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South County Alligator Creek Stormwater Treatment System

This Treatment Train Needs a Locomotive to Meet Tough TMDL Challenges!

***Mark J. Flint, PE and Dr. Marty Wanielista**, PE*

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TODAY'S AGENDA

- What is the Treatment Locomotive?
- Site Location and Project Background
- The Challenges of Stormwater Treatment-The need to Meet Tough TMDL's and FDEP 319h Grant Conditions
- Treatability-Background Water Quality Defined Treatment Needs
- The Mission-Build a Train that Meets Treatment Goals on 6 acres!
- How do I Build a Locomotive?
  - Consider Treatment Strategies for Inter-event Conditions
  - Consider Use of Sustainable Sources and LID Strategies
  - Bold and Gold Upflow/Sorption is the "Heart " of the Treatment
  - Design the System for Flexible Operations and Low Maintenance
- Challenges of Construction-A Story of Innovation and Success!
- Operational Alternatives-Flexibility of the Locomotive

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THE TREATMENT LOCOMOTIVE

WHAT IS THE "TREATMENT LOCOMOTIVE"?

- High rate removal requires a "*Driving Force*"
- The *"Driving Force"* is continuous flow treatment
- Treated stormwater is also stored for recycling
- Continuous flow treatment is provided by a VFD controlled pumping system
- Continuous flow treatment removes more solids and nitrogen through contact with a filter and biological system

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THE CHALLENGES OF TREATMENT

DEAD CATFISH OBSERVED IN 2010 AT THE OUTFALL WEIR

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FDEP GRANT CONDITIONS

The Performance Goals for the Briarwood Treatment Train defined by the 319h Grant are "Ambitious"!

- TSS -90% reduction or 35,881 lbs removed annually
- TP - 72% reduction or 449 lbs removed annually
- TN - 68% reduction or 3,847 lbs removed annually

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BACKGROUND WATER QUALITY DATA

Briarwood Lakes background water quality is not “typical” stormwater runoff!

- N Speciation tells the story
- P Speciation follows trend
- **“Very Bad Water!”**

PARAMETER	AVERAGED MEASUREMENT (N=3)
TSS, mg/l	40
TN, mg/l	3.00
PARTICULATE ORGANIC N, mg/l	1.60
DISSOLVED ORGANIC N, mg/l	1.40
TP, mg/l	0.2
PARTICULATE ORGANIC P mg/l	0.2
DISSOLVED ORGANIC P, mg/l	0.02

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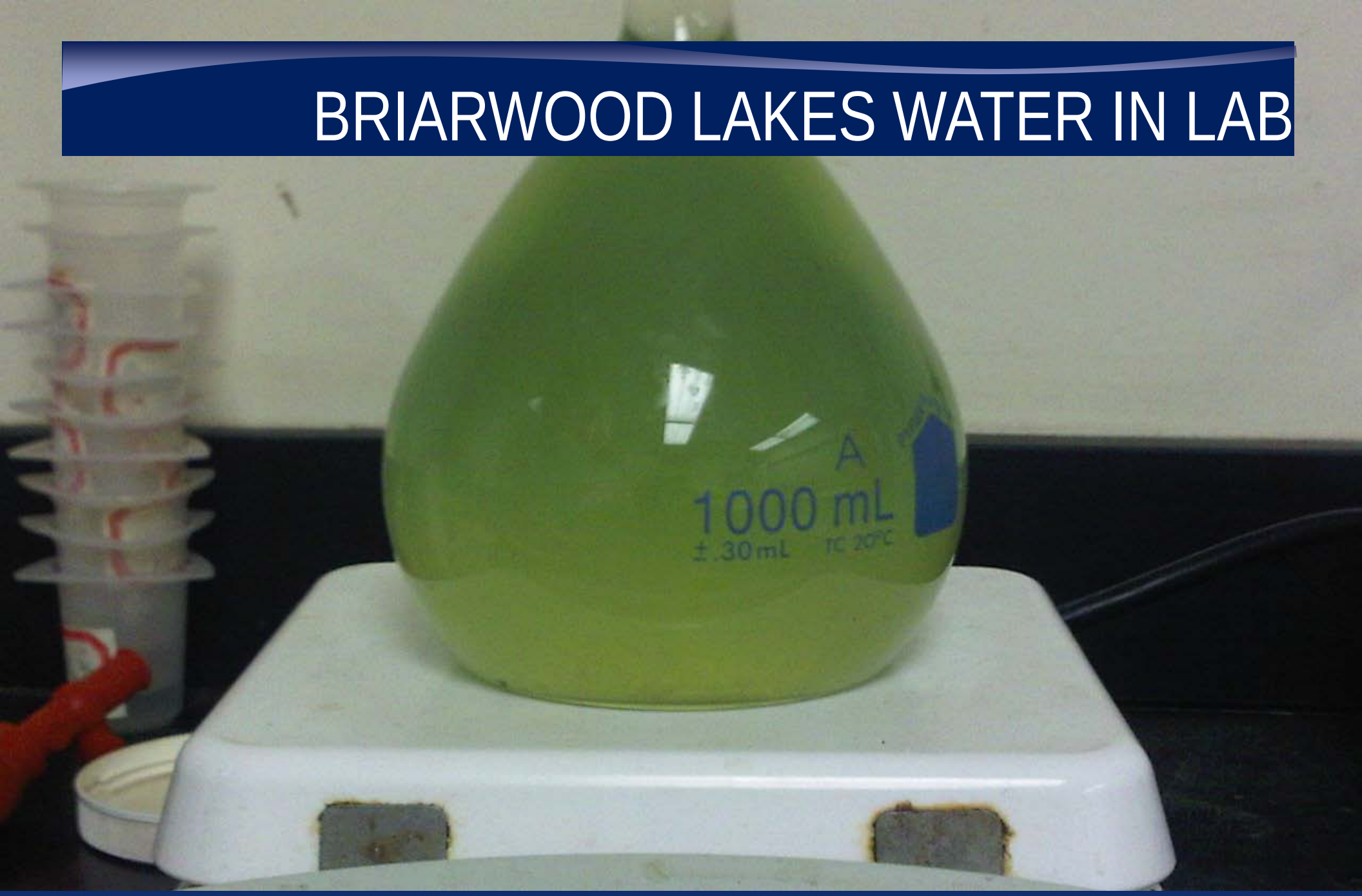
BRIARWOOD LAKES WATER IN LAB



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TREATABILITY STUDIES

- Source Water Sample taken from Alligator Creek, Venice FL
- Setup filter by adding a layer of washed 57 stone then filter fabric, then filter media, then filter fabric, then washed 57 stone.
- Add 25 gallons of sample water to reservoir

