Case Studies on Implementing Low-Cost Modifications to Improve Nutrient Reduction at Wastewater Treatment Plants

Webcast sponsored by EPA's Watershed Academy

Thursday, October 15, 2015

1:00pm – 3:00pm Eastern

Instructors:

- **Dr. Ellen Gilinsky**, Senior Policy Advisor, Office of Water, U.S. Environmental Protection Agency
- **Victor D'Amato**, Senior Engineer, Tetra Tech Inc.
- **John Hricko**, Superintendent of Water Utilities for the Town of Crewe, Virginia
- **Gilbert Perez**, Director of Operations for the Victor Valley Wastewater Reclamation Authority (VVWRA) in California

Webcast Logistics

- **To Ask a Question** – Type your question in the "Questions" tool box on the right side of your screen and click "Send."
- **To report any technical issues** (such as audio problems) – Type your issue in the "Questions" tool box on the right side of your screen and click "Send" and we will respond by posting an answer in the "Questions" box.

Overview of Today’s Webcast

- Introduction by Dr. Gilinsky
- Overview of the Report Including Key Findings
- Case Study from Town of Crewe, VA
- Case Study from Victor Valley, CA

Webinar:
Case Studies on Implementing Low Cost Modifications for Improving the Nutrient Reduction Performance of Wastewater Treatment Plants

Dr. Ellen Gilinsky, Senior Advisor
Office of Water
Introductory Remarks
October 15, 2015

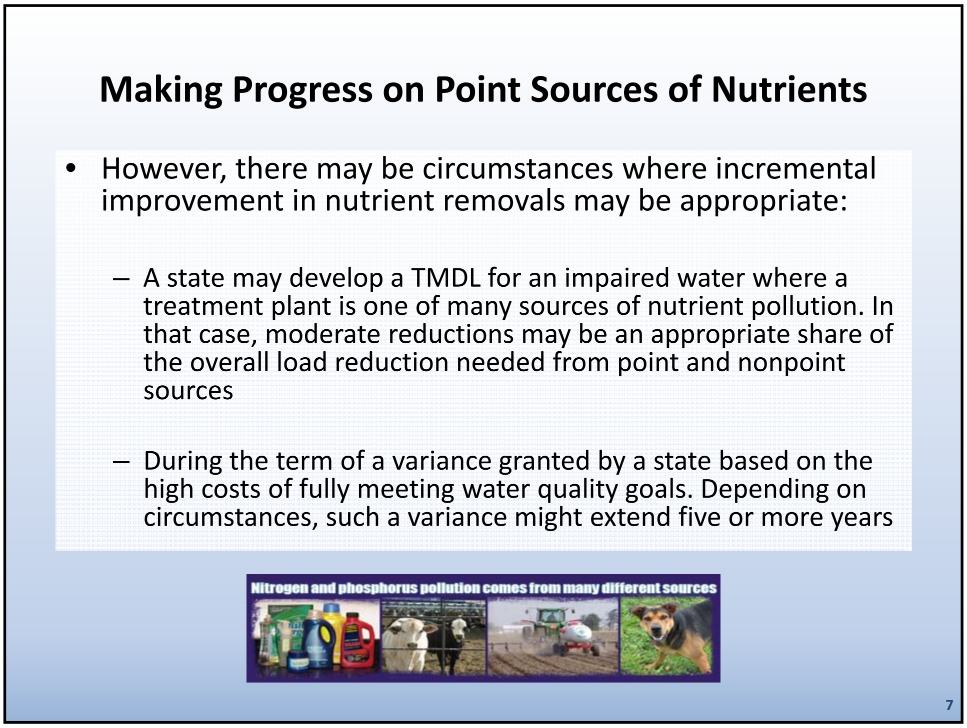
Nutrient Pollution Is a Serious, Widespread Problem

- Nutrient pollution is one of America's costliest and most challenging environmental problems
- Impacts to water bodies across the United States from nutrient pollution are well-documented affecting:
  - The environmental and economic viability of our nation's waters, including tourism, real estate values, and commercial enterprises
  - The quality of waters used for fishing, swimming, and other recreational purposes
  - Public health and well being
- The challenge before us is how we can most effectively work and collaborate at all levels to address sources of nutrient pollution
- While it is critical to reduce nutrients from all source sectors, this webinar focuses on the point source opportunities

Too much nitrogen and phosphorus in the water can have diverse and far-reaching impacts on public health, the environment and the economy. Photo credit: Bill Yates.

