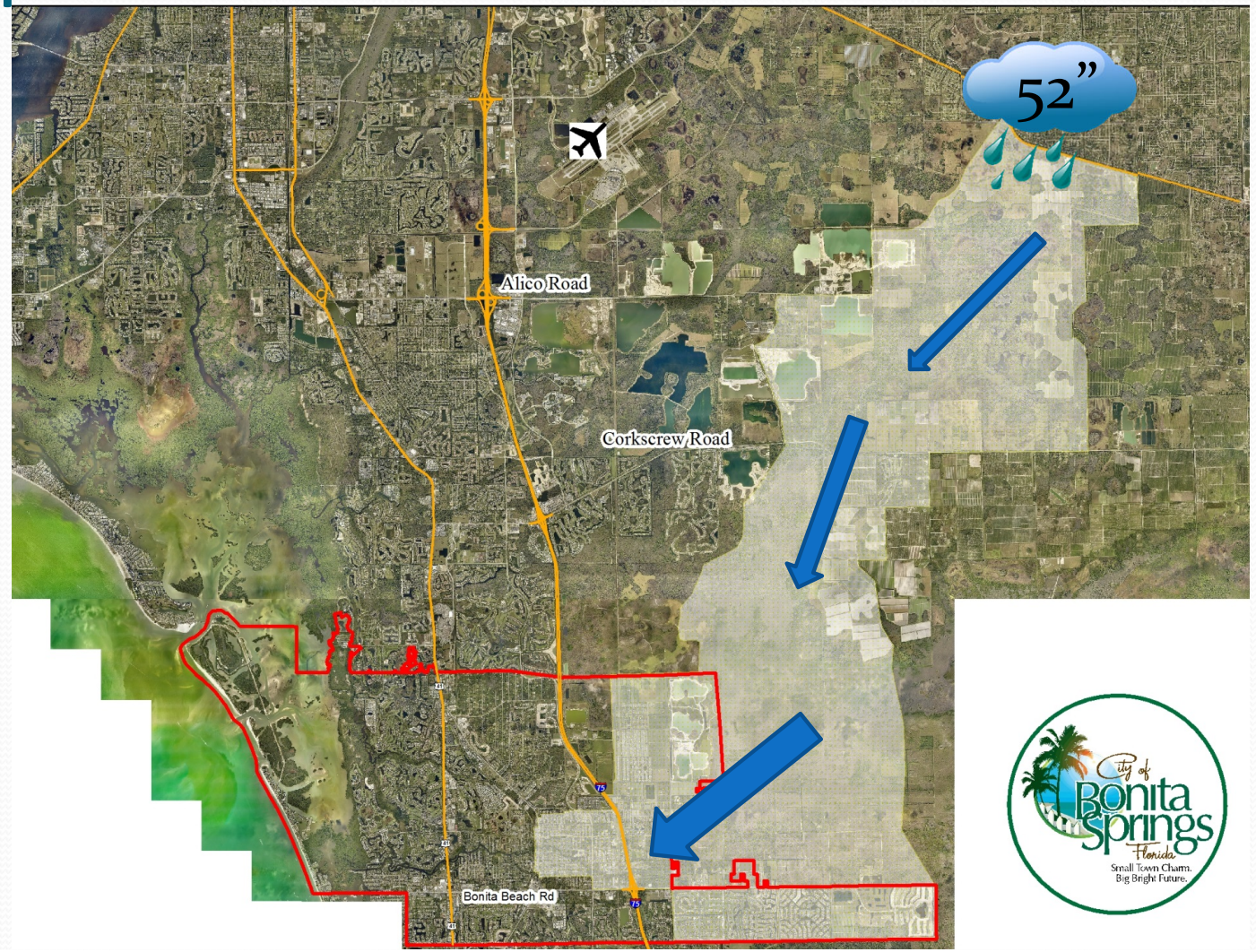
City of Bonita Springs:
Felts Ave Bio-Reactor

Presented by:
Matt Feeney
Assistant City Manager

Background: Imperial River Watershed

- Freshwater Basin: 70.2 Square Miles (44,960 Acres)
- Major Tributary to Estero Bay
- Current Landuses:
  - 10% Urban
  - 26% Agriculture
  - 4% Mining
  - 49% Wetlands
  - 11% Upland Forest & Rangeland



