Bonita Springs Strategy for Total Nitrogen reduction using nitrate removal

SUTRON

South Florida Engineering & Consulting

City of Bonita Springs Florida

Table 3.2. Statistical Summary of Freshwater Sample Stations in the Southwest Coast Planning Unit WBIDs

WBID	Station Number	Number of Samples	Minimum	Maximum	Median
3278G	21FLSFWMBC12	59	0.005	1.260	0.240
3278G	21FLSFWMBC18	60	0.005	5.320	0.610
3278G	21FLSFWMBC19	59	0.005	4.230	0.810
3278G	21FLSFWMBC21	59	0.005	4.520	0.800
3278G	21FLSFWMCHKMATE	15	0.005	2.000	0.830
3278H	21FLFTM 28030070FTM	5	0.588	0.839	0.695
3278H	21FLSFWMFAKA858	56	0.008	1.240	0.750
3278I	21FLSFWMBC10	57	0.010	1.300	0.370
3278I	21FLSFWMBC20	59	0.005	5.030	0.650
3278I	21FLSFWMBC7	58	0.010	1.360	0.435
3278I	21FLSFWMBC8	60	0.005	1.470	0.365
3278I	21FLSFWMBC9	57	0.010	1.540	0.500
3278I	21FLSFWMFAKA	58	0.010	2.700	0.380
3278V	21FLSFWMBC22	57	0.010	1.800	0.640
				75th Percentile of Medians =	**0.74**

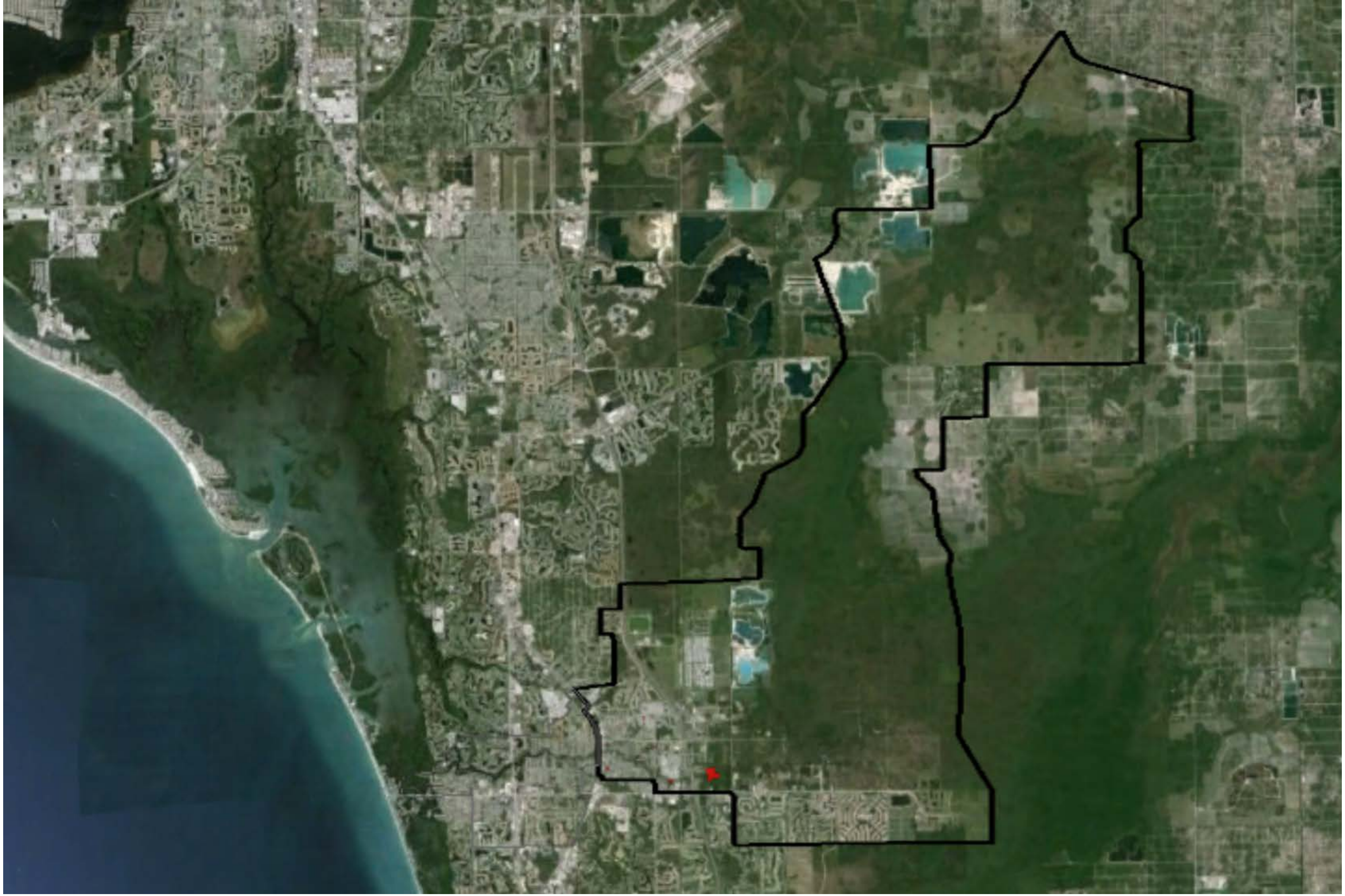


TABLE 31: TN REQUIRED REDUCTIONS FOR THE IMPERIAL RIVER BASIN MS4S

ENTITY	AREA (ACRES)	EXISTING TN (LBS/YR)	ALLOCATION (LBS/YR)	% REDUCTION	REDUCTION REQUIRED
Lee County	26,113	94,469	92,913	1.6%	1,556
City of Bonita Springs	7,154	37,426	27,524	26.5%	9,903
FDOT	96	347	252	27.4%	95
Agriculture	11,597	120,084	71,514	40.4%	48,570
Totals:	**44,960**	**252,326**	**192,202**	**23.8%**	**60,125**

Table 33: Bonita Springs Projects in the Imperial River Basin

N/A = Not available
- = Empty cell/no data

Project Number	Project Name	Type of BMP	Acres Treated	Estimated Cost	Status	Project TN Reduction (lbs/yr)
BS-1	Education/Fertilizer Ordinance	Ordinances	7,154	N/A	Completed	696
BS-2	FYN Program	Ordinances	7,154	N/A	Future	835
BS-3	Old 41 Catch Basin Inserts	Catch Basin Inserts	21	N/A	Completed	5
BS-4	Residential Dry Detention	Dry Detention	4	N/A	Completed	1
BS-5	Morton Avenue Swales	Swale with Raised Inlet	26	N/A	Completed	212
BS-6	Marni Fields	Dry Detention	16	N/A	Completed	6
BS-7	Felts Avenue Stormwater Treatment	Dry Retention	31	N/A	Future	258
BS-8	Street Sweeping	Street Sweeping	7,154	N/A	Ongoing	45
-	-	-	-	-	**Total:**	**2,058**

TN Reduction Targets

Start Year	End Year	TN lbs/year Captured	TN lbs/year Target Remaining	Total
2013	2017	2,058	1,243	3,301
2018	2022		3,301	3,301
2023	2027		3,301	3,301
Total:		**2,058**	**7,845**	**9,903**

TABLE 6: APPROVED TN REMOVAL EFFICIENCIES

BMP	TN % REDUCTION
Off-line Retention 0.25-in. treatment volume	40%
Off-line Retention 0.50-in. treatment volume	62%
Off-line Retention 0.75-in. treatment volume	75%
Off-line Retention 1.00-in. treatment volume	84%
On-line Retention 0.25-in. treatment volume	30%
On-line Retention 0.50-in. treatment volume	52%
On-line Retention 0.75-in. treatment volume	65%
On-line Retention 1.00-in. treatment volume	74%
Grass swales with swale blocks or raised culverts	Use on-line retention BMPs above
Grass swales without swale blocks or raised culverts	50% of value for grass swales with swale blocks or raised culverts
Wet detention ponds	% Removal = (43.75 * td)/(4.38 + td) ; where td is the mean annual residence time

TABLE 6: APPROVED TN REMOVAL EFFICIENCIES

BMP	TN % REDUCTION
BMP treatment trains using a combination of BMPs	Use BMP Treatment Train (TT) equation: BMP TT Efficiency = Eff1 +((1-Eff1)*Eff2)
Dry detention	10%
Baffle box	0.5%
Nutrient baffle box (2nd generation)	19.05%
Catch basins/inlet filters	Determine kg of materials removed and multiply by 467.2 mg/kg (commercial), 773.8 mg/kg (residential), or 785.4 mg/kg (highway)
Street sweeping	Determine kg of materials removed and multiply by 429.6 mg/kg (commercial), 832.4 mg/kg (residential), or 546.4 mg/kg (highway)

TABLE 6: APPROVED TN REMOVAL EFFICIENCIES

BMP	TN % REDUCTION
Alum injection	50%
Stormwater reuse	Estimate amount water not discharged annually because used for irrigation.
Stormceptor	2%
Continuous deflective separation (CDS) units	Not applicable
Floating islands	20%
Public education	1-6%, depending on extent of program
Low impact development practices	Not quantified