Making Progress on Point Sources of Nutrients

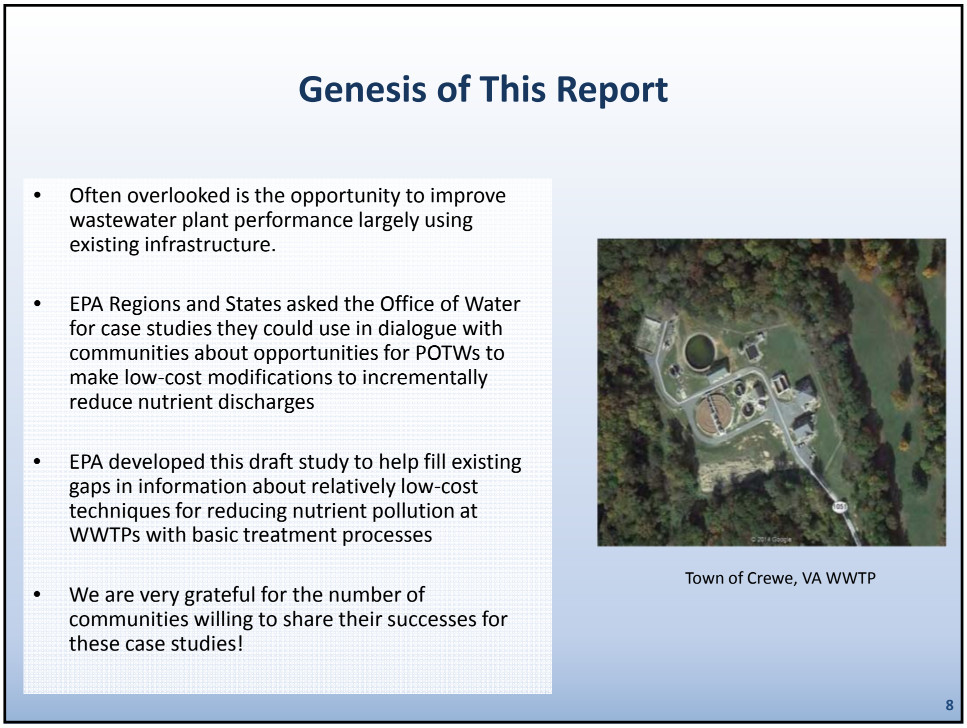
- Cost is often seen as a barrier to enhancing nutrient removal at community wastewater treatment plants:
  - High cost is typically associated with building new infrastructure, or major facility retrofits and operation and maintenance costs to achieve <u>very significant</u> nutrient reductions
  - In some cases, the levels of nutrient removal needed to fully achieve water quality goals **will** require costly investments. For example, if a treatment plant is the <u>primary</u> source of nutrient loads to a waterbody impaired by nutrients



Making Progress on Point Sources of Nutrients

- However, there may be circumstances where incremental improvement in nutrient removals may be appropriate:
  - A state may develop a TMDL for an impaired water where a treatment plant is one of many sources of nutrient pollution. In that case, moderate reductions may be an appropriate share of the overall load reduction needed from point and nonpoint sources
  - During the term of a variance granted by a state based on the high costs of fully meeting water quality goals. Depending on circumstances, such a variance might extend five or more years

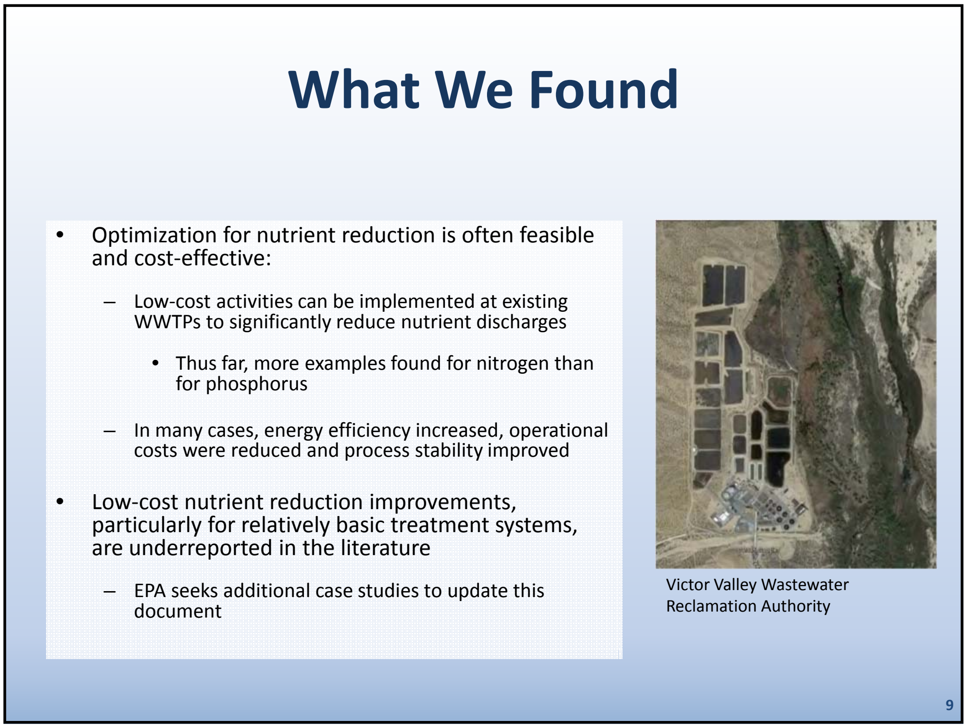
Nitrogen and phosphorus pollution comes from many different sources



Genesis of This Report

- Often overlooked is the opportunity to improve wastewater plant performance largely using existing infrastructure.
- EPA Regions and States asked the Office of Water for case studies they could use in dialogue with communities about opportunities for POTWs to make low-cost modifications to incrementally reduce nutrient discharges
- EPA developed this draft study to help fill existing gaps in information about relatively low-cost techniques for reducing nutrient pollution at WWTPs with basic treatment processes
- We are very grateful for the number of communities willing to share their successes for these case studies!

