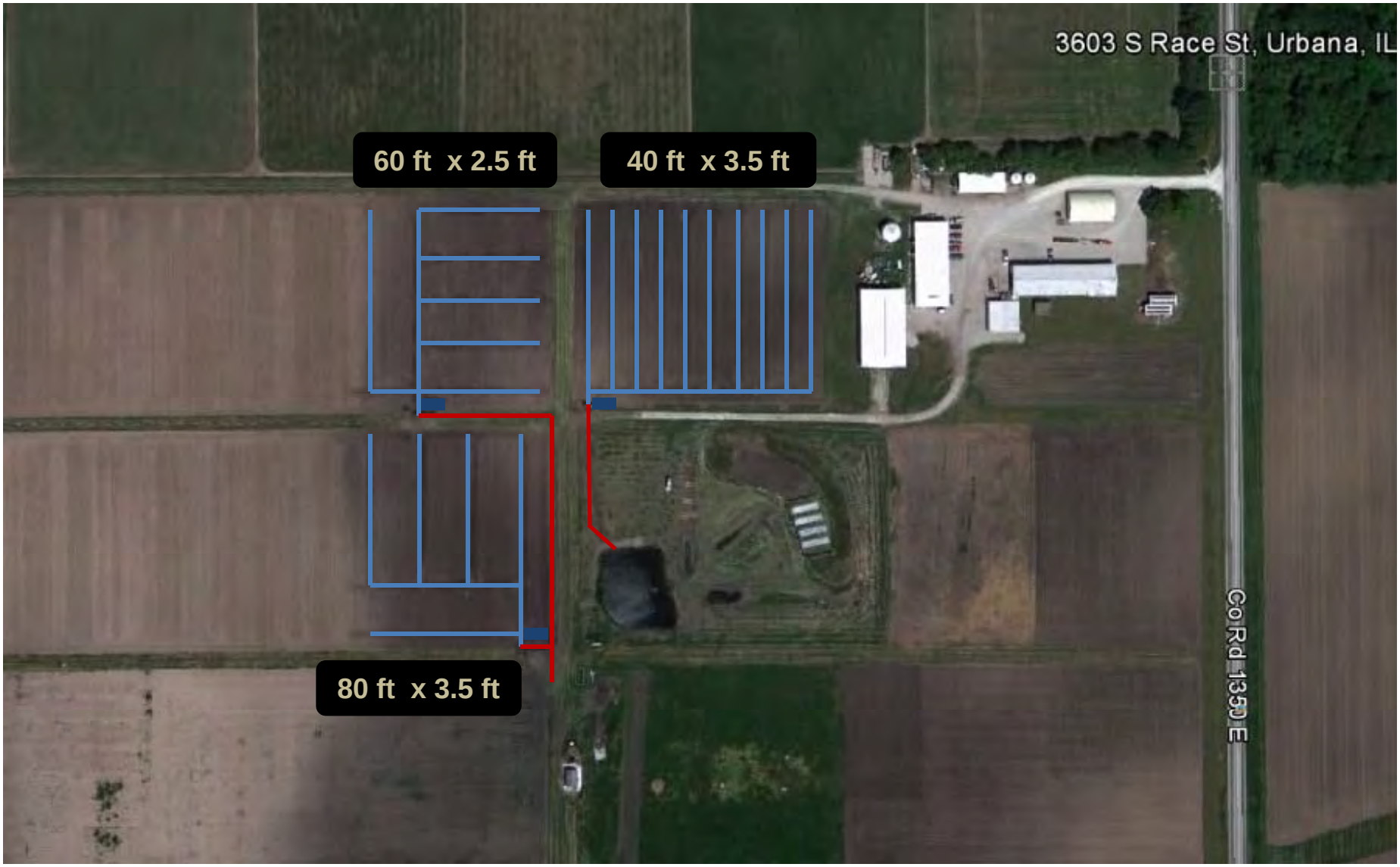


# Report Generation

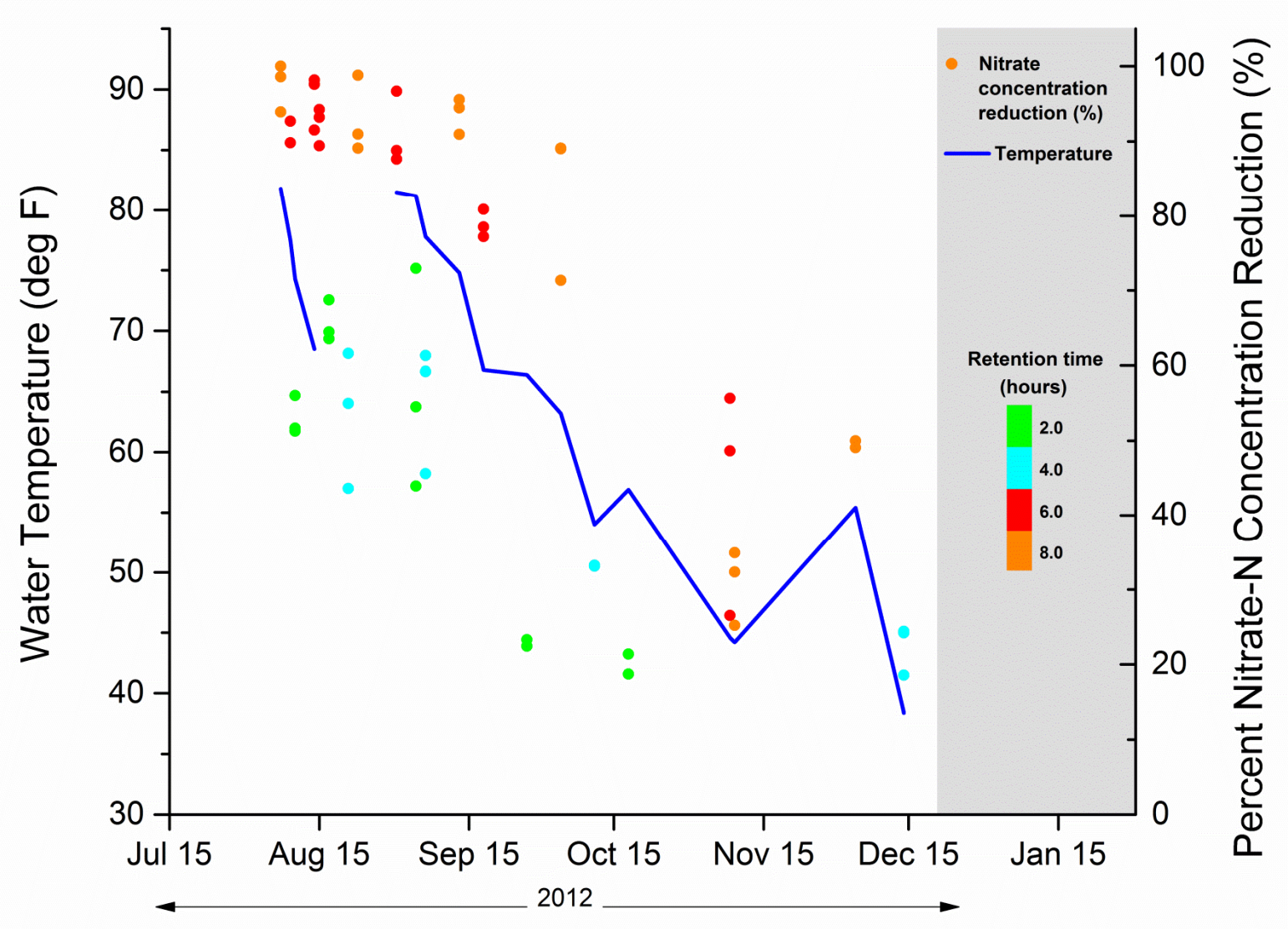


# Future Work: Residence Time

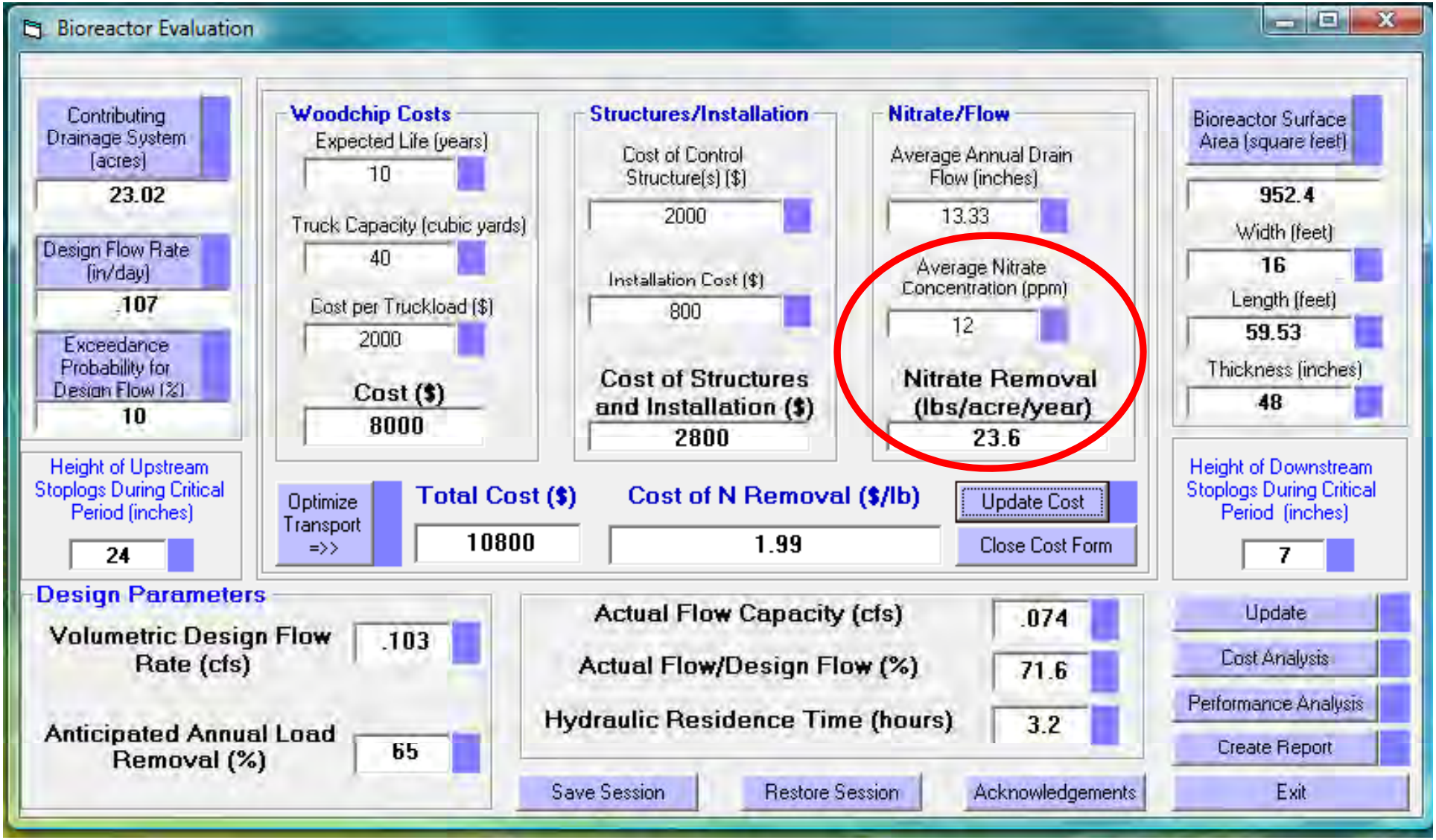




# Preliminary Results



# Future Work: Nitrate Loads



# Acknowledgements

This routine was developed for the Illinois NRCS as part of a Conservation Innovation Grant titled "The Development of Performance Curves for Bioreactors in Illinois." Supplemental funding was provided by The Sand County Foundation. The bioreactors were constructed with funds provided by the Environmental Protection Agency.

Close Window