Effluent Phosphorus Control

Manitowoc WWTF finds a better way

Session content

- History of the WWTF
- 2001 – 2008 Issues, equipment, and improvements
- Permit renewal / Optimization Plan
- Orthophosphate Analyzer
- Evaluating performance with data
- Lessons learned / Questions

History of Manitowoc WWTF

- 1939 – The first treatment plant was built on the site at a cost of $980,000
- This was a primary treatment plant consisting of primary clarifiers, a primary and secondary digester, and sand biosolids drying beds.
- None of the original plant remains on the site today

First Upgrade – 1954-1956

- The first upgrade began in 1954 and was completed at a cost of $1,430,000
- Secondary treatment was added to enhance suspended solids and BOD removal
- The major changes were the addition of rock trickling filters, secondary sludge pumping and 3 square final clarifiers

Second upgrade 1974-1976

- Major plant upgrade to increase both hydraulic and organic capacity and to accommodate growth within the city
- The project addressed organic overloading by adding stack trickling filters along with three circular secondary clarifiers, and repurposing the then three square finals as primary clarifiers
- Tertiary sand filters were constructed to further remove suspended solids and BOD

Second upgrade 1974-1976

- Chemical storage tanks and feed pumps were added to precipitate and settle phosphorus from the effluent

Third Upgrade 1998-2001

- The most recent upgrade was completed in 2001 at a cost of $20.3M
- Three separate structures were demolished and replaced with a new preliminary treatment building that incorporated influent pumping, screening, and grit removal into one building
- A new circular primary clarifier was built effectively doubling primary clarifier capacity
- The stack filter booms were refurbished and motorized drives were added to control media wetting rates and biogrowth
- A new rock filter pumping station and replacement and automation of the tertiary filter operations were the major liquids process improvements

Third Upgrade 1998-2001

- The primary digester covers were replaced with new floating gas holder covers with integrated draft tube mixers
- Belt presses and cake loading station were included to provide for flexibility in disposal of biosolids
- PLC's, SCADA controls, and automation were a major component of the plant upgrade

Plant Design Parameters-2001

Plant Design Parameters		Design Capacity of Plant	Actual 2012 Figures
POPULATION		53,000	34,500
FLOW DESIG	Average	15.5	5.690
	Maximum	25.9	
	Peak Hour	30.9	
BOD (lbs/day)		37,500	16,135
	Average daily, mg/ℓ	290	340
SS (lbs/day)		28,400	8,637
	Avera	220	182
P (lbs/day)		1,160	169
	Average daily, mg/ℓ	9	3.57
EFFLUENT L	Monthyl Average		
	BOD, mg/ℓ	30	17.6
	SS, mg/ℓ	30	5.5
	P, mg/ℓ	0.6	0.58

Phosphorus Removal

- Manitowoc is a tricking filter facility and wholly dependent on chemical addition - Bio P is not an option
- Ferric chloride has been successfully in use for many years at the plant
- Significant changes have been made since 2001 to improve performance and operability

Phosphorus Equipment - 2001

- Dual 10,500 gallon ferric chloride storage tanks with spill containment
- Building 321 was constructed and houses the chemical feed pumps
- Heat traced underground line was installed

Phosphorus Equipment - 2001

- Building 321 was constructed to house the new chemical feed pumps
- The chemical storage tanks, piping, and a heat traced line were installed
- Ferric addition point did not change and is fed to aerated channel well ahead of the secondary clarifiers
- PD blowers mix the channel and keep sloughed biosolids from settling ahead of the secondary clarifiers. More air is pushed thru the first 3 or 4 diffusers nearest the addition point to provided aggressive mixing and contact

Control Strategies- General

Several chemical feed options were now available including flow pacing for the first time

- Constant Feed Rate – “old school” method! Set feed pump and set dose based on effluent phosphorus results from lab
- Flow paced via influent flow meter and SCADA sending a 4-20 ma output to control the speed of chemical feed pumps
- Constant Feed Rate (Gravity feed) – “old old school” method!

Constant Feed dosing

- Common and simple method of chemical delivery to the flow stream
- Can be done low tech and fed by gravity or with a constant speed chemical pump
- Tried and true when you can match the feed rate to a consistent influent phosphorus loading
- Operator tendency is to over feed chemical to remain under 1.0 mg/L at all times

Flow paced dosing

- Influent flow meter is used to pace chemical feed to match influent and phosphorus loading
- The diurnal flow patterns caught by the influent flow meter are matched by the chemical feed system
- Chemical addition is slowed during low flow times of the day
- There is still a tendency to over feed chemical to remain under 1.0 mg/L at all times

2001 - 2004

- Flow paced chemical addition was used to meet the 1.0 mg/L effluent limitation
- The chemical feed pumps proved to be a maintenance nightmare!! They plugged up and quit pumping, drips and leaks and ferric stains were common, and repair parts were expensive
- Valves and piping to gravity feed were after the upgrade so that chemical could still be fed if the pumps went down

2001 - 2004

- Operators shut off the ferric pumps when off loading tankers stir up the sediments and debris in the storage tanks
- Staff just "dealt with it" and if both pumps plugged we could always gravity feed until the obstruction was cleared

Phosphorus Equipment 2004

- New chemical metering pumps – installed in 2004
- Pump output is adjustable by motor speed or manual stroke length adjustment
- 4-20 ma signal drives pump speed

Phosphorus Equipment 2006

- The north ferric tank sprung a leak taking out the in floor heating system. Both the inner and outer tank walls were compromised so a new tank was installed. This tank uses heating pads in the sidewalls. A 6 inch tall baffle was incorporated on the tank floor just ahead of the with drawl pipe
- We began drawing down the tanks and washing debris and ferric sludge out

Phosphorus Equipment 2006

- Plant staff piped in new chemical strainers and isolation valves in 2006

Phosphorus Equipment 2008

- To maximize operational flexibility a second ferric addition point was added to multi point dose ferric
- Schedule 80 piping, insulation and heat tracing wire were purchased and plant staff trenched in and installed the chemical line to the well mixed influent flow meter flume just ahead of the primary clarifiers
- Chemically enhanced primary clarification was desirable in the fall when receiving heavy loadings from the local cannery. A reduction in chemical use was also desired

Ferric feed

- The new chemical pumps proved to be less prone to clogging
- Washing out the tanks reduced the build up and debris the pumps had seen in the past
- Installation of the chemical strainers proved to be the solution to the last of the lingering pump plugging issues
- A reduction of 25,000 gallons of ferric chloride was observed from 2008 to 2009
- The changes and enhancements made resulted in reduced maintenance and reliable performance and so life was good!