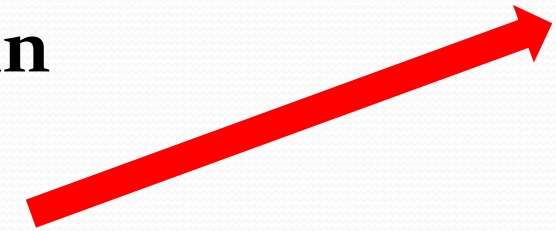
Background: Regulation BMAP

- **Total Maximum Daily Load (TMDL) of .74 mg/l of Nitrogen established for the River**

- **Basin Management Action Plan Established by the state in November 2012 to achieve reduction of .74 mg/l goal by 2027.**

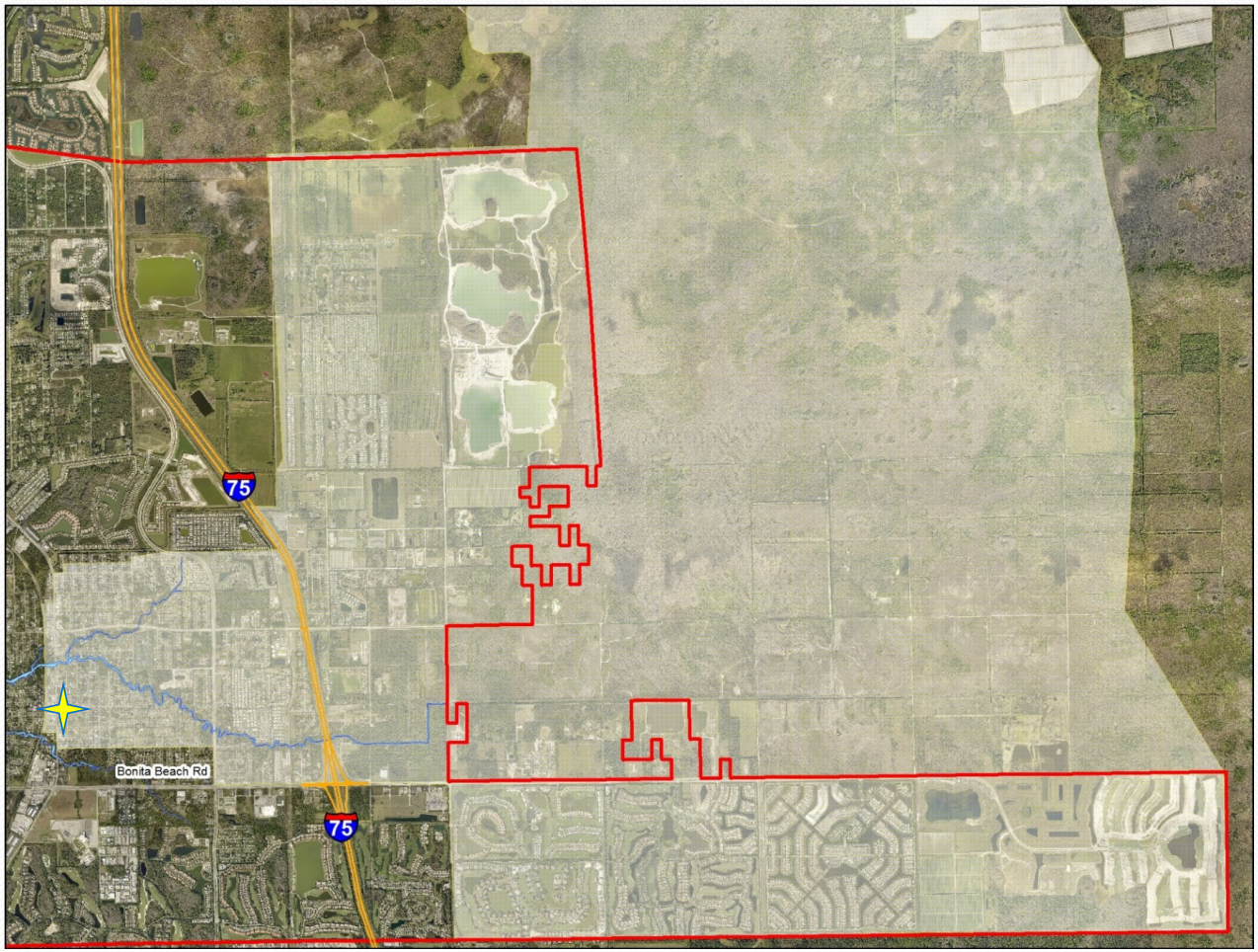
TABLE 31: TN REQUIRED REDUCTIONS FOR THE IMPERIAL RIVER BASIN MS4S

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**



Background: Project Siting

- **Projects eligible for consideration in the reduction of the City's nitrogen quota are limited to the Imperial's basin**



