MASTER PLANNING NEW PHOSPHORUS LIMITS & ASSET MANAGEMENT NEEDS

Dayton, Ohio

Water Reclamation Facility

Presenters:

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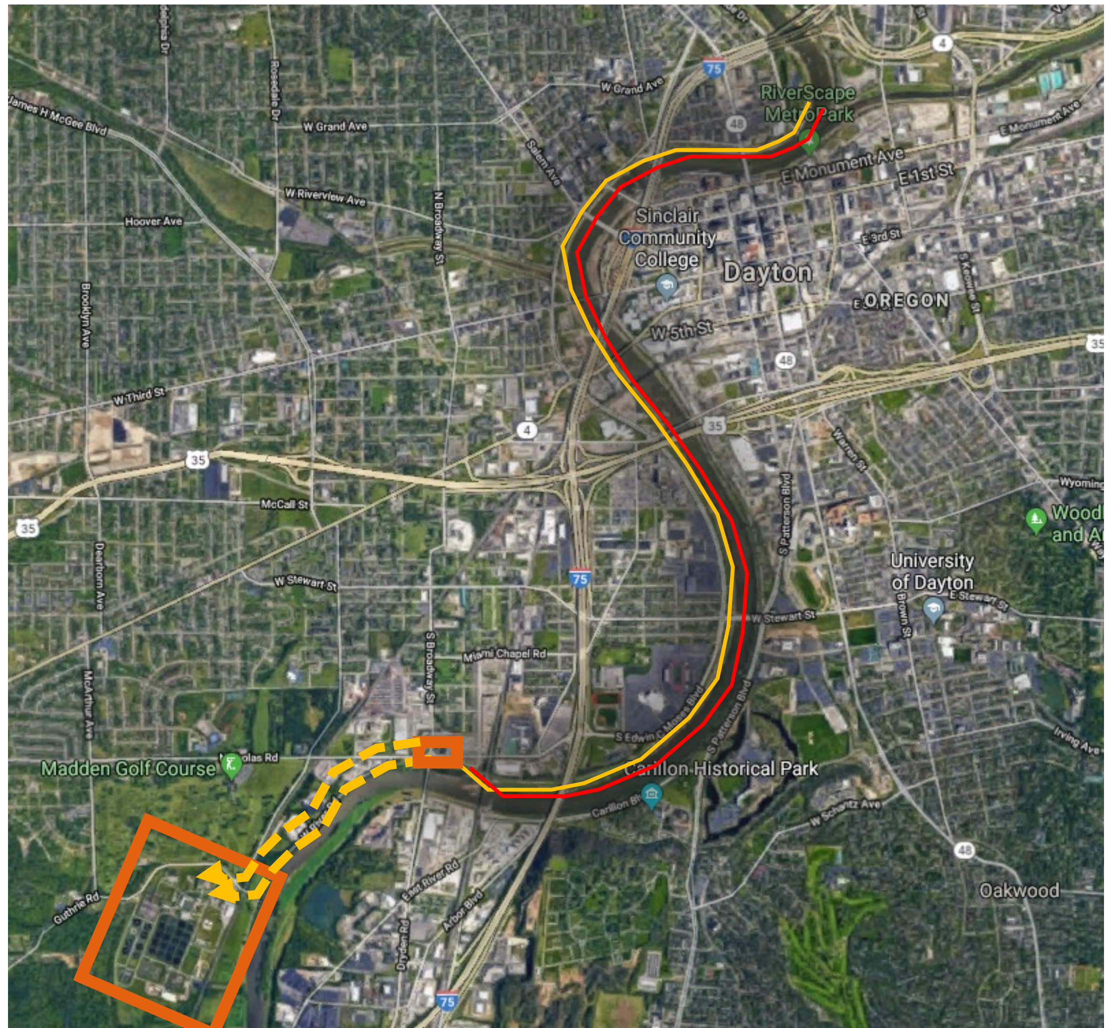
Associate firms

	CAD Concepts Inc. (CCI)	Electrical Assessment
	Kabil Associates	Structural Assessment
	PCS Technologies	I&C Assessment
	Gerkin Swafford Engineering Solutions	Civil/Mechanical Assessment, Project Management Assistance
	Jones-Warner Consultants	Surveying, Utility Locating, Forcemain cost planning
	Automated Systems Engineering (ASE)	Electrical Engineering
	Burgess & Niple	Asset Management Assistance
	Andromeda Systems Inc. (ASI)	Reliability Centered Maintenance
	EmNet	Collection System Modeling
	Webster Environmental Associates	Odor Control
	Bowker & Associates	Odor Control QA/QC

Dayton Wastewater Final Infrastructure



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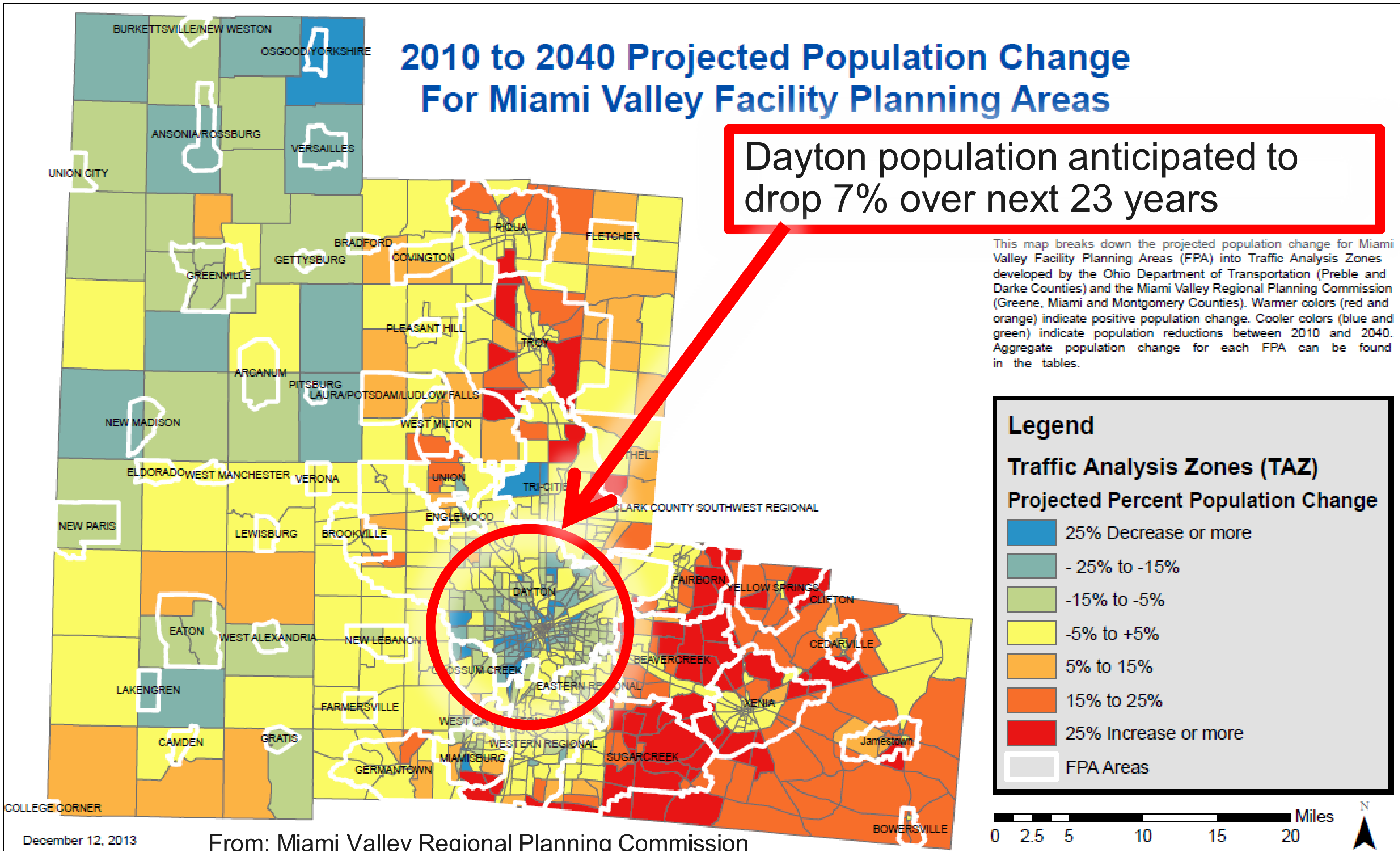
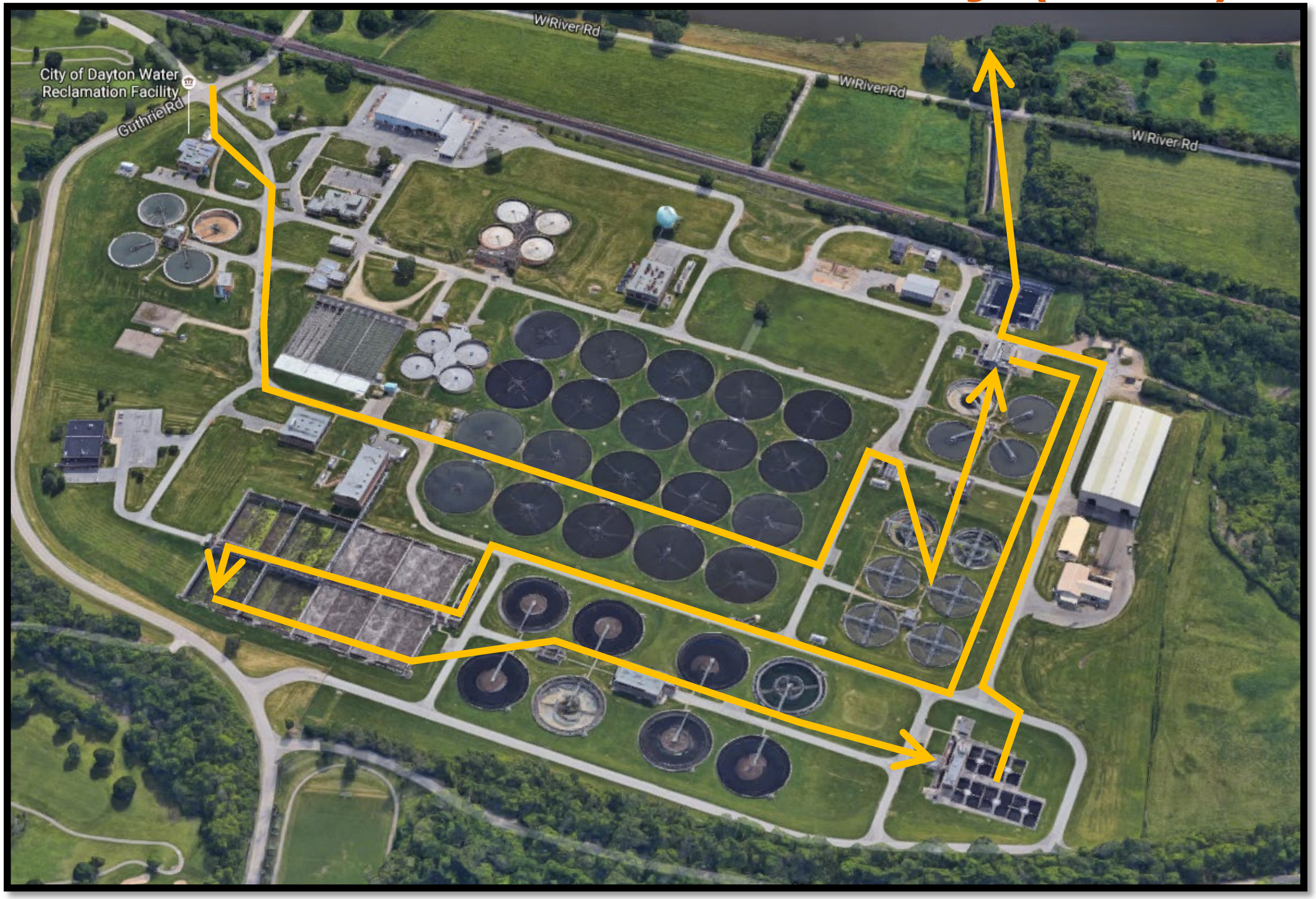
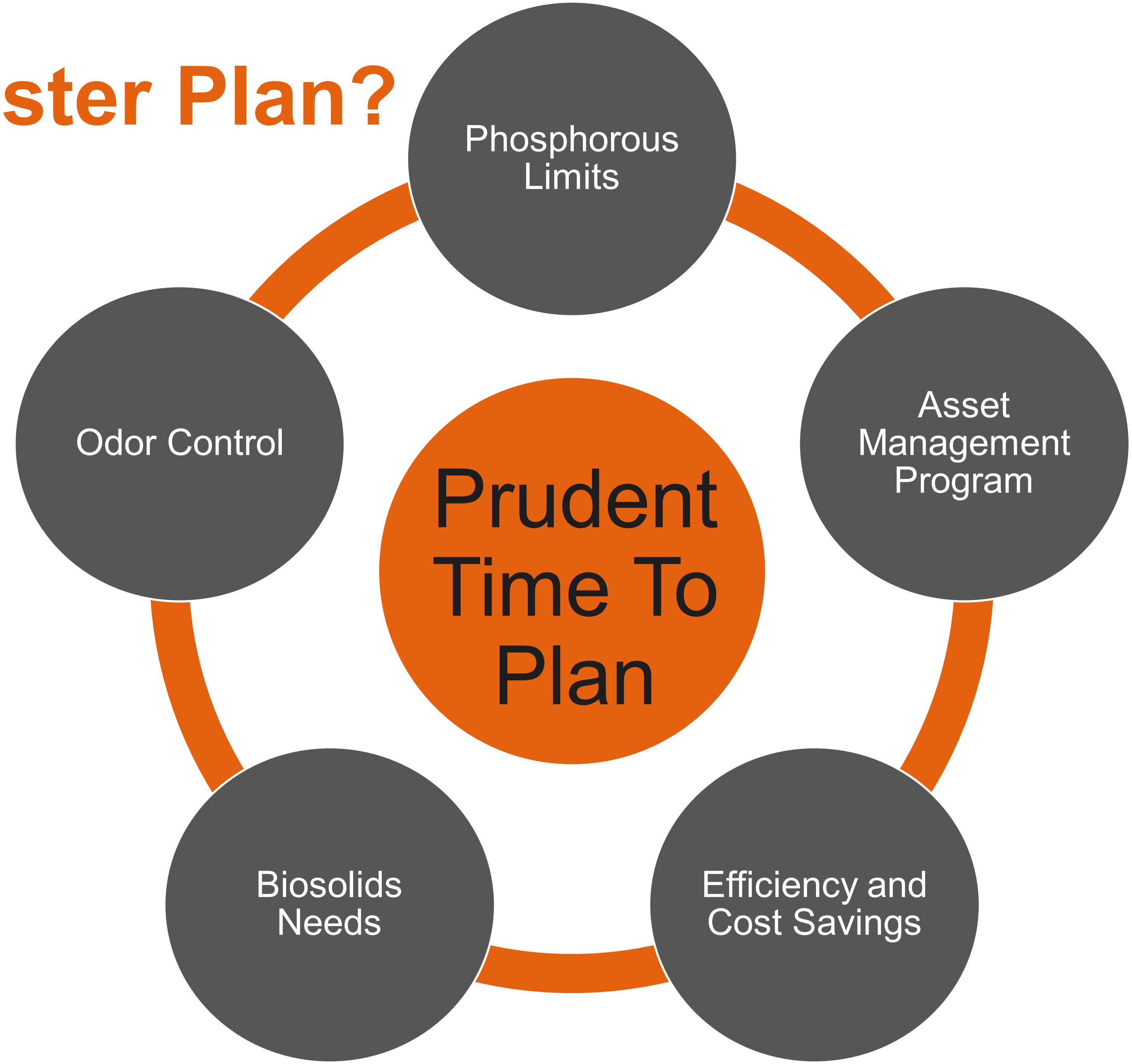
Population anticipated to drop