The Perfect Storm!

- Late in 2010 the largest sewer user in town began to ramp down and closed its doors in 2011. This sewer user had contributed nearly 26% of annual sewage revenue and contributed 1.2 MGD to the POTW leaving a gaping hole in the WWTF budget

The Perfect Storm!

- Manitowoc's WPDES permit was reissued for 1/1/2012 requiring an Optimization Plan, Plan Implementation, and an interim limit of 0.6 mg/L as a 6 month average and 78 lbs/day as an annual average effective 1/1/14

NPDES Permit WI-0024601-08

- Optimization Plan Submittal: Prepare and submit an Optimization Plan detailing how the facility will attain the highest amount of phosphorus removal achievable given its *current operational configuration*. The plan is to include a schedule for implementation – Due 3/31/12

NPDES Permit WI-0024601-08

- Optimization Plan Implementation: Begin implementation of the Optimization Plan – Due 04/01/12

NPDES Permit WI-0024601-08

- Interim Phosphorus Limits Effective: Comply with the interim phosphorus limits of 0.6 mg/L as a 6 month average, and 78 lbs/day as an annual average. Due 01/01/14

Phosphorus Optimization Plan

- Manitowoc was one of the first in the state to prepare and submit an Optimization plan
- The WWTF process is based on chemical feed alone so the complexities of Bio P was not an issue
- Permit stated the plan was to optimize the “existing facility” so it was decided to prepare a plan without the use of a consultant

Phosphorus Optimization Plan

- Based on the fact that the 0.6 mg/L interim limit was fact and going to happen we decided to meet it, or try to meet it, and see what happened
- Chemical feed was constant feed and the pumps ramped up to meet the “new” limit

January 2012

Jan-12 DATE	FLOW MGD	Inf mg/L	FeCl3 Gal. Fed	EFF mg/L
1	4.415	3.62	426	0.43
2	4.456	4.71	426	0.44
3	4.493	4.69	426	0.86
4	4.551	4.79	426	0.83
5	4.635	10.75	568	0.76
6	4.584		426	
7	4.225		284	
8	4.068	4.06	426	0.58
9	4.443	15.58	568	0.55
10	4.588	5.21	426	0.75
11	4.629	5.18	284	0.77
12	4.641	5.18	426	0.58
13	4.526		426	
14	4.284		426	
15	4.344	4.16	568	0.38
16	4.437	11.71	568	0.32
17	4.373	4.61	710	0.98
18	4.514	8.05	568	0.90
19	4.659	6.01	284	0.80
20	4.778		568	
21	4.429		710	
22	4.474	3.81	426	0.27
23	5.841	8.65	568	0.46
24	5.600	4.01	426	0.71
25	5.417	6.41	568	0.49
26	5.038	4.46	426	0.42
27	4.970		426	
28	4.652		426	
29	4.561	3.34	284	0.36
30	5.169	9.75	568	0.36
31	5.105	3.99	568	0.96
COUNT	31	23	31	23
TOTAL	144.899	142.73	**14626**	13.96
AVG	4.674	6.21	472	**0.61**
MAX	5.841	15.58	710	0.98
MIN	4.068	3.34	284	0.27

February 2012

Feb-12 DATE	FLOW MGD	Inf mg/L	FeCl3 Gal. Fed	EFF mg/L
1	4.971	4.41	568	0.64
2	4.856	5.09	426	0.32
3	4.830		426	
4	4.655		426	
5	4.521	3.76	284	0.38
6	4.782	4.96	568	0.30
7	4.820	4.69	284	0.36
8	4.901	4.32	426	0.44
9	5.218	4.69	426	0.30
10	6.153		426	
11	5.946		426	
12	5.317	3.96	284	0.32
13	4.338	5.86	568	0.32
14	4.624	4.54	284	0.49
15	4.464	5.14	426	0.82
16	4.060	5.54	284	0.84
17	4.661		426	
18	4.488		284	
19	4.490	4.26	284	0.59
20	4.602	5.79	142	0.71
21	4.682	4.88	284	0.67
22	4.602	4.84	426	0.63
23	4.205	13.01	284	0.82
24	3.724		284	
25	3.493		426	
26	4.203	4.16	284	0.76
27	4.661	5.36	142	0.74
28	4.548	5.26	568	0.50
29	5.206	4.31	426	0.54
30				
31				
COUNT	29	21	29	21
TOTAL	136.021	108.83	10792	11.49
AVG	4.690	5.18	372	**0.55**
MAX	6.153	13.01	568	0.84
MIN	3.493	3.76	142	0.3

Meeting the 0.6 mg/L interim limit

- Based on our “unofficial” study it appeared that we could reach 0.6 mg/L but meeting the limit would come at a price!

How much does it cost to go from 1.0 mg/L to 0.6 mg/L?