Mathematical Nutrient Model

- **Nutrient Loading Rates are applied based on land use**

Imperial River Basin Loading Rates by Land Use			
Key	**Category**	**Included FLUCCS**	**MG/L Loading**
1100	Single-Family Residential	1100s	1.03
1200	Medium-Density Residential	1200s	1.29
1300	Multi-Family Residential	1300s	1.38
1400	Commercial	1400	1.28
1550	Industrial	1550	1.24
1610	Mining	1610, 1620, 1630, 7400, 7430	0.29
1660	Mining - Holding Ponds	1660	0.73
1700	Institutional/Transportation/Utilities	1700, 1710, 8140, 8310, 8320	0.53
1800	Golf Courses and Parks	1800, 1820, 1850	0.77
1900	Rangeland	1900, 1920, 3100, 3200, 3210, 3300	0.52
2000	Agriculture	2000s	3.05
4000	Upland Forested	4000s	0.17
5000	Freshwater - Open Water	5000s	0.73
6120	Forested - Freshwater Wetlands	6120-6300	0.54
6410	Non-Forested Freshwater Wetlands	6410, 6430, 6440	0.47
6420	Saltwater Wetlands	6420, 6510	0

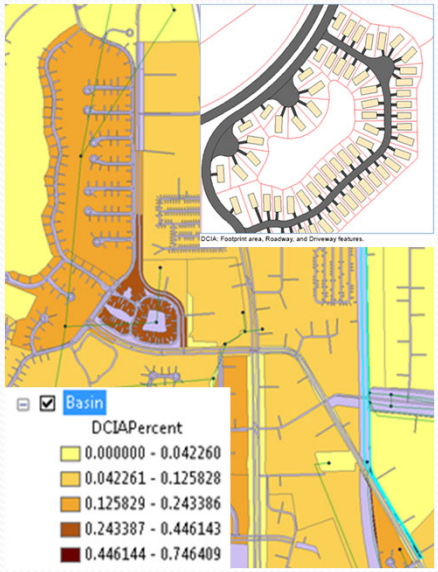
Mathematical Nutrient Model

- **Pervious & Impervious Areas Calculated**

- **Runoff Pollution Amounts are derived**
  - **Soil Type**
  - **Seasonal High Water Table**
  - **Directly Connected Runoff**

Site Data Table

Land Use	Area (acres)	Pervious (water can pass through)	DCIA (directly connected impervious area)		NDCIA (non directly connected impervious area)		CN (curve number)
			%	acres	%	acres	
SF Residential	18.5	65%	5%	0.9	30%	5.6	69
MF Residential	1.0	35%	5%	0.1	50%	0.5	77
Commercial	9.3	35%	63%	5.9	2%	0.2	89
Open Grass Area	7.8	99%	0%	0.0	1%	0.1	44
Total Basin	36.6	64%	19%	6.8	17%	6.3	----



Mean Annual Mass Removal Efficiencies (%) for 0.40-inches of Retention for Zone 4