Dayton Water Reclamation Facility (WRF)



Why Master Plan?



Approach

Strategy

Break Plant into Parts & Establish Treatment Necessities (aka "Level of Service")

Research & Asset Data Acquisition

Historic Data And New Data

Brainstorm and Test Alternatives

For Individual Process Areas & "Entire Facility"

Assemble projects into a sequence

Determine financial forecast

Approach

1. Required to → Control Phosphorous, Improve odors
2. Need to → Maintenance/Replacement Projects
3. Should do → Status Quo or Replacement Alternatives or Sweeping change
4. Complete → Ongoing Projects

Advance all 4 simultaneously

and then evaluate best path forward

Determine the metrics: Establish Levels of Service

Criteria for each process, what it HAS to do

1. Provides firm metrics/“rules” by which alternatives must abide, which
2. enables a fair comparison between alternatives

Examples Level of Service Statements:

1. Flows: plant flows , component flows
2. *Digesters:*
   - *Maintain temperature of 98-degrees Fahrenheit in all digesters.*
   - *All recirculated digester feed to be at 98-degrees Fahrenheit (+/- 1 F).*
   - *For disposal solutions involving land application, achieve a Class B stabilized biosolid. (15 days SRT at Max Month Flow)*
   - *Process max month solids production with two digesters out of service (one east and one west out of service)…..”*

Phosphorus Limit Received

OEPA set the limit based on 1 mg/L

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1PF00000*OD

Effluent Characteristic	Discharge Limitations							Monitoring Requirements		
	Concentration Specified Units				Loading* kg/day					
Parameter	Maximum	Minimum	Weekly	Monthly	Daily	Weekly	Monthly	Measuring Frequency	Sampling Type	Monitoring Months
01220 - Chromium, Dissolved Hexavalent - ug/l	-	-	-	-	-	-	-	1/Month	Grab	All
31648 - E. coli - #/100 ml	-	-	284	126	-	-	-	1/Day	Grab	Summer
39100 - Bis(2-ethylhexyl) Phthalate - ug/l	-	-	-	-	-	-	-	1/Quarter	Composite	Quarterly
50050 - Flow Rate - MGD	-	-	-	-	-	-	-	1/Day	Continuous	All
50060 - Chlorine, Total Residual - mg/l	0.035	-	-	-	-	-	-	1/Day	Multiple Grab	Summer
50092 - Mercury, Total (Low Level) - ng/l	1700	-	-	12	0.464	-	0.00328	1 / 2 Weeks	Grab	All
51173 - Cyanide, Free (Low-Level) - ug/l	92	-	-	30	25.1	-	8.18	1 / 2 Weeks	Grab	All
51451 - Phosphorous, Total - Kg	131.64	-	-	-	-	-	-	1/Year	Calculated	December
61941 - pH, Maximum - S.U.	9.0	-	-	-	-	-	-	1/Day	Continuous	All
61942 - pH, Minimum - S.U.	-	6.5	-	-	-	-	-	1/Day	Continuous	All

g. Phosphorus seasonal loading - Phosphorus, Total - Kg (Parameter Code 51451) is actually a calculated seasonal loading in "kilograms"

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1PF00000*OD

although it is listed under a maximum concentration limit. Calculate the seasonal loading as follows: [median daily effluent flow (MGD) for period July 1 - October 31] x [median total phosphorus concentration (mg/l) for the period July 1 - October 31] x 3.7854. Round the result to two decimals and enter the calculated loading for this parameter in eDMRs once during the month of December. Also, see Part II, Item BB.

Current Phosphorus concentrations

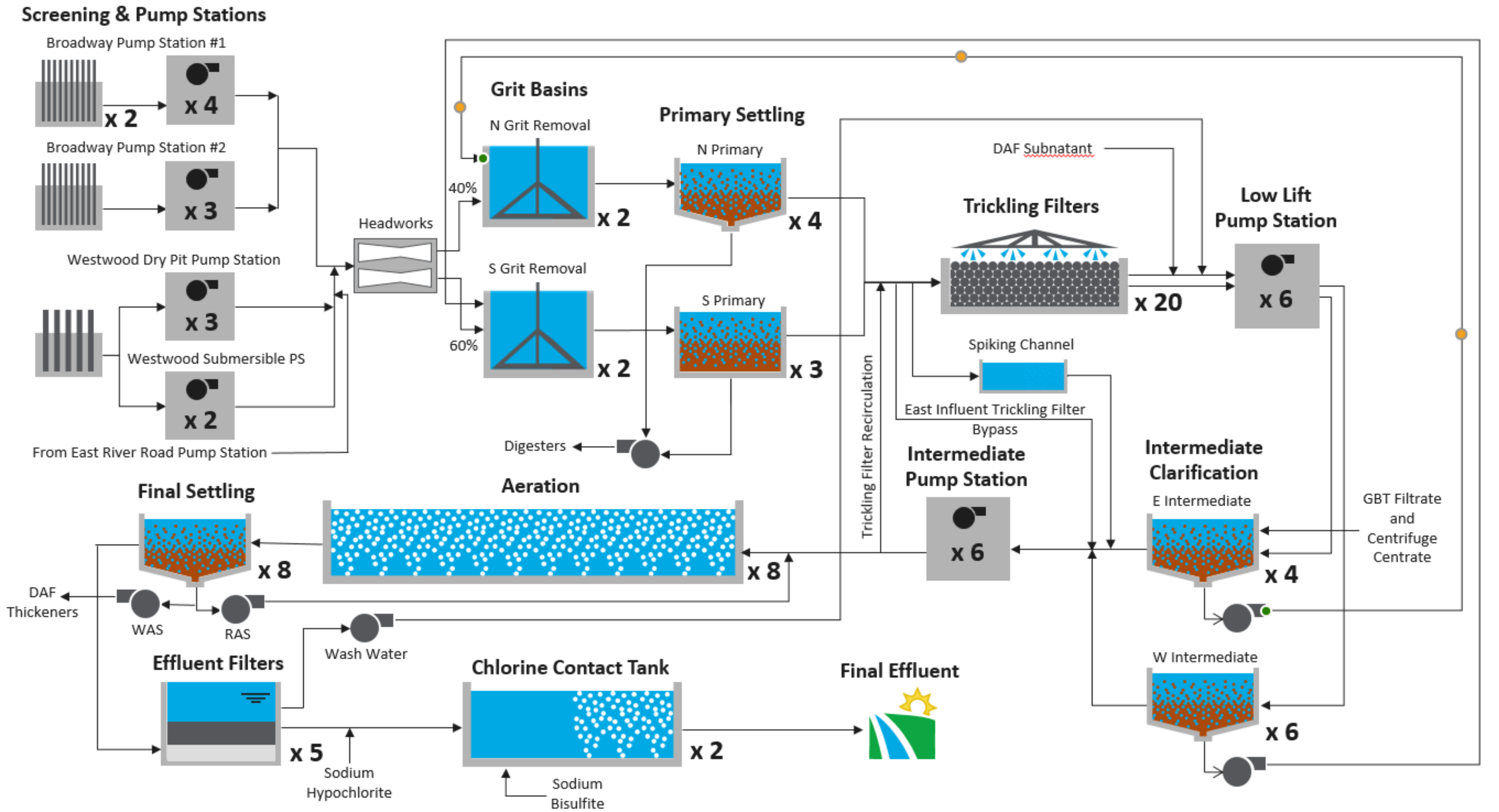
Typical Phosphorus Concentrations July 1 - October 31			
Min	Usual Range Lower limit	Usual Range Upper Limit	Max
mg/L	mg/L	mg/L	mg/L
0.28	1.0	3.0	4.0

