MAXIMIZING RESOURCE RECOVERY THROUGH SOLIDS AND ENERGY FLOW MODELING

Catherine Moskos, Arcadis

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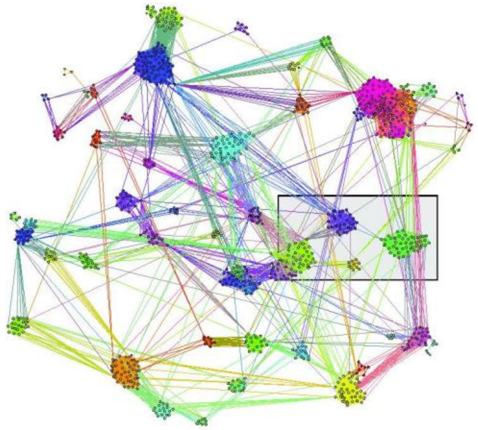
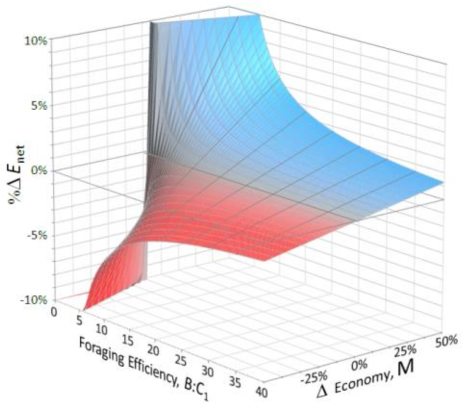
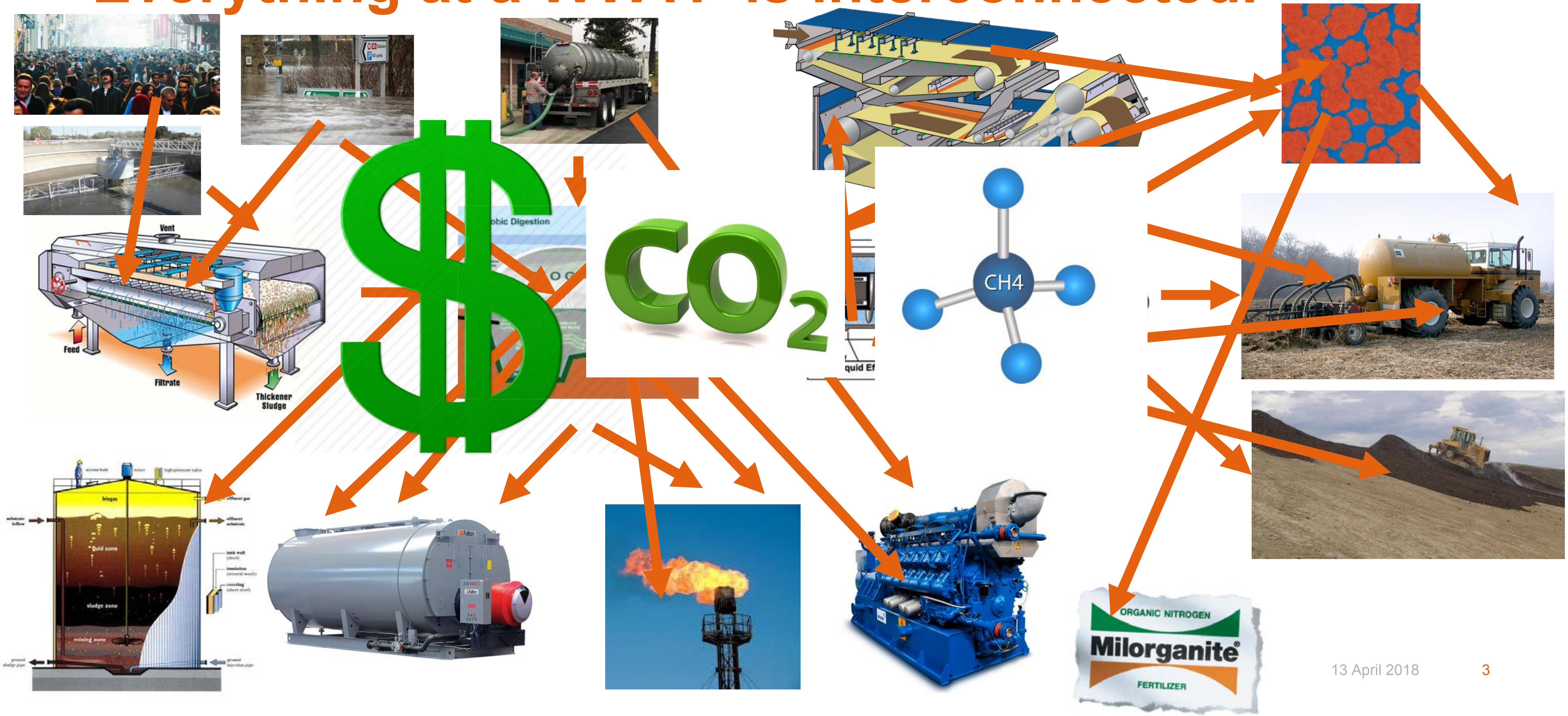
Why Do We Model?

- Difficult to measure
- Underlying math is complicated
- Too many permutations
  - 5 processes with 2 options each = $2^5 = 32$
  - 5 processes with 3 options each = $3^5 = 243$





Everything at a WWTP is interconnected.



