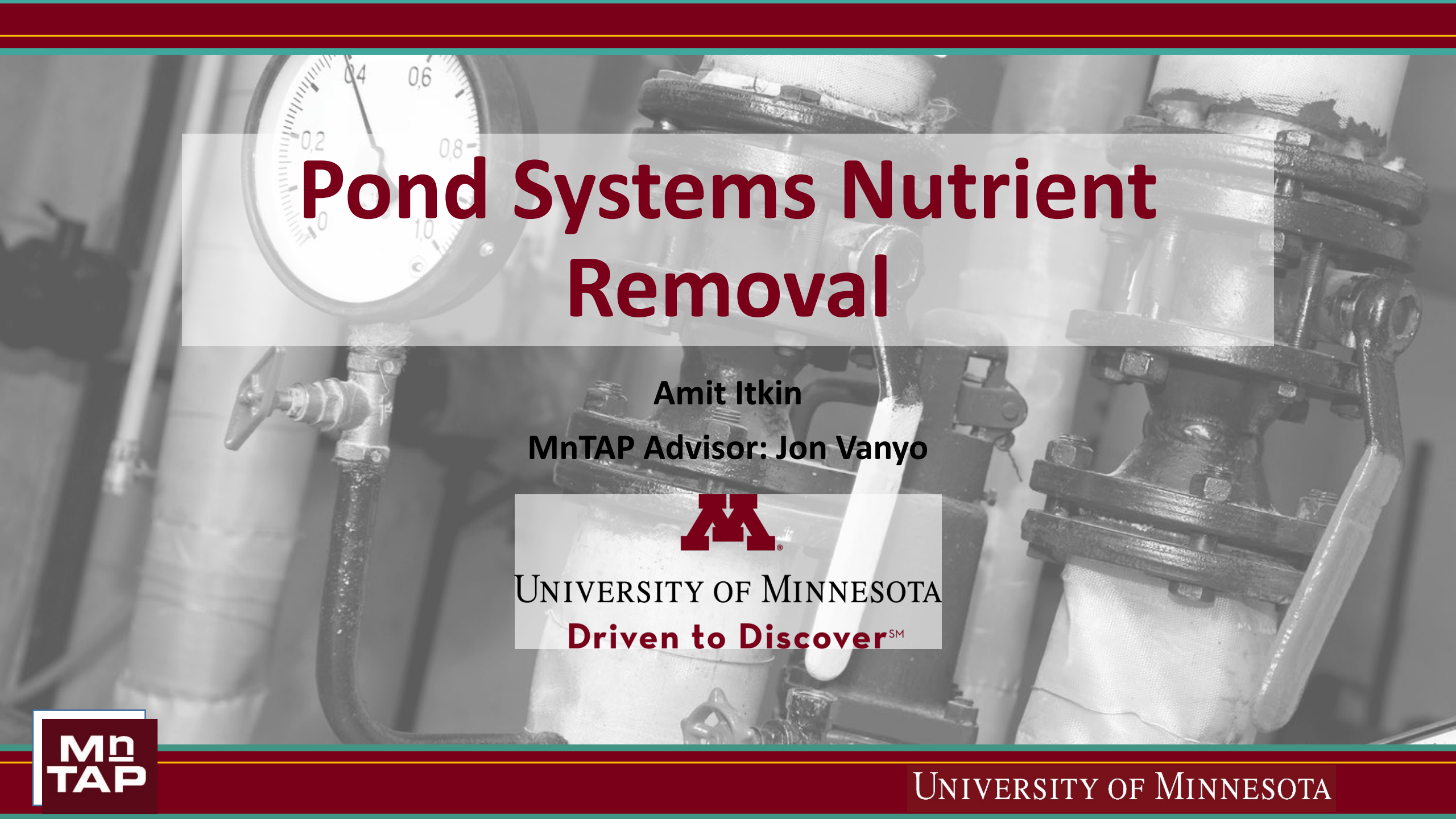

Pond Systems Nutrient Removal

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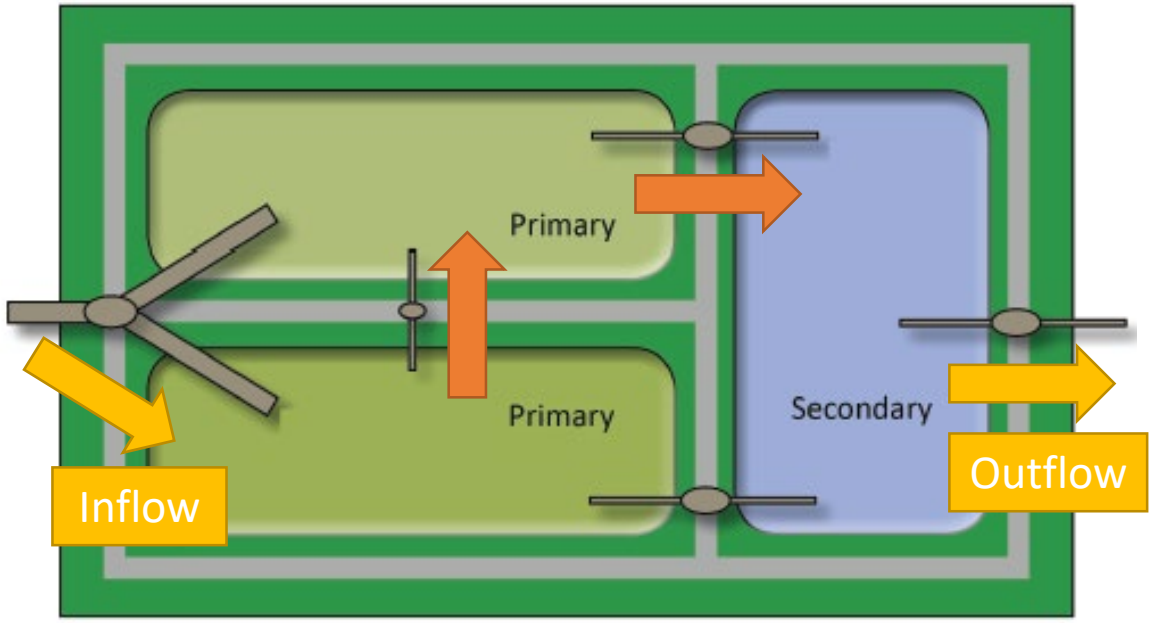
Project Background

- Project started in 2017
- Working with MRWA and MPCA
- Phosphorus and nitrogen removal in facultative WWTPs
- Nutrients cause algae blooms
- Sandstone, Onamia, and Grand Meadow

Project Overview

- **How facultative ponds work**
  - Aerobic and anaerobic zones
  - Water flows through several treatment ponds
  - Longer held and deeper waters more effective
  - Phosphorus often an issue



Typical Facultative Pond Layout

Source: MPCA, "Stabilization Pond Systems", 2013

Approach

- **Pond Operation Spreadsheet**
  - 327 ponds
  - Phosphorus removal ranking
  - Correlation analysis
- **Correlation between phosphorus removal treatment and hydraulic retention time (HRT)**