~ 20% of samples below 1.0 mg/L

~70% in usual range 1.0 to 3.0 mg/L

~10% of sample above 3.0 mg/L

Process Modeling to evaluate proposed solutions



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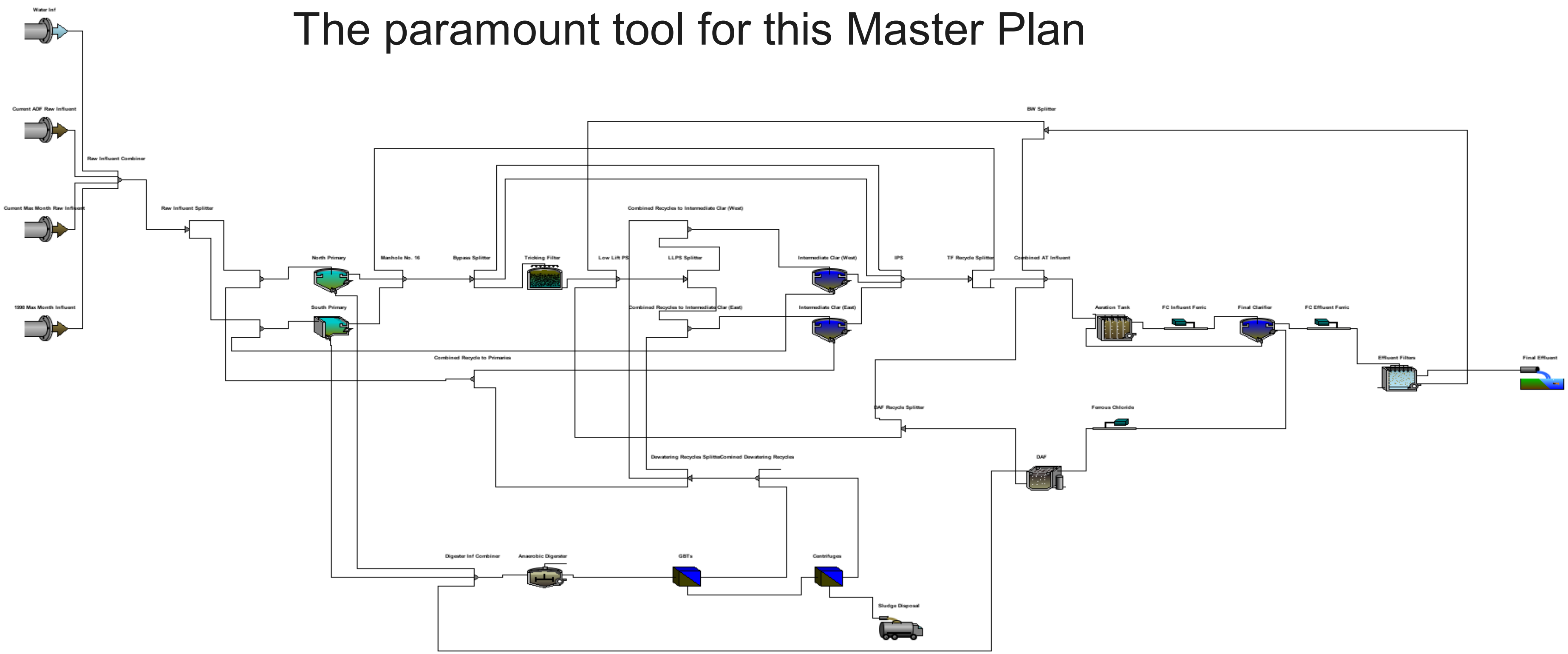
GPS-X Modeling Software by Hydromantis

The paramount tool for this Master Plan



Additional Process Lab Testing

Weekly Sampling and Analytical Requirements for Wastewater Characterization										
Location	Influent	North Primary Effluent	South Primary Effluent	Combined TF Effluent @ Low Lift PS	East Hummus Tanks Effluent	West Hummus Tanks Effluent	Final Settling Tank Combined Effluent	Plant Effluent	Centrifuge Centrate	GBT Filtrate
Sampling Station -->	1	4	5	6a	6	NEW	8	10	grab	grab
TSS	5x	5x	5x	5x	5x	5x	5x	5x	5x	5x
VSS	5x	5x	5x	5x	5x	5x			2x	2x
COD	5x	5x	5x	5x	5x	5x	5x	5x	2x	2x
sCOD(GF)	5x	5x	5x	5x						
ffCOD	5x	5x	5x	5x				5x		
TBOD5	5x									
sTBOD5(GF)	5x									
NO3 at end of TBOD test	5x									
CBOD5	5x	5x	5x	5x	5x	5x	5x	5x		
sCBOD (GF)	5x	5x	5x	5x						
TKN	5x	5x	5x	5x	5x	5x	5x	5x	2x	2x
sTKN (GF)	5x									
NH3-N	5x	5x	5x	5x	5x		5x	5x	2x	2x
NO3-N				5x				5x		
NO2-N				5x				5x		
TP	5x	5x	5x	5x	5x	5x	5x	5x	2x	2x
sTP (GF)										
PO4-P	5x			5x	5x			5x	2x	2x
Alk	5x									
Dissolved Sulfide	5x									

Color Legend:
- (dark blue) currently collected parameter, no change in normal sampling frequency
- (light blue) currently collected parameter, increased sampling frequency
- (yellow) new parameter

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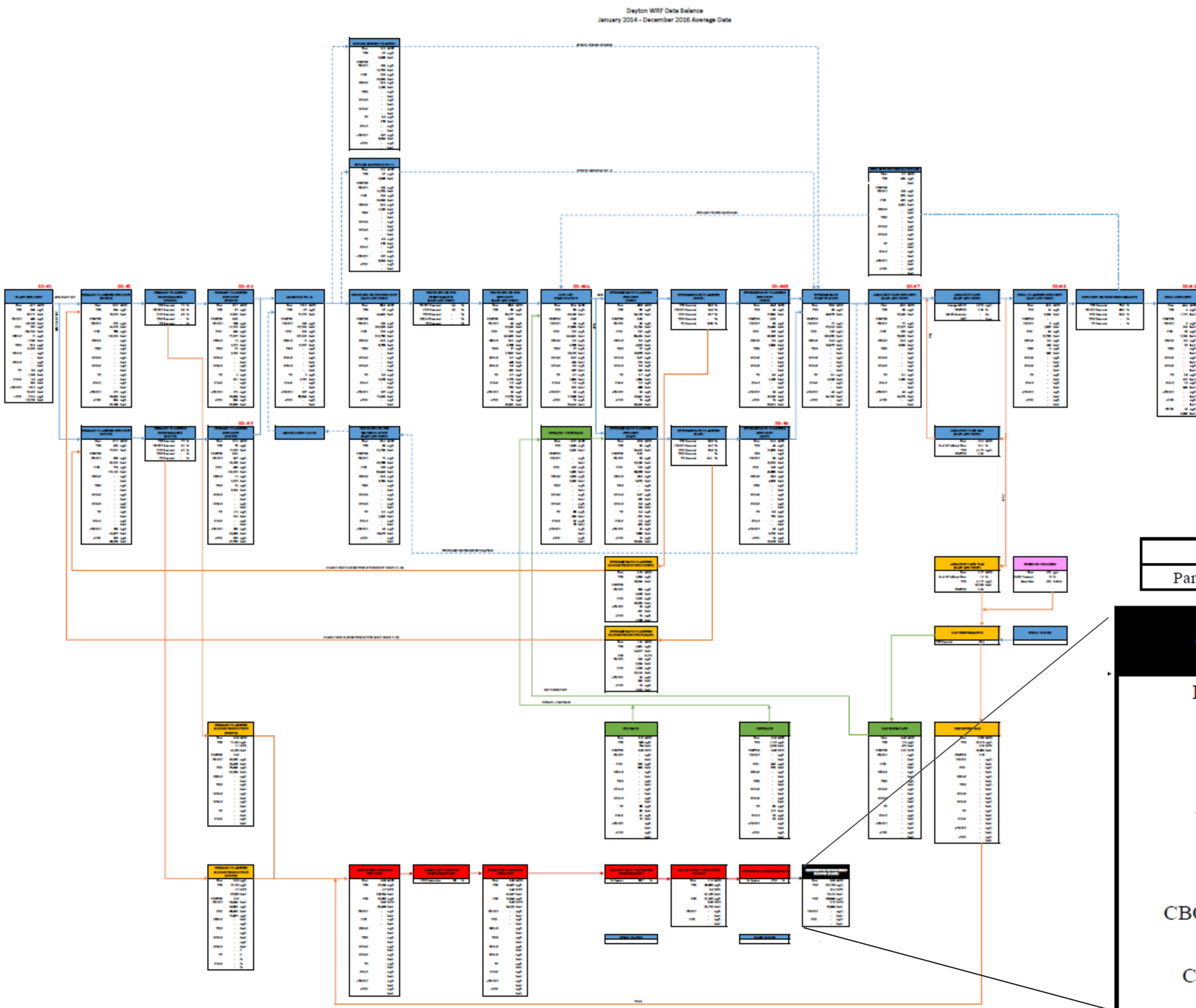
Testing Data used to calibrate model



LEGEND				
Parameter	Plant Data	*Model Results*	Units	% Diff

CENTRIFUGE DEWATERED SLUDGE (CAKE)

Flow	**0.03**	*0.03*	MGD	1%
TSS	233,708	*234,000*	mg/L	0%
	23.4	*23.40*	%TS	0%
	59,614	*60,035*	lbs/d	1%
VSS	**128,840**	*125,193*	mg/L	-3%
	0.55	*0.54*	%VS	-3%
	32,864	*32,119*	lbs/d	-2%
CBOD5	-	*33,807*	mg/L	
	-	*8,674*	lbs/d	
COD	-	*201,238*	mg/L	
	-	*51,630*	lbs/d	

Modeled Alternatives

Existing Conditions

2.2.4 LS-EC-1 –

2.2.5 LS-EC-1 –

Primary Clarification Alternative

2.4.1 Alternative LS-PC-1 –

2.4.2 Alternative LS-PC-2 –

2.4.3 Alternative LS-PC-3 –

Baseline Alternative -

2.5.1 Alternative LS-CA-1 –

Phosphorus Removal Alternative

2.6.1 Alternative LS-PR-1 –

2.6.2 Alternative LS-PR-2 –

2.6.3 Alternative LS-PR-3 –

Combined Nitrogen and Phosp

2.7.1 Alternative LS-NR-1 – I

2.7.2 Alternative LS-NR-2 –

2.7.3 Alternative LS-NR-3 – C

2.7.4 Alternative LS-NR-4 – Si

Secondary Treatment Investiga

2.8.1 Investigation LS-ST-1 –

2.8.2 Investigation LS-ST-2 –

2.8.3 Investigation LS-ST-3 –

2.8.4 Investigation LS-ST-4 –

2.8.5 Investigation LS-ST-5 –

Pretreatment of Industrial Discharges Alternatives

2.9.2 Alternative LS-PT-1 –

2.9.3 Alternative LS-PT-2 –

2.9.4 Alternative LS-PT-3 –

Effluent Filters Alternatives

2.10.1 Alternative LS-EF-1 –

2.10.2 Alternative LS-EF-2 –

Disinfection Alternatives

2.11.1 Alternative LS-DI-1 –

2.11.2 Alternative LS-DI-2 –

Phosphorus Control

Three practical methods:

1. Chemical Addition
2. Biological Nutrient Removal
3. Phosphorus Recovery

Chemical Addition Phosphorus Control

Addition of Phosphorus Sequestering Chemical into water:

Typical Locations:

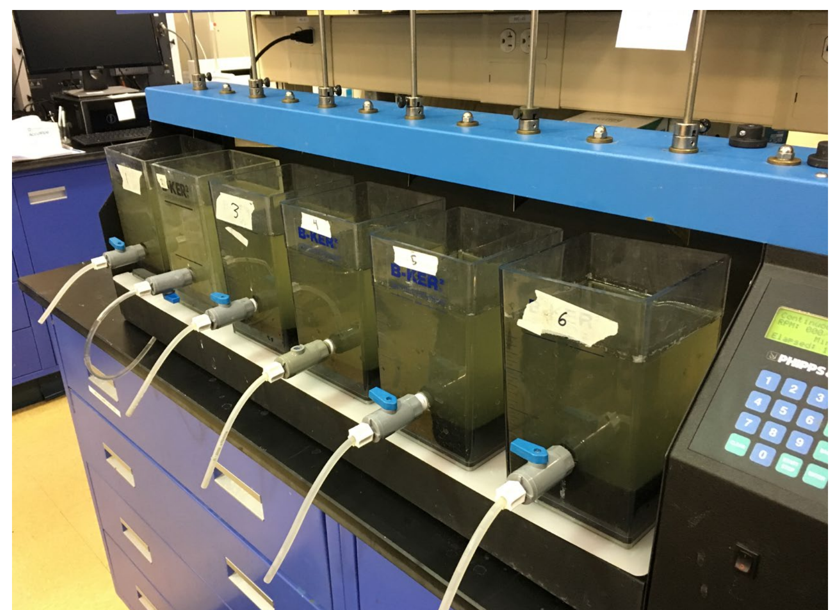
1. After Aeration Basins
2. After Biosolids Dewatering
3. At Primary Clarifiers (Careful!)