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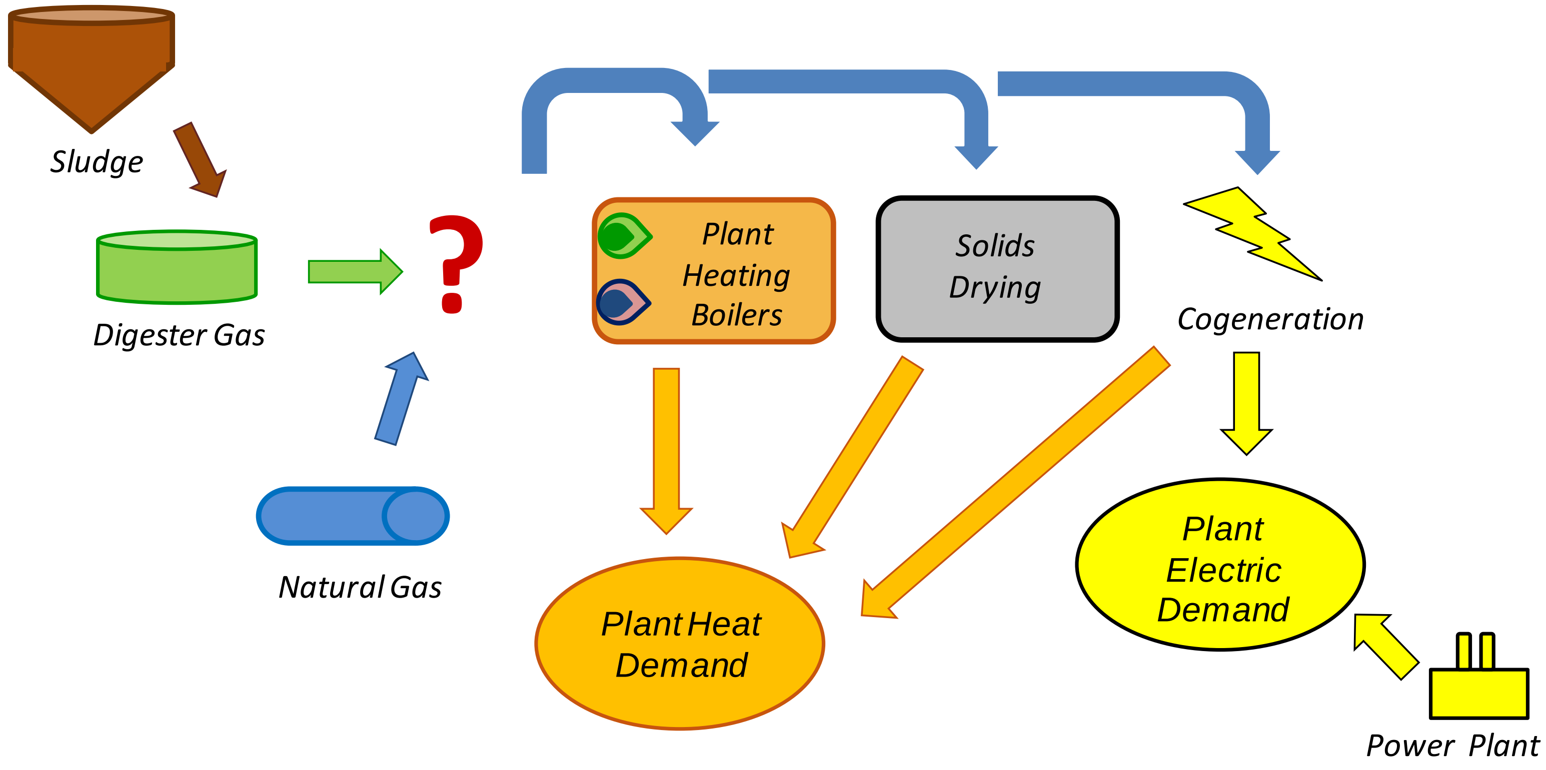


A dynamic and quantitative tool is required!

Case Studies

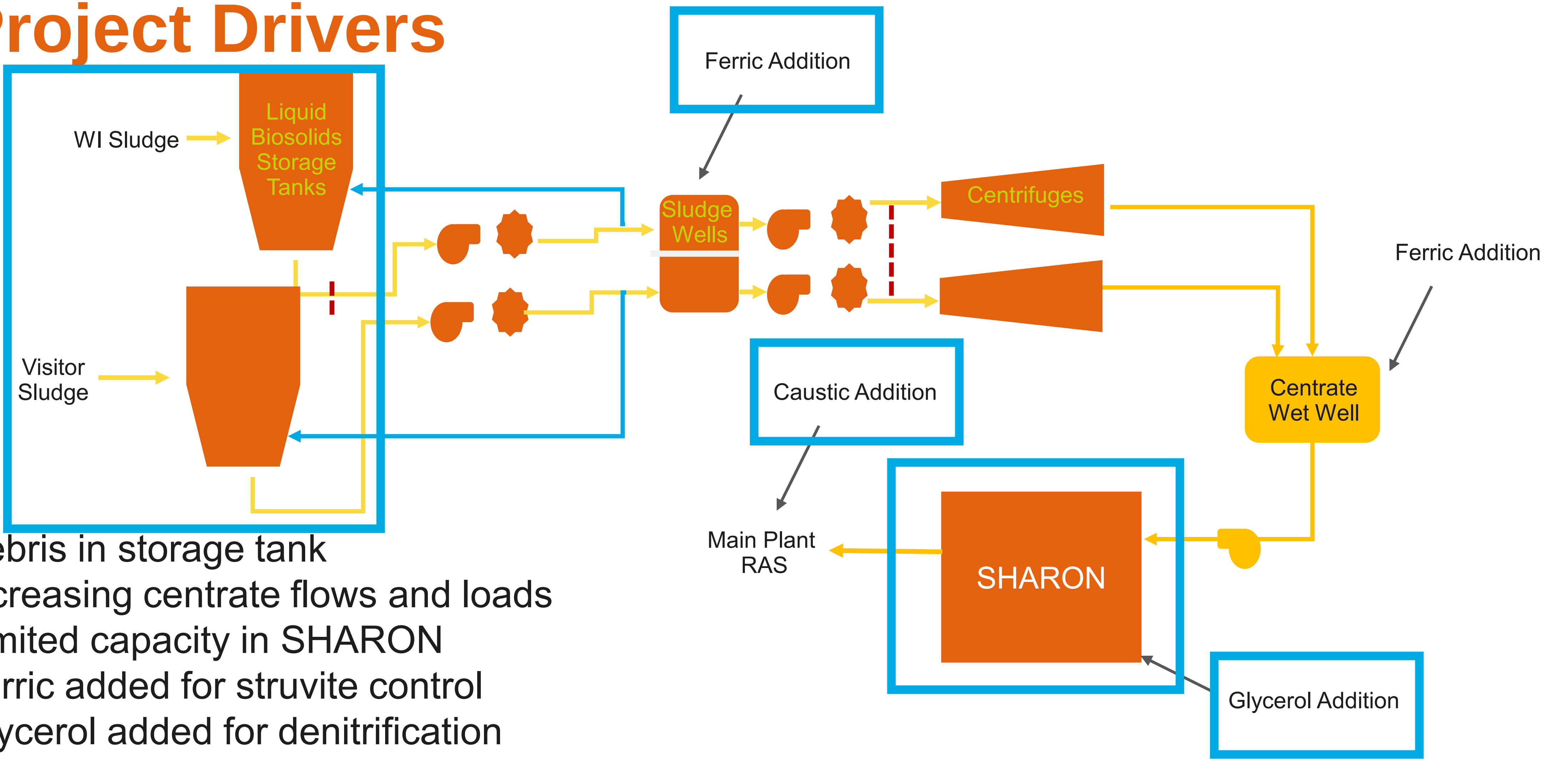
Sidestream Nutrient Management at the Wards Island WWTF - NYCDEP