	Average Influent P [mg/L]	Average Effluent P [mg/L]	Mass Influent P [lb/d]	Mass Effluent P [lb/d]	Theoretical P loading [lb P/d/acre]	Actual P loading [lb P/d/acre]	P Remov
Average Influent P [mg/L]	1.000						
Average Effluent P [mg/L]	0.194	1.000					
Mass Influent P [lb/d]	0.421	0.027	1.000				
Mass Effluent P [lb/d]	0.136	0.386	0.653	1.000			
Theoretical P loading [lb P/d/acre]	0.946	0.453	0.192	0.223	1.000		
Actual P loading [lb P/d/acre]	0.387	0.305	0.551	0.408	0.377	1.000	
P Removal Efficiency	0.299	-0.619	0.188	-0.215	0.218	0.001	
Average Effluent N [mg/L]	0.059	0.265	0.008	0.041	0.194	0.336	
Mass Effluent N [lb/d]	0.068	0.130	0.382	0.335	-0.008	0.412	
Average Influent TSS [mg/L]	0.332	0.130	0.257	0.195	0.388	0.237	
Average Effluent TSS [mg/L]	0.143	-0.043	0.201	0.015	0.073	-0.019	
Theoretical TSS loading [lb TSS/d/acre]	0.408	0.031	0.131	0.067	0.392	0.200	
Actual TSS loading [lb TSS/d/acre]	0.122	0.059	0.484	0.298	0.075	0.770	
TSS Removal Efficiency	0.001	-0.056	-0.056	-0.018	0.201	0.123	
BOD inf [mg/L]	0.473	0.230	0.265	0.064	0.793	0.271	
BOD eff [mg/L]	0.140	-0.050	0.192	-0.007	-0.083	-0.091	
Prefered Flow [mgd]	0.079	-0.102	0.661	0.583	0.034	-0.004	
Recorded Flow [mgd]	0.023	-0.099	0.753	0.705	-0.133	0.419	
% Difference	-0.186	-0.040	0.090	0.195	-0.275	0.739	
Surface area [acres]	0.061	0.162	0.776	0.577	0.033	0.028	
Prefered HRT Assuming full Volume [d]	0.210	0.051	0.076	-0.078	-0.085	0.040	
Recorded HRT Assuming full Volume [d]	0.396	-0.107	-0.348	-0.308	0.313	-0.497	
Actual BOD Loading [lb BOD/d/acre]	0.389	0.271	0.429	0.294	0.370	0.871	
Theoretical BOD loading [lb BOD/d/acre]	0.793	0.356	0.140	0.133	0.843	0.277	
BOD Removal Efficiency	0.008	-0.115	-0.017	0.000	0.204	0.120	
pH	-0.016	-0.040	-0.024	-0.030	0.125	0.182	
Temp [C]	-0.101	-0.311	0.534	-0.439	#DIV/0!	#DIV/0!	
Fecal Coliform [#/100 ml]	0.020	-0.043	-0.017	0.021	0.119	-0.072	
DO [mg/L]	-0.048	-0.061	-0.057	-0.062	-0.247	-0.156	
Chloride, Total [mg/L]	0.201	-0.021	0.136	0.148	-0.226	0.273	
Precipitation [in/month]	-0.084	-0.025	0.026	0.033	-0.233	-0.012	
Discharges/Yr	-0.029	-0.075	0.286	0.192	-0.244	-0.092	
# of Ponds	-0.033	-0.135	0.477	0.079	-0.013	-0.004	
# of Primaries	0.015	-0.085	0.535	0.175	0.027	0.049	
# of Secondaries	-0.055	-0.120	0.256	-0.061	-0.031	-0.039	
Waterfowl Estimate	0.337	0.835	0.744	0.536	0.386	0.158	
Total Volume [FT^3]	0.051	0.156	0.763	0.585	0.029	0.019	
% Primary SA	0.179	0.097	-0.062	-0.037	0.183	0.008	
% Primary Vol	0.126	0.152	-0.335	-0.067	0.130	0.000	
P Prioritization	0.006	0.226	0.062	0.078	-0.119	0.042	
N Prioritization	-0.033	0.089	0.126	0.144	-0.076	0.151	
Criteria Score Excluding Mass Effluent	-0.088	0.826	-0.119	0.236	0.208	0.315	
Ranking	-0.085	0.819	-0.117	0.231	0.218	0.329	
Criteria Score	-0.065	0.780	0.093	0.448	0.192	0.420	
Ranking	-0.057	0.776	0.086	0.429	0.189	0.439	

Example of correlation analysis

Approach

- Visited the sites
- Analyzed flow schemes
- Determined opportunities for removal
- Looked for major sources of phosphorus