Chemical Addition Jar Test

- Multiple chemicals
- Multiple plant locations
- Multiple doses
- Multiple tests
- Multiple people

<u>4 Chemicals Tested</u>

- Aluminum Chloride
- Polyaluminum Chloride (PACL)
- Ferric Chloride
- Rare Earth Metal



Chemical Addition Costs

Chemical Unit Costs Quotes

Chemical	Cost per wet pound ($/lb)	Cost per gallon ($/gal)
Ferric Chloride (a)	0.14	2.05
Ferric Chloride (b)	0.093	1.08
Alum (a)	0.1175	1.21
Alum (b)	0.08	0.90
PACl	0.165	1.80
Rare Earth Metal	0.68	8.80

Estimated Yearly Chemical Costs for Phosphorus Control to 1 mg/L

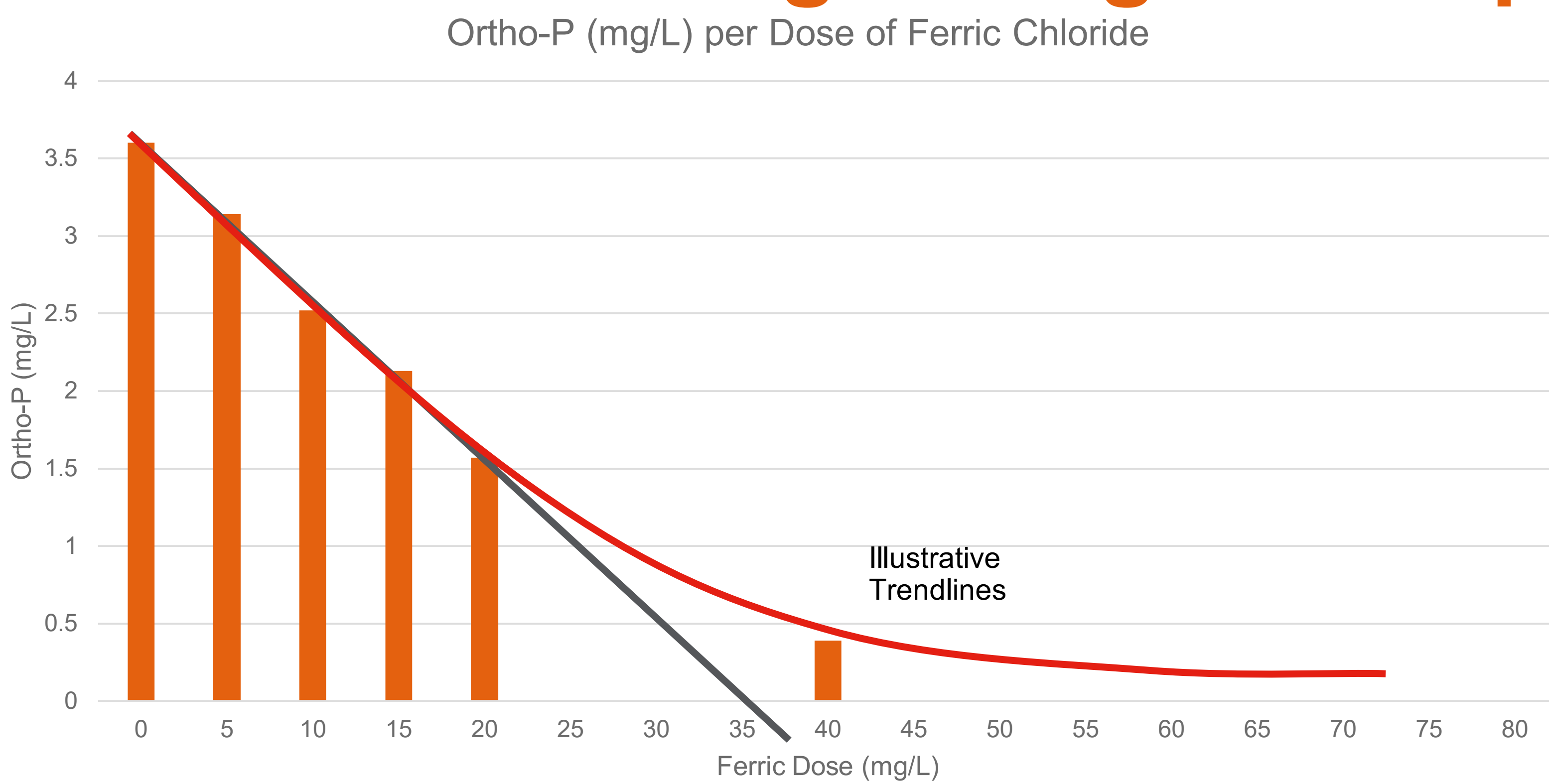
Chemical	Dose Ratio (lb chemical/ lb ortho-P)	Ortho-P to be removed (lb/day)	Chemical Dose Required (lb/day)	Daily Chemical Cost ($/day)	Annual Chemical Cost ($/year)
Ferric Chloride	12.6	487	6,119	569	208,000
Alum	21.6	487	10,513	841	306,000
PACl	15.8	487	7,683	1,268	463,000
Rare Earth Metal	13.8	487	6,707	4,651	1,665,000

Estimated Yearly Additional Sludge Hauling Costs for Phosphorus Control to 1mg/L

Chemical	Sludge Generated (lb/day)	Daily Cost ($/day)	Annual Cost ($/day)
Ferric Chloride	4,836	79.34	28,960
Alum	3,034	49.78	18,168
PACl	5,233	84.85	31,333
Rare Earth Metal	2,418	39.67	14,480

For Costs: Sludge Hauling wasn't as influential as chemical

Ferric Chloride target range Example



To drive Ortho-P removal closer to 0 requires exponentially more Ferric Chloride.

Control Phosphorus Using BNR

BNR

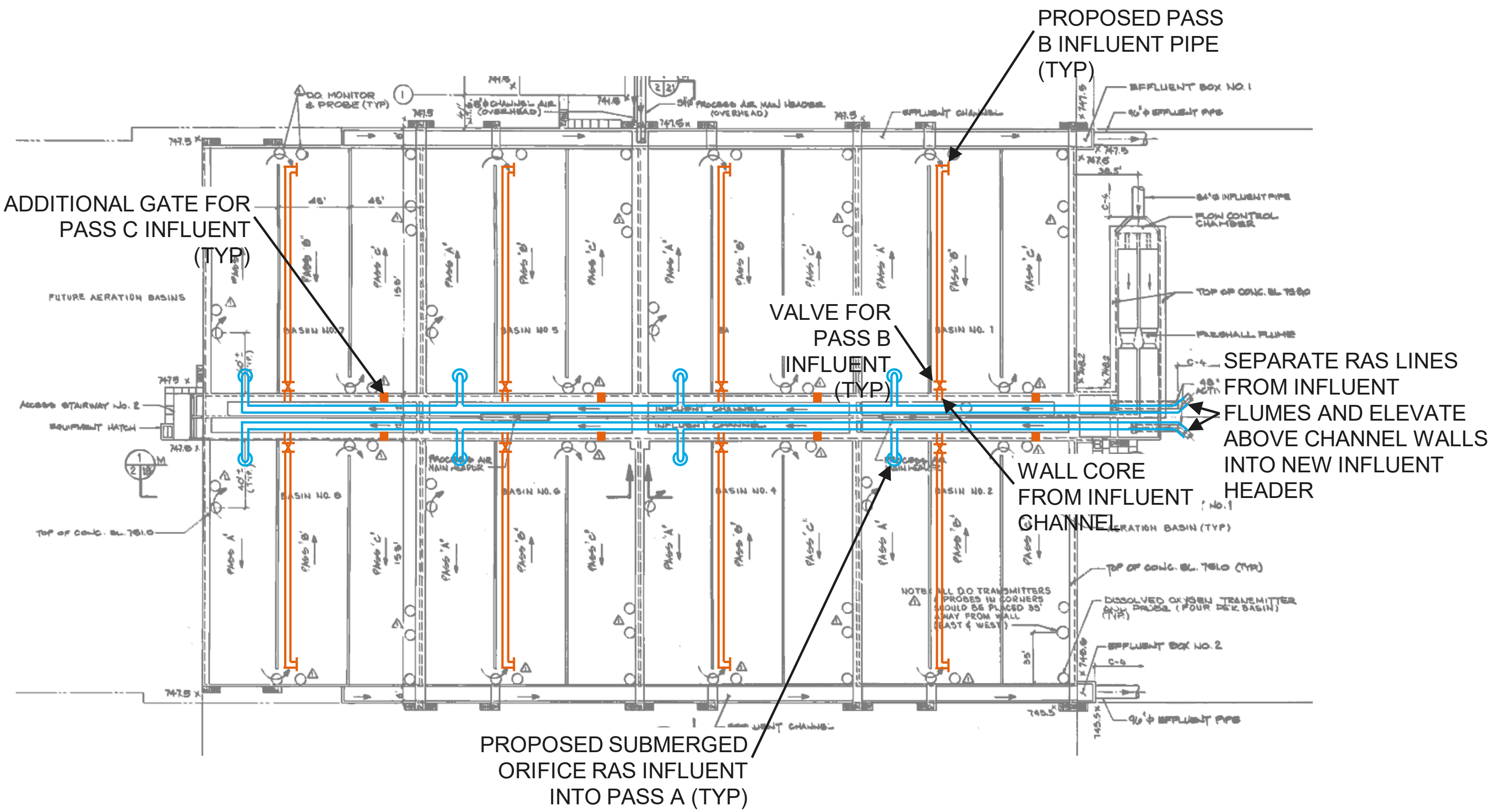
- Biological Phosphorus Removal (BioP), or
- Biological Nitrogen & Phosphorus Removal (TN)

- Control (starve or feast) Oxygen and Mixing to encourage Biology to Uptake Phosphorus …then remove/waste the Biomass quickly before it releases the phosphorus.

- Step feed to maximize aeration basin capacity during wet weather

Step Feed

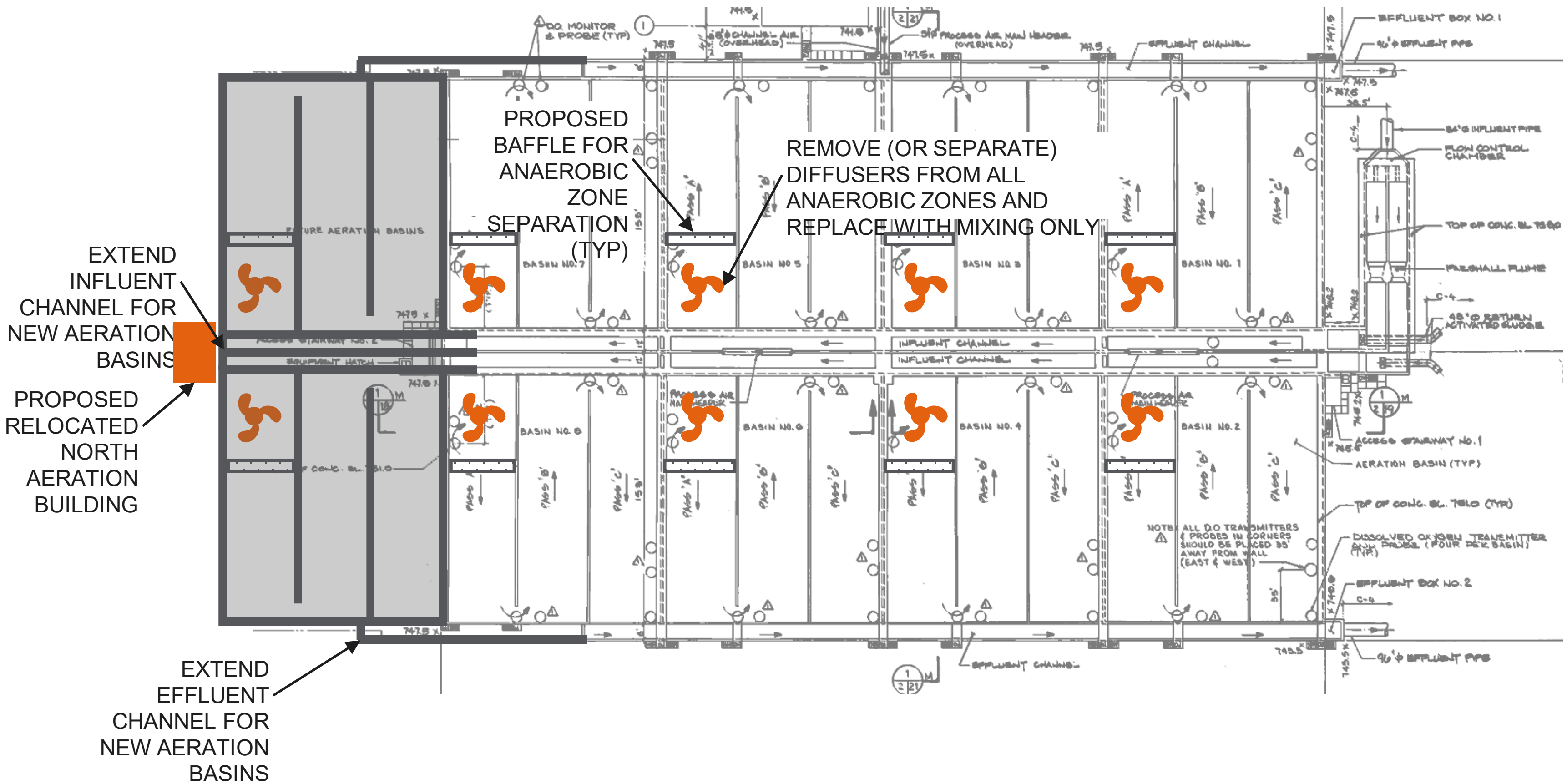
Legend
- IPS Flow Modifications
- RAS Flow Modifications