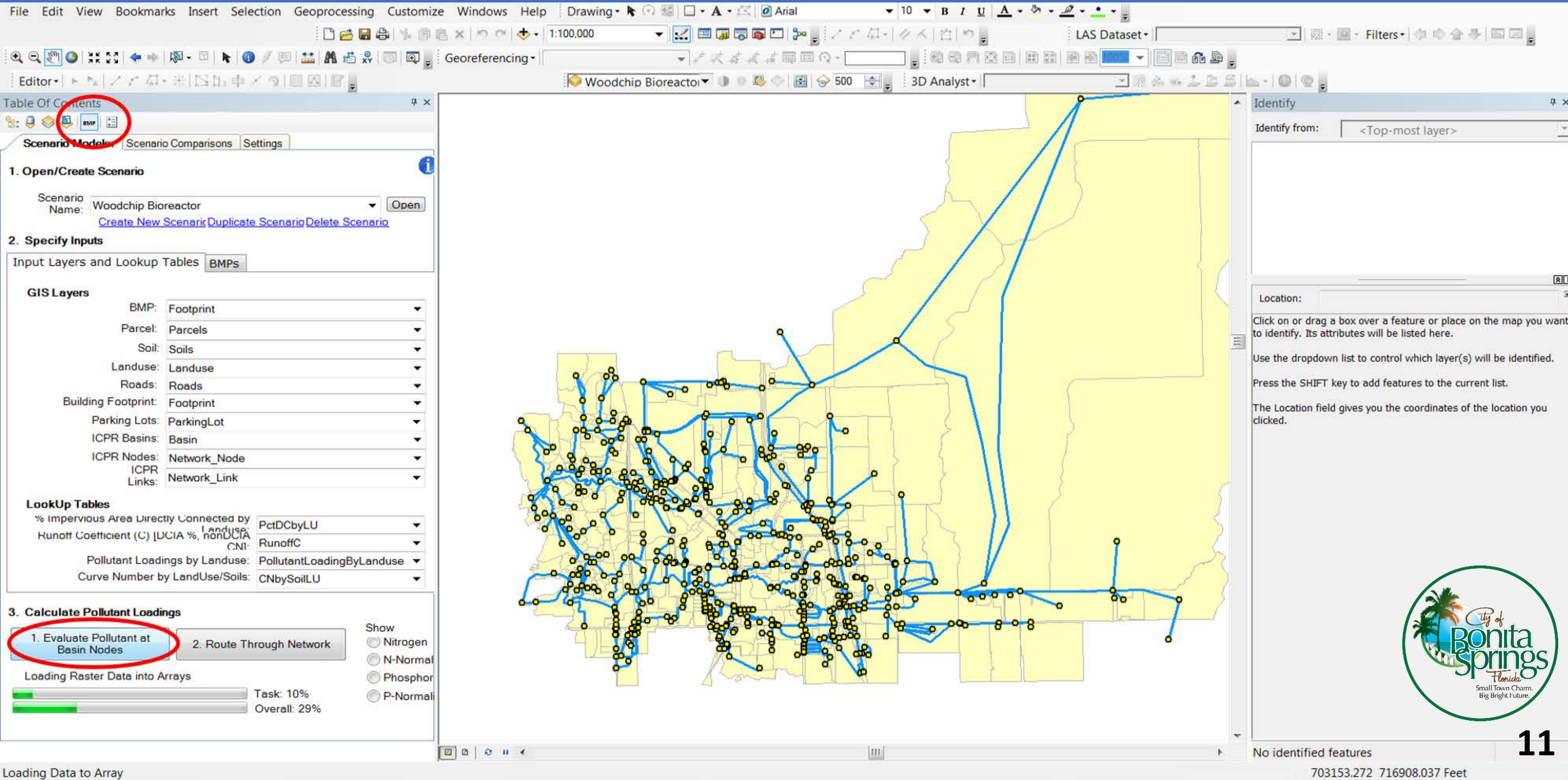
Using science and technology to improve treatment and environmental health.

Goals:

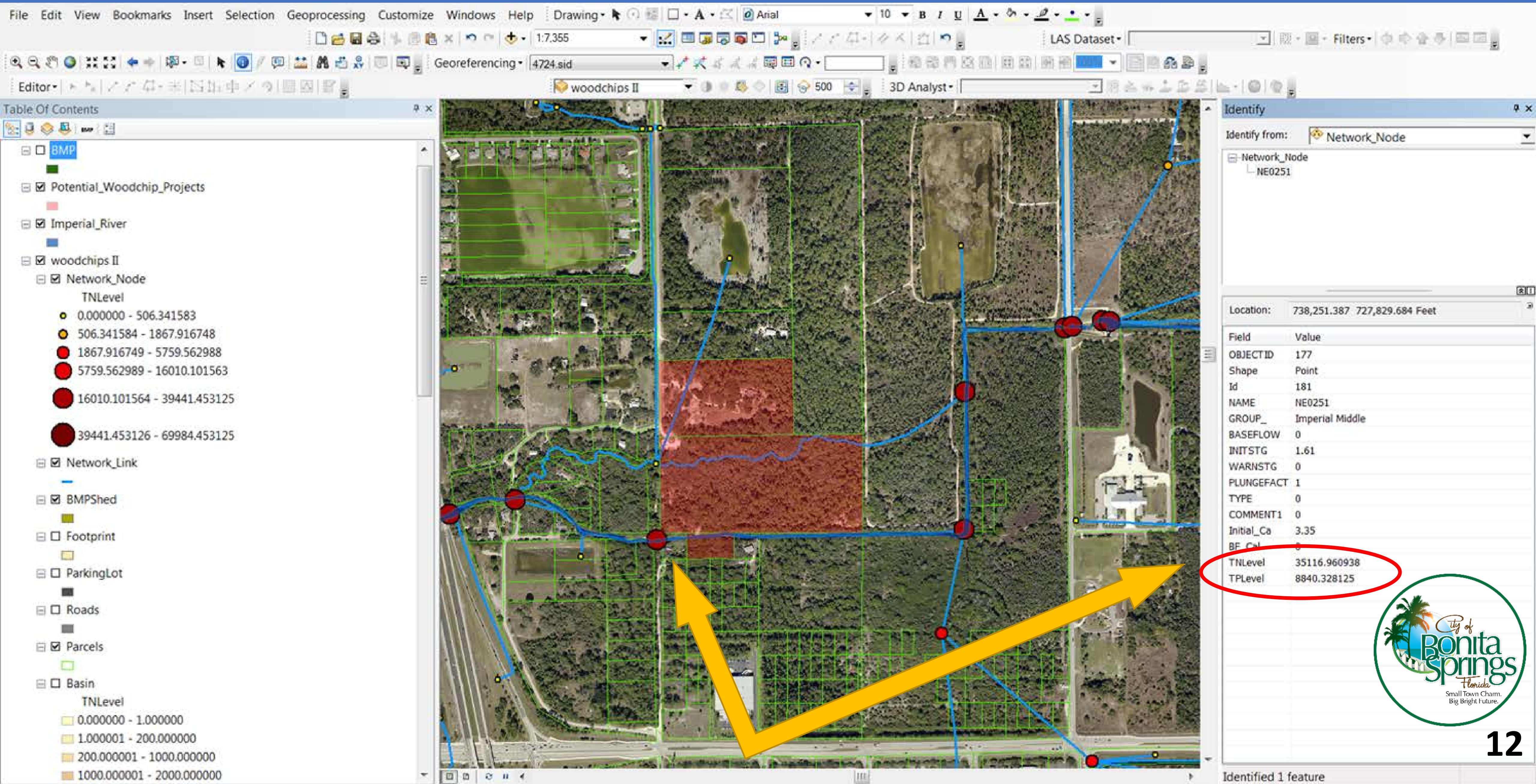
1) To work collaboratively with FDEP to implement a denitrification "woodchip bio-reactor" to decrease nitrogen loading to the Imperial River.

2) Develop a preliminary credit system so Bonita Springs can implement a pilot program which will provide data to support future learning regarding performance and credits.