- There was only 2 months worth of data from the winter months so we were forced to make some assumptions
- Compared the January and February data to the 2 prior years at and compared consumption

Ferric Dosing to achieve 0.6 mg/L

Year	Month	Flow	Inf Phos lbs	Eff phos lbs	Removed lbs	Gallon FeCl3 fed	gal fed per lb removed		
2012	January	4.674	7595	744	6851	14626	2.135		
2012	February	4.690	5800	609	5191	10792	2.079	**2.107**	**Avg gal/lb/rer**

2011	January	4.467	6014	806	5208	9656	1.854		
2011	February	5.585	10052	952	9100	11502	1.264		
2010	January	6.568	9641	1085	8556	9940	1.162		
2010	February	5.346	8904	1036	7868	10650	1.354	**1.408**	**Avg gal/lb/rer**

-0.699

-0.496033

49.60% increase

Year	Bid Price	Bid Price % Increase	Gallons	Cost/Year
2004	272.93	3.216%	277,432.215	150,970.88
2005	295.93	8.427%	212,386.620	145,437.65
2006	334.88	13.162%	254,422.339	180,233.56
2007	356.75	6.531%	248,153.541	175,293.28
2008	426.00	19.411%	278,952.427	231,721.93
2009	571.00	34.038%	253,108.412	279,346.28
2010	406.00	-28.897%	153,986.151	119,644.14
2011	420.00	3.448%	148,284.281	120,552.60

How much is it going to cost to get down to 0.6 mg/L?

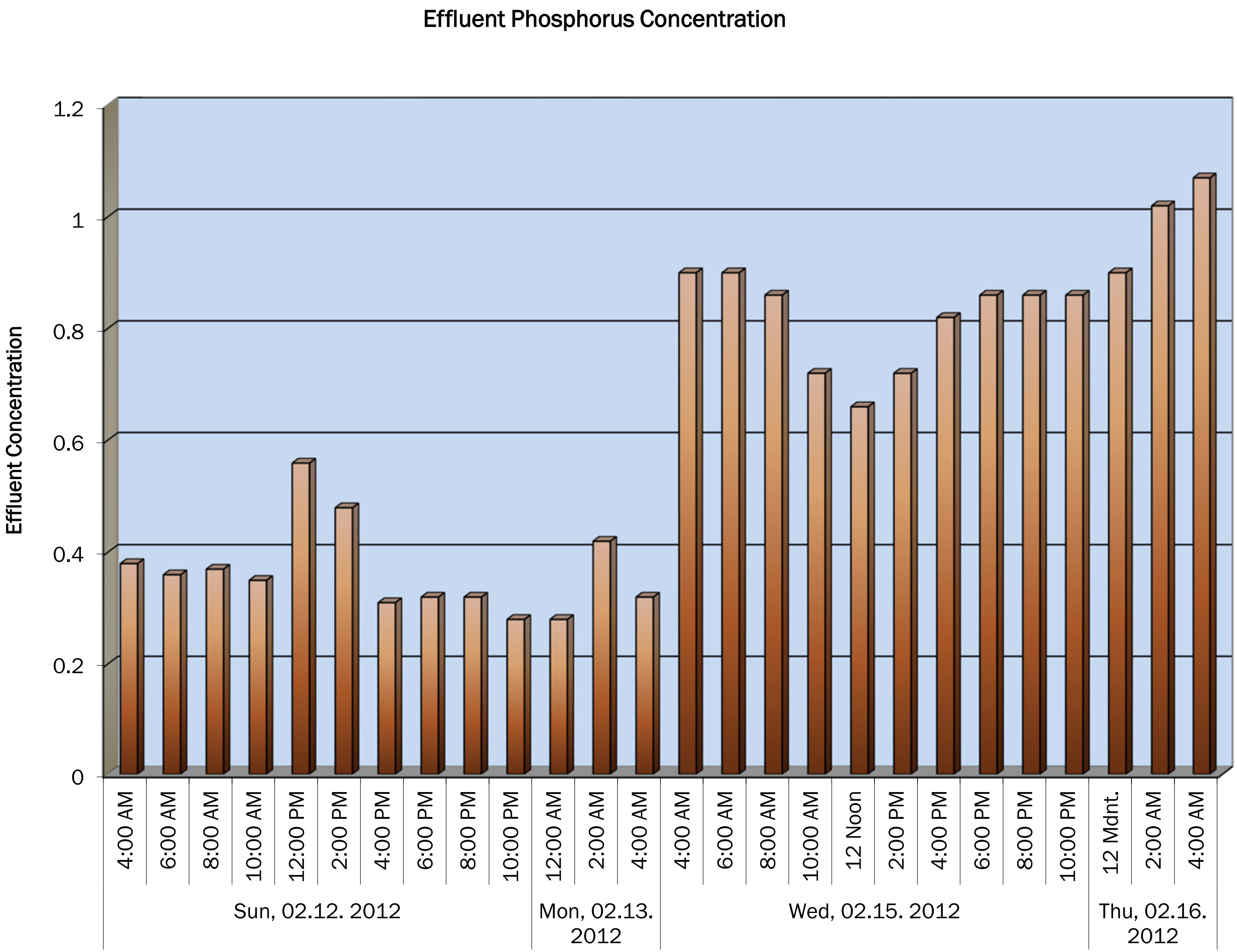
- Assuming phosphorus loadings stayed the same, ferric bid pricing stayed constant, and the ferric behaved in the spring, fall, and summer the same as in January and February my best estimate was $60,000 more per year

Could we better dose the ferric with an Ortho P analyzer?

- Despite the major industry shutting down, the Manitowoc influent waste stream is still influenced by a high industrial contribution
- Two neighboring communities had already installed Ortho P analyzers and were having success
- We thought there was room for improvement and so decided to do some in house testing

In house testing

- The plant is staffed 24/7 and so our operators collected effluent grab samples every 2 hours to see how much the concentration varied
- Influent loadings drop on weekends due to industry ramping down so we selected a Sunday and Wednesday and collected a grab sample every 2 hours and analyzed them for total P