Biosolids and Energy Optimization Study at the East and West Evansville Plants - EWSU

Wards Island Nutrient Management

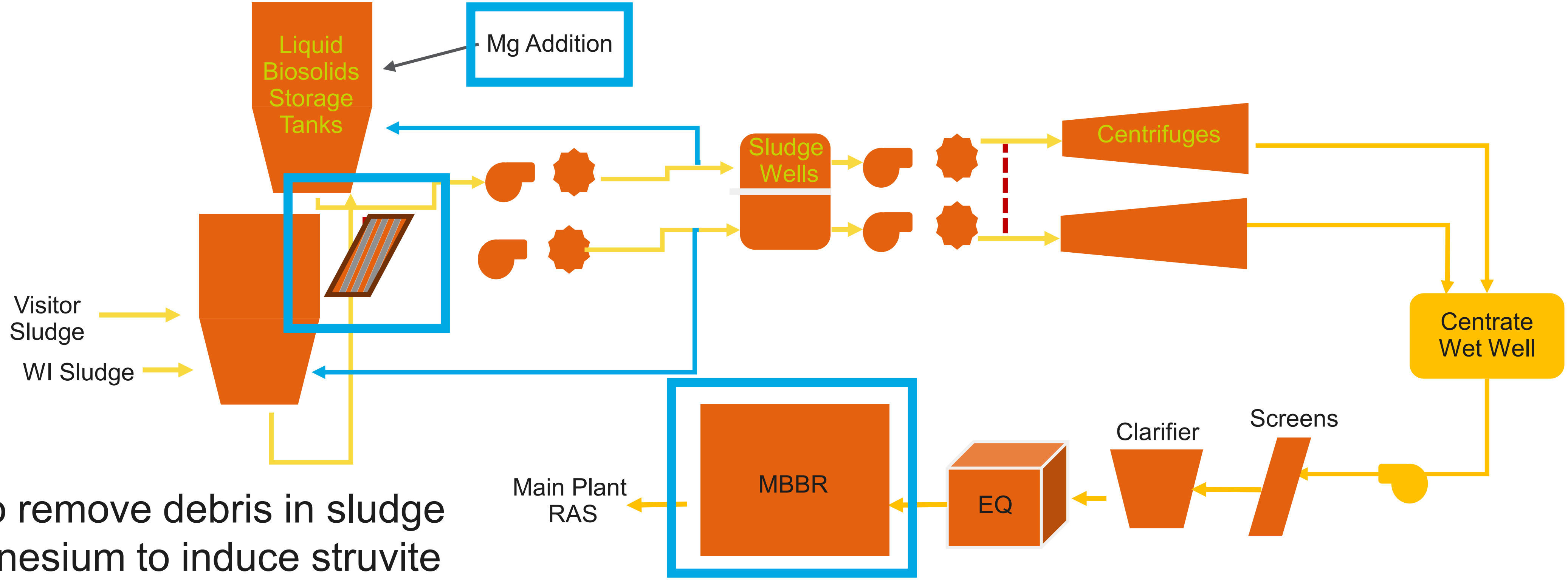
- Average Influent Flow = 275 MGD
- Central Dewatering Facility
- Solids Handling = 260 dtpd
- SHARON for Side Stream Nutrient Removal