BMP Assessment Tool

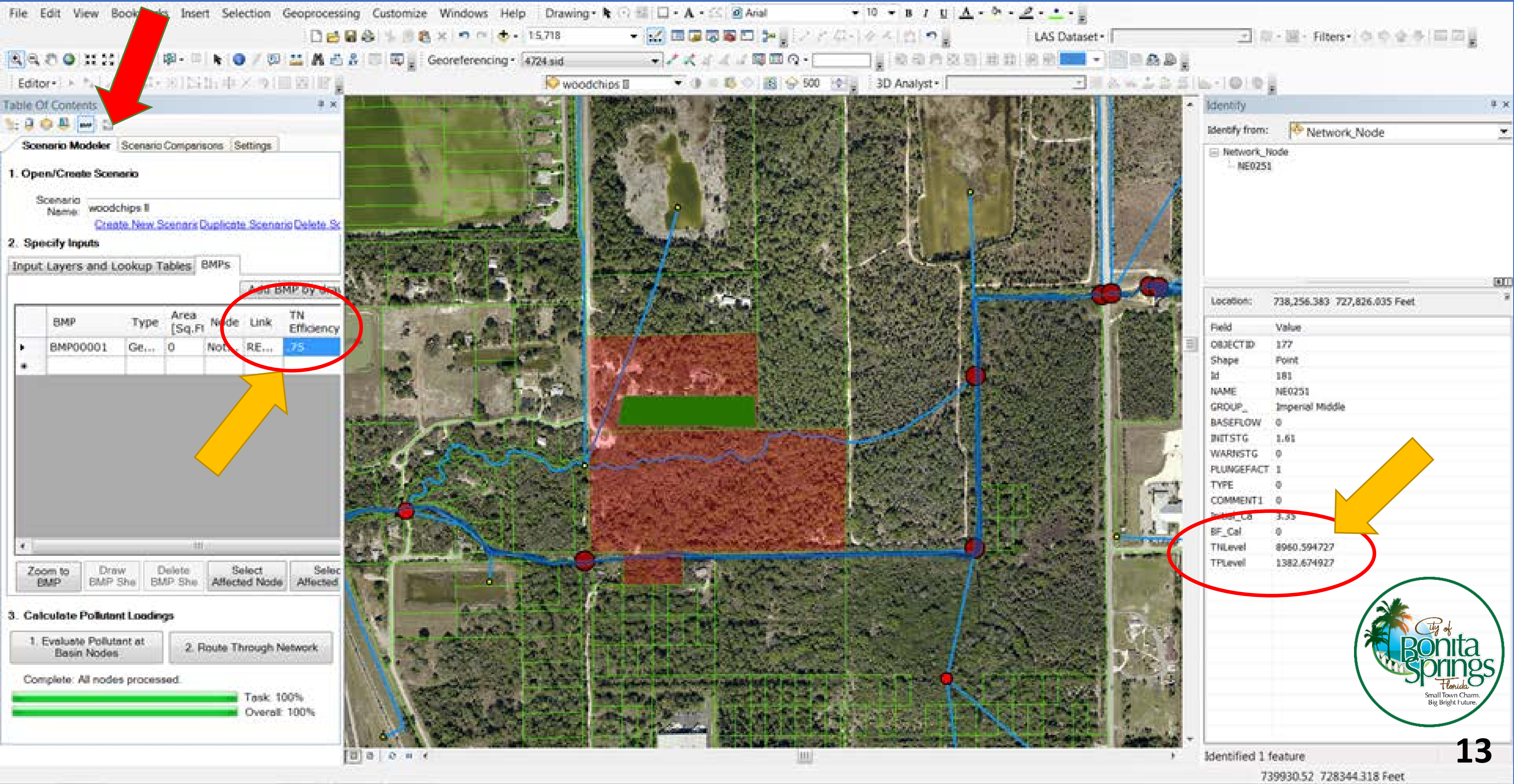


Hotspots Identified



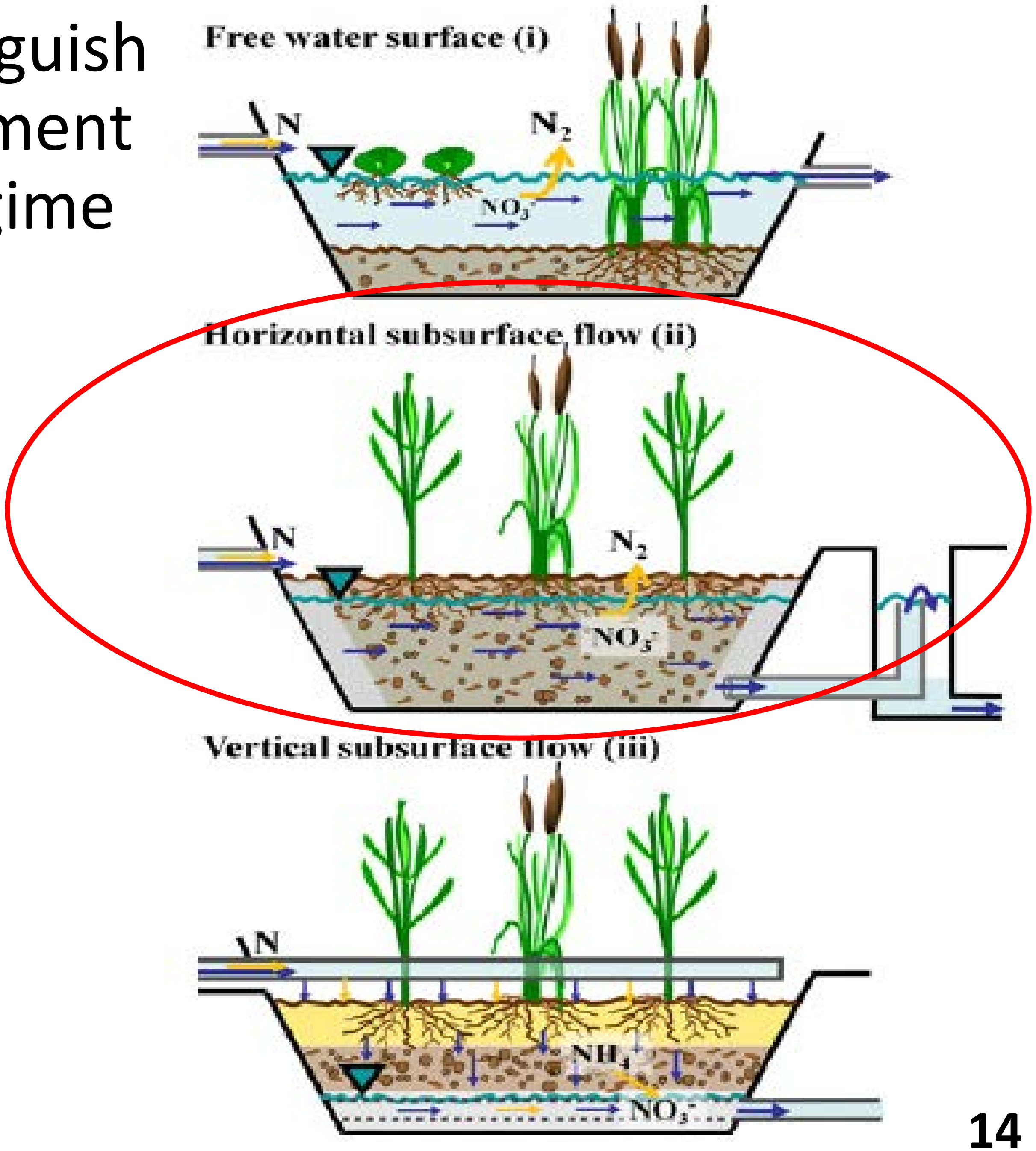
City of Bonita Springs Florida
Small Town Charm. Big Bright Future.

Solutions Modeled



Kadlec and Wallace (2008) distinguish three types of constructed treatment wetlands based on their flow regime

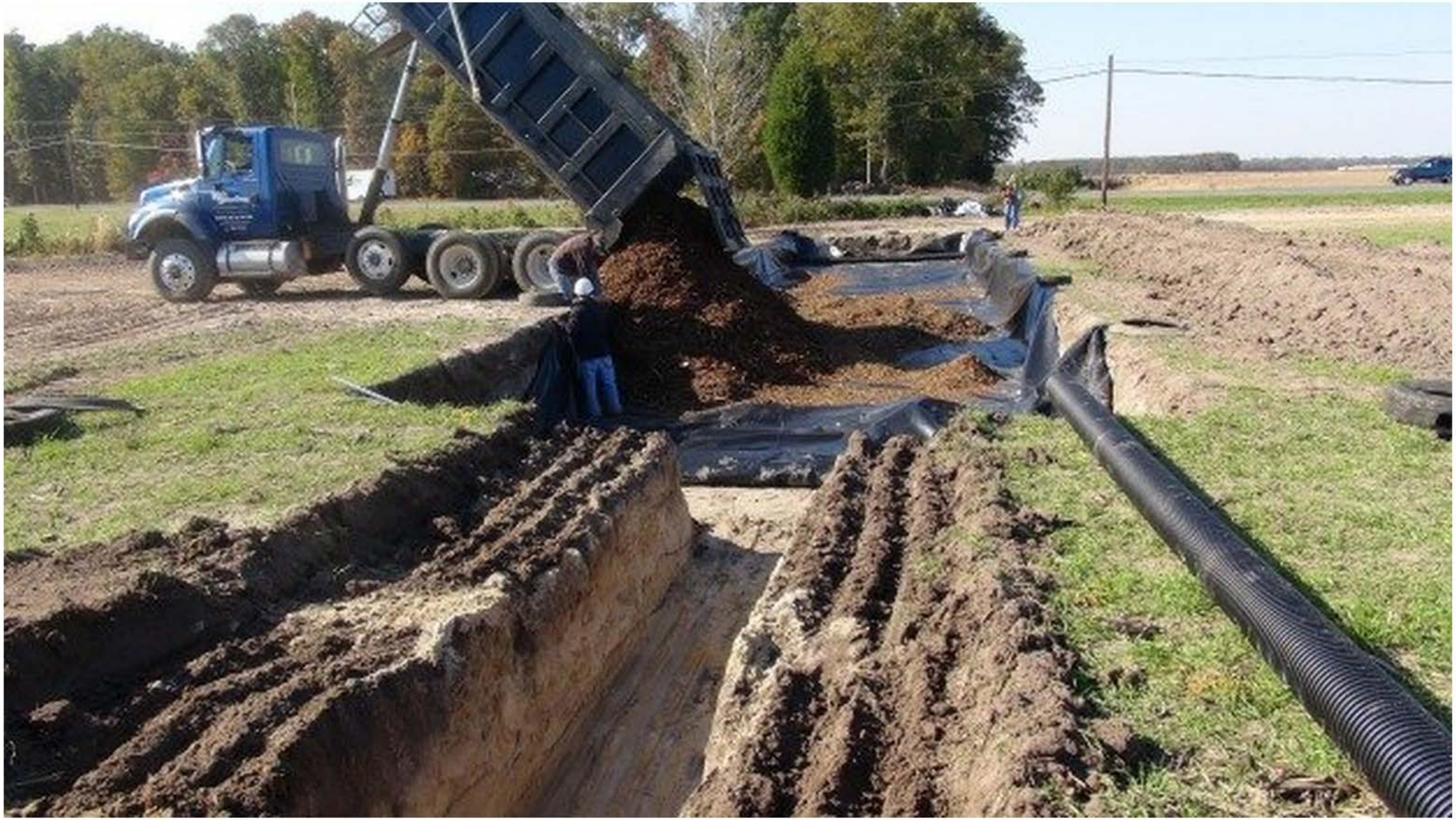
- Free water surface (FWS) wetlands;
- **Horizontal subsurface flow (HSSF) wetlands; and**
- Vertical subsurface flow (VSSF) wetlands.