Effluent Phosphorus Concentration
Effluent Concentration
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0.6
0.8
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10:00 AM
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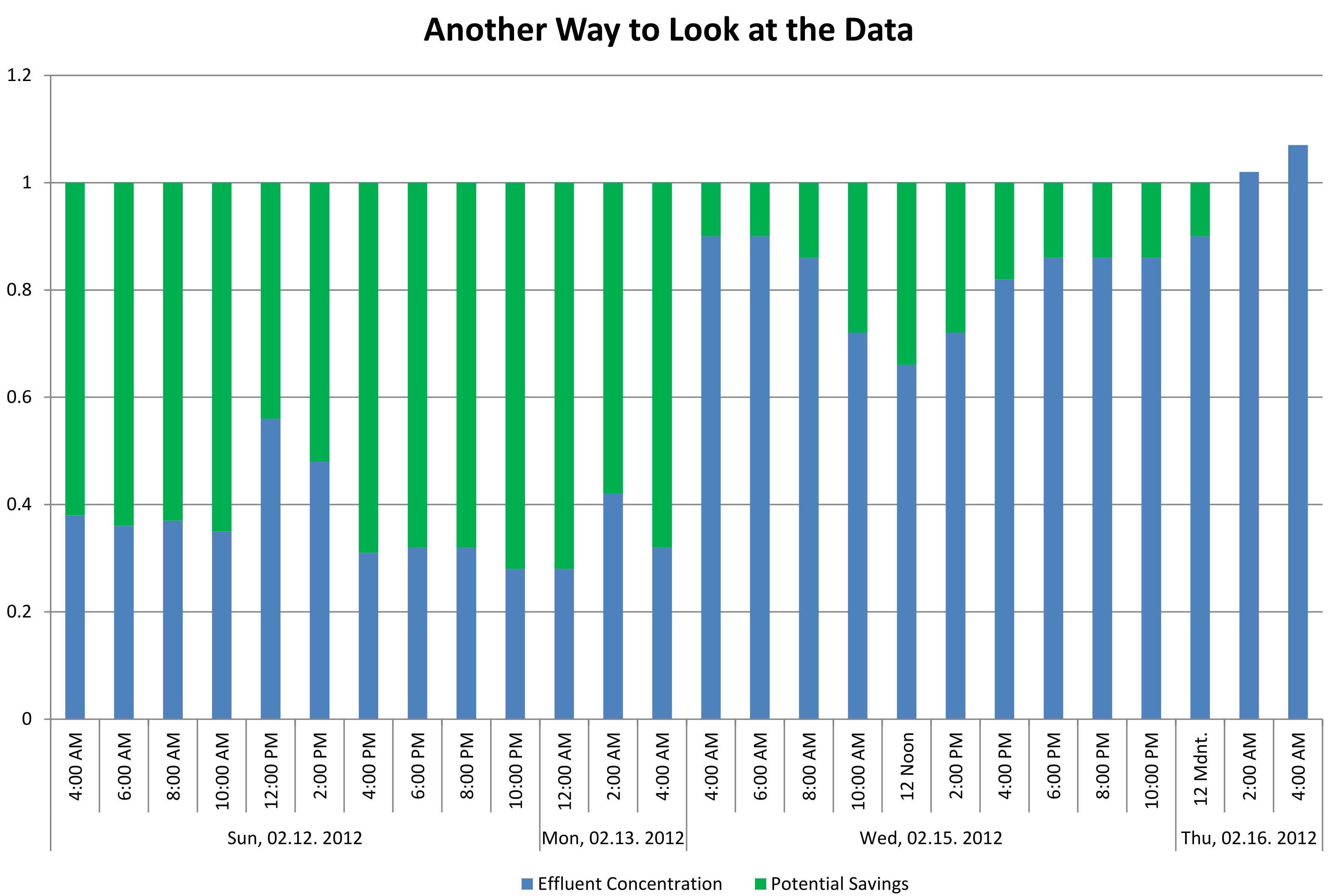
Wed, 02.15. 2012
Thu, 02.16. 2012



Another Way to Look at the Data
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0.6
0.4
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Sun, 02.12. 2012
Mon, 02.13. 2012
Wed, 02.15. 2012
Thu, 02.16. 2012
Effluent Concentration
Potential Savings

Time to make a change!

- We obtained a quotation from the manufacturers rep and got a separate quote from a SCADA integrator
- Presented the information and quotes to the WWTF Board and got the go ahead in March
- A PO was issued and the analyzer started up April 27, 2012
- The initial goal was a 10% reduction in ferric feed and a means to meet the pending 0.6 mg/L effluent limit cost effectively

Questions / Doubts / Unknowns

- Will this thing work for us?
- What about the lag time? It will take hours for the ferric to get here! The last place chemical is introduced is ahead of the finals and tertiary filters – a total of 1.572 MG worth of detention time?
- How do we correct for the difference between Ortho P and Total P?
- Are we going to have to adjust this thing every day?
- How easy is it to use? Is it easy to understand?

Orthophosphate Analyzer

- Location selected was adjacent to the effluent dipper sampler

- Electricity was already there, floor drain near by, and a PLC was in an adjacent office area

Orthophosphate Analyzer

- Plant staff installed the analyzer, ran power and signal wiring to the PLC
- Manufacturers rep was on site for initial start up and training
- Integration, control logic, and Wonder ware HMI work was contracted out

Required reagents

- VMo Phosphate reagent – purchased from the manufacturer
- 10% Muriatic Acid – bought locally and diluted for analyzer use
- A representative source of plant effluent

We did some experimenting!

- At start up we simply observed the analyzer readings and made an adjustments to the chemical feed according to the reading
- We found the readings varied some and few adjustments were made each day. Typically after the noon hour it was increased and after midnight the dose decreased
- A correlation was built on solid data by simultaneously grabbing analyzer results and effluent samples and analyzing them for Total P in the lab