Grand Meadow WWTP Secondary Pond

Primary Recommendation

- **Optimize flow scheme**

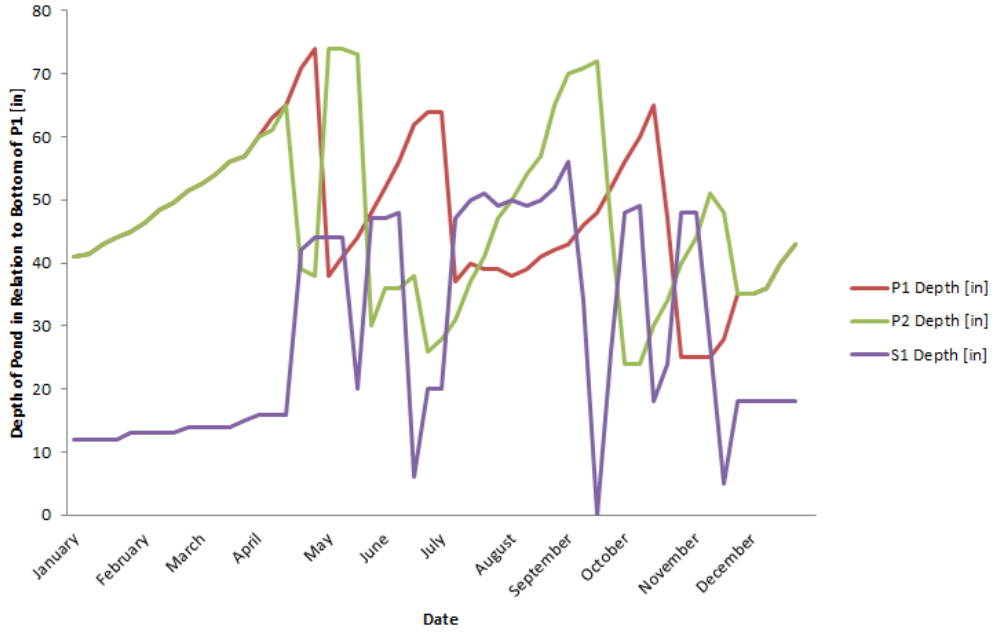


Figure 1: Onamia Current Flow Scheme

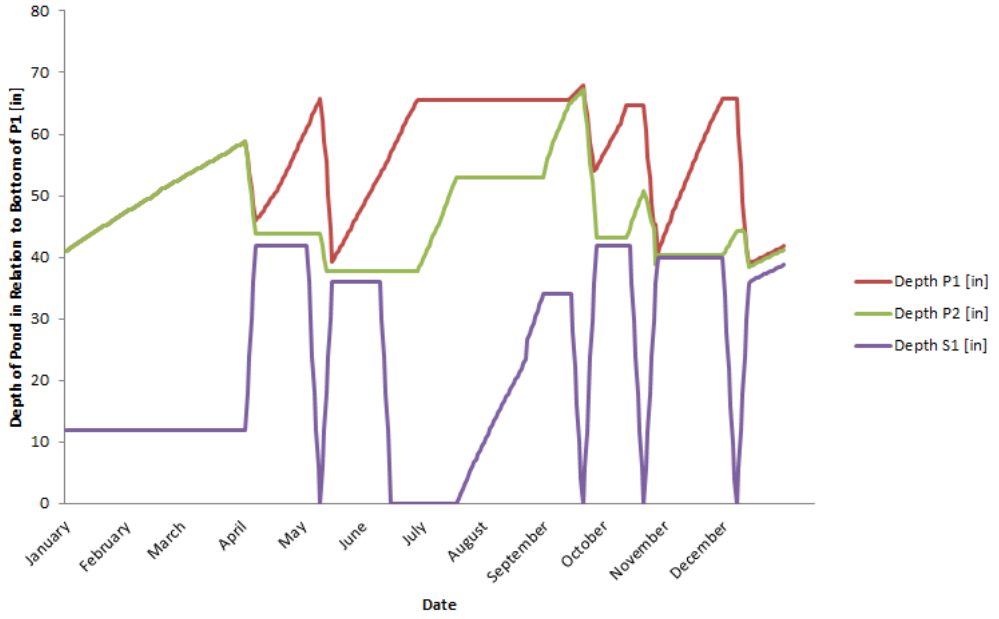


Figure 2: Onamia Modified Flow Scheme

Solutions: Sandstone

Recommendation	Annual Phosphorus Reduction (lb)	Implementation Cost (per year)	Cost effectiveness ($ per P lb)	Annual Savings	Status
Modify Flow Scheme	100 lb 60,000 kWh	$0	$0	$4,800	Implementing
Alum Phosphorus Removal	Up to 3,600lb	Up to $26,000	$8.33	N/A	Recommended

Solutions: Onamia

Recommendation	Annual Phosphorus Reduction (lb)	Implementation Cost (per year)	Cost effectiveness ($ per P lb treatment)	Status
Modify Flow Scheme	70 lb	$0	$0	Implementing
Alum Phosphorus Removal	Up to 760 lb	Up to $6,800	$8.33	Recommended
Waterfowl Prevention	130 lb	$142 $120 one-time cost	$0.98	Implementing
Inflow and Infiltration Reduction	180 lb 27,000,000 gal water	Unknown	N/A	Recommended

Solutions: Grand Meadow

Recommendation	Annual Phosphorus Reduction (lb)	Implementation Cost (per year)	Cost effectiveness ($ per P lb treatment)	Status
Modify Flow Scheme	35 lb	$0	$0	Implementing
Alum Phosphorus Removal	Up to 1,000 lb	Up to $8,200	$8.33	Recommended
Waterfowl Prevention	170 lb	$90 $120 one-time cost	$0.54	Implementing
Inflow and Infiltration Reduction	120 lb 28,000,000 gal water	Unknown	N/A	Planning

Personal Benefits

- Lessons in communicating ideas
- How to ‘sell’ recommendations
- Importance of organization

Willow River WWTP Primary Pond