Controlled Drainage and Bioreactor-Research & Demonstration Site

Principal Investigator: Kathy Smith
Co-Investigators: Rich Perrine and Ashley Brenke
Organization: Martin Soil and Water Conservation District
Sponsor: Clean Water Fund
Award Amount: $119,396
Start Date: 5/15/2012 | End Date: 6/30/2016
Project Manager: Heidi Peterson (Heidi.Peterson@state.mn.us)
Photo used with permission

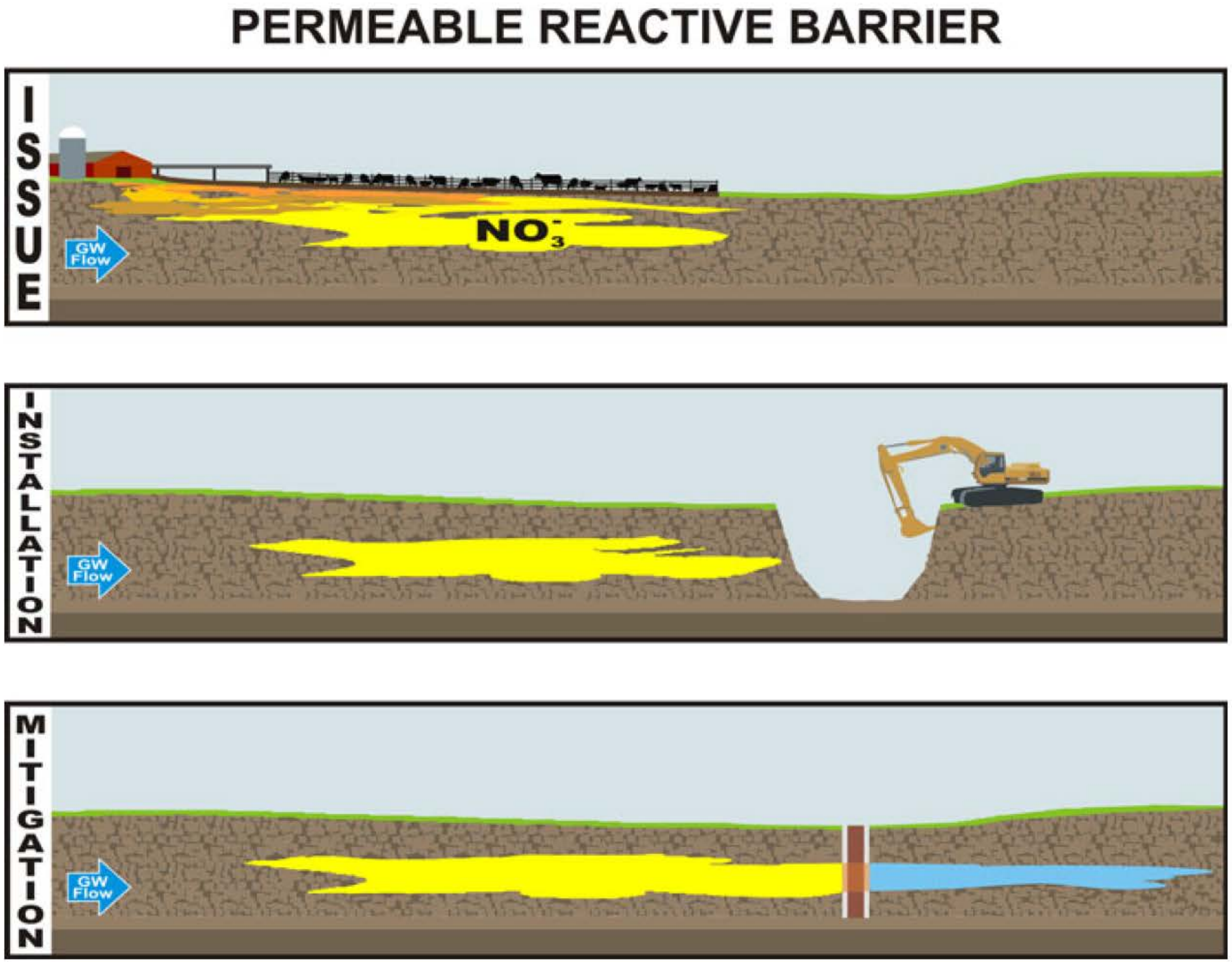
Minnesota Department of Agriculture



WAMU/Bryan Russo

Woodchips are dumped into a lined bioreactor trench at Oakland View Farms on Maryland's Eastern Shore.

Fig. 6 PRB depicted as a management approach for concentrated N in groundwater (GW). (*Issue*) N from a known source such as an animal feeding operation may accumulate in groundwater. (*Installation*) The PRB is constructed to intercept subsurface flow. (*Mitigation*) N in the groundwater contacts organic substrates in the barrier where denitrification by microbes may remove N