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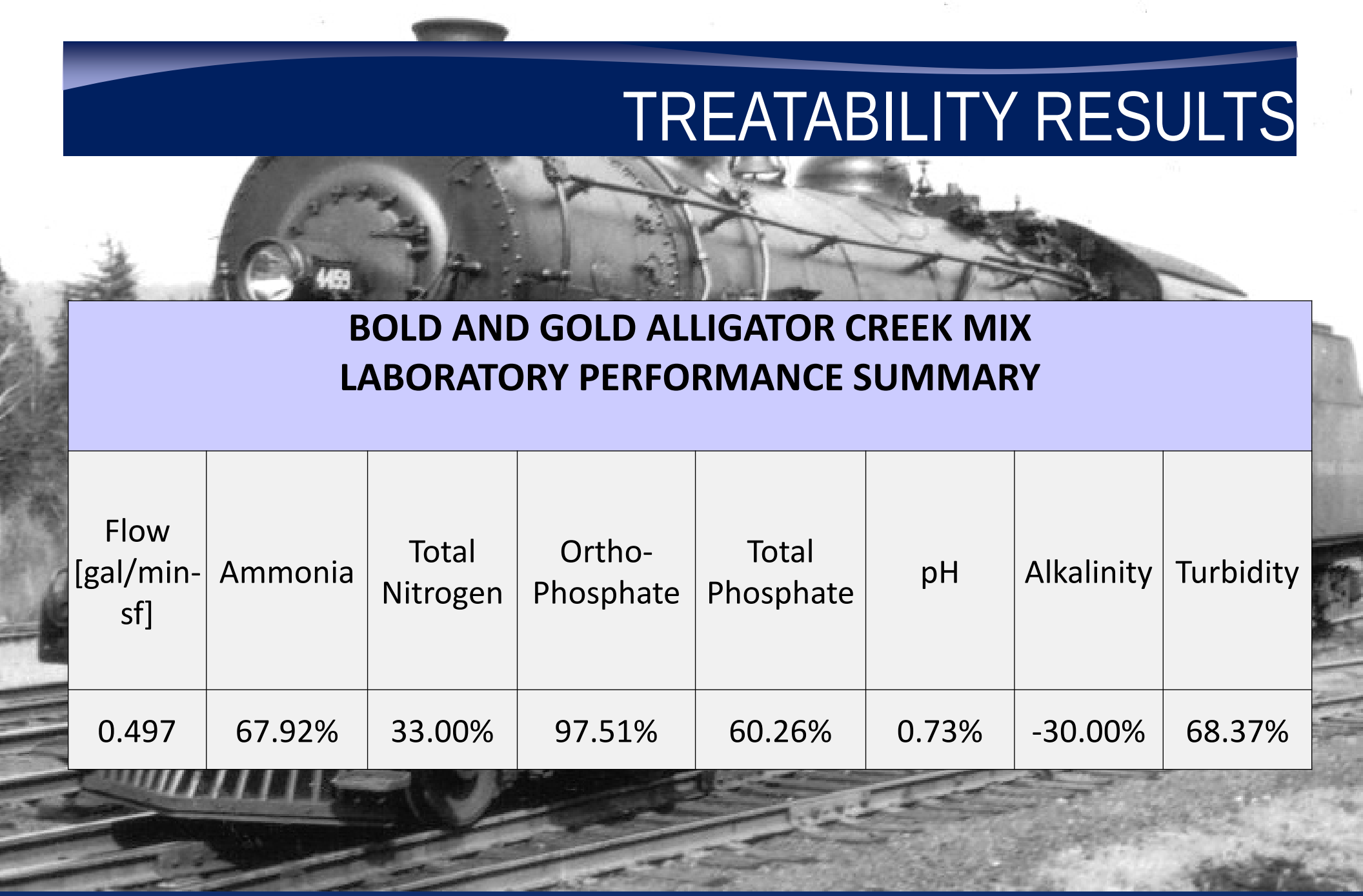
TREATABILITY PROCEDURES

- Maintain a 0.1 gpm per sf water flow through filter
  - By inlet control valve
- Take flow measurements at 10 minute intervals
- Experiments at 60 minutes in duration
- Samples tested for water quality

TREATABILITY RESULTS



BOLD AND GOLD ALLIGATOR CREEK MIX
LABORATORY PERFORMANCE SUMMARY

Flow [gal/min-sf]	Ammonia	Total Nitrogen	Ortho-Phosphate	Total Phosphate	pH	Alkalinity	Turbidity
0.497	67.92%	33.00%	97.51%	60.26%	0.73%	-30.00%	68.37%

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TREATABILITY RESULTS

	WATER QUALITY PARAMETER							
CONTINUOUS RUN TIME	Ammonia [mg/L]	Nitrate [mg/L]	Total Nitrogen [mg/L]	Ortho-Phosphate [mg/L]	Total Phosphate [mg/L]	pH	Alkalinity [mg/L]	Turbidity [NTU]
START	0.030	0.11	5.32	0.29	1.05	7.40	105	57.8
10h:10 m	0.060	0.30	3.38	0.56	1.51	7.43	57	143.0
23h:10 m	0.016	0.02	1.13	0.06	0.04	7.58	52	2.0
29h:45m	0.035	0.03	0.88	0.05	0.15	7.85	35	5.3
CHANGE	-14.69%	74.94%	83.47%	81.62%	85.96%	-6.08%	66.67%	90.76%

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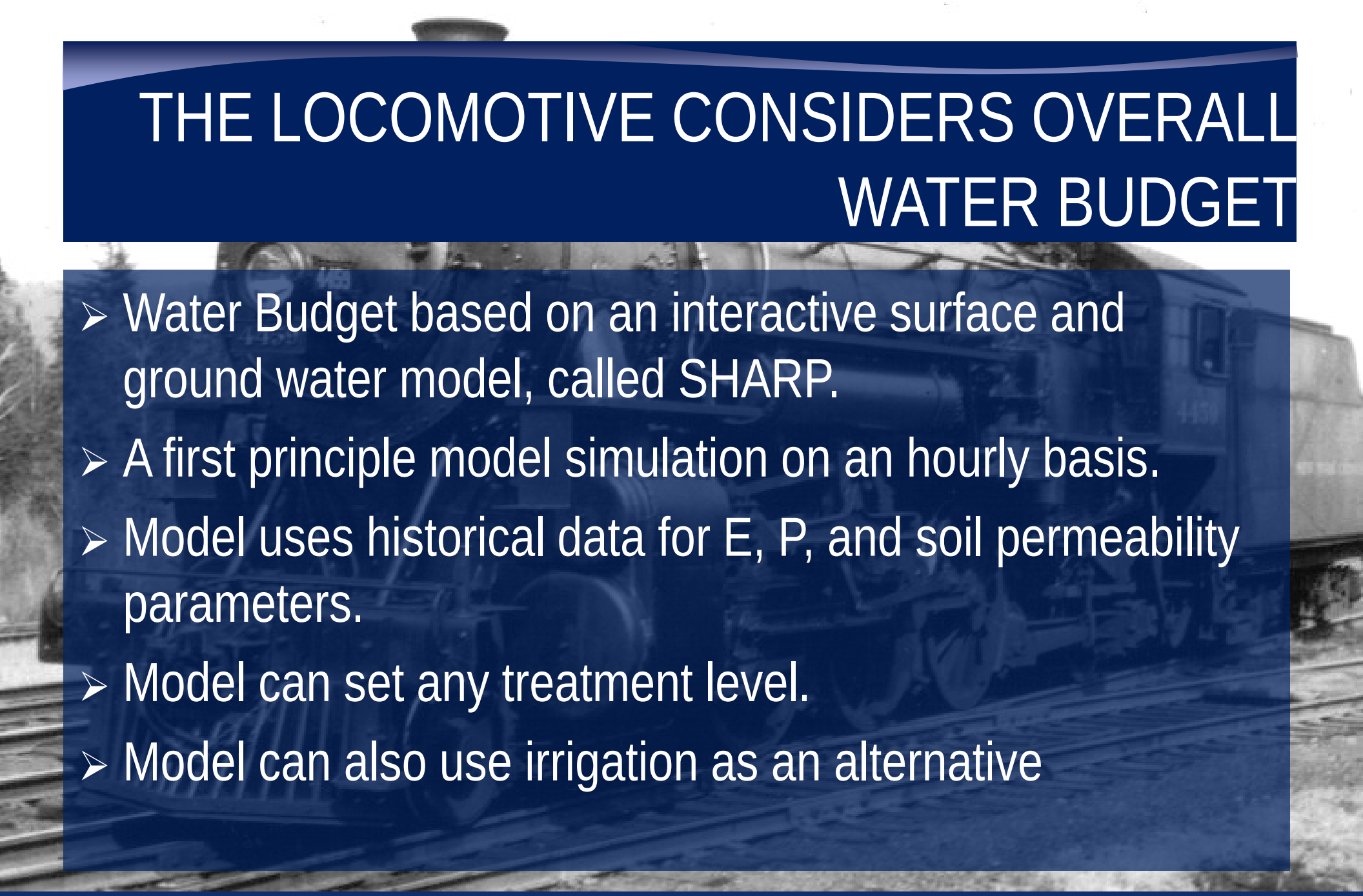
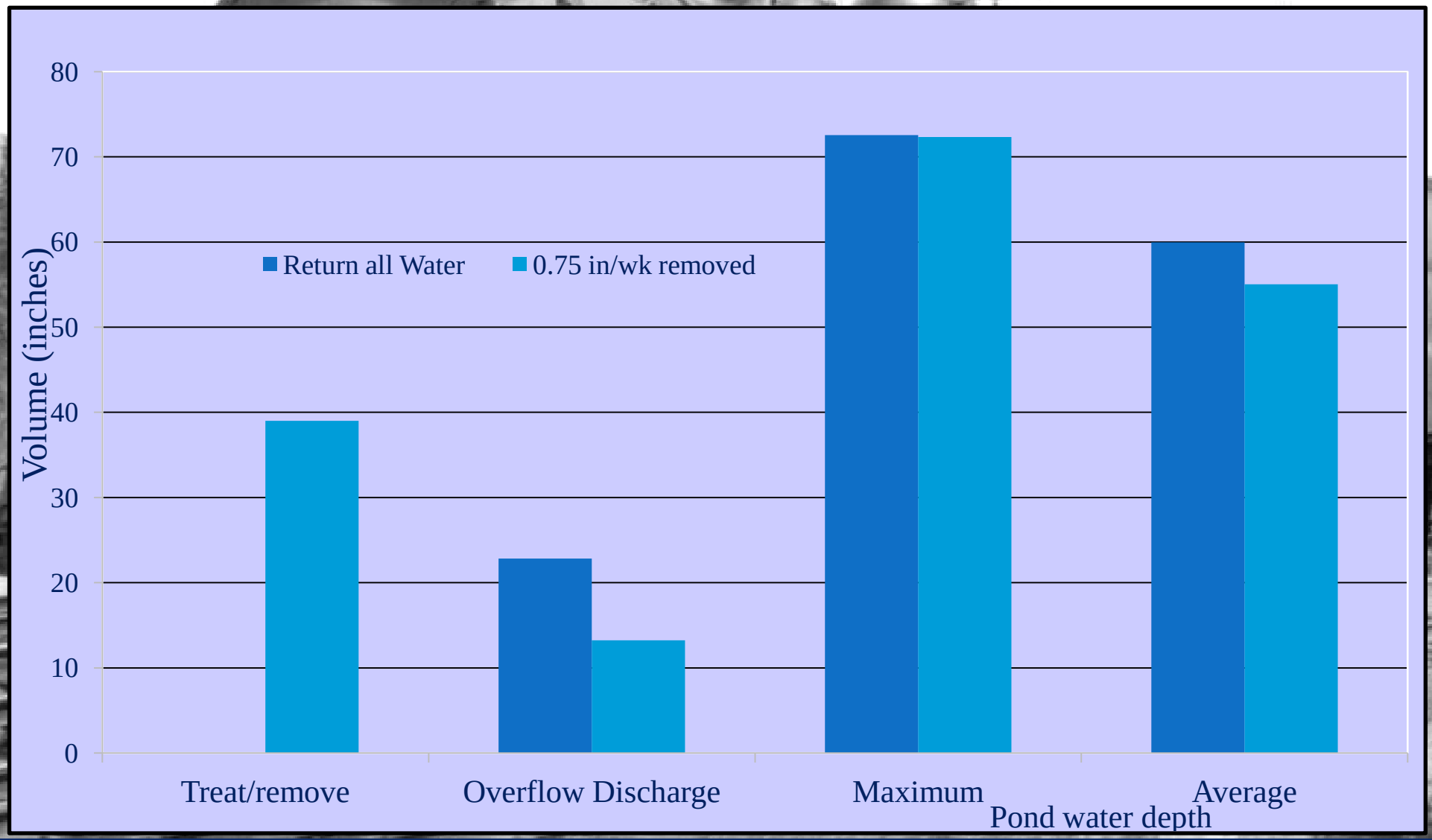
THE LOCOMOTIVE CONSIDERS OVERALL WATER BUDGET