Ortho P vs. Lab Total P grab vs. Effluent Composite

May-2012

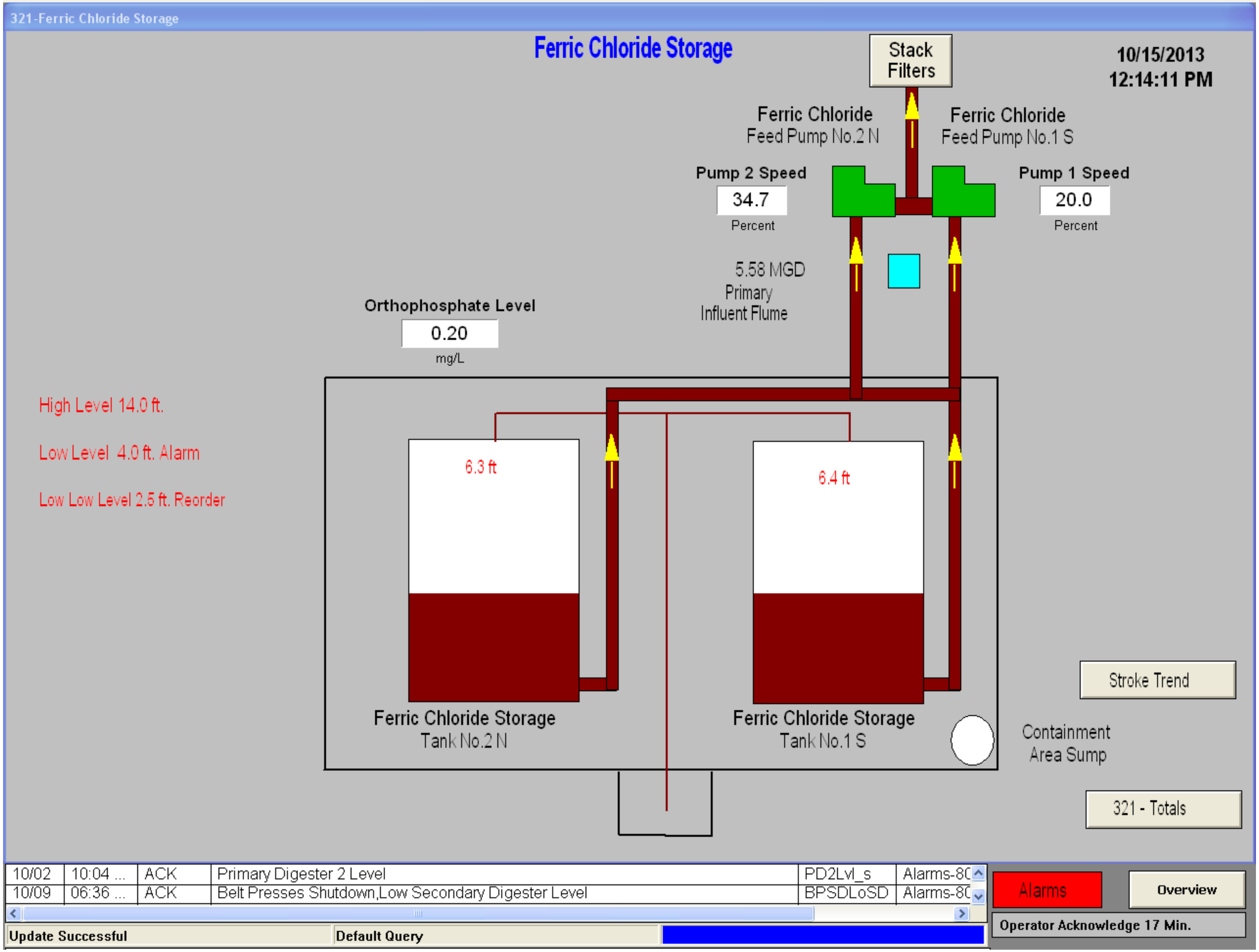
Date	Analyzer Ortho-P (grab)	Lab Total P (grab)	Lab Total P (composite)
1-May	0.67	0.94	0.74
2-May	0.95	0.93	0.93
3-May	0.93	0.98	0.88
4-May	0.33	0.48	0
5-May			
6-May			0.55
7-May	0	0.50	0.80
8-May	0.55	0.66	0.80
9-May	0.48	0.57	0.76
10-May	0.52	0.67	
11-May			
12-May			
13-May			
14-May	0.65	0.64	0.94
Average	0.564444	0.707778	0.711111

Going fully Auto

- Based on the lab testing results we set the system up knowing the effluent composite should be near 1.0 mg/L if we kept the Ortho P set point at about 0.7 or 0.8 mg/L
- We now had several options for dosing. We tried multi point addition to primary influent and ahead of the secondary clarifiers, single point addition ahead of the secondary clarifiers and constant manual speed to the primary clarifiers and auto control for the pump ahead of the secondary clarifiers

Going fully Auto (various notes)