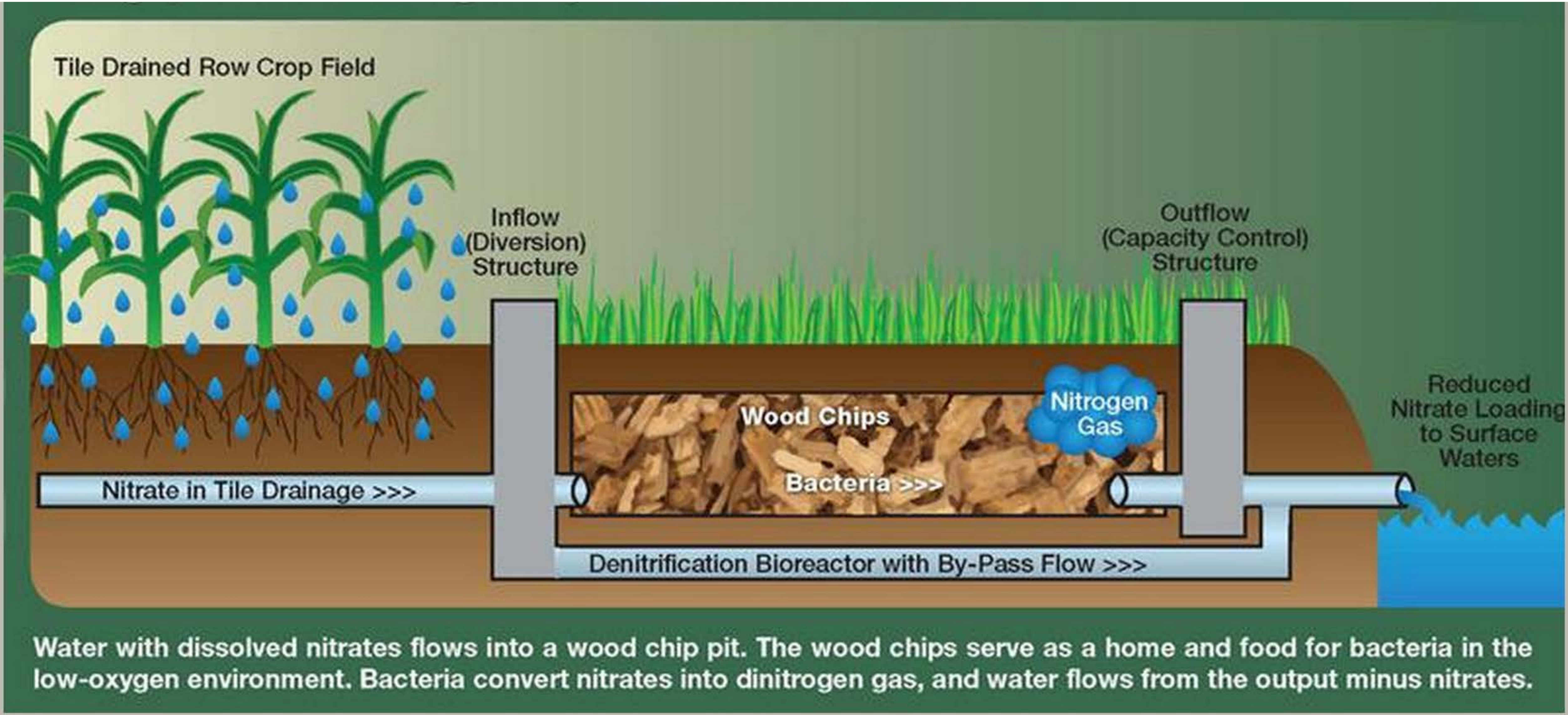
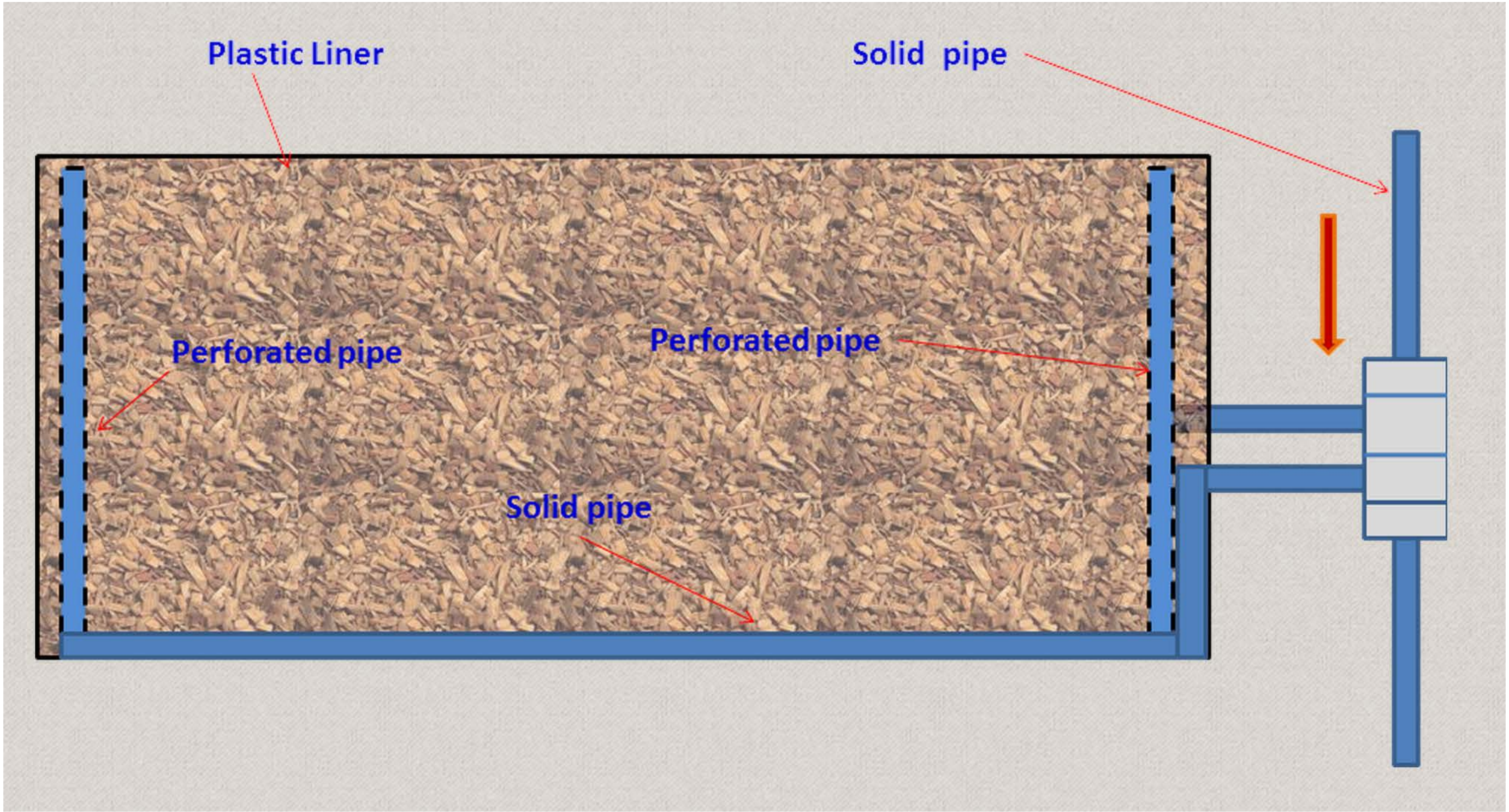
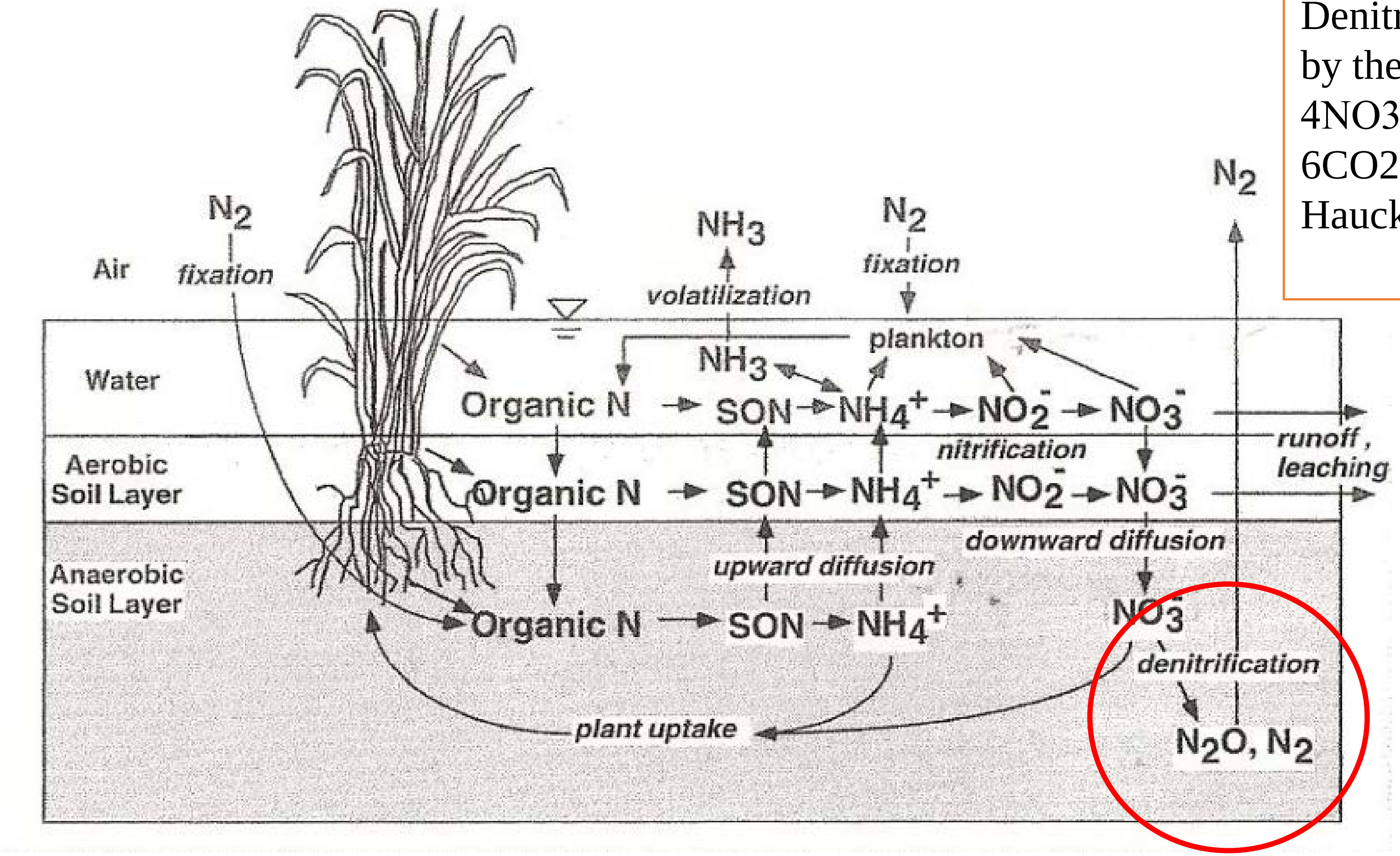


Image Courtesy ***Farm Journal Magazine***

University of Illinois Extension



Nitrogen transformations in wetlands



Denitrification is illustrated by the equation:
$4NO_3^- + 6(CH_2O) \rightarrow 6CO_2 + 2N_2 + 6H_2O$ (3)
Hauck, 1984

Mitsch and Gosselink 1993

DESIGN TOOLS FOR VEGETATED TREATMENT SYSTEMS/ CONSTRUCTED WETLANDS/ WOODCHIP BIOREACTORS

Pam Krone-Davis & Marc Los Huertos
Division of Science and Environmental Policy
California State University, Monterey Bay
PG&E Fund Grant #2005-0735