- Water Budget based on an interactive surface and ground water model, called SHARP.
- A first principle model simulation on an hourly basis.
- Model uses historical data for E, P, and soil permeability parameters.
- Model can set any treatment level.
- Model can also use irrigation as an alternative



BRIARWOOD LAKES WATER BALANCE



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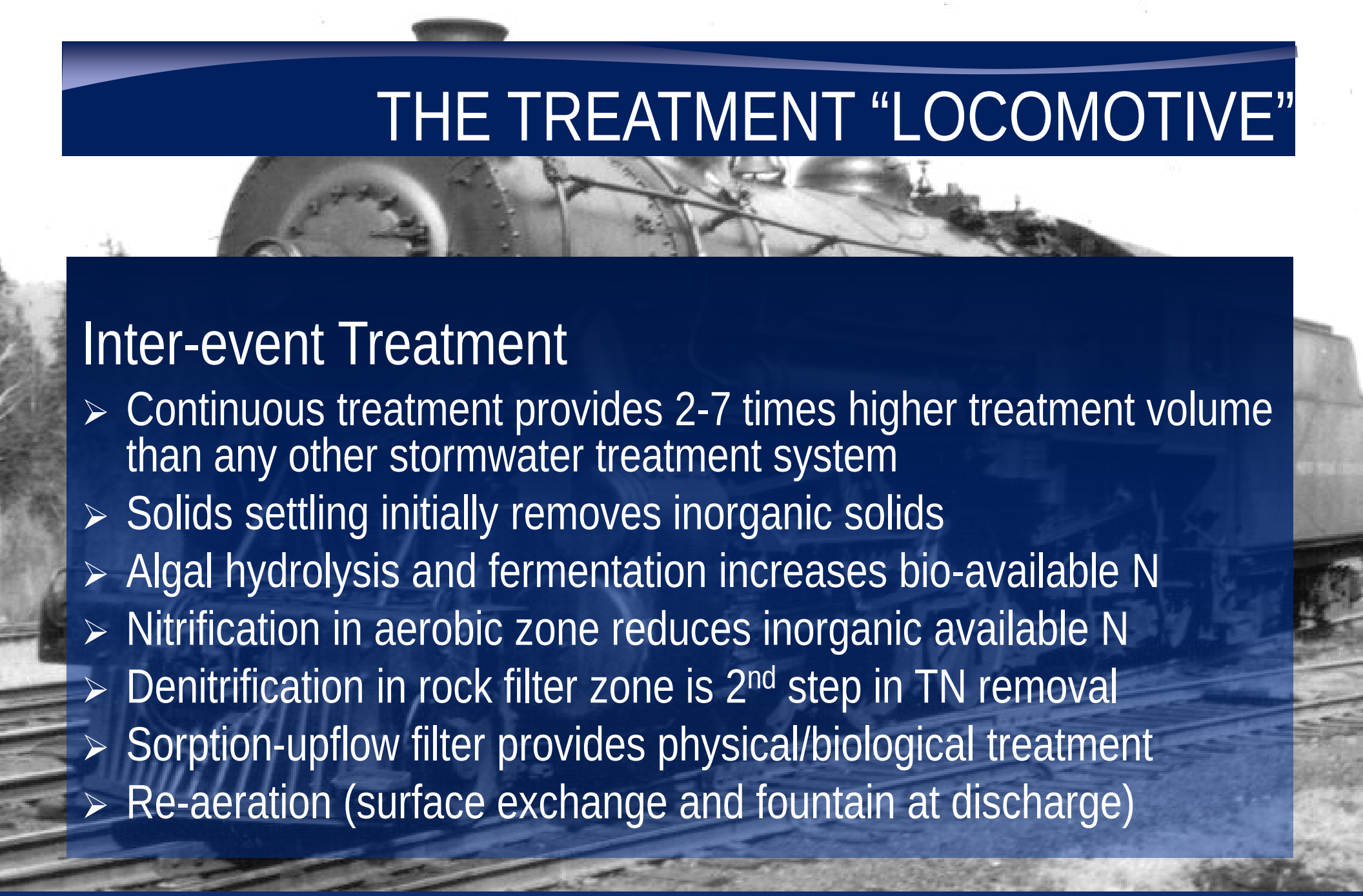
UPFLOW FILTER FLEXIBLE DESIGN

FILTER OPERATIONS CRITERIA	BATCH FLOW	LOW FLOW	HIGH FLOW	REVERSE FLOW (BACKWASH)
SINGLE FILTER SURFACE AREA (SF)	3040	3040	3040	3040
B&G MEDIA DEPTH, FT	2	2	2	2
AVERAGE FLOW RATE PER FILTER CELL (GPM)	125.0	187.5	375.0	750.0
FILTER APPLICATION RATE (GPM/SF)	0.1645	0.2467	0.4934	0.9868
LABORATORY FALLING HEAD MEASURED B&G PERMEABILITY (IN/HR)	228	228	228	228
MINIMUM DESIGN CONSTANT VERTICAL PERMEABILITY FOR EFFECTIVE FILTRATION (IN/HR)	15.8	23.7	47.5	-95.0
FILTER RESIDENCE TIME IN B&G (HRS)	1.5	1.0	0.5	0.3