- Went into automatic dosing on 6/7/12
- Chemical pumps stop running below 13% speed! Reduced stroke length to speed up the pumps.
- July 2012 – Ortho P unit was controlling both chemical pumps in multi point chemical feeding arrangement
- 7/23/12 No more 2 pumps – our pumps are too big!
- 8/3/13 Ordered smaller chemical pump to couple with existing motor (18 gph vs 90 gph)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Pump 2 Speed
34.7
Percent
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Percent
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Primary Influent Flume
Orthophosphate Level
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mg/L
High Level 14.0 ft.
Low Level 4.0 ft. Alarm
Low Low Level 2.5 ft. Reorder
6.3 ft
6.4 ft
Ferric Chloride Storage Tank No.2 N
Ferric Chloride Storage Tank No.1 S
Stroke Trend
Containment Area Sump
321 - Totals
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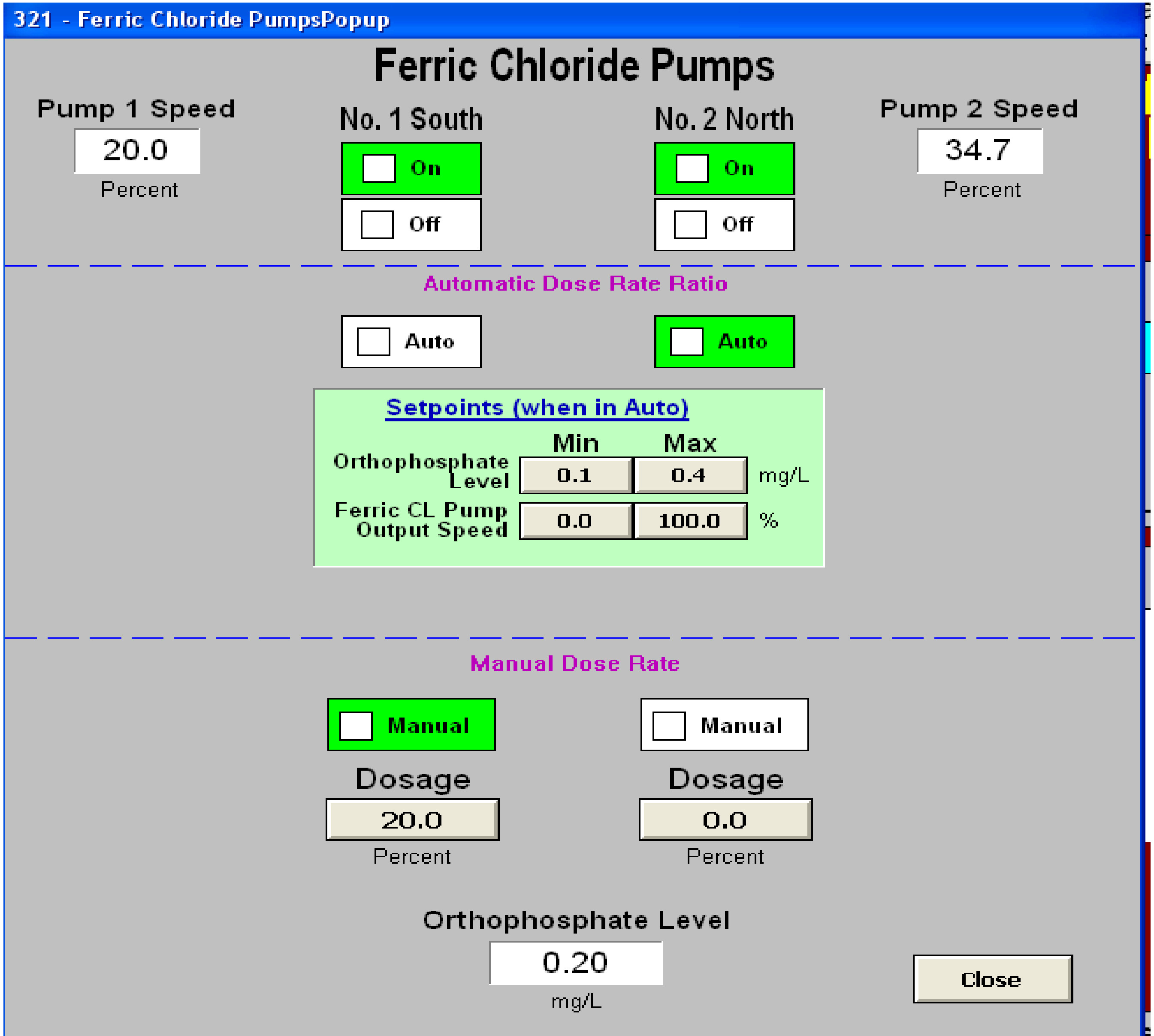

321 - Ferric Chloride PumpsPopup
Ferric Chloride Pumps
Pump 1 Speed
20.0
Percent
No. 1 South
On
Off
No. 2 North
On
Off
Pump 2 Speed
34.7
Percent
Automatic Dose Rate Ratio
Auto
Auto
Setpoints (when in Auto)
Min
Max
Orthophosphate Level
0.1
0.4
mg/L
Ferric CL Pump Output Speed
0.0
100.0
%
Manual Dose Rate
Manual
Manual
Dosage
20.0
Percent
Dosage
0.0
Percent
Orthophosphate Level
0.20
mg/L
Close

Annual Ferric consumption by year

	2010	2011	2012	2013
January	9940	9656	14626	5396
February	1650	11502	10792	5964
March	15336	12354	10792	5822
April	11786	10650	8804	5467
May	11644	9656	8662	7100
June	9514	8662	9869	8662
July	11076	9230	5680	7526
August	12070	11218	5254	8946
September	12070	11928	7668	8378
October	19738	15196	9656	
November	16472	14768	6236	
December	9656	13916	6135	
Gallons $FeCl_3$	**142962**	**140747**	**106186**	**65274**

Does gallons of ferric fed tell the whole story?

- Doesn’t account for increases/decreases phosphorus loading to the plant?
- Doesn’t account for additional or changes in side stream loading?
- Removal of phosphorus should be assessed by mass removed or treated and not simply gallons added

Digging deeper

- Chemical phosphorus removal cannot be gauged based on gallons fed alone – things change and there are too many variables
- A better measure of performance than gallons fed is the actual mass or pounds of phosphorus removed versus the gallons fed
- At first glance Manitowoc’s reduction in gallons fed is impressive but a closer look at the data is needed

July 2010

Jul-10 DATE	FLOW MGD	Influent mg/L	Headworks mg/L	Effluent mg/L	FeCl3 Gal. Fed	Inf P lbs	Eff P lbs	Phos lbs Removed	Influent lbs removed per gallon FeCl3 fed	Total Plant Load	Total Phos lbs Removed	Total lbs removed per gallon FeCl3 fed
1	8.166	4.52	4.71	0.85	426	308	58	250	0.587	321	263	0.753
2	7.891				284							
3	7.067				284							
4	6.821	3.77		0.87	284	214	49	165	0.581			
5	7.188	3.74	4.46	0.83	284	224	50	174	0.614	267	218	0.941
6	7.741	4.31	4.89	0.77	284	278	50	229	0.805	316	266	1.112
7	8.142	5.14	5.91	0.82	284	349	56	293	1.033	401	346	1.413
8	8.114	5.29	5.38	1.38	284	358	93	265	0.932	364	271	1.282
9	8.289				284							
10	7.808				142							
11	7.152	4.02	4.61	1.09	284	240	65	175	0.615	275	210	0.968
12	7.656	4.61	5.14	0.82	426	294	52	242	0.568	328	276	0.770
13	7.520	4.66	5.04	0.60	284	292	38	255	0.897	316	278	1.113
14	8.030	6.46	6.23	0.72	426	433	48	384	0.902	417	369	0.979
15	11.13	3.52	3.97	1.02	284	327	95	232	0.817	369	274	1.298
16	10.31				568							
17	9.673				284							
18	9.918	4.31	5.03	0.68	426	357	56	300	0.705	416	360	0.977
19	12.16	3.41	4.28	0.82	284	346	83	263	0.925	434	351	1.528
20	15.30	2.22	2.6	0.44	426	283	56	227	0.533	332	276	0.779
21	12.57	4.34	3.79	0.32	426	455	34	421	0.989	397	364	0.933
22	13.97	3.32	3.64	0.61	284	387	71	316	1.112	424	353	1.493
23	14.79				568							
24	13.41				284							
25	12.12	2.07	2.64	0.34	426	209	34	175	0.410	267	232	0.626
26	12.14	3.51	3.54	0.42	284	355	43	313	1.102	358	316	1.262
27	12.97	2.72	3.31	0.64	426	294	69	225	0.528	358	289	0.840
28	10.61	3.22	4.51	0.40	568	285	35	250	0.439	399	364	0.703
29	8.859	3.46	3.69	0.32	426	256	24	232	0.545	273	249	0.640
30	8.890				568							
31	8.793				284							
COUNT	31	21	20	21	31	21	21	21	21	20	20	20
TOTAL	305.1984	82.62	87.37	14.76	11076	6544	1159	5385	16	7033	5923	20
AVG	9.845	3.93	4.37	0.70	357	312	55	256	0.745	352	296	1.021
MAX	15.3	6.46	6.23	1.38	568	455	95	421	1.112	434	369	1.528
MIN	6.821	2.07	2.6	0.32	142	209	24	165	0.410	267	210	0.626