Bio P

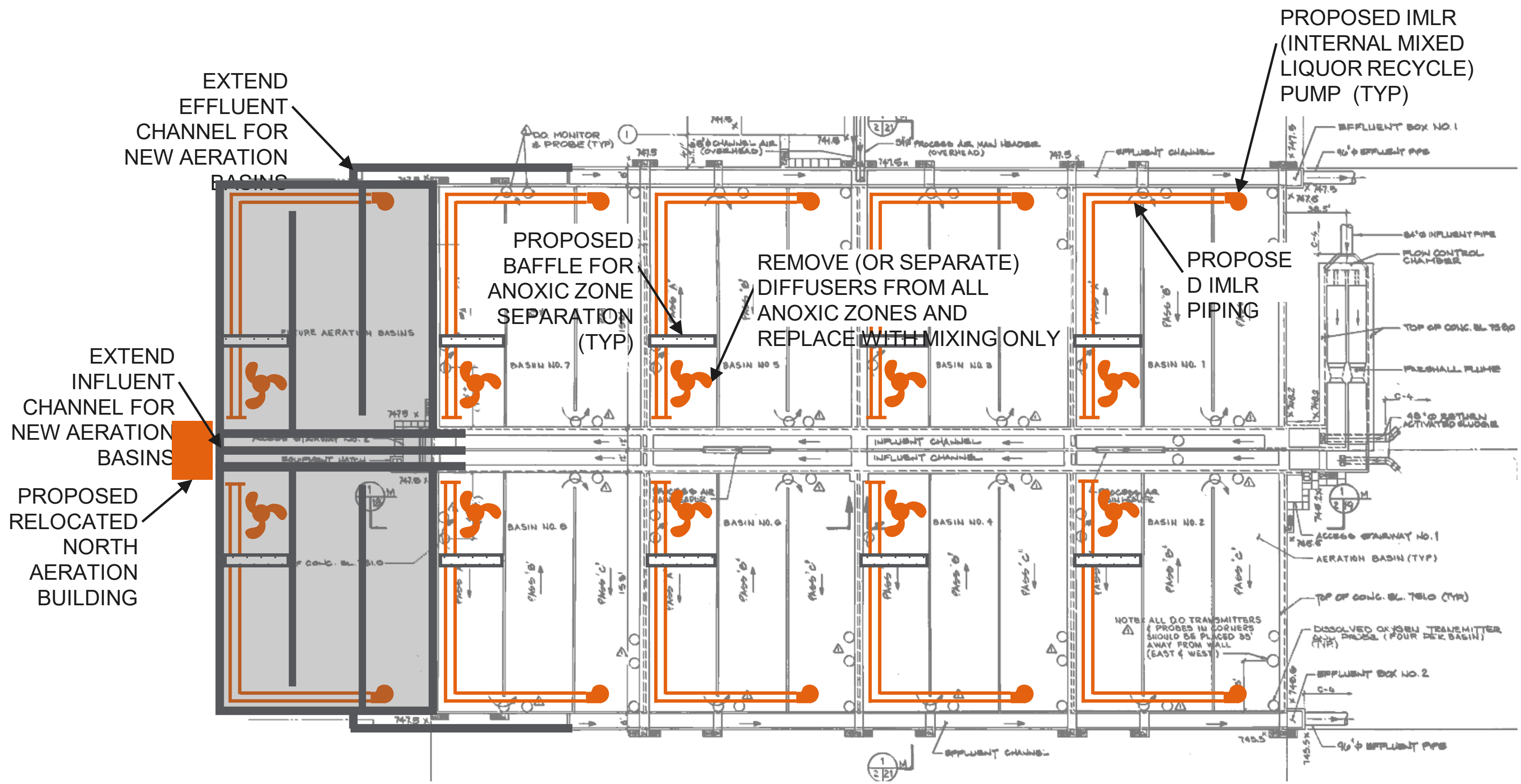
Legend

- Structural Modifications
- Process Modifications



TN Removal

Legend
- Structural Modifications
- Process Modifications



TN with Step Feed

Legend
- Structural Modifications
- Process and IPS Flow Modifications
- RAS Flow Modifications

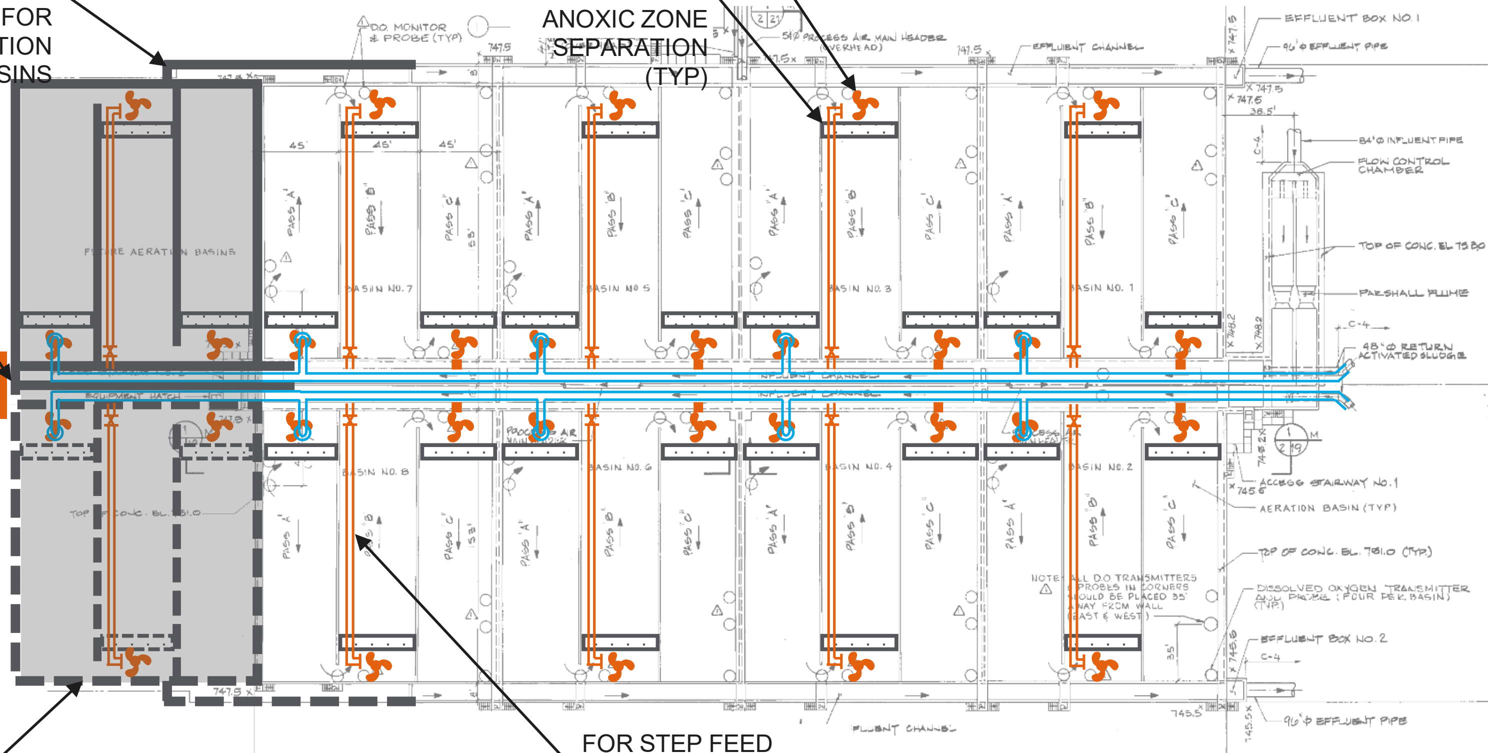
REMOVE (OR SEPARATE) DIFFUSERS FROM ALL ANOXIC ZONES AND REPLACE WITH MIXING ONLY

PROPOSED BAFFLE FOR ANOXIC ZONE SEPARATION (TYP)

EXTEND EFFLUENT CHANNEL FOR NEW AERATION BASINS

EXTEND INFLUENT CHANNEL FOR NEW AERATION BASINS

PROPOSED RELOCATED NORTH AERATION BUILDING

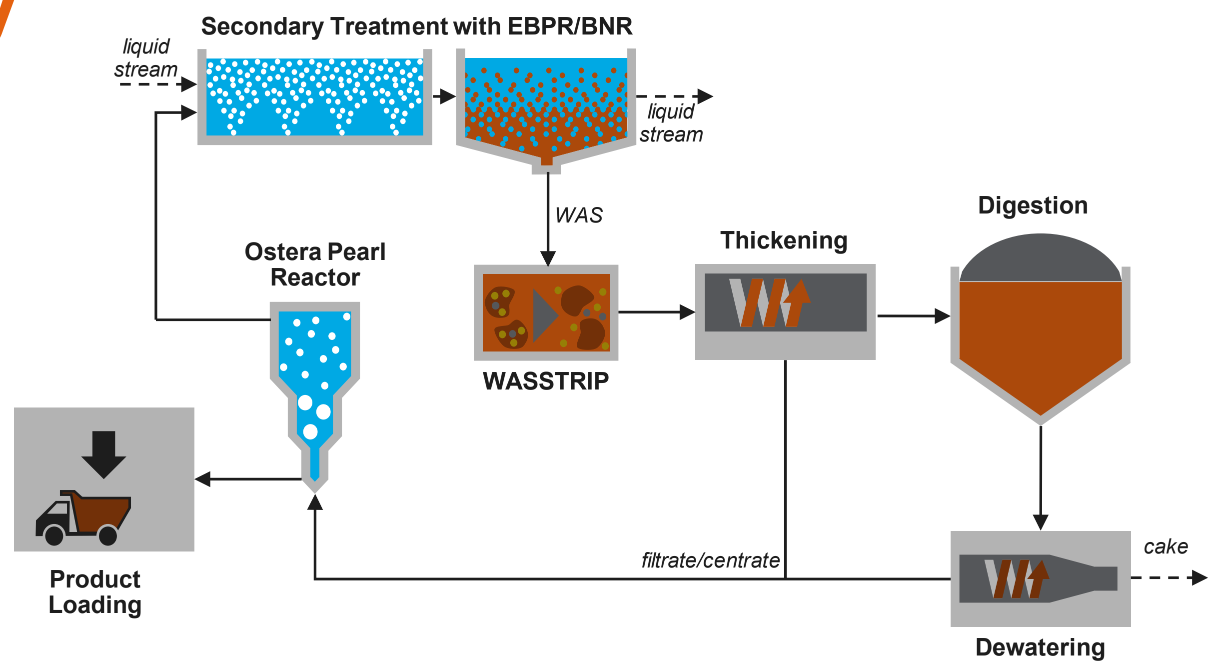


10TH AERATION BASIN POTENTIALLY NOT REQUIRED BUT MAY BE CONSTRUCTED FOR FUTURE USE AND SYMMETRY

FOR STEP FEED PIPING DESCRIPTIONS SEE ALTERNATIVE LS-PR-2

Control Phosphorus with P extraction and Recovery

Excluded for two main reasons: Nutrient Recovery is most financially feasible behind BNR and Dayton adds ferric to sequester H2S for their air emissions permit which also binds phosphorus