THE MISSION-HOW TO BUILD THE TRAIN ON 6 ACRES

- Approximately 50% of TN is dissolved organic nitrogen (DON)
- 80% of the DON is “recalcitrant” (not available for biological uptake)
- High performance goals for solids removal will result in high mass removal management
- Removal of TN will require both physical and biological removal

THE TREATMENT "LOCOMOTIVE"



Inter-event Treatment

- Continuous treatment provides 2-7 times higher treatment volume than any other stormwater treatment system
- Solids settling initially removes inorganic solids
- Algal hydrolysis and fermentation increases bio-available N
- Nitrification in aerobic zone reduces inorganic available N
- Denitrification in rock filter zone is 2nd step in TN removal
- Sorption-upflow filter provides physical/biological treatment
- Re-aeration (surface exchange and fountain at discharge)

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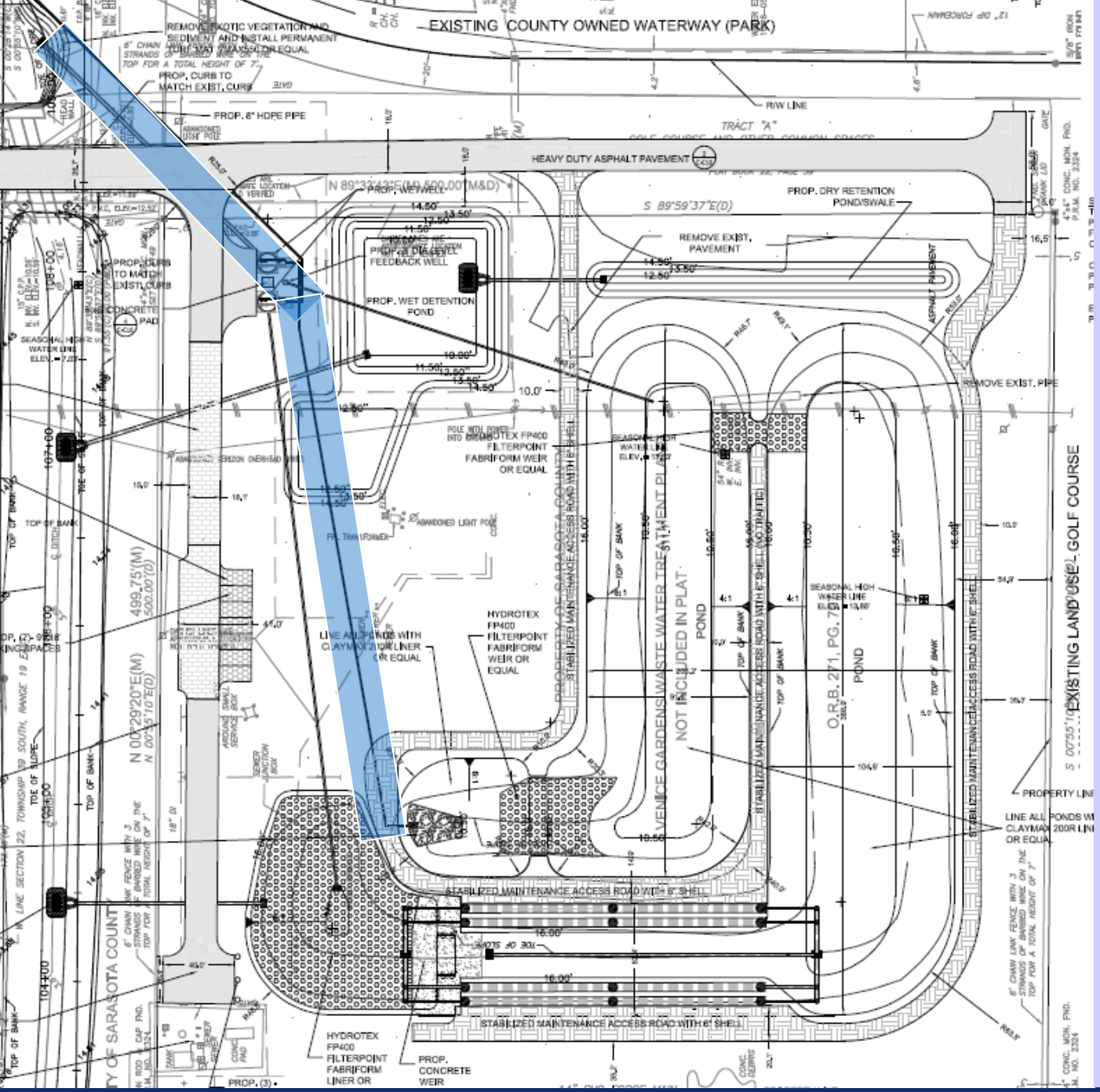
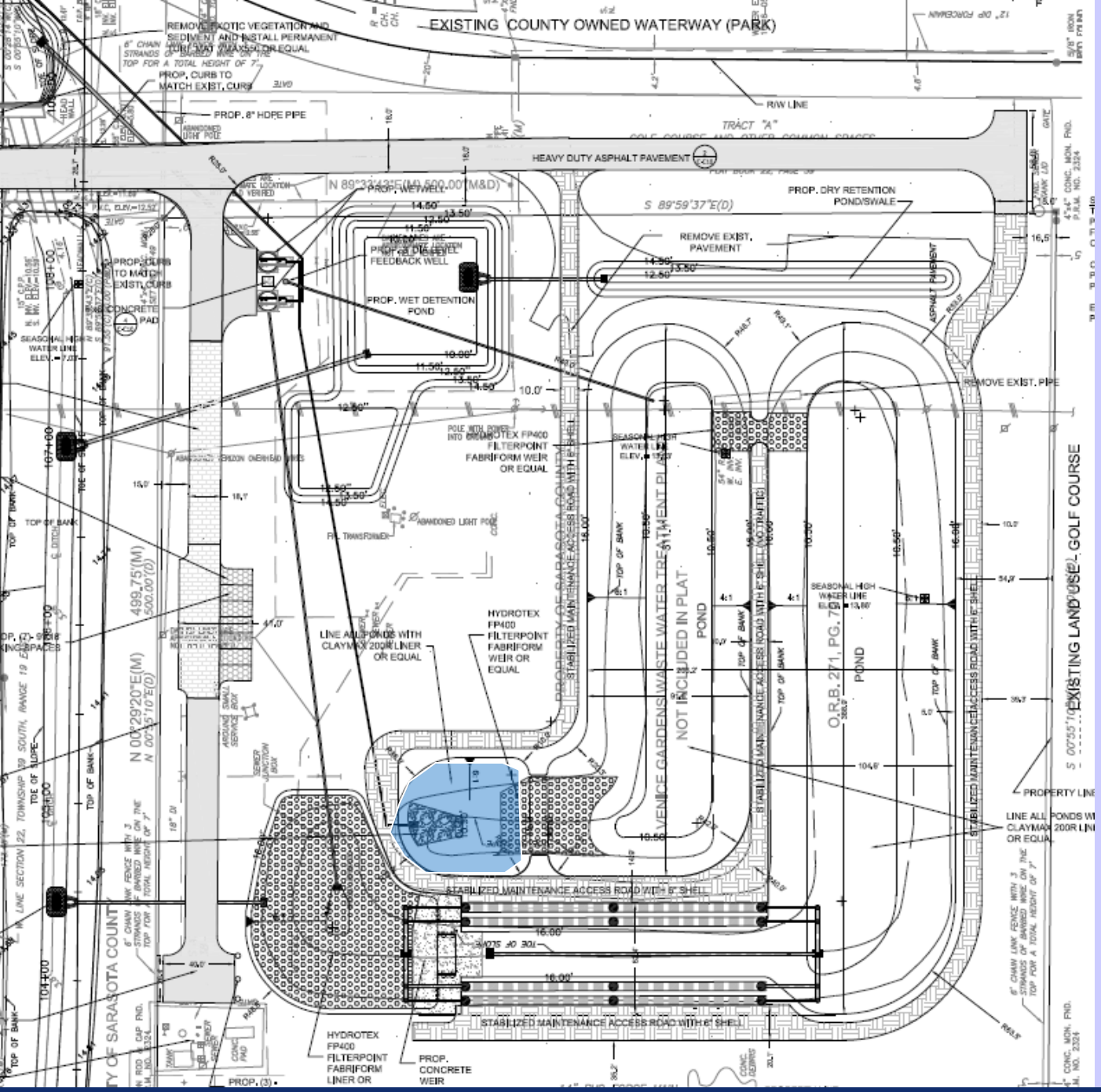


STEP 1

Flow Diversion & pump station

The influent pump station (PS-A) functions to supply the settling basin and BIST system with VFD pump controls.