July 2011

<u>Jul-11</u> DATE	FLOW MGD	Influent mg/L	Headworks mg/L	Effluent mg/L	FeCl3 Gal. Fed	Inf P lbs	Eff P lbs	Phos lbs Removed	Influent lbs removed per gallon FeCl3 fed	Total Plant Load	Total Phos lbs Removed	Total lbs removed per gallon FeCl3 fed
1	7.724				284		0					
2	7.017				284		0			0	0	
3	6.984	2.82		0.40	284	164	23	141	0.496			
4	6.909	3.89	4.24	0.45	284	224	26	198	0.698	244	218	**0.860**
5	7.396	2.86	3.64	0.64	284	176	39	137	0.482	225	185	**0.791**
6	7.328	4.24	6.75	0.58	142	259	35	224	1.575	413	377	**2.905**
7	7.553	4.48	7.30	0.96	284	282	60	222	0.781	460	399	**1.619**
8	7.430				284		0			0	0	
9	7.339				426		0			0	0	
10	6.773	2.94	3.71	0.66	284	166	37	129	0.453	210	172	**0.738**
11	7.769	4.91	7.43	1.22	284	318	79	239	0.842	481	402	**1.695**
12	7.432	3.82	4.79	1.53	142	237	95	142	1.000	297	202	**2.091**
13	7.099	8.40	5.31	1.00	284	497	59	438	1.543	314	255	**1.107**
14	7.305	4.52	5.56	1.03	284	275	63	213	0.749	339	276	**1.193**
15	6.846				426		0			0	0	
16	6.303				284		0			0	0	
17	6.479	3.02	4.44	0.62	426	163	34	130	0.304	240	206	**0.563**
18	7.040	4.24	6.13	1.18	284	249	69	180	0.633	360	291	**1.267**
19	7.202	3.69	5.48	0.85	284	222	51	171	0.601	329	278	**1.159**
20	7.250	4.29	6.71	0.85	284	259	51	208	0.732	406	354	**1.429**
21	7.272	3.69	5.04	1.10	426	224	67	157	0.369	306	239	**0.718**
22	6.563				284		0	0		0	0	
23	7.004				284		0	0		0	0	
24	6.694	3.34		0.61	284	186	34	152	0.537	0	-34	
25	6.864	4.41	5.64	0.70	426	252	40	212	0.499	323	283	**0.758**
26	6.645	3.37	4.16	0.76	142	187	42	145	1.019	231	188	**1.624**
27	6.555	8.00	6.33	0.78	426	437	43	395	0.927	346	303	**0.812**
28	6.678	3.84	5.21	1.06	284	214	59	155	0.545	290	231	**1.022**
29	6.560				284		0	0		0	0	
30	6.025				284		0	0		0	0	
31	5.886	3.59	5.33	0.64	284	176	31	145	0.510	262	230	**0.921**
COUNT	31	21	19	21	31	21	31	25	21	29	29	**19**
TOTAL	215.924	88.36	103.2	17.62	**9230**	5170	1039	4131	15	6074	5058	**23**
AVG	6.965	4.21	5.43	0.84	**298**	246	34	165	**0.728**	209	174	**1.225**
MAX	7.769	8.4	7.43	1.53	426	497	95	438	1.575	481	402	**2.905**
MIN	5.886	2.82	3.64	0.4	142	163	0	0	0.304	0	-34	**0.563**