Project Drivers



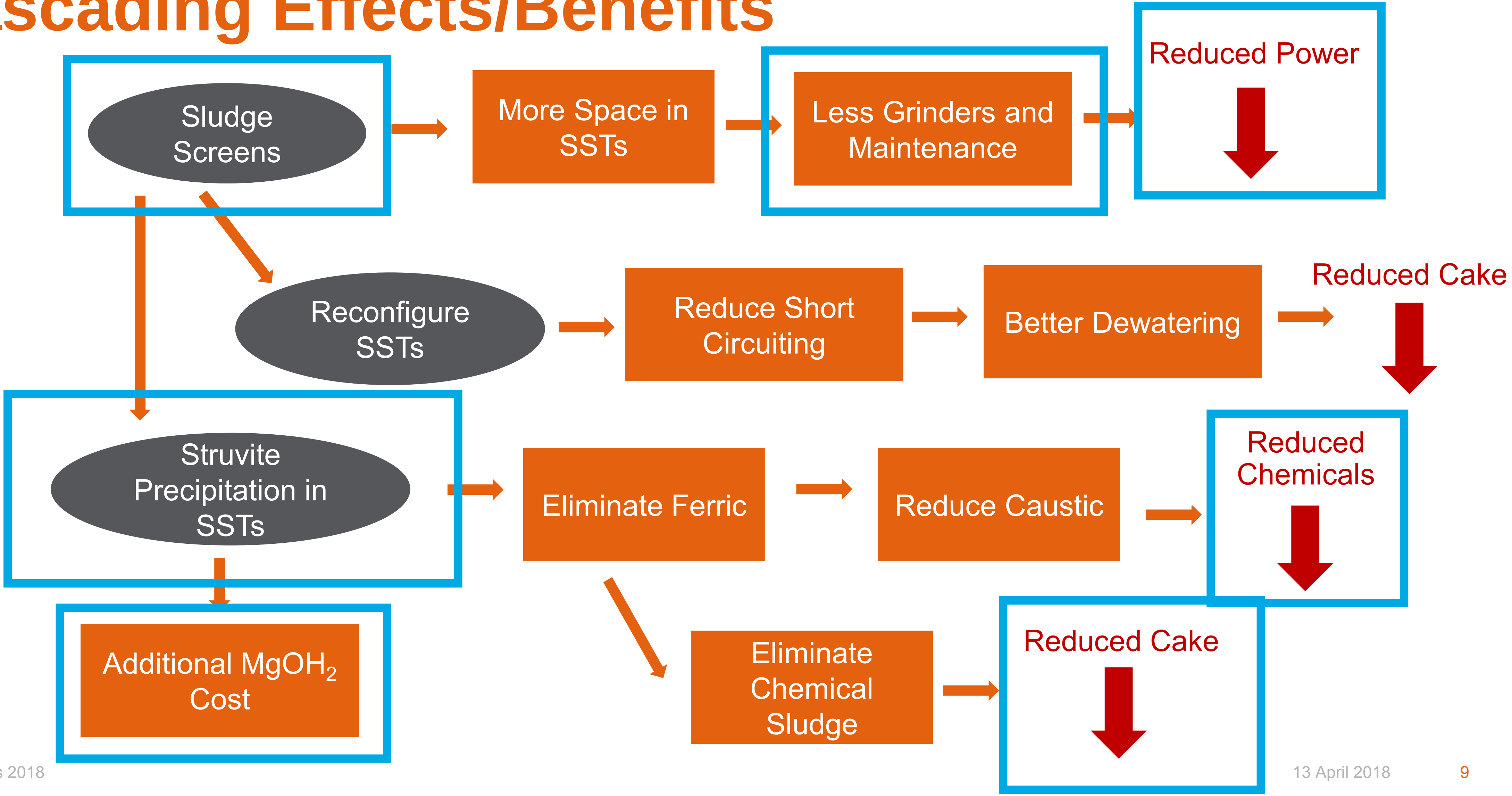
- Debris in storage tank
- Increasing centrate flows and loads
- Limited capacity in SHARON
- Ferric added for struvite control
- Glycerol added for denitrification
- Caustic added to replace alkalinity

Project Drivers



- Screen to remove debris in sludge
- Add magnesium to induce struvite precipitation
- Increase centrate treatment capacity while maintaining current air/power draw
- Eliminate ferric, caustic, and glycerol

Cascading Effects/Benefits



Modeling to Capture Cascading Effects

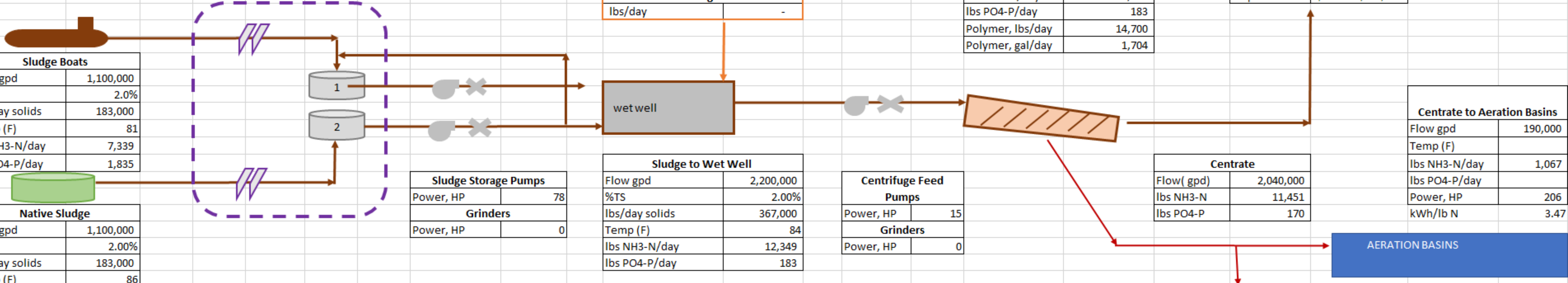
Sludge Scenario	
Design	
Flow by Gravity	OFF

Induced Struvite Reactor		
ON	Power, HP	64
	MgOH2 lbs/day	13,045
	gal MgOH2/day	1003

Chemical Addition	
Ferric dose, gal/MG	0
Ferric gal/day	-
Caustic, gal/day	-
Chemical Sludge Produced	
lbs/day	-

To Centrifuge	
Flow gpd	2,200,000
%TS	2.00%
lbs/day solids	366,000
lbs NH3-N/day	12,349
lbs PO4-P/day	183
Polymer, lbs/day	14,700
Polymer, gal/day	1,704