NDCIA CN	Percent DCIA																	
	0-15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
30	89.1	84.4	79.1	74.1	69.3	65.0	61.1	57.6	54.4	51.6	49.0	46.6	44.4	42.5	40.7	39.0	37.5	36.1
35	87.6	83.3	78.4	73.5	68.9	64.7	60.9	57.4	54.3	51.4	48.9	46.5	44.4	42.5	40.7	39.0	37.5	36.1
40	85.8	81.9	77.4	72.6	68.4	64.3	60.6	57.2	54.1	51.3	48.8	46.4	44.3	42.4	40.6	39.0	37.5	36.1
45	83.5	80.2	76.1	71.8	67.6	63.7	60.1	56.8	53.8	51.1	48.6	46.3	44.2	42.4	40.8	39.0	37.5	36.1
50	80.8	78.2	74.6	70.6	66.7	63.0	59.6	56.4	53.5	50.8	48.4	46.2	44.1	42.3	40.5	38.9	37.5	36.1
55	77.8	75.8	72.7	69.2	65.6	62.2	58.9	55.9	53.1	50.5	48.2	46.0	44.0	42.2	40.5	38.9	37.4	36.1
60	74.2	73.0	70.5	67.5	64.3	61.1	58.1	55.2	52.6	50.1	47.8	45.7	43.8	42.0	40.4	38.8	37.4	36.1
65	70.3	69.8	67.9	65.4	62.5	59.8	57.0	54.4	51.9	49.6	47.4	45.4	43.6	41.8	40.3	38.8	37.4	36.1