Water levels in the BIST system are controlled by level controllers in the fermentation zone.



STEP 2

Settling Basin

A lined channel functions to collect settleable *inorganic* solids prior to further treatment.

Flow enters the channel as turbulent, aerated flow as it passes over a rip-rap liner

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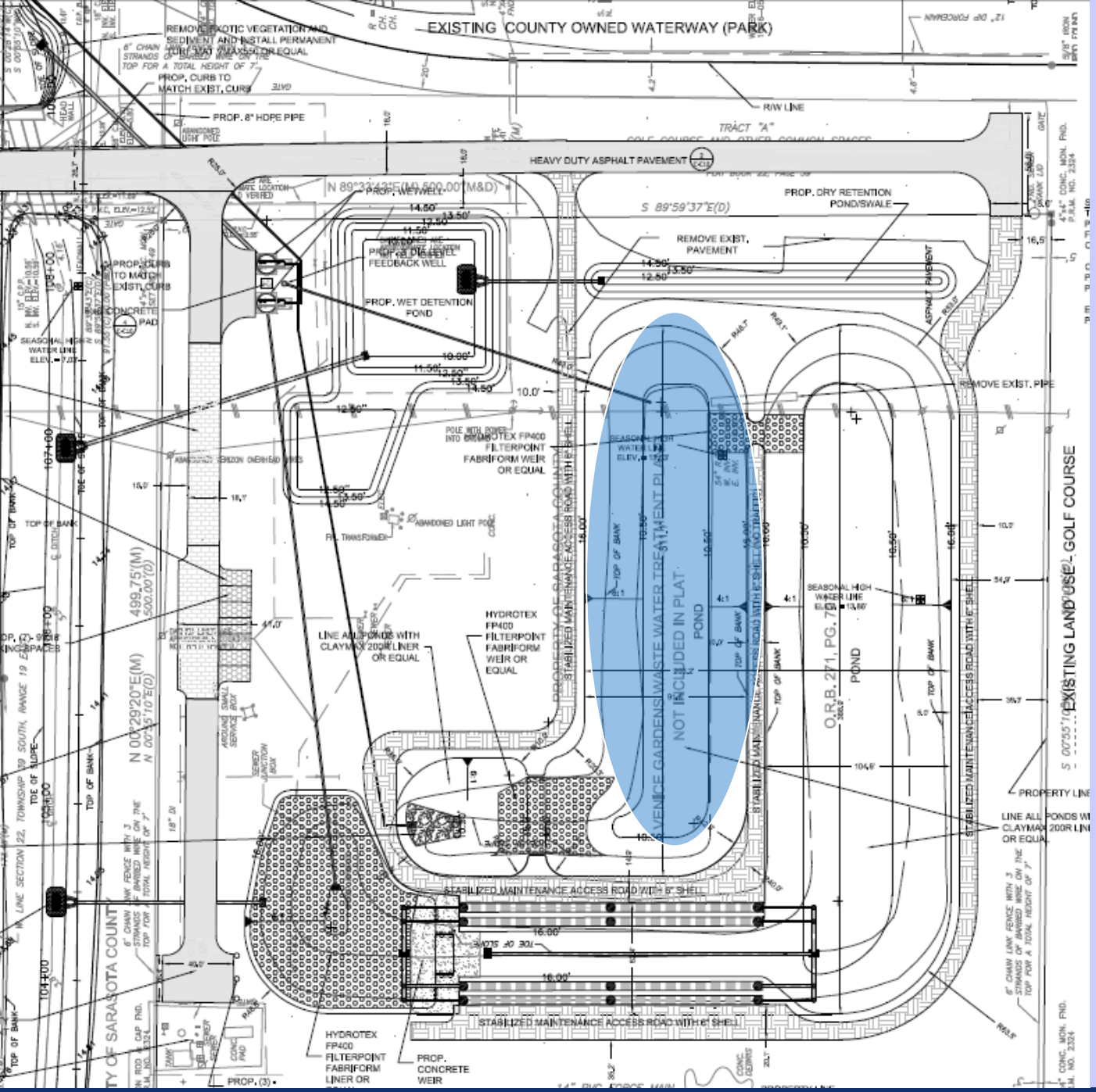
Flow leaves channel over broad crest weir structure