Cake Off Load	
%TS	27.5%
lbs/day solids	358,972
wtpd	653
Disposal Cost	$ 25,728,000



Sludge Boats	
Flow gpd	1,100,000
%TS	2.0%
lbs/day solids	183,000
Temp (F)	81
lbs NH3-N/day	7,339
lbs PO4-P/day	1,835

Native Sludge	
Flow gpd	1,100,000
%TS	2.00%
lbs/day solids	183,000
Temp (F)	86
lbs NH3-N/day	7,339
lbs PO4-P/day	1,835

Sludge Storage Pumps	
Power, HP	78
Grinders	
Power, HP	0

Sludge to Wet Well	
Flow gpd	2,200,000
%TS	2.00%
lbs/day solids	367,000
Temp (F)	84
lbs NH3-N/day	12,349
lbs PO4-P/day	183

Centrifuge Feed Pumps	
Power, HP	15
Grinders	
Power, HP	0

Centrate	
Flow(gpd)	2,040,000
lbs NH3-N	11,451
lbs PO4-P	170

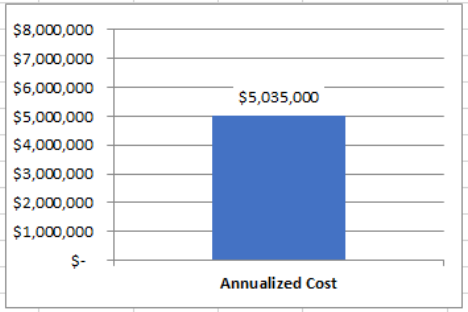
Centrate to Aeration Basins	
Flow gpd	190,000
Temp (F)	
lbs NH3-N/day	1,067
lbs PO4-P/day	
Power, HP	206
kWh/lb N	3.47

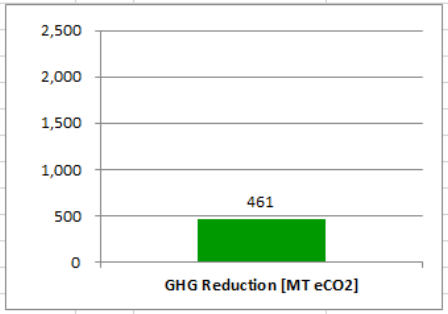
Total Nitrogen Treatment		
lbs NH3-N/day	11,451	
Power, HP	1,296	
kWh/lb N	2.03	
Glycerol	4,264	gal/day

SHARON	Flow gpd	1,850,000
ON	Temp (F)	
	lbs NH3-N/day	10,385
	Power, HP	1,089
	kWh/lb N	1.88
	scfm	13,335

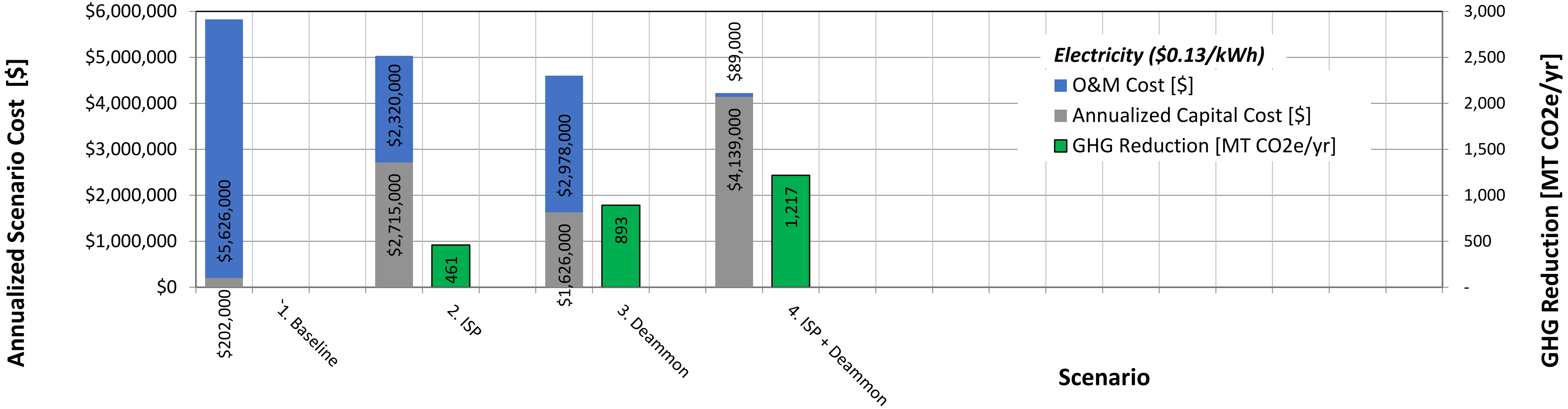
	Flow gpd	-
ANAMMOX	Temp (F)	
OFF	lbs NH3-N/day	-
Blowers	Power, HP	0
Existing	kWh/lb N	#DIV/0!
	scfm	0

Total NH3-N In	14,678	lbs/day
Total PO4-P In	3,670	lbs/day





Model Results



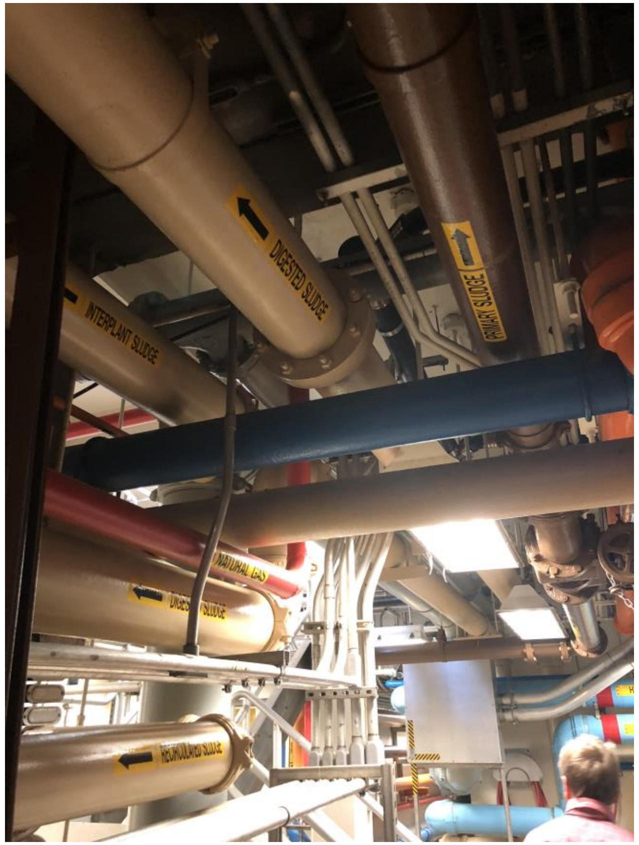
Scenario	Annualized Capital Cost [$]	O&M Cost [$]	Annualized Cost [$]	GHG Reduction [MT CO2e/yr]	Power Draw, kW
1. Refurbished SHARON at Design Loadings	$202,000	$5,626,000	$5,828,000	-	1,255
2. Add Induced Struvite Precipitation (ISP)	$2,715,000	$2,320,000	$5,035,000	461	1,083
3. Add Deammonification	$1,626,000	$2,978,000	$4,604,000	893	922
4. Add ISP and Deammonification	$4,139,000	$89,000	$4,228,000	1,217	801

Evansville Optimization Study

- Average Influent Flow = 30 MGD for both the East and West Plants
- Intraplant Transfer
- Solids Handling = 10 dtpd
- Combined Heat and Power Engines

Project Drivers

- Maximizing digester gas energy
- Optimizing imports of organic wastes to digesters
- Examine other potential technologies
- **Phase 1**
  - Assess existing operations
  - Optimization without capital expenditure
- **Phase 2**
  - Assess other optimization technologies



Model Scenarios

0: No CHP or FOG/Septage

1a: Average Baseline (Pre-October 2017)

1b: HWR and Electrical Fix, NG to CHP

1c: Average Baseline (Post-October 2017)

2: Maximize Biogas to CHP

3a: Add FOG to Theoretical Maximum Digester Capacity

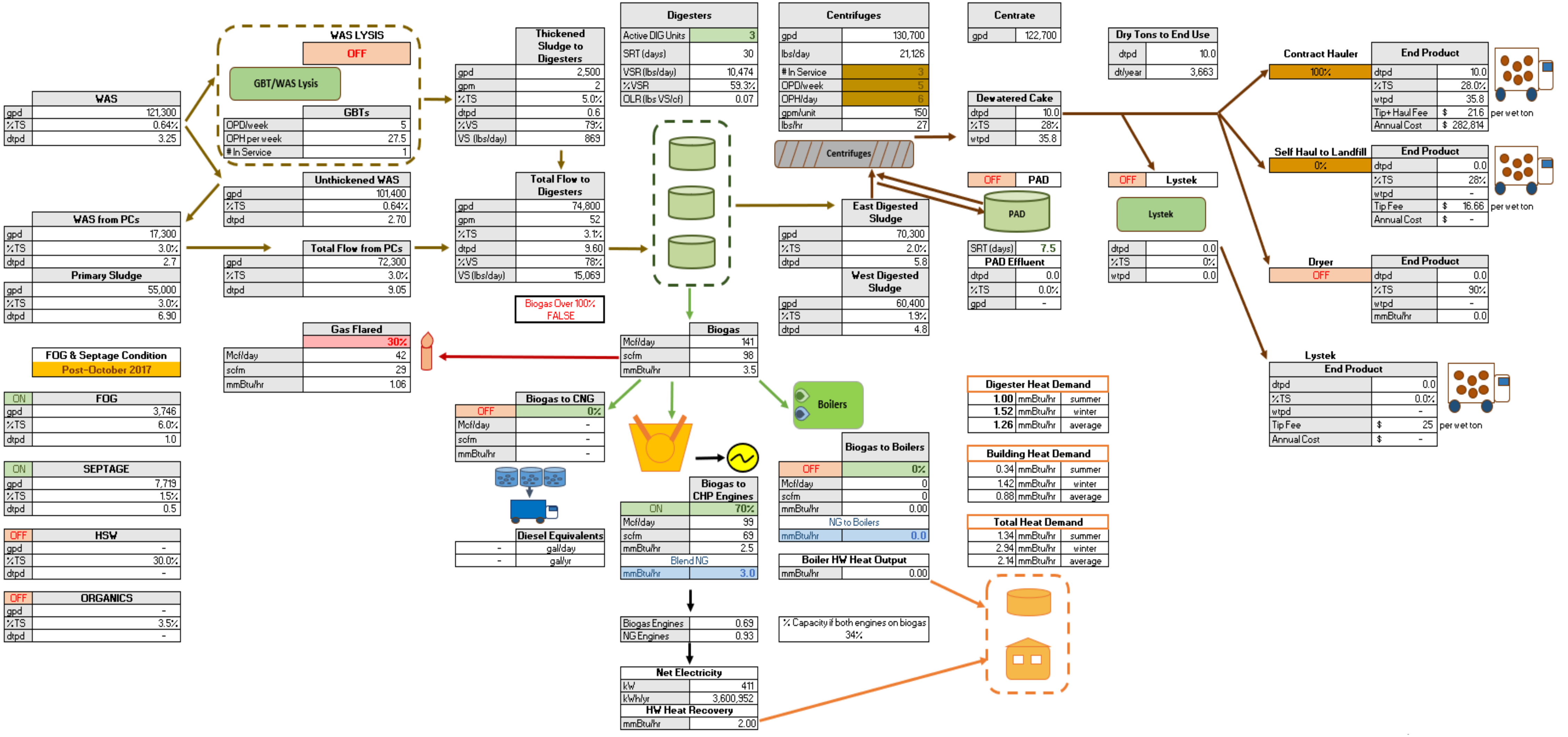
3b: Add FOG to Run Both CHP Engines on Biogas

4: Automate East Plant GBTs

5: HSW at West Plant

6: Self-Hauling Cake to Landfill

Evansville Phase 1 Model



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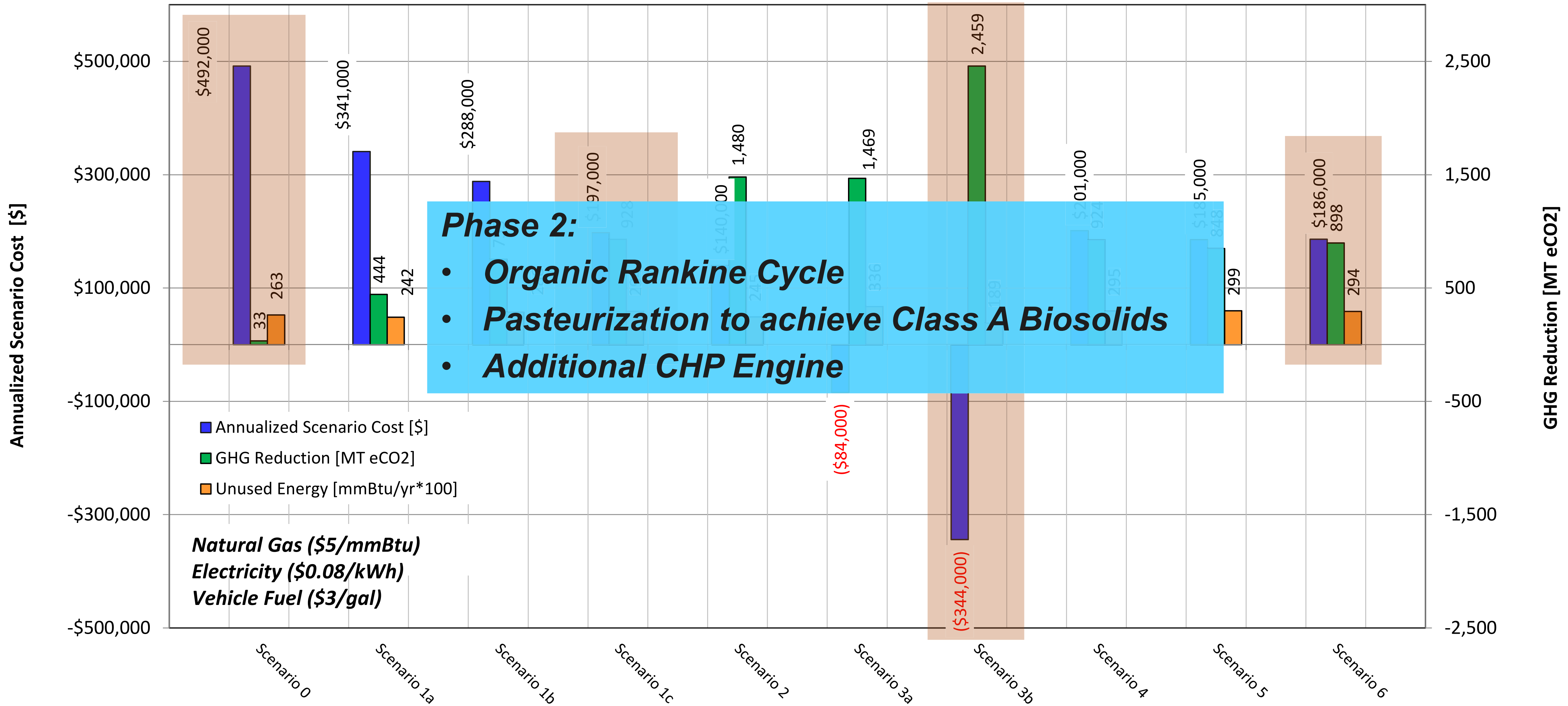


Phase 2:

- ***Organic Rankine Cycle***
- ***Pasteurization to achieve Class A Biosolids***
- ***Additional CHP Engine***

Conclusions

- Sludge has traditionally been viewed as a waste product for disposal.
- Mounting disposal and energy costs have shifted this view. Sludge is now being viewed as a valuable resource!
- Plants are looking to recover this resource, beneficially utilize digester gas, and optimize their operations.
- The Flow Model tool is user-friendly and allows plants to quantitatively investigate resource recovery options.
- We’re moving towards sustainability, energy neutrality, and comprehensive strategies for biosolids and energy management.

Solids and Energy Flow Modeling

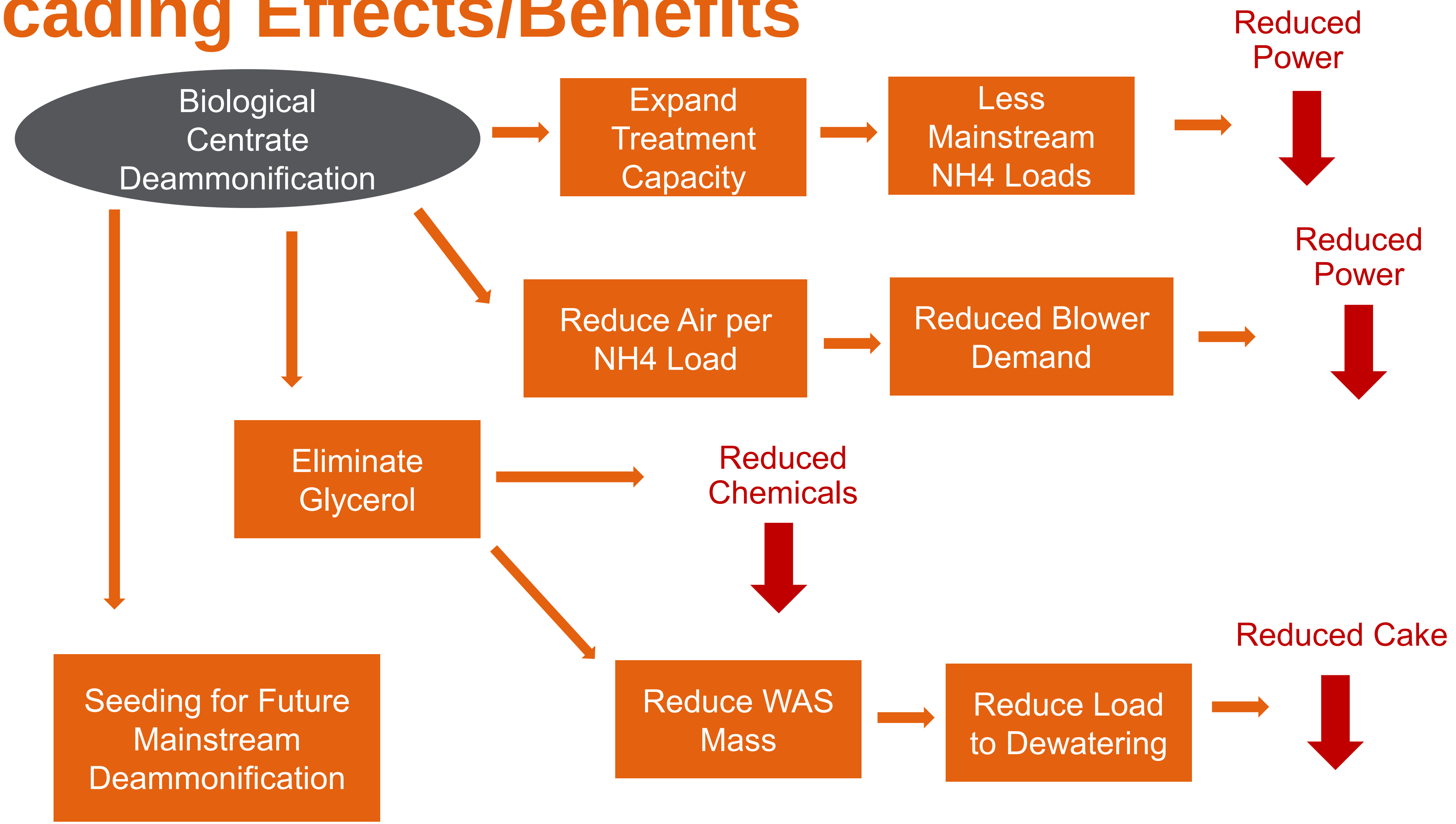
Sidestream Nutrient Management at the Wards Island WWTF - NYCDEP

NYC Environmental Protection

Biosolids and Energy Optimization Study at the East and West Evansville Plants - EWSU

Evansville WATER AND SEWER UTILITY

Cascading Effects/Benefits



West Plant Phase 1 Model

WAS	
gpd	102,000
%TS	0.57%
dtpd	2.4

WAS LYSIS	
	OFF

GBT/WAS Lysis

	GBTs
OPD/week	7
OPH per week	38.5
# In Service	1

Thickened Sludge to Digesters	
gpd	1,905
gpm	1.32
%TS	7.0%
dtpd	0.6
%VS	79%
VS (lbs/day)	869

Digesters	
Active DIG Units	3
SRT (days)	32
VSR (lbs/day)	8,000
%VSR	58.1%
OLR (lbs VS/cf)	0.07

Digested Sludge	
gpd	60,400
%TS	1.9%
dtpd	4.8

→ To East Plant

Unthickened WAS	
gpd	78,600
%TS	0.57%
dtpd	1.85

WAS from PCs	
gpd	12,500
%TS	2.5%
dtpd	1.9

Primary Sludge	
gpd	66,000
%TS	2.5%
dtpd	6.90

OFF	HSW
gpd	-

Total Flow from PCs	
gpd	78,500
%TS	2.5%
dtpd	8.20

Total Flow to Digesters	
gpd	80,405
gpm	55.84
%TS	2.6%
dtpd	8.8
%VS	79%
VS (lbs/day)	13,769

Biogas Over 100%
FALSE

Gas Flared	
	38%
Mcf/day	46
scfm	32
mmBtu/hr	1.1

Biogas	
Mcf/day	120
scfm	83
mmBtu/hr	3.0

Biogas to CNG	
OFF	0%
Mcf/day	-
scfm	-
mmBtu/hr	-

Diesel Equivalents	
-	gal/day
-	gal/yr

Biogas to Engine Driven Pumps	
ON	12%
Mcf/day	14.4
scfm	10.0
mmBtu/hr	0.4
% Pump Fuel	81%

Boilers

Biogas to Boilers	
ON	50%
Mcf/day	60
scfm	42
mmBtu/hr	1.5
NG to Boilers	
mmBtu/hr	0.5

Boiler HW Heat Output	
mmBtu/hr	1.6

Digester Heat Demand		
0.91	mmBtu/hr	summer
1.46	mmBtu/hr	winter
1.19	mmBtu/hr	average

Building Heat Demand		
0.09	mmBtu/hr	summer
0.79	mmBtu/hr	winter
0.44	mmBtu/hr	average

Total Heat Demand		
1.00	mmBtu/hr	summer
2.25	mmBtu/hr	winter
1.63	mmBtu/hr	average

EWSU Process Flow