70	66.0	66.0	64.6	62.9	60.6	58.2	55.7	53.4	51.1	48.9	46.9	45.0	43.3	41.7	40.1	38.7	37.4	36.1
75	61.7	61.7	61.2	59.9	58.1	56.1	54.1	52.0	50.0	48.1	46.2	44.5	42.9	41.4	39.9	38.6	37.3	36.1
80	57.0	57.0	56.9	56.2	55.0	53.6	51.9	50.3	48.6	46.9	45.3	43.8	42.3	41.0	39.6	38.4	37.2	36.1
85	52.0	52.0	52.0	51.7	51.1	50.2	49.1	47.9	46.6	45.3	44.0	42.6	41.5	40.4	39.2	38.1	37.1	36.1
90	46.8	46.8	46.8	46.8	46.4	46.0	45.3	44.6	43.8	43.0	42.1	41.2	40.3	39.5	38.6	37.7	36.9	36.1
95	41.4	41.4	41.4	41.3	41.2	41.0	40.7	40.4	40.1	39.7	39.3	38.9	38.5	38.0	37.5	37.1	36.6	36.1
98	38.5	38.4	38.4	38.3	38.2	38.1	37.9	37.8	37.7	37.5	37.4	37.2	37.0	36.9	36.7	36.5	36.3	36.1

Current Standard: Dry & Wet Retention

Limitations:

- Land Intensive
- Less Effective with High Water Table
- Single Purpose Use of Real Estate
- Treatment Volume Limited/not Continuous

Bio-Reactor: Emergent Technology

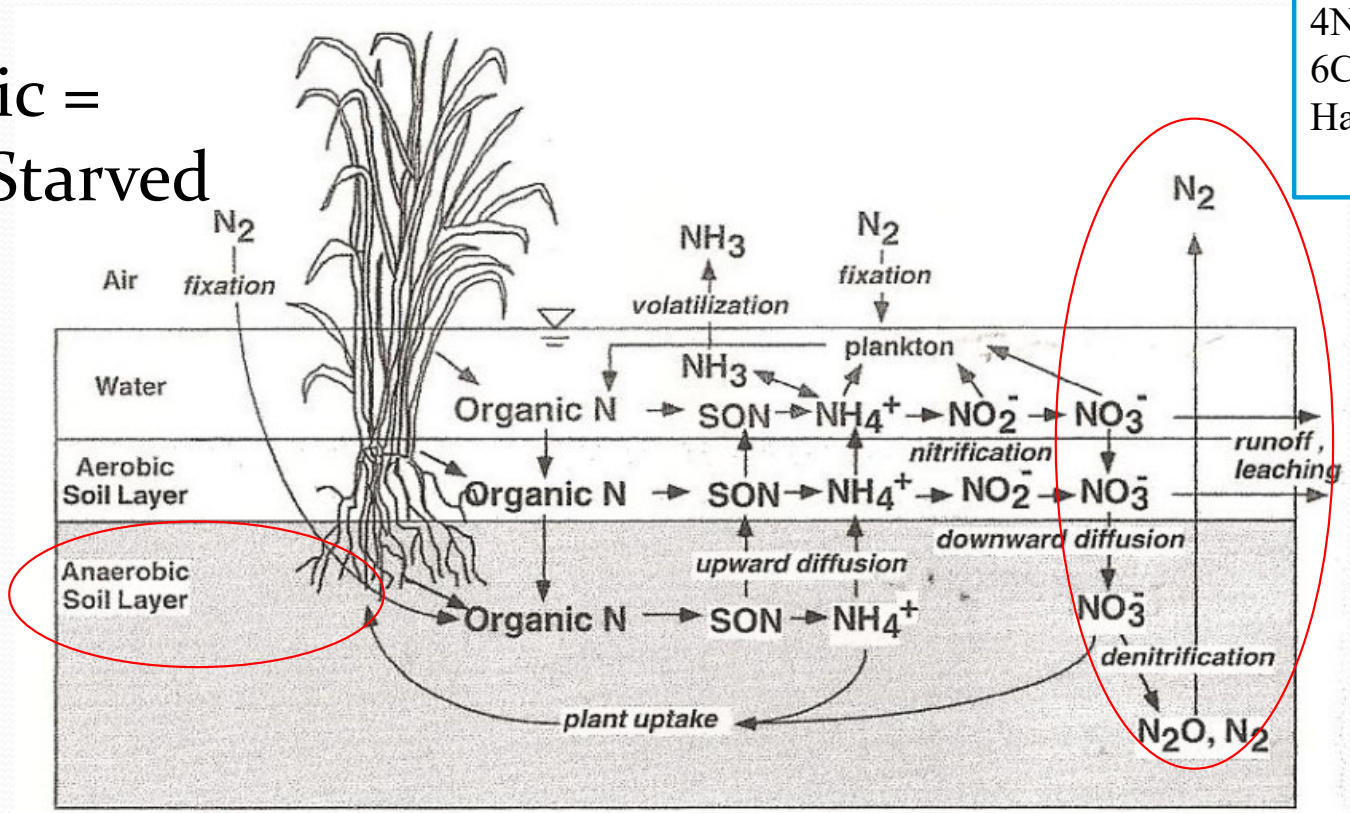
WHY?