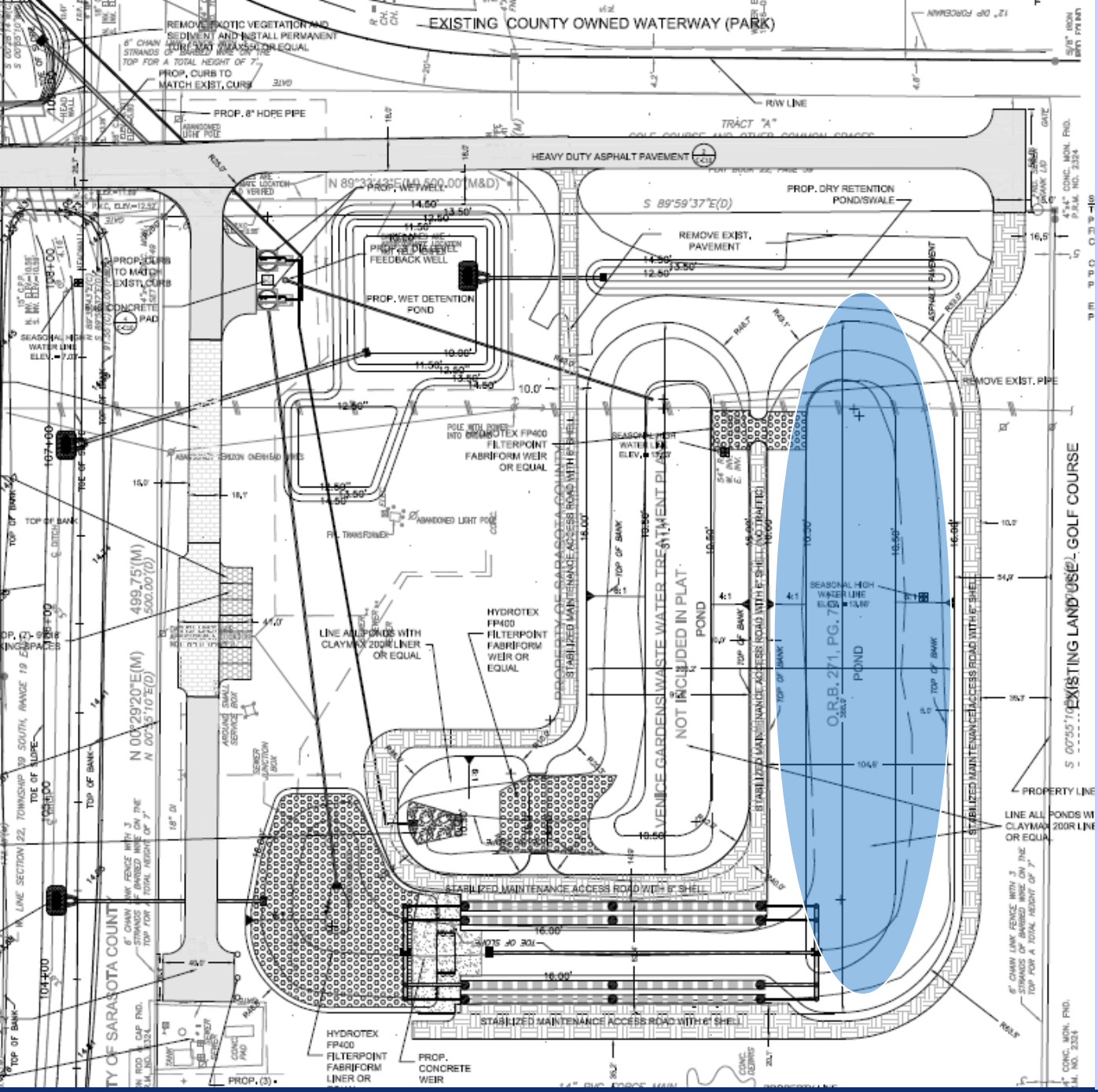
STEP 3

Fermentation Basin



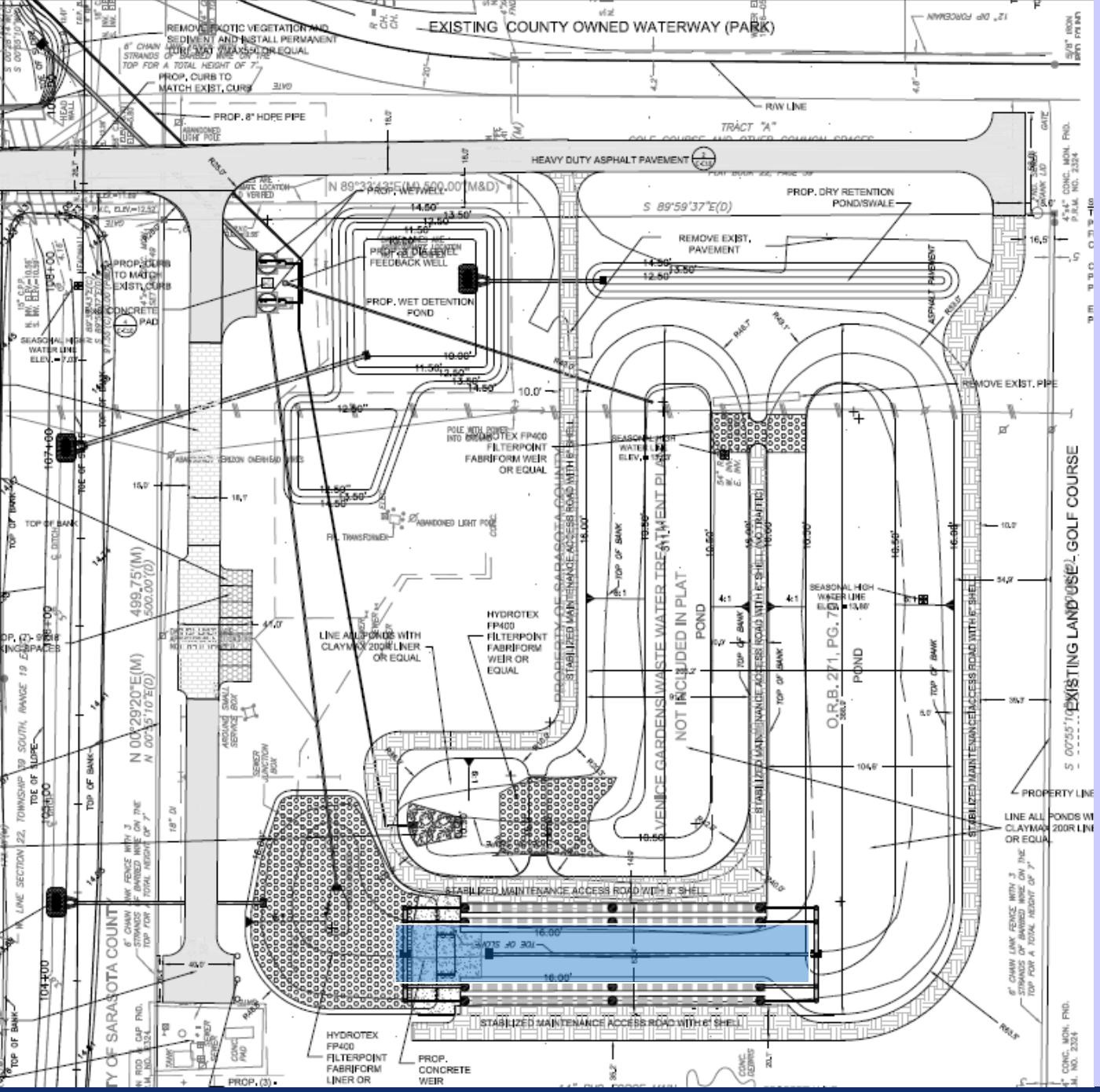
Water from settling basin passes over a broad crested weir into a basin with full macrophytic plant coverage. Organics settling, hydrolysis, fermentation, colloidal adsorption will be promoted.

STEP 4
Nitrification Zone



Water passes over a weir from the fermentation zone into an open water basin with wetland plantings in littoral shelf area.

In this basin, further settling will occur, in addition to sorption of solids on wetland vegetation, and aerobic nitrification will be promoted.



STEP 5

Denitrification Basin

Water passes through a central rock filter channel that will provide for a “rough” filtration of large macrophytes and algal mats. The 8 Ft. deep rock filter is constructed of No. 4 broken concrete rock and will provide an anoxic environment to promote denitrification processes.

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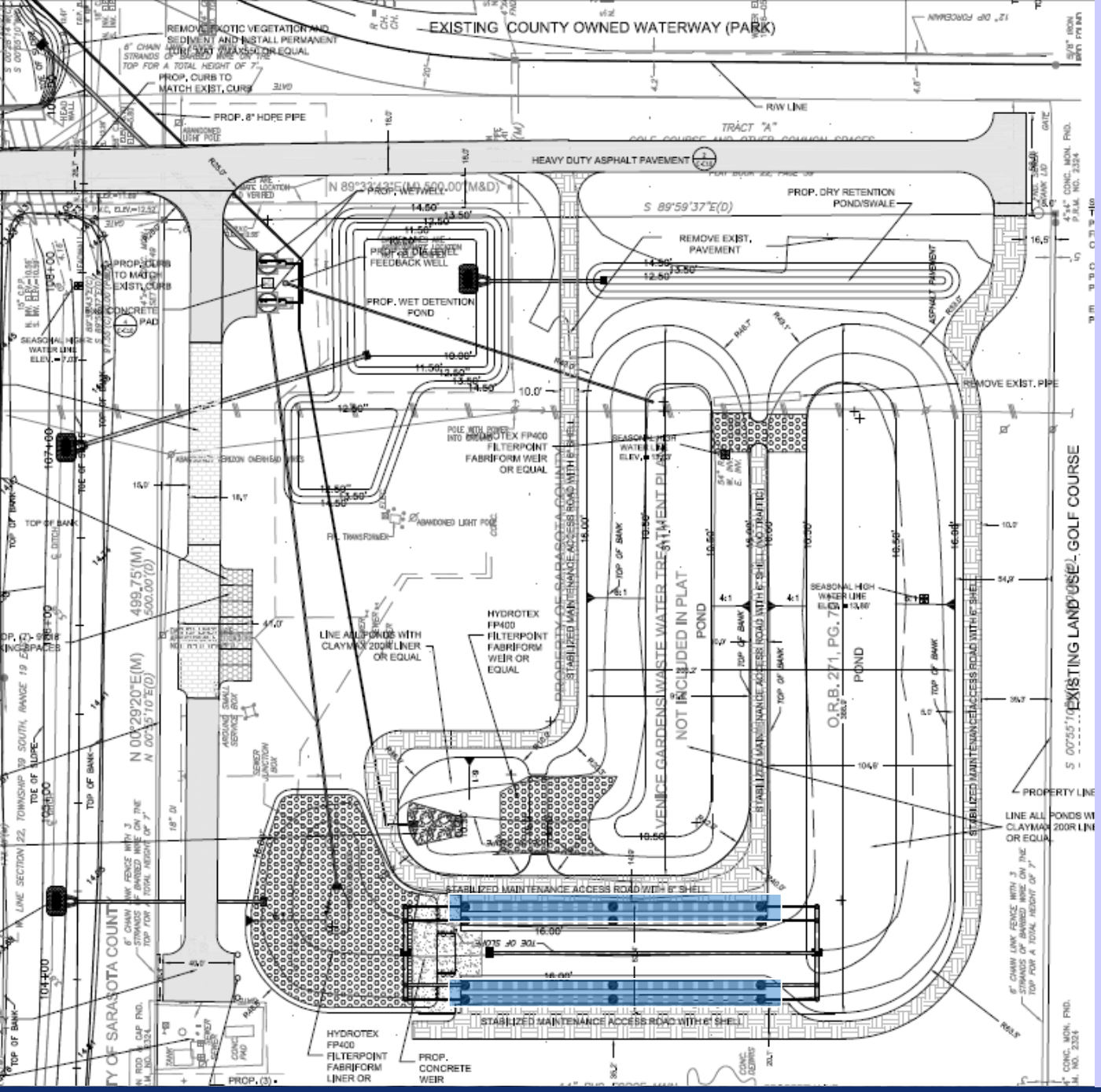