Should BNR be implemented in the future, P recovery could be revisited

Results of Phosphorus Removal Alternatives Evaluation

Status Quo- No longer compliant
20-year Life Cycle

	Status Quo	Alternative LS-PR-2 Step Feed and Chemical Phosphorus Removal	Alternative LS-PR-3 Biological Phosphorus Removal	Alternative LS-NR-2 Step Feed with Nitrogen Removal and Partial Chemical Phosphorus Removal
Construction Cost ($2018)	**$4,408,000**	**$33,255,000**	**$38,462,000**	**$52,294,000**
Annual Chemical Costs	$0	$223,000	$0	$45,000
Annual Energy Costs	$851,000	$912,000	$936,000	$1,017,000
Annual Maintenance Costs	$521,000	$875,000	$997,000	$1,109,000
Total Annual Costs ($2018)	**$1,372,000**	**$2,010,000**	**$1,933,000**	**$2,171,000**
NPV Chemical Costs	$0	$3,531,000	$0	$706,000
NPV Energy Costs	$13,462,000	$14,438,000	$14,808,000	$16,093,000
NPV Maintenance Costs	$8,242,000	$13,851,000	$15,782,000	$17,542,000
NPV Replacement Costs	$492,000	-$3,534,000	-$4,485,000	-$6,039,000
Total Costs over Present Worth Period	**$22,196,000**	**$28,286,000**	**$26,105,000**	**$28,302,000**
Life Cycle Cost ($2018)	**$26,604,000**	**$61,541,000**	**$64,567,000**	**$80,596,000**

Odor Control

Asset Management

Asset Management is a body of management practices that…

Targets the **acceptable level of risk** to the organization

Delivers **service levels** customers desire and regulators require

Applies to the **entire portfolio of infrastructure assets** at all levels of the organization

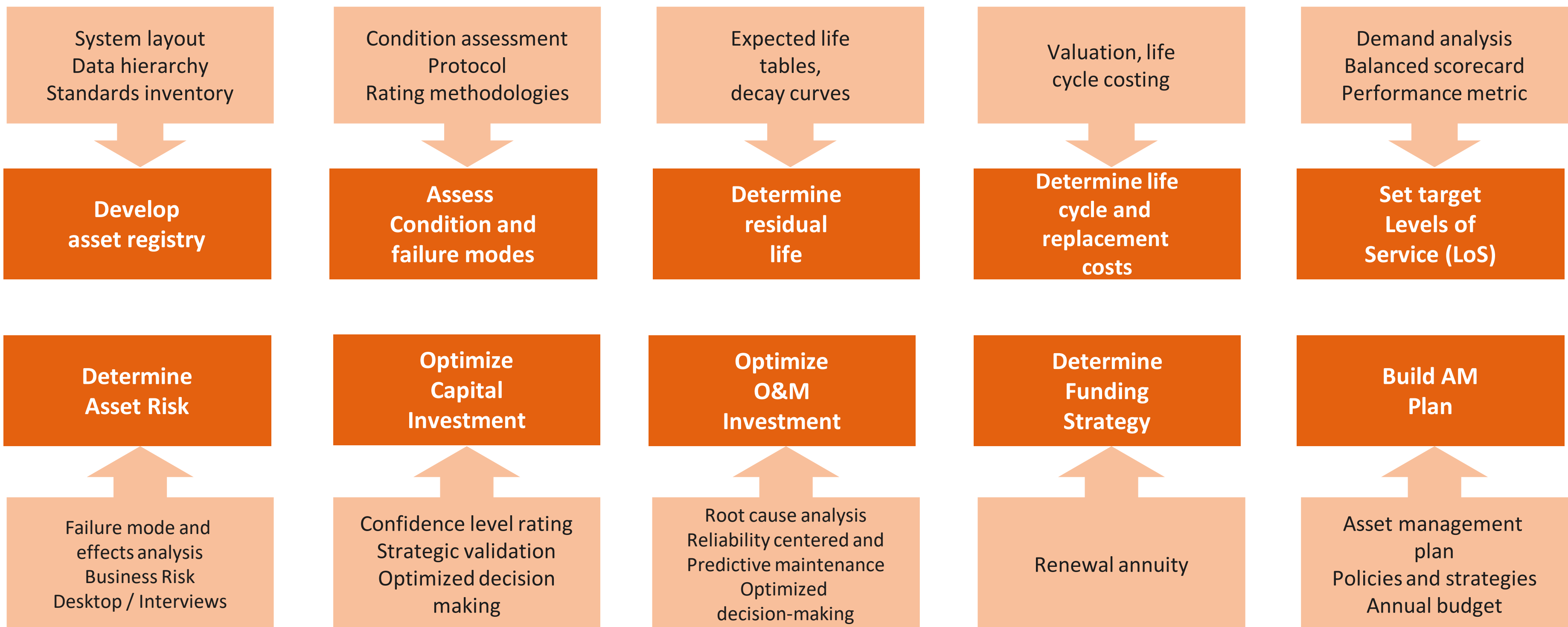
Seeks to **minimize total costs** of acquiring, operating, maintaining, and renewing assets

Works within an environment of **limited resources**

EPA / WERF/ WaterRF Framework

1. What is the current state of my assets?

2. What is the required LOS?



3. Which assets are critical?

4. What are my best CIP and O&M strategies?

5. What is my best funding strategy?

Leading Practice Concepts of Asset Management for Capital Planning

Levels of Service Based on Customer and Stakeholder Expectations

\+

Risk Management Based on Likelihood and Consequence of Failure

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CIP Using Life Cycle Cost, Business Cases and Prioritization

=

Leading Practice Asset Management

Dayton's Condition Assessment

- 2 Weeks
- 10 People (Tablets)
- 3,989 Assets in 46 Categories
- 2 Facilities (WRF & PS)

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Condition Assessment Tools

fulcrum Software

mobile location leverage

Visual Condition Assessment - Overall Scoring Approach

Score	Description
1 - Excellent	Fully operable, well maintained, and consistent with current standards. Little wear shown and no further action required.
2 – Good	Sound and well maintained but may be showing slight signs of early wear. Delivering full efficiency with little or no performance deterioration. Only minor renewal or rehabilitation may be needed in the near term.
3 - Moderate	Functionally sound and acceptable and showing normal signs of wear. May have minor failures or diminished efficiency with some performance deterioration or increase in maintenance cost. Moderate renewal or rehabilitation needed in near term.
4 - Poor	Functions but requires a high level of maintenance to remain operational. Shows abnormal wear and is likely to cause significant performance deterioration in the near term. Replacement or major rehabilitation needed in the near term.
5 – Very Poor	Effective life exceeded and/or excessive maintenance cost incurred. A high risk of breakdown or imminent failure with serious impact on performance. No additional life expectancy with immediate replacement needed.

Performance Assessment

Stepped through each treatment area and discussed each components

performance,

maintenance history,

opinion of remaining useful life

- Division Manager
- Plant Administrator
- Plant Engineer
- Treatment Supervisor
- Operation Supervisors
- Supervisor of Maintenance
- Supervisor of Electrical

Asset Management- Assembling a sequential List

Condition Assessment Scores

Physical Condition
(i.e. Corrosion, Leakage, Supports, Electrical, Structural Cracking)

Performance Condition
(Capacity, Regulatory, Reliability, O&M issues, Obsolescence)

Consequence of Failure (CoF) Scores

Environmental
- Regulatory Compliance
- Impacts to Sensitive Areas

Social
- Level of Service delivery
- Health and Safety

Economic
- Capital Costs
- O&M Impact

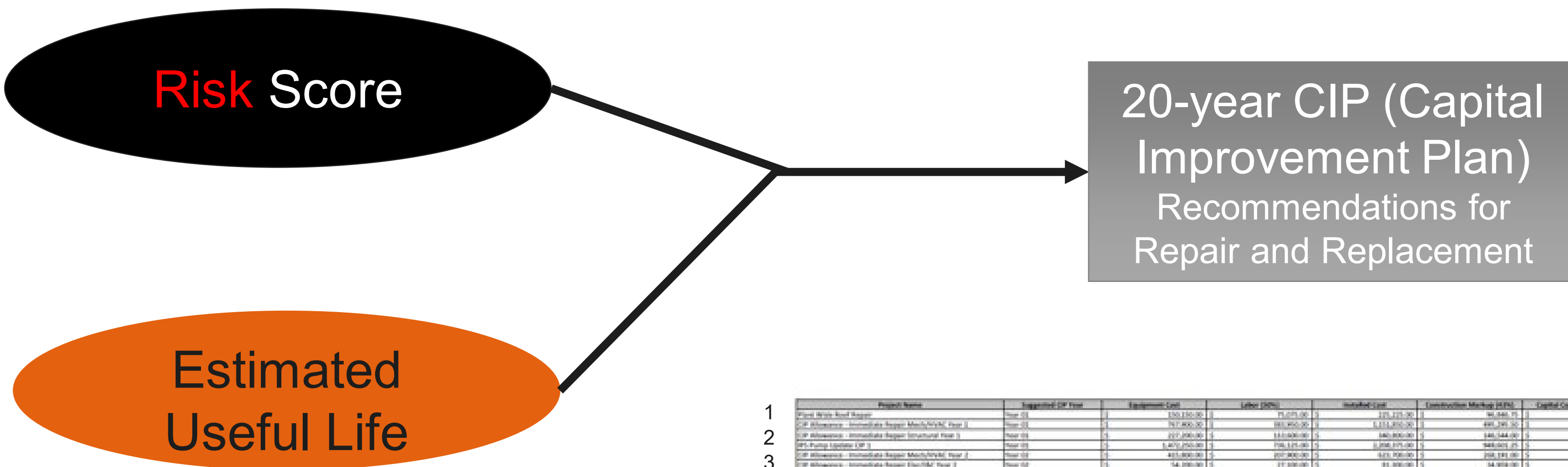
Average of maximum in each category

Redundancy Factor

Redundant units reduce the impact of failure

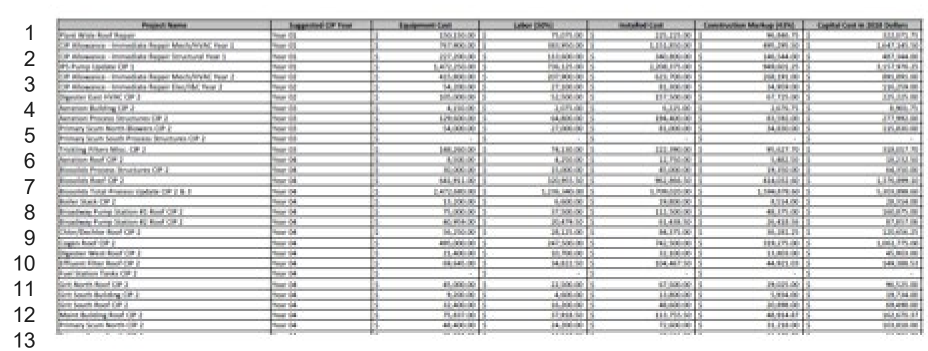
Risk = Max Condition Score x Overall CoF Score x Redundancy Reduction Factor

Asset Management -Assembling a sequential List



Remaining Useful Life based on:

- Years in Service
- Adjusted Estimated Useful Life (EUL)
  - General Asset EUL
  - Physical Condition
  - Asset Age/Expended Life