July 2012

<u>Jul-12</u>

DATE	FLOW MGD	Influent mg/L	Headworks mg/L	Effluent mg/L	FeCl3 Gal. Fed	Inf P lbs	Eff P lbs	Phos lbs Removed	Influent lbs removed per gallon FeCl3 fed	Total Plant Load	Total Phos lbs Removed	Total lbs removed per gallon FeCl3 fed
1	4.809	3.52		0.70	284	141	28	113	0.398			
2	5.695	5.51	5.71	0.89	284	262	42	219	0.773	271	229	**0.955**
3	5.606	5.14		0.86	284	240	40	200	0.705			
4	5.241	4.18	5.29	0.84	142	183	37	146	1.028	231	195	**1.628**
5	5.729	4.18	4.79	0.91	284	200	43	156	0.550	229	185	**0.806**
6	5.702				142							
7	4.803				284							
8	4.642	4.19	4.88	0.82	142	162	32	130	0.919	189	157	**1.330**
9	5.279	5.29	5.56	0.88	284	233	39	194	0.684	245	206	**0.862**
10	4.948	6.75	6.68	0.88	142	279	36	242	1.706	276	239	**1.941**
11	4.896	5.83	5.9	0.92	284	238	38	200	0.706	241	203	**0.848**
12	4.930	4.89	5.76	0.88	284	201	36	165	0.581	237	201	**0.834**
13	5.190				142							
14	4.715				284							
15	4.604	4.09	6.48	0.80	142	157	31	126	0.890	249	218	**1.752**
16	4.999	4.64	5.64	0.74	142	193	31	163	1.145	235	204	**1.656**
17	5.496	4.44	5.63	0.93	142	204	43	161	1.133	258	215	**1.817**
18	6.247	4.14	4.49	0.73	142	216	38	178	1.251	234	196	**1.647**
19	6.259	4.74	5.81	0.80	142	247	42	206	1.448	303	262	**2.136**
20	5.716				142							
21	5.183				142							
22	5.110	3.67	5.31	0.96	142	156	41	115	0.813	226	185	**1.594**
23	4.942	4.91	7.15	0.96	142	202	40	163	1.147	295	255	**2.075**
24	5.167	5.09		0.92	142	219	40	180	1.265			
25	5.019	5.28	5.13	0.82	142	221	34	187	1.315	215	180	**1.512**
26	8.633	4.09		0.88	142	294	63	231	1.628			
27	8.664				142							
28	6.689				142							
29	6.297	3.27	5.61	0.90	284	172	47	124	0.438	295	247	**1.037**
30	6.661	3.82	4.73	0.68	142	212	38	174	1.228	263	225	**1.850**
COUNT	30	22	18	22	30	22	22	22	22	18	18	**18**
TOTAL	167.871	101.66	100.55	18.7	**5680**	4633	858	3775	22	4491	3804	**26**
AVG	5.596	4.62	5.59	0.85	**189**	211	39	172	**0.989**	249	211	**1.460**
MAX	8.664	6.75	7.15	0.96	284	294	63	242	1.706	303	262	**2.136**
MIN	4.604	3.27	4.49	0.68	142	141	28	113	0.398	189	157	**0.806**

Analyzing the analyzer

Analyzing the analyzer

Monthly average - Total Phos lbs removed per gallon FeCl3 added

	2011	2012	% Increase	2013	% Increase
July	1.225	1.4600	19.18%		
August	0.654	1.7780	171.87%		
September	0.695	1.1160	60.58%		
October	0.629	1.0700	70.11%		
November	0.694	1.4820	113.54%		
December	0.625	1.2930	106.88%		
January	0.522	1.4860	184.67%		
February	0.957	1.0120	5.75%		
March		0.9870		1.257	27.36%
April		1.0820		1.710	58.04%
May		1.4330		1.339	-6.56%
June		1.1710		1.054	-9.99%
July		1.4600		1.121	-23.22%
Average			91.57%	1.2962	9.13%

Blue - Automatic dosing for 1.0 mg/L

Red - Automatic dosing for 0.6 mg/L

ASA Analyzer Simple Payback

Month	2011	2012	Reduction	$/gallon	$ Saved
July	9230	5680	3550	0.87	3,088.50
August	11218	5254	5964	0.87	5,188.68
September	11928	7668	4260	0.87	3,706.20
October	15194	9356	5838	0.87	5,079.06
November	14768	6236	8532	0.87	7,422.84
December	13916	6135	7781	0.87	6,769.47

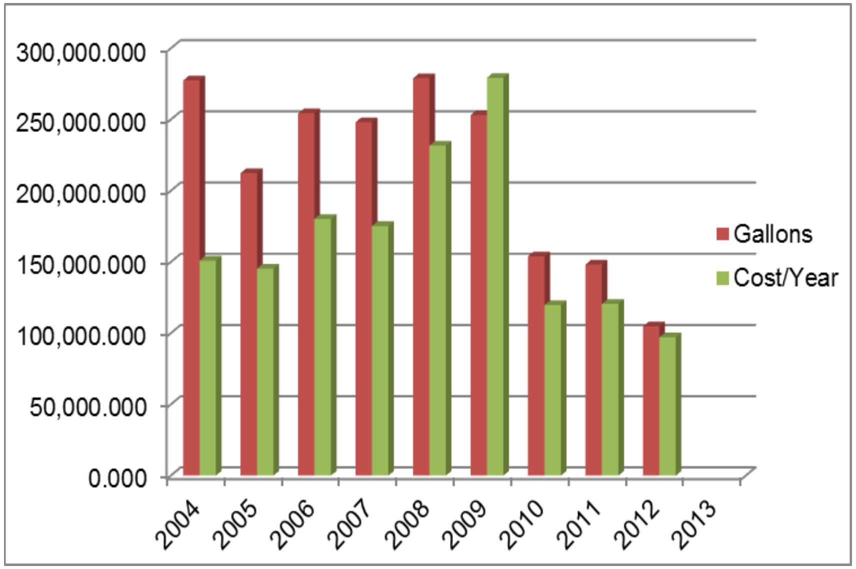
$ 31,254.75

Instrument and SCADA programming cost $16,760

2012 Results

FERRIC BID PRICES

Year	Bid Price	Bid Price % Increase	Gallons	Cost/Year
2004	272.93	3.216%	277,432.215	150,970.88
2005	295.93	8.427%	212,386.620	145,437.65
2006	334.88	13.162%	254,422.339	180,233.56
2007	356.75	6.531%	248,153.541	175,293.28
2008	426.00	19.411%	278,952.427	231,721.93
2009	571.00	34.038%	253,108.412	279,346.28
2010	406.00	-28.897%	153,986.151	119,644.14
2011	420.00	3.448%	148,284.281	120,552.60
2012	460.00	9.524%	104,750.502	97,106.00
2013	512.00	11.304%		



Lessons Learned – so far

- If feeding ferric chloride, in line chemical strainers are priceless! If you have problems and don't have strainers – get them!
- The most sophisticated system in earth will not make up for bound phosphorus in suspended solids – we have found it works best below 8 mg/L TSS
- An online analyzer can "watch" your Bio P system and trigger an alarm or activate the chemical feed pumps

Thanks to:

Manitowoc WWTF Staff

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Brad Mentink & Lynn TeBeest, Best Systems/Energenecs

Questions?