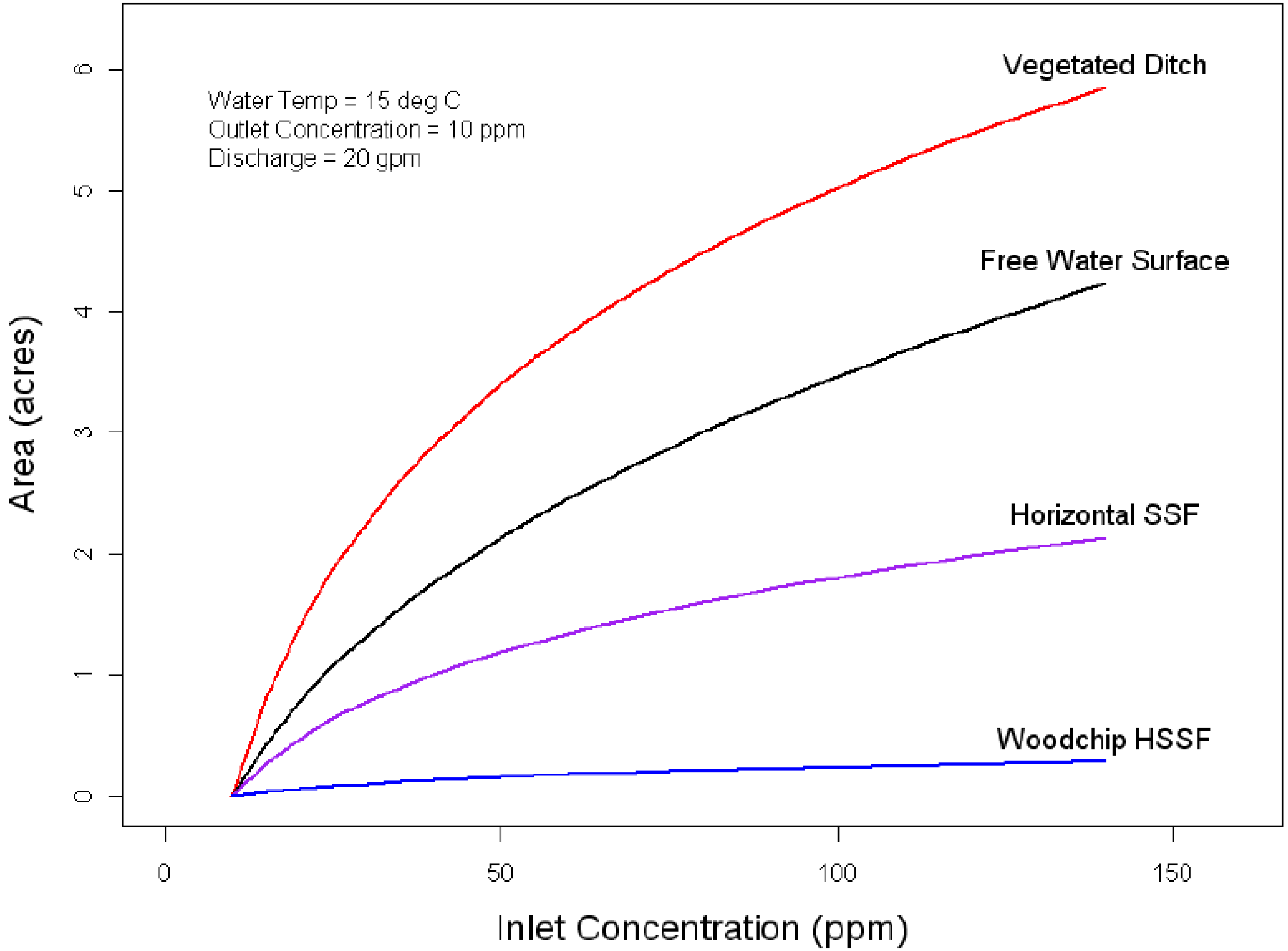
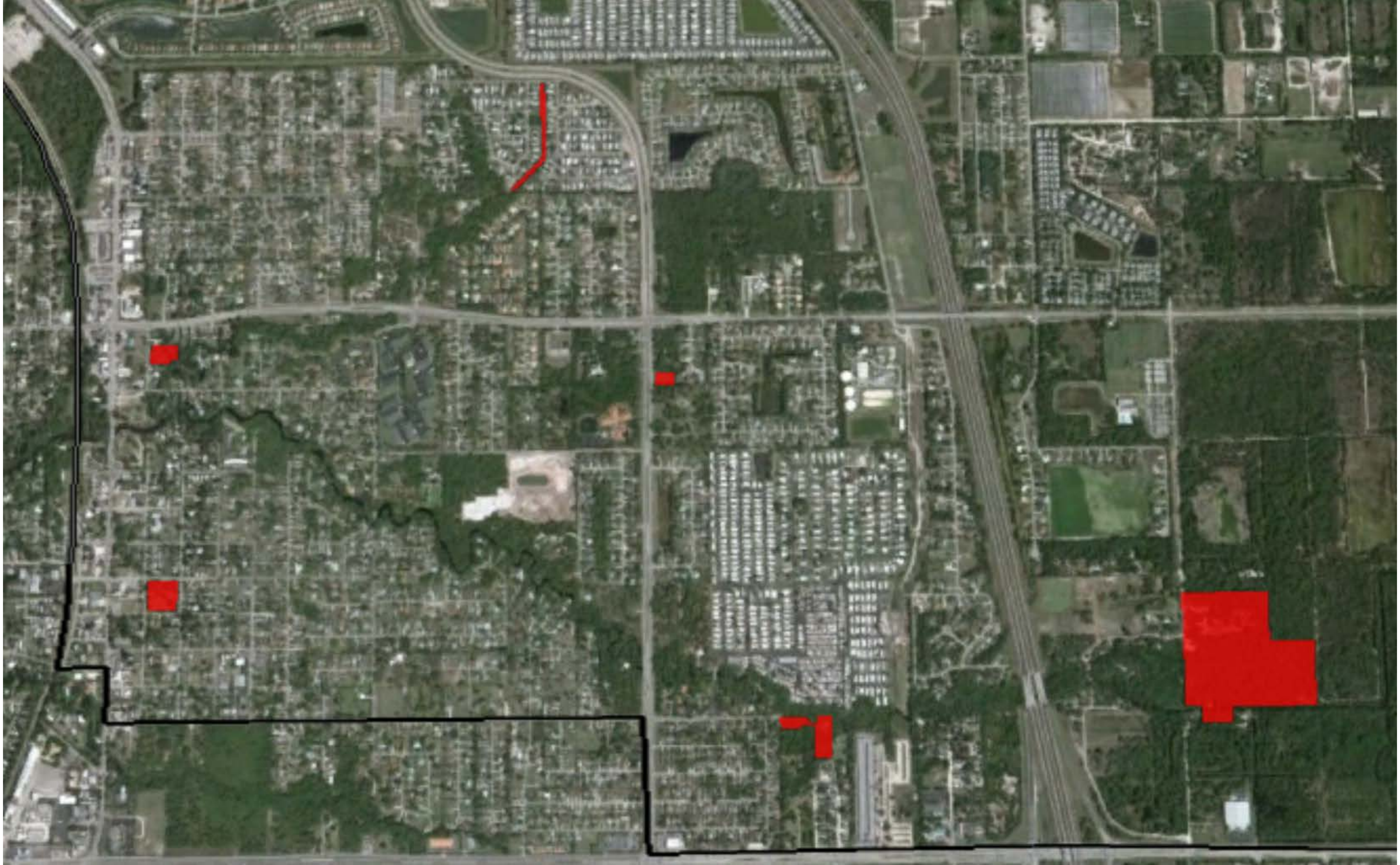
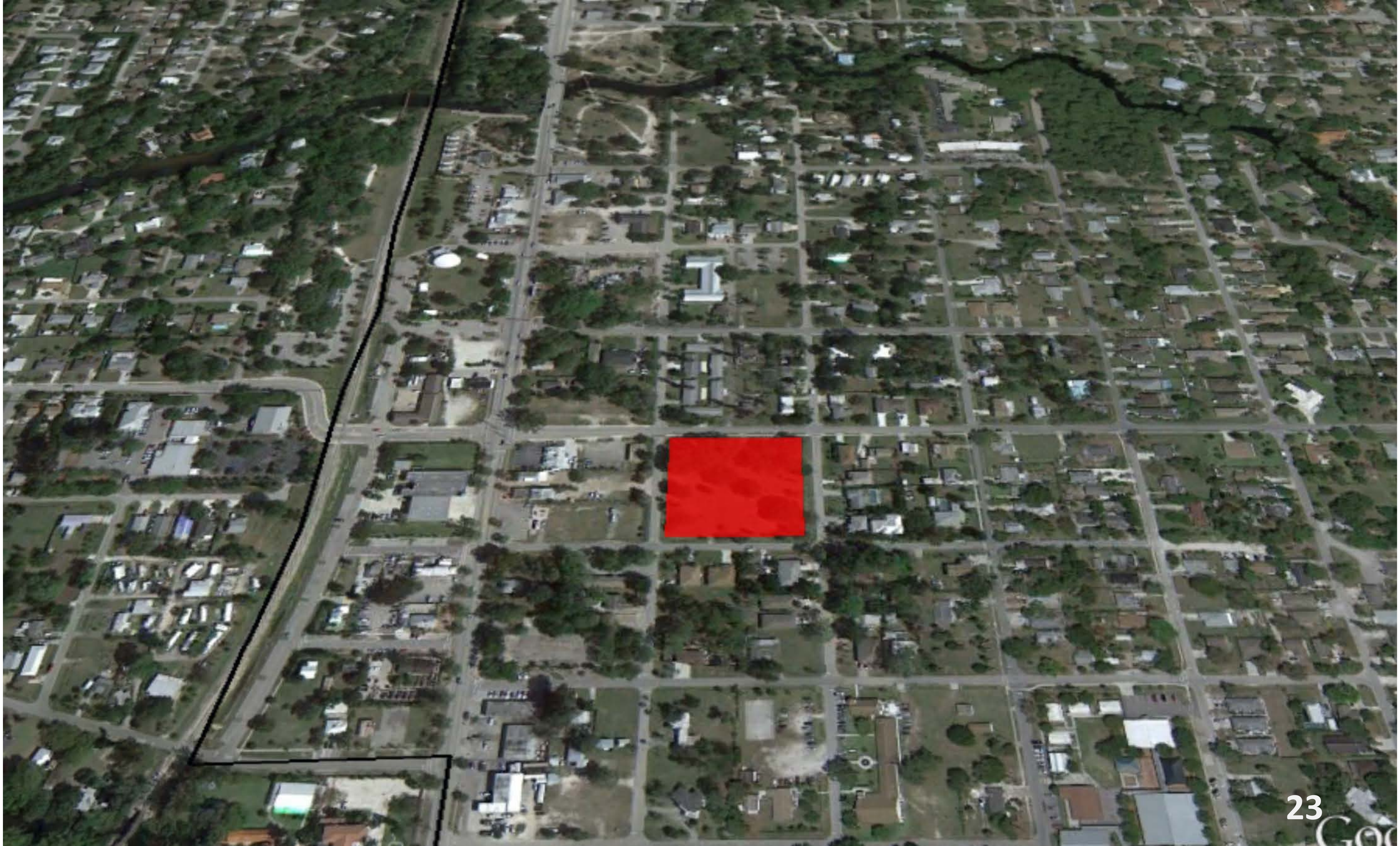
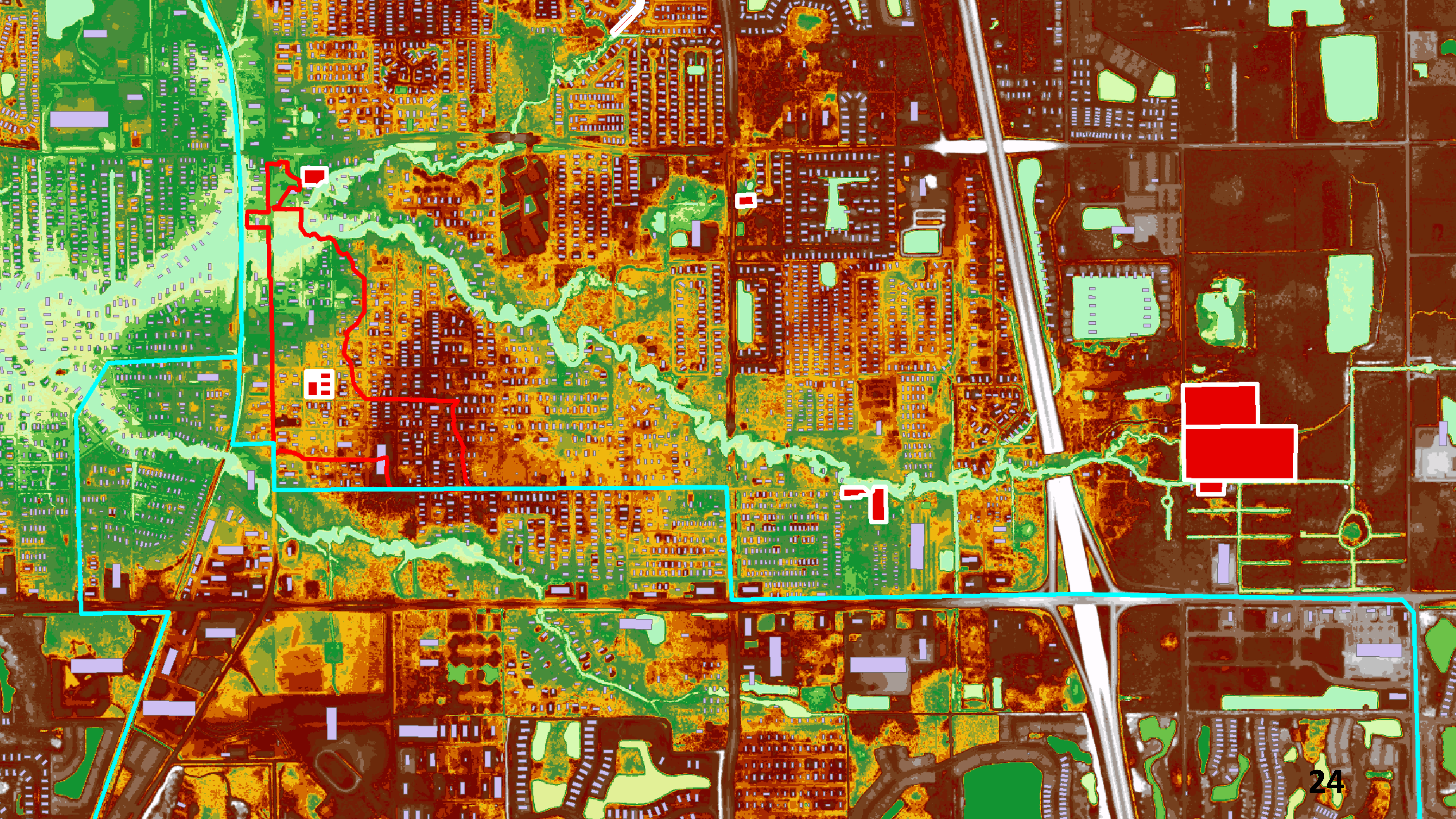
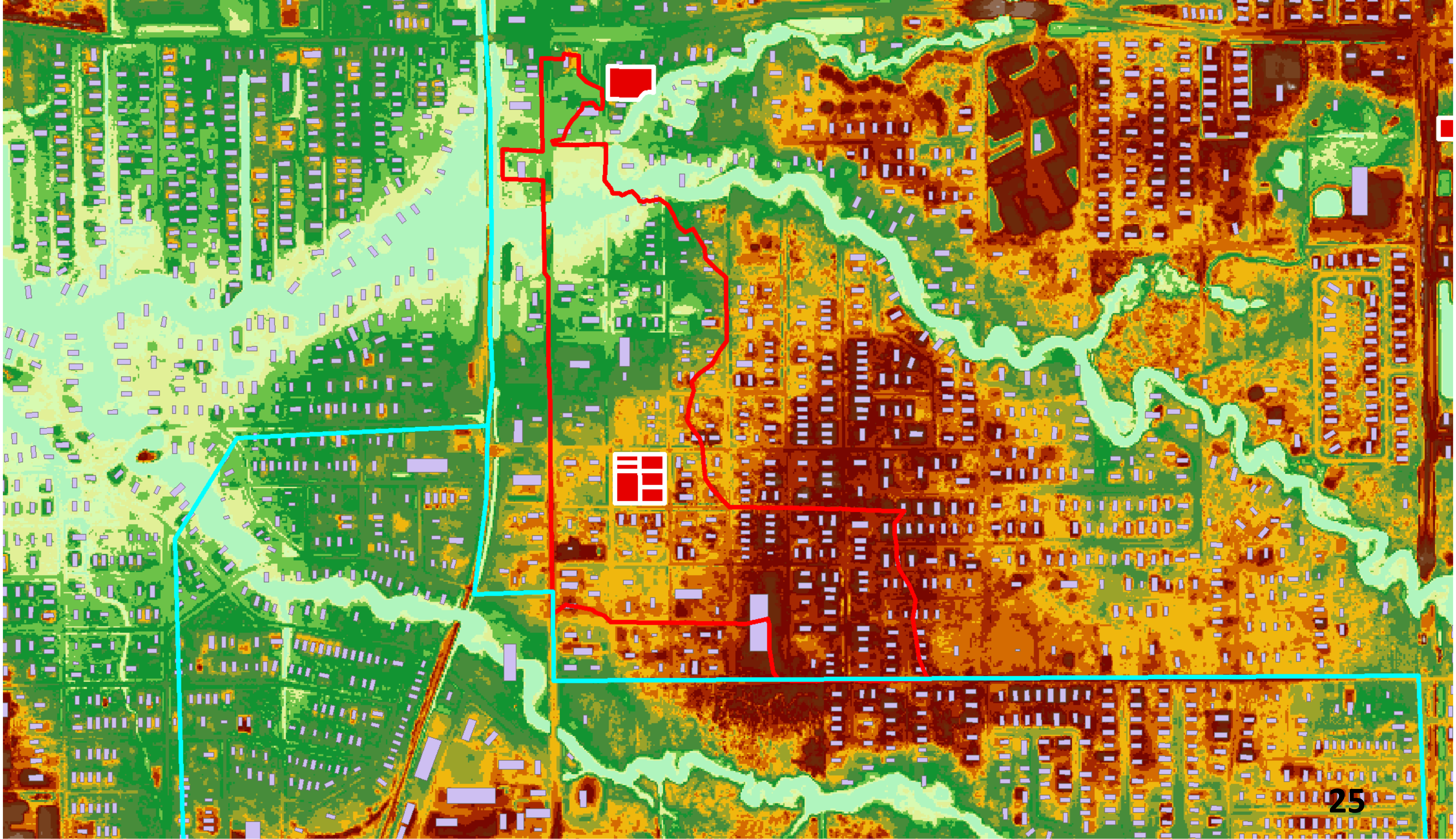