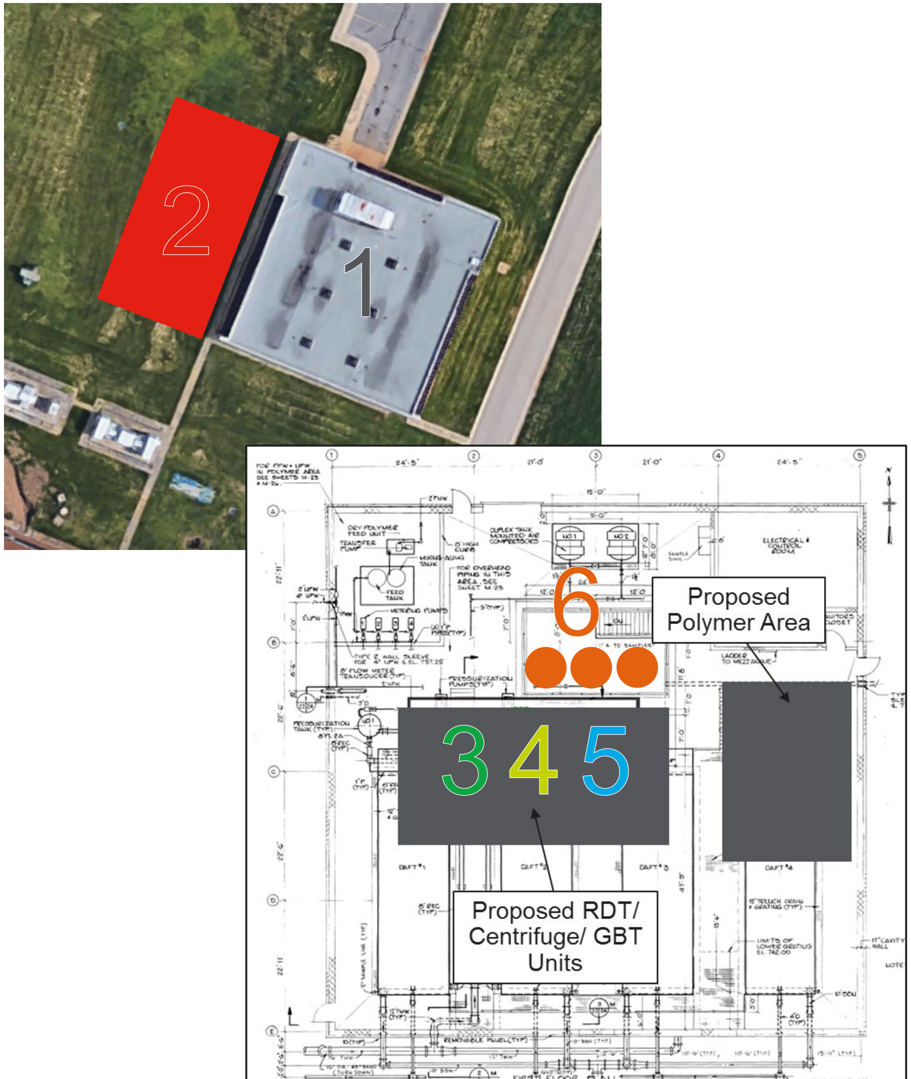


Result is a Sequential List of Asset Maintenance Projects

Alternatives for Treatment Areas

1. Liquid Treatment Train
2. Solids Treatment Train
3. Odor Control
4. Preliminary Treatment
5. Pumping
6. Electrical & Standby Power
7. Instrumentation & Control
8. Gas & Energy Use
9. Non-Potable Water

Alternatives Brainstormed



Example of Alternatives for Thickening Process:

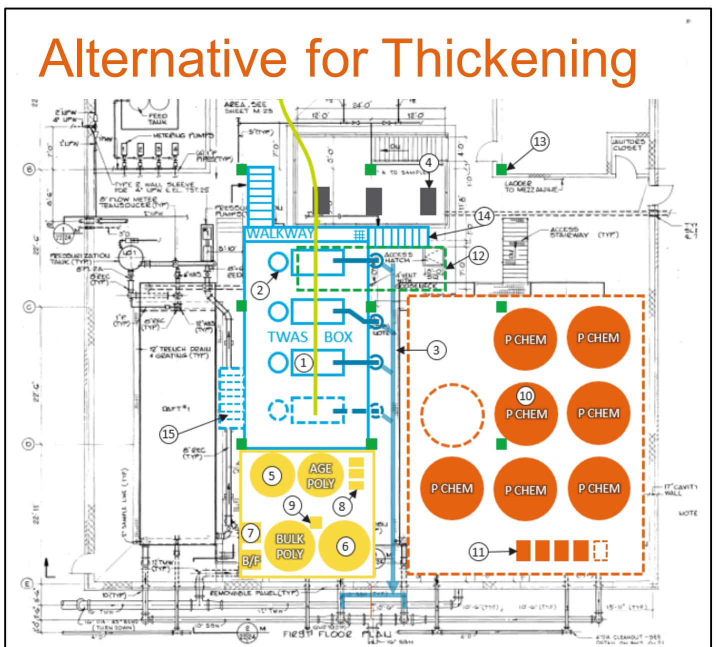
1. Status Quo: known deficiencies = DAF capacity and obsolescence
2. ~~Additional DAF in new building~~ → not cost-effective
3. Rotary Drum Thickeners (RDTs)
4. Centrifuges
5. Gravity Belt Thickeners (GBTs)

Potential Improvements:

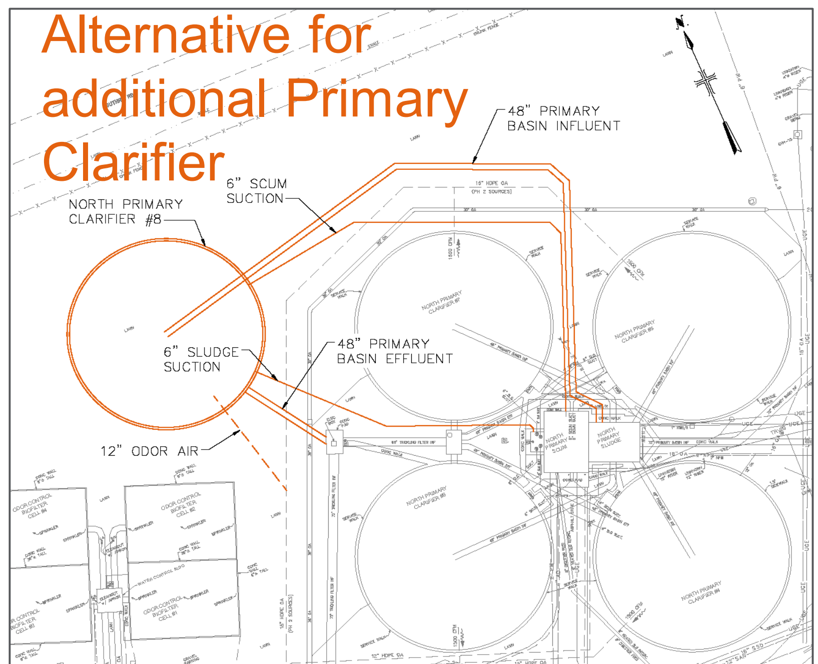
6. Replace TWAS pumps with larger pumps

Alternatives Evaluated and Costed

1. Further investigated to conceptual engineering level
2. Triple bottom line scored: Environmental, Social, Financial
3. Best Scoring Alterative Selected



Alternative for Thickening



Alternative for additional Primary Clarifier

Tying it all together: Project Priority List

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Asset Management

Risk Based
Schedule & Sequence

1.
2.
3.
4.
5.
6.
7.
8.
9.
10.
11.
12.
13.
14.
15.

Logical Priority Levels

Process Area Alternatives Analyses

Liquid Stream Alternatives
- A
- **B**
- C

Solids Stream Alternatives
- D
- **E**

Odor Control Alternatives
- F

Preliminary Treatment
- **G**
- H
- I

Pumping
- **J**
- K

Electrical & Standby Power
- **L**

Instrumentation and Control (SCADA)
- **Status Quo**

Non-Potable Water
- **Status Quo**

Tying it all together: Project Priority List

Logical Priority Levels

- **Priority Level 0:** Projects already Underway (IPS Pumps, Final Clarifier Mechanism Replacement, etc.)
- **Priority Level 1:** Projects required for an Immediate Regulatory Need (phosphorus limit driven).
- **Priority Level 2:** Critical Asset Management.
- **Priority Level 3:** Projects for Financial Gain (Selling of Biogas for profit)
- **Priority Level 4:** Projects supporting typical Regulatory Needs
- **Priority Level 5:** Projects Providing an Identified Benefit (aka. Potential Improvement projects).
- **Priority Level 6:** Projects for Asset Management and Existing Capacity/Future Capacity.
- **Priority Level 7:** Projects supporting Predicted Regulatory Need (expected in 10 years).

Conceptual Implementation Plan

Conceptual Implementation Plan Sequential Project List

B- Liquid Stream Highest Scoring Alternative
1. Asset
2. Asset

E- Solid Stream Highest Scoring Alternative

3. Asset
4. Asset
5. Asset
6. Asset

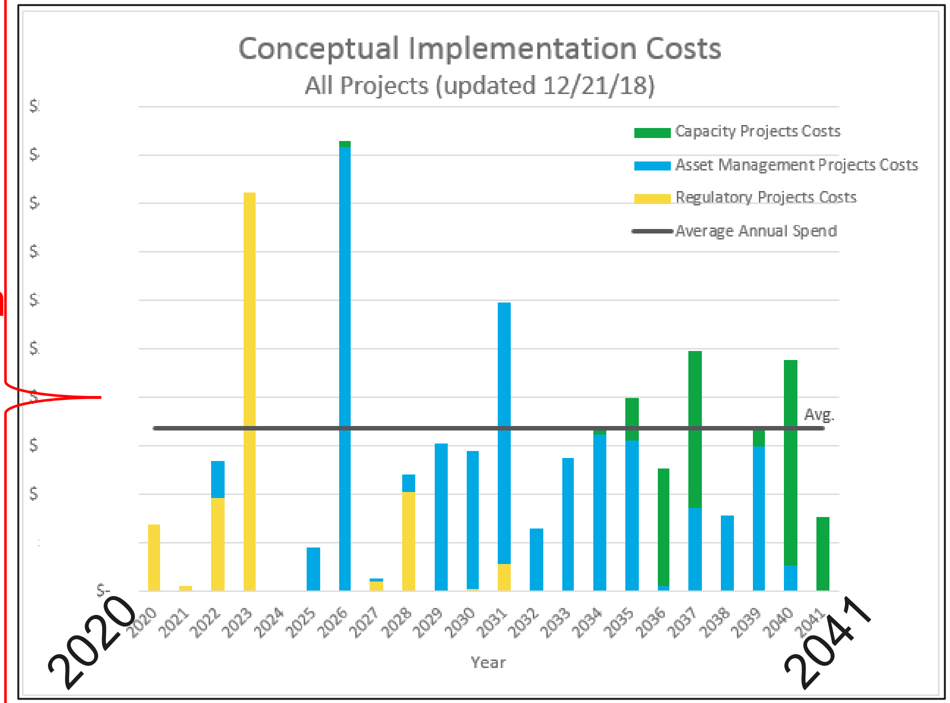
J- Pumping Highest Scoring Alternative

7. Asset
8. Asset
9. Asset
10. Asset
11. Asset
12. Asset

G – Preliminary Treatment Highest Scoring Alternative

13. Asset
14. Asset
15. Asset

Results in the following spend & schedule



Conceptual Implementation Plan

Conceptual Implementation Plan Sequential Project List

B- Liquid Stream Highest Scoring Alternative
1. Asset
2. Asset

E- Solid Stream Highest Scoring Alternative

3. Asset
4. Asset
5. Asset
6. Asset

J- Pumping Highest Scoring Alternative

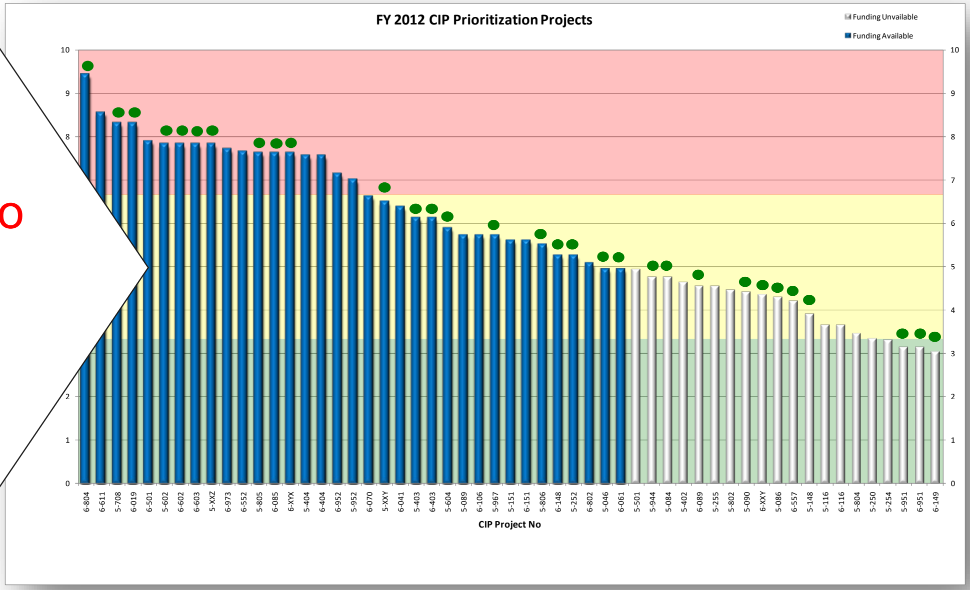
7. Asset
8. Asset
9. Asset
10. Asset
11. Asset
12. Asset

G – Preliminary Treatment Highest Scoring Alternative

13. Asset
14. Asset
15. Asset

Loaded into Financial Model

Financial Model



Conclusion

- Regarding Odors:
  - ❑ Installing Biofilters for Odor Control at Trickling Filters
    - ❑ BOD has not dropped enough to omit the Trickling Filters or even half of them.
    - ❑ The cost for additional Aeration Basins that could replace the Trickling Filters is too high compared to Biofilters

- Regarding Phosphorus
  - ❑ Chemical addition using Ferric Chloride is being installed at the WRF because:
    - ❑ BNR is decisively more expensive than chemical addition and,
    - ❑ Phosphorus limits aren't below the practical range for chemical addition.