- Scalable Technology
- Multiple uses of Land allowed (not just water treatment)
- Benefits from High Water Table
- Allows for Continuous Water Treatment

Bio-Reactor Concept: Mimic Natural Process

- Anaerobic = Oxygen Starved

Nitrogen transformations in wetlands

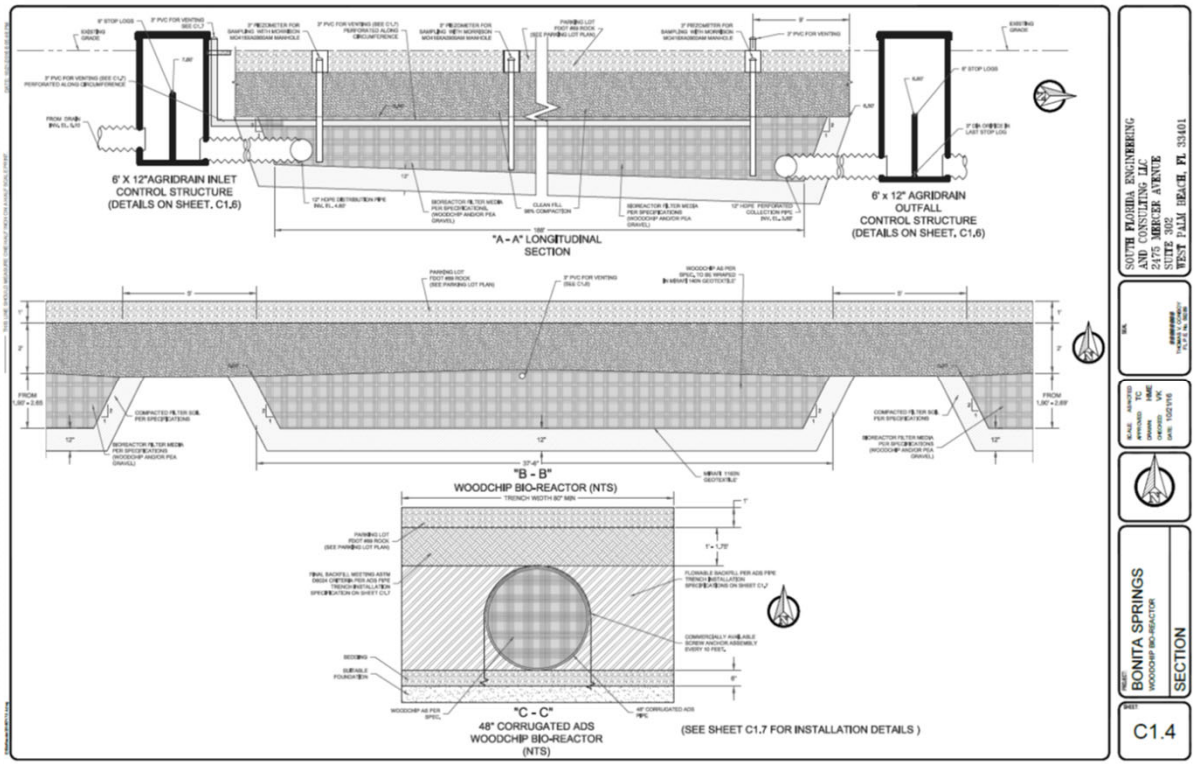


Denitrification is illustrated by the equation:
$4NO3^- + 6(CH2O) \rightarrow 6CO2 + 2N2 + 6H2O$ (3)
Hauck, 1984

City of Bonita Springs:
Felts Ave Bio-Reactor Phase I Funding

- **$250,000 State Budget Appropriation FY 14/15**
- **$100,000 Grant form SFWMD Oct 2016**
- **$450,705 City funds**

Total Cost: $800,705



Phase I Bio-Reactor Design Features

- Four 37FT X 185 FT Bio-Reactor Cells
- 185 LF of 48" ADS Bio-Reactor

Project Components

- ¾ inch hardwood woodchips free of bark Bio-Reactor Media
- Pea Gravel
- One Eco Vault Filter Media
- Revised Surface Water Drainage System Piping

Phase I Construction

- Component installation

Project Completion

- 101 Additional Parking Spaces
- Multi-Use/Flexible Design

Land Utilization

Simply Put.....

=

Testing

- 21,000 Gallon Baker Tank Fed Surface Water into 48 Inch Bio-Reactor #1
- Water Quality Monitored of Bio-Reactor #1 Influent and Effluent
- Samples sent to Laboratory for Analysis

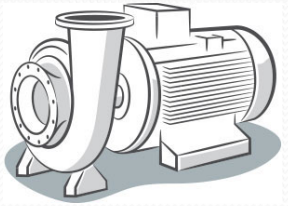
Bio-Reactor #1 Nitrate Testing Results

- Nitrate (NO_3) removal efficiency rate ranging from 77% - >98%
- Average Influent contained .253 mg/l NO_3
- Hydraulic Residency times varied from 0.5 to 1.09 days

Influent		Effluent		HRT	Removal
Date & Time	NO3 (mg/l)	Date & Time	NO3 (mg/l)	(days)	Efficiency
9/12/19 15:00	0.247	-	-	-	-
9/15/19 9:59	0.255	9/15/19 9:54	0.006	0.61	>98%
9/15/19 14:18	0.26	9/15/19 14:18	0.006	0.59	>98%
9/16/19 11:19	0.266	9/16/19 10:49	0.006	0.64	>98%
9/16/19 16:00	0.258	9/16/19 16:00	0.006	1.09	>98%
9/17/19 10:22	0.256	9/17/19 10:01	0.006	1.07	>98%
9/17/19 16:04	0.254	9/17/19 16:15	0.006	1.02	>98%
9/18/19 9:50	0.257	9/18/19 10:10	0.028	1.02	89%
9/18/19 16:00	0.233	9/18/19 16:10	0.006	1.02	>98%
9/19/19 9:35	0.247	9/19/19 10:15	0.059	0.5	77%

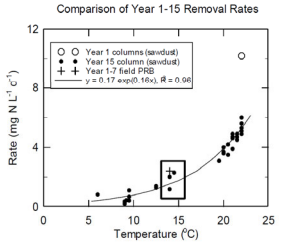
Average Influent Concentration (mg/l)	*0.253*	*Average Effluent Concentration (mg/l)*	*0.014*

Testing: Lessons Learned



- Continuous Water Supply = Longer Project Lifespan (Constant Anaerobic State)

Wood chip longevity: Little decline in rates over 15 years of observation



Robertson, 2010.