STEP 6

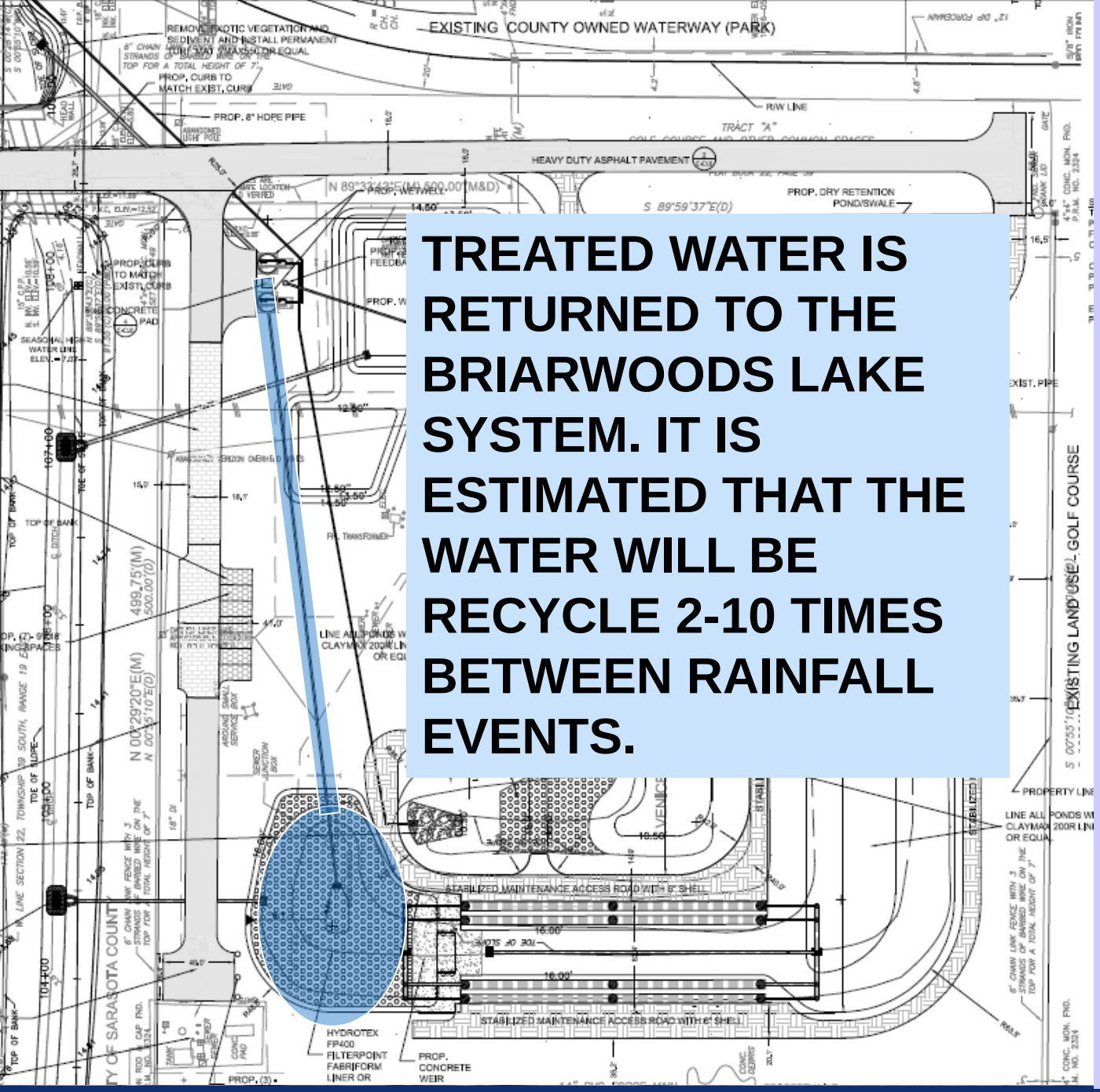
Adsorption flow filter

The adsorption upflow filter will utilize “Bold and Gold” mixed media.

The upflow filter is operated in an automatic programmed “downflow phase” to facilitate cleaning of the media filter surface.

STEP 7

Re-aeration



TREATED WATER IS RETURNED TO THE BRIARWOODS LAKE SYSTEM. IT IS ESTIMATED THAT THE WATER WILL BE RECYCLE 2-10 TIMES BETWEEN RAINFALL EVENTS.

Water from the adsorption upflow filter flows to the reaeration basin through two motor controlled gates where surface air exchange will re-oxygenate the treated water.

Water levels in the Re-aeration basin is equalized with PS-B that discharges water back to Briarwoods Lake or alternatively free discharge to canal.

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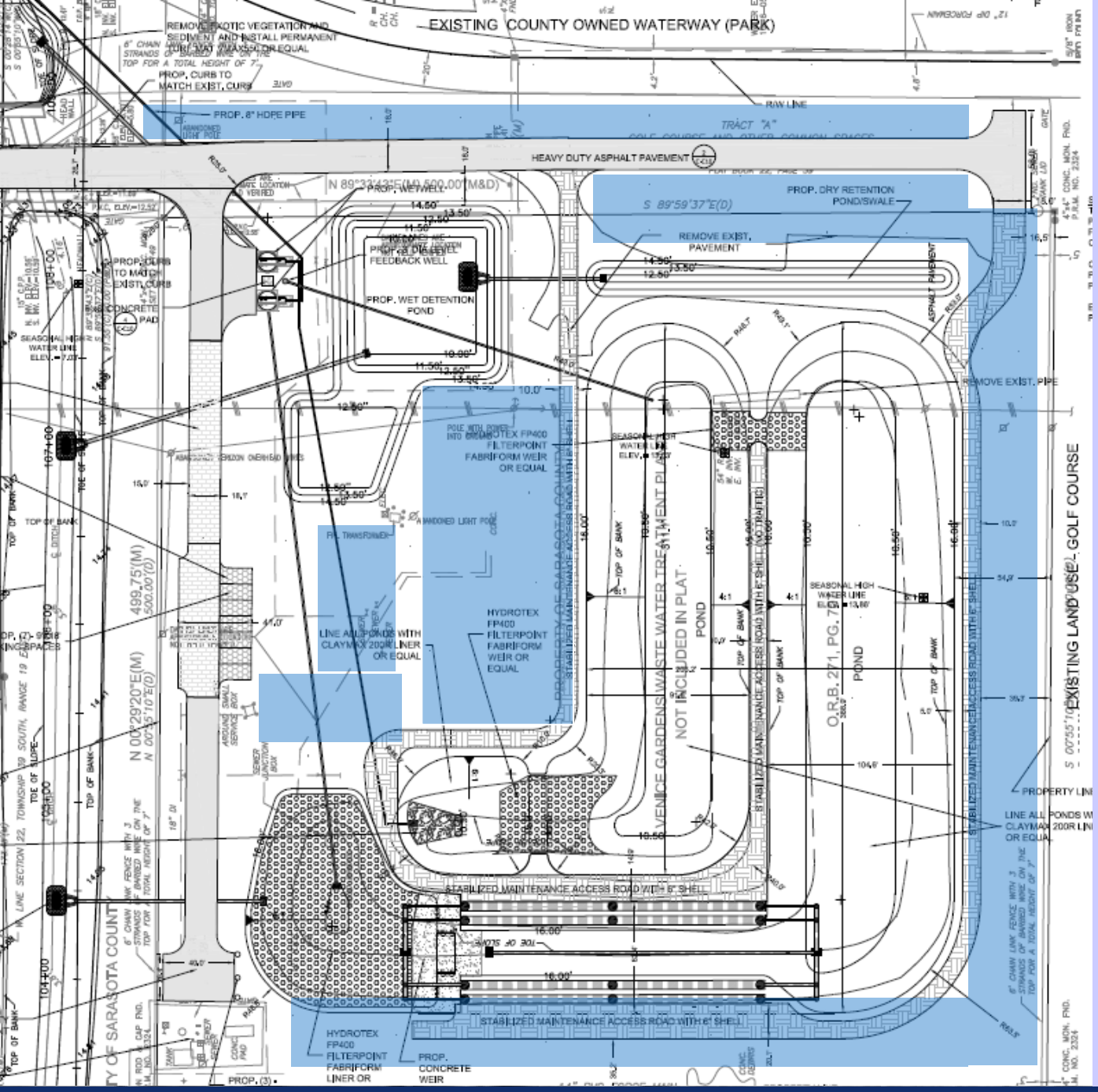