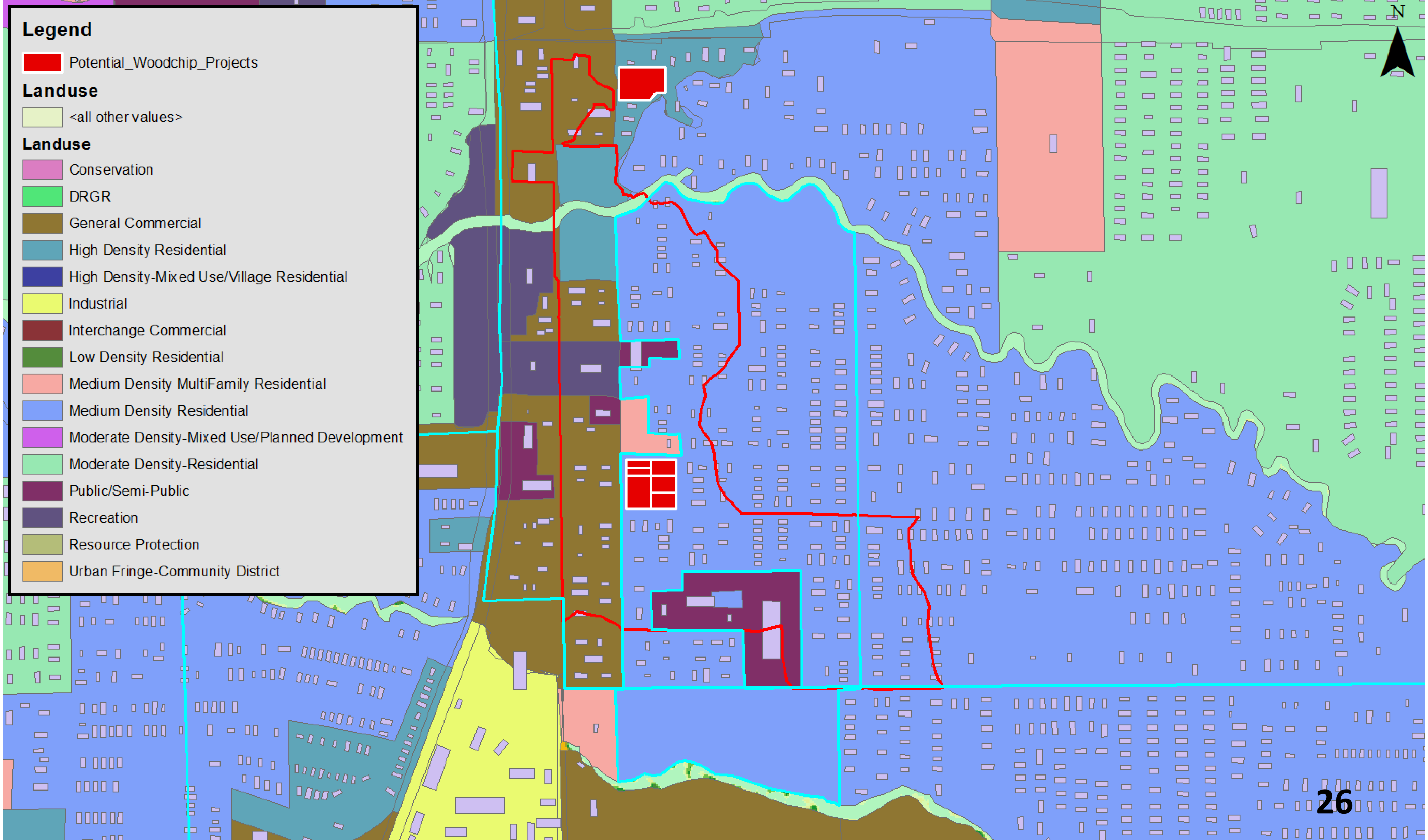
Figure 4. Area requirements for different wetland types at different inlet concentrations. Based on the median decay rate for each type show Woodchip HSSF require the least area. The relatively large area for FWS and HSSF wetlands, could be lessened by designing them specifically for nitrate reduction. Woodchip HSSF area was calculated based on 4 feet depth.