- Continuous Treatment: Facility capable of providing continuous treatment of water with a Hydraulic Residency Times as low as .6 Days
- Felts Avenue Bio-Reactor Site is located within close proximity to a constant water supply, the Imperial River.
- Treatment Results are actual in nature, not model based

Extrapolated Annual Removal of Nitrogen for Retrofit Phase I Bio-Reactor Chambers #1 through #5

Hydraulic Residence Time (Days)	Total Flow for All Five Existing Bio-Reactors (gpm)	Annual Removal Efficency (Lbs) Based on Nitrogen Removal Rate per Unit Volume		
		0.25 mg/l	0.5 mg/l	1.0 mg/l
0.5	408	447.7	895.5	1790.9
0.6	340	373.1	746.2	1492.4
0.7	292	319.8	639.6	1279.2
0.8	255	279.8	559.7	1119.3
0.9	227	248.7	547.2	995.0
1	204	223.9	447.7	895.5
1.1	186	203.5	407.0	814.1

Cost Effectiveness of Implementation of Phase II

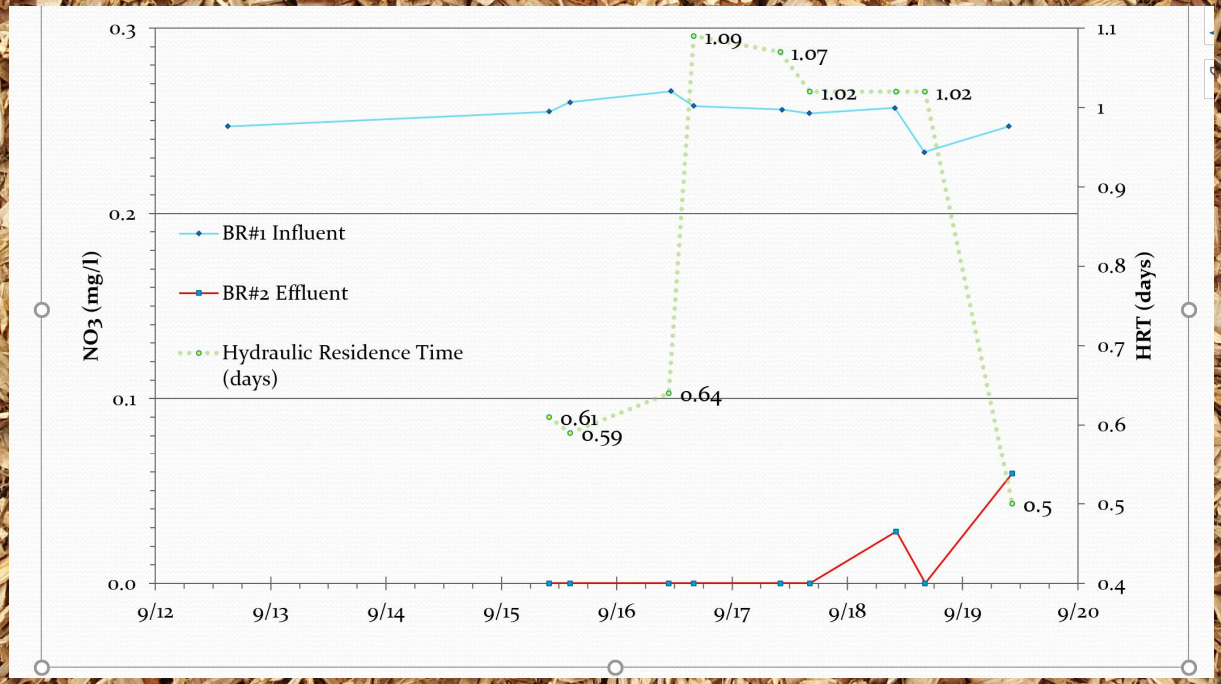
	Capital Cost	Depreciation Period	Projected Nitrogen Removal (lbs/yr)	per Lbs of Nitrogen Removal
Phase I & Phase II	$1,553,705	15	895.5	$115.67
Phase II Only	$753,000	15	895.5	$56.06

$638/lb. of Nitrogen removed is FDEP project cost average cost **not inclusive** of land acquisition costs.

Recent Accolades:

- City Applied for and Received $400,000 in FDEP Harmful Algal Bloom Funding to assist in the design and construction of Phase II
- City Partnered with FGCU to Fund a “Water Steward” position in the City duties include to assist in the sampling of Phase II project
- Project Recently Awarded The Florida League of Cities Environmental Stewardship Award

Questions?


0.3
0.2
0.1
0.0
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
NO3 (mg/l)
HRT (days)
BR#1 Influent
BR#2 Effluent
Hydraulic Residence Time (days)
1.09
1.07
1.02
1.02
0.64
0.61
0.59
0.5
9/12
9/13
9/14
9/15
9/16
9/17
9/18
9/19
9/20