STEP 8

Stormwater Harvesting and Reuse

Stormwater is harvested for irrigation. An irrigation pump installed in PS-B will provide pressurized flow to the irrigation system.

About 2 acres of irrigable area is available at the Briarwood Treatment Site.

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THIS TREATMENT TRAIN DEMONSTRATES TRUE SUSTAINABILITY

- Briarwood Site incorporates LID Demonstration
  - Sarasota County is developing LID Manual-LID practices are proposed as part of this project;
  - "Sustainable" features include use of many "recycled" materials
- LID Practices
  - Site demonstrates LID in pervious pavements, bioswales, and the prescribed treatment technologies for the watershed
  - Treatment optimizes biological uptake and managed biomass harvesting
  - Site includes stormwater harvesting as part of treatment train

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BOLD AND GOLD MEDIA MIX

THE HEART OF THE UPFLOW FILTER IS THE MEDIA THAT PROVIDES SORPTIVE PROPERTIES AND SURFACE AREA FOR ATTACHED GROWTH

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BOLD AND GOLD MEDIA MIX

- MIX UNIT WEIGHT (80% EC / 20% TC by volume)
- Unit weights (lbs/CF) 34 Dry 43 SSD (sat surf dry)

Characteristic	Value
Bulk Density (dry weight basis)	0.544 g/cm^3 (34 lbs/ft^3)
Bulk Density (at maximum water capacity)	0.98 g/cm^3 (61.35 lbs/ft^3)
Water Permeability	9.65 cm/min (3.80 in/min)

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CONSTRUCTION CHALLENGES

Building a Locomotive Requires Design Innovation ….and Patience!

- Innovation from the pipe suppliers-over 600 LF of 60 inch pipe and special fittings
- Blending of Bold and Gold, and installation within pipe filter
- Consideration of maintenance-filter backwash (low pressure reversal of flow)
- Lots of design development and contractor interaction
- Consider value added improvements in design

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THE CONTRACTOR DEMONSTRATED INNOVATION IN TRANSFER OF THE MEDIA!

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INTERNAL MEDIA INSTALLATION IN THE FILTER PIPES WAS MADE SIMPLE!

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THE FINISHED FILTER AREA-TWO FILTER SYSTEMS IN ONE!

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FINAL REAERATION BASIN AND AUTOMATED BACKWASH CONTROLS

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20 HP SUBMERSIBLE PUMPS-USE VFD CONTROLS IN BOTH PUMP STATIONS!

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CONSTRUCTION COSTS

Current construction contract (Tampa Contracting Services)

- Total Contract Amount $ 1,853,969.45
- Briarwood Treatment Locomotive $ 1,650,000.00 (estimated for Briarwoods alone)

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OPERATIONAL OPTIONS-BATCH FLOW

TREATMENT AREA	AVERAGED APPLIED FLOW (GPM)	CHANNEL VELOCITY (FT/S)	HYDRAULIC HEAD, FT	AVERAGE DETENTION TIME, HRS	AVERAGE DETENTION TIME, DAYS
SETTLING BASIN	500	0.006	0.10	1.99	0.08
FERMENTATION ZONE	500	0.004	0.10	18.78	0.78
AERATION ZONE	500	0.003	0.10	29.45	1.23
ANOXIC ZONE	500	0.004	0.10	5.07	0.21
UPFLOW FILTER NO 1	125	0.010	3.00	1.10	0.05
UPFLOW FILTER NO 2	125	0.010	3.00	1.10	0.05
UPFLOW FILTER NO 3	125	0.010	3.00	1.10	0.05
UPFLOW FILTER NO 4	125	0.010	3.00	1.10	0.05
REAERATION BASIN	500	na	2.00	1.10	0.05
INTER-EVENT STORAGE AT 72 HRS ANTECEDANT PERIOD	500	0.003	0.00	107.71	4.49
SUMMARY OF HYDRAULIC DETENTION TIME				**168.5**	**7.0**

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OPERATIONAL OPTIONS-LOW FLOW

TREATMENT AREA	AVERAGED APPLIED FLOW (GPM)	CHANNEL VELOCITY (FT/S)	HYDRAULIC HEAD, FT	AVERAGE DETENTION TIME, HRS	AVERAGE DETENTION TIME, DAYS
SETTLING BASIN	750	0.008	0.10	1.33	0.06
FERMENTATION ZONE	750	0.006	0.10	12.52	0.52
AERATION ZONE	750	0.005	0.10	19.64	0.82
ANOXIC ZONE	750	0.006	0.10	3.38	0.14
UPFLOW FILTER NO 1	187.5	0.015	3.00	0.73	0.03
UPFLOW FILTER NO 2	187.5	0.015	3.00	0.73	0.03
UPFLOW FILTER NO 3	187.5	0.015	3.00	0.73	0.03
UPFLOW FILTER NO 4	187.5	0.015	3.00	0.73	0.03
REAERATION BASIN	750	na	2.00	1.95	0.08
INTER-EVENT STORAGE AT 72 HRS ANTECEDANT PERIOD	500	0.003	0.00	71.81	2.99
SUMMARY OF HYDRAULIC DETENTION TIME				**113.6**	**4.7**

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OPERATIONAL OPTIONS-HIGH FLOW

TREATMENT AREA	AVERAGED APPLIED FLOW (GPM)	CHANNEL VELOCITY (FT/S)	HYDRAULIC HEAD, FT	AVERAGE DETENTION TIME, HRS	AVERAGE DETENTION TIME, DAYS
SETTLING BASIN	1500	0.017	0.10	0.66	0.03
FERMENTATION ZONE	1500	0.012	0.10	6.26	0.26
AERATION ZONE	1500	0.010	0.10	9.82	0.41
ANOXIC ZONE	1500	0.011	0.10	1.69	0.07
UPFLOW FILTER NO 1	375	0.030	3.00	0.37	0.02
UPFLOW FILTER NO 2	375	0.030	3.00	0.37	0.02
UPFLOW FILTER NO 3	375	0.030	3.00	0.37	0.02
UPFLOW FILTER NO 4	375	0.030	3.00	0.37	0.02
REAERATION BASIN	1500	na	2.00	0.98	0.04
INTER-EVENT STORAGE AT 72 HRS ANTECEDANT PERIOD	1500	0.009	0.00	35.90	1.50
SUMMARY OF HYDRAULIC DETENTION TIME				**56.8**	**2.4**

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CONCLUSIONS

TMDL'S AND NUMERIC NUTRIENT REQUIREMENTS DEMAND A LOCOMOTIVE APPROACH TO BE EFFECTIVE

- Consider what works from treatability studies
- Continuous treatment is a good starting point to meet *tough TMDL or Numeric Nutrient goals!*
- Understand maintenance limitations of passive treatment versus the use of chemicals

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FINALLY IT HAS BEEN SAID

"BUILD IT AND THEY WILL COME!"

The true success of our work as water resource professionals is found in environmental compatibility when mother nature moves in!

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