Legend
Potential_Woodchip_Projects
Landuse
<all other values>
Landuse
Conservation
DRGR
General Commercial
High Density Residential
High Density-Mixed Use/Village Residential
Industrial
Interchange Commercial
Low Density Residential
Medium Density MultiFamily Residential
Medium Density Residential
Moderate Density-Mixed Use/Planned Development
Moderate Density-Residential
Public/Semi-Public
Recreation
Resource Protection
Urban Fringe-Community District
N


300 ft
300 ft

Rainfall intensity runoff that is treatable by the Bioreactor

Rational Equation	Q = C * i * A				
Flow =	Q =	5.16	ac-in/hr	5.20	cfs
Runoff coefficient =	C =	0.6	dimensionless		
Rainfall intensity =	i =	0.2	in/hr		
Area =	A =	43	acres		
Average Annual Rainfall =		52	inch/y	186.33	ac/ft/yr
Averge Annual Runoff =		31.20	inch/y	111.80	ac/ft/yr
Existing Average Annual TN loading =		470	lbs/y	10.94	lbs/acre/y
# of Bio-Reactors =		15			
Capacity of 1 Bio-Reactor =		0.004581	in/hr of rainfall intensity		
Capacity of 15 Bio-Reactors =		0.068722	in/hr of rainfall intensity		
% of Runoff treated =		32%			
%TN removal Rate of Bioreactor =		87%			
Average lbs of TN removed per year =		130.13	lbs/yr		

Flow in Sub Surface Media

Darcy's Equation	Q = Ks *A * S				
Bio-Reactor Flow =	Q =	291.60	m^3/d		ft^3/d
Hydraulic Conductivity =	K_s =	0.15	m/s	Range .09 to .15	
Hydraulic Conductivity =	K_s =	12,960.00	$m^3/m^2/d$		$ft^3/ft^2/d$
Bio-Reactor X - Section =	A =	7.50	m^2		ft^2
Slope = dh/dL =	S =	0.0030	m/m		ft/ft

Water Quality Constituent Transport Equations

	t = (n*L*W*d)/Q				
HRT =	t =	1.39	d	33.26	hr
eff porosity =	n =	0.60	%		
Length =	L =	89.81	m	294.66	ft
Width =	W =	5.00	m	16.40	ft
Depth =	d =	1.50	m	4.92	ft
Flow =	Q =	291.60	m^3/d		ft^3/d
	$K_T = K_{20} * (\Theta)$^ (T-20°)				
Rate Constant at Temp. =	K_T =	1.48			
Rate Constant at 20° C =	K_{20} =	1.10			
	Θ =	1.06			
Ave Water Temp =	T =	25.00	°C		
C Effluent	C_e =	0.20	mg/l - (ppm)		
C Inlet	C_o =	1.55	mg/l - (ppm)		
	$\ln(C_o/C_e)$ =	2.05			
	As = Q*[ln(Co/Ce)]/(K_T *d*n) = (L)*(W)				
	As = Q*[ln(Co/Ce)]/(KT *d*n) =	449.07			
A_s =	(L)*(W)				
Length =	L =	As/(W)			
Length =	L =	89.81	m	294.66	ft
	Elevation Drop = L * S				
	Elevation Drop =	0.2694404	m	0.88	ft

Strengths

- Very high TN removal Rates
- Low Cost
- Smaller footprint

Design Challenges

- Flow Rates are Low
- Requires Head Differential
- Seasonal rainfall
- Potential Sulfur/Mercury Issues
- Potential Carbon & Nutrient flux from Media
- Potential Clogging

Monitoring of the Pilot Project

- Inflow and Outflow
  - Water Level Stage
  - Volume
  - TN
  - TP
  - DO

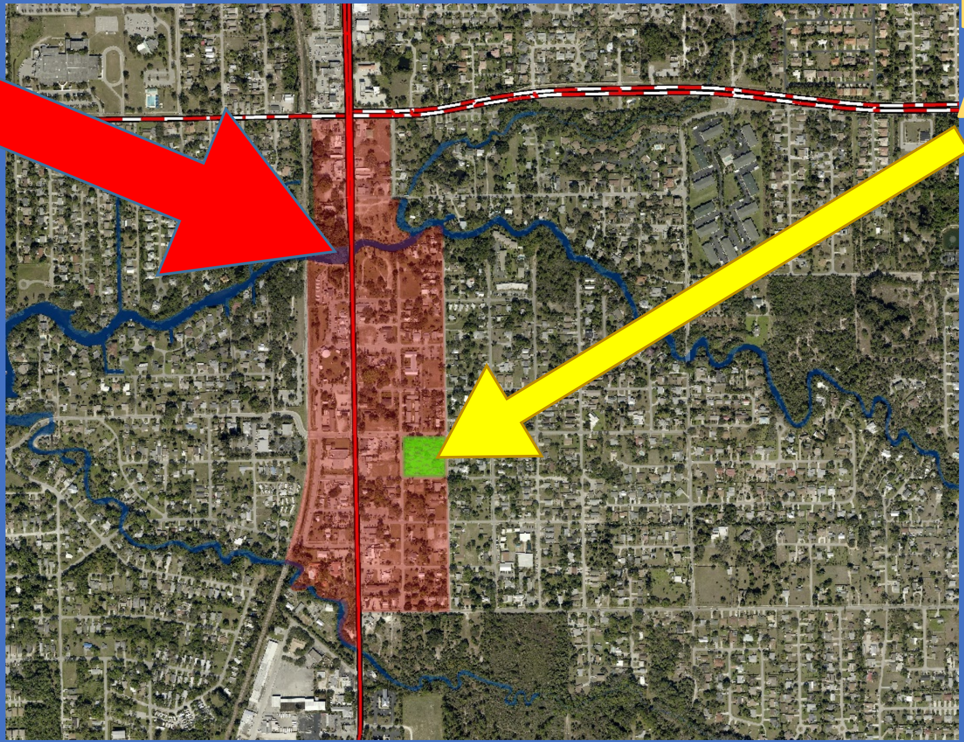
Pilot Project

- Include in BMAP
- Credit for Pilot Project
- Monitoring
- Increased credit for Increased Performance
- Credit for Future Woodchip Bio-Reactors

Timelines

- $16 Million Dollar Downtown Design-Build Renovation Project: Construction to Start 1 April 2015.

Felts Project Area



  - July 2014: $250,000 received in State Grant Dollars for the Felts Water Quality Project

    - 1st 5 Year BMAP Period ends 2017