Dayton is advancing their Implementation Plan

Thank you.

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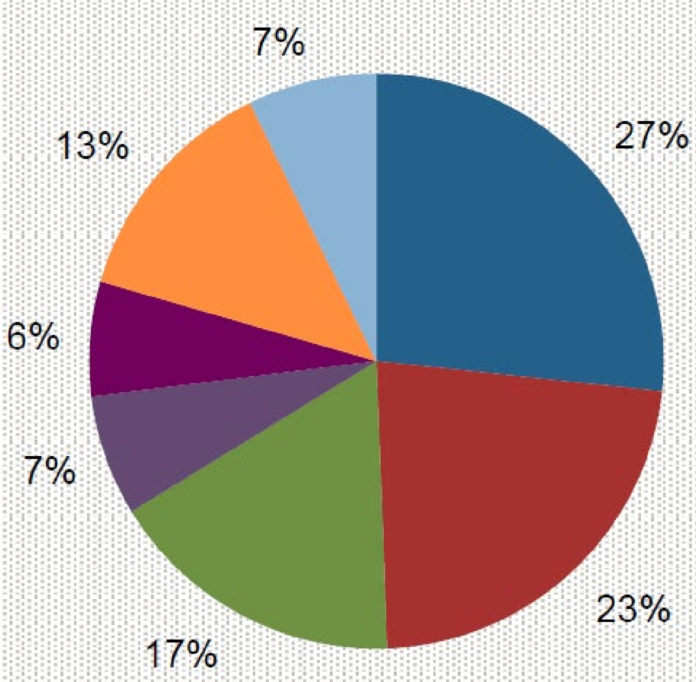
Additional Items to Share

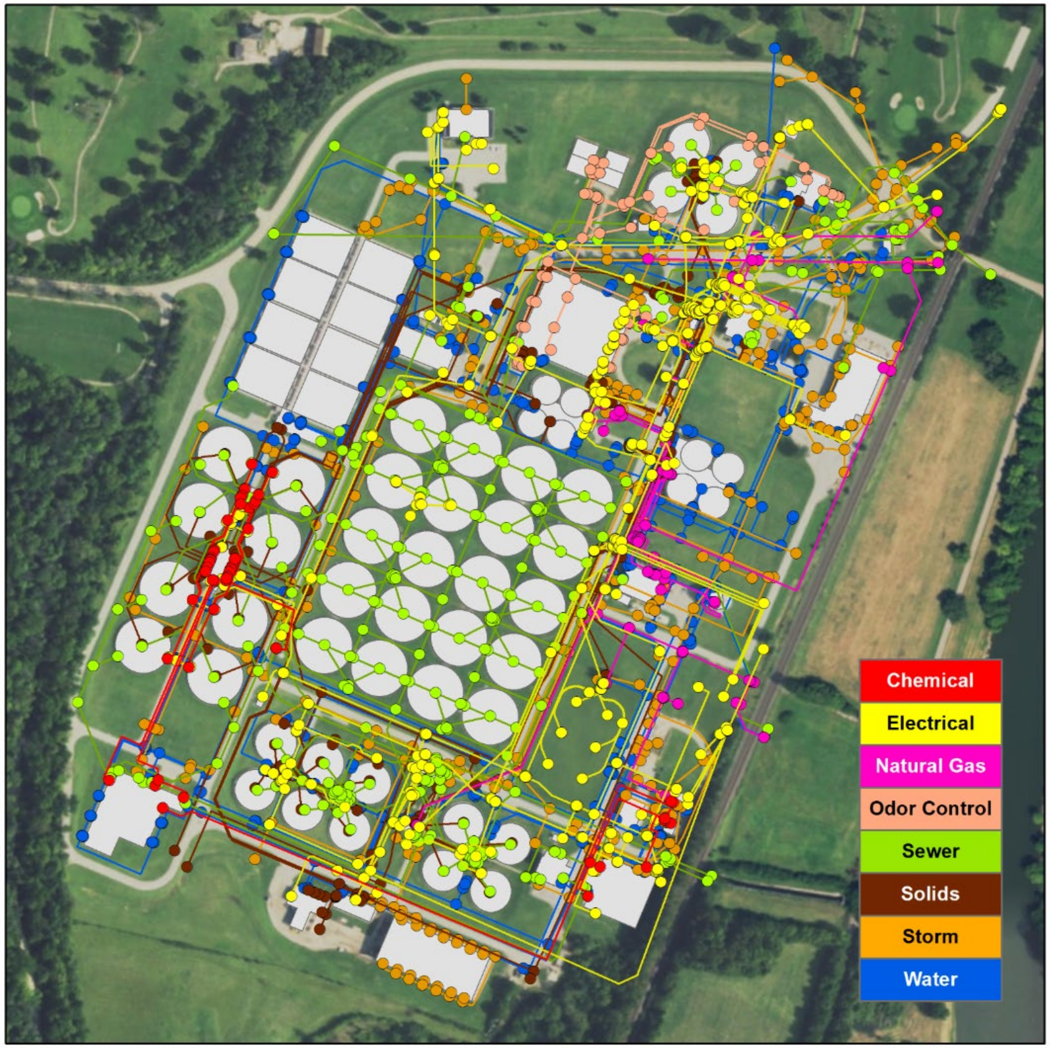
Energy Efficiency Recommendations

Top 5 Energy Use Systems



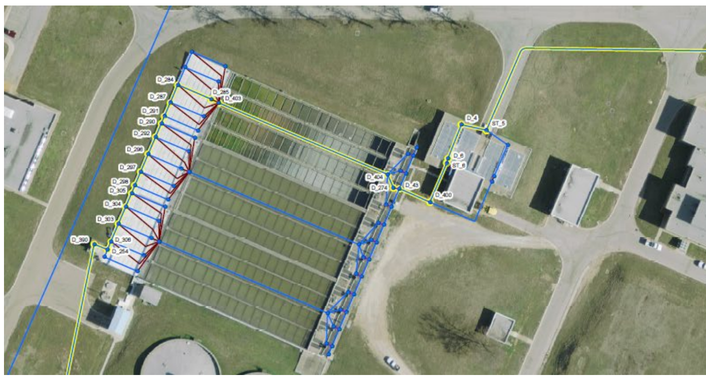
Major Process/Top Energy Use Systems	Electric Energy Use (%)
#1 INTERNAL PLANT PUMPING	26.68%
#2 SECONDARY TREATMENT	22.73%
#3 INFLUENT PUMPING	16.84%
#4 SLUDGE HANDLING	6.78%
#5 ANAEROBIC DIGESTION	6.43%
Balance of Plant Identified	13.28%
Balance of Plant Unidentified	7.25%
Total	100.00%

GIS created


Chemical
Electrical
Natural Gas
Odor Control
Sewer
Solids
Storm
Water

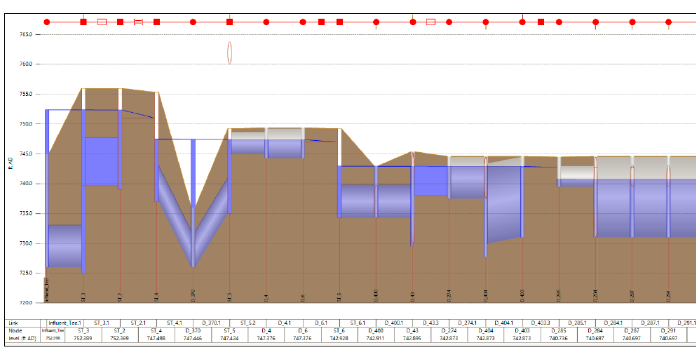
Hydraulic Profile

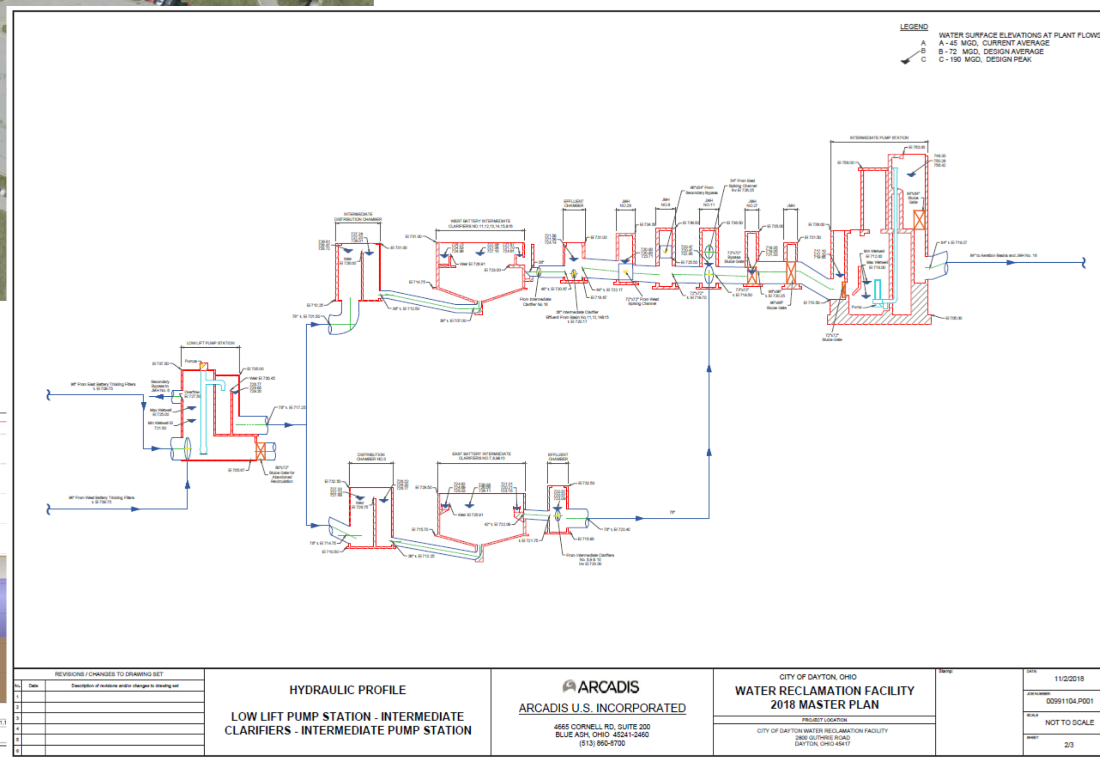
Using InfoWorks Integrated Catchment Model (ICM)



Profile 2 - South Headworks, Grit Removal, and Primary Settling

FLOW = 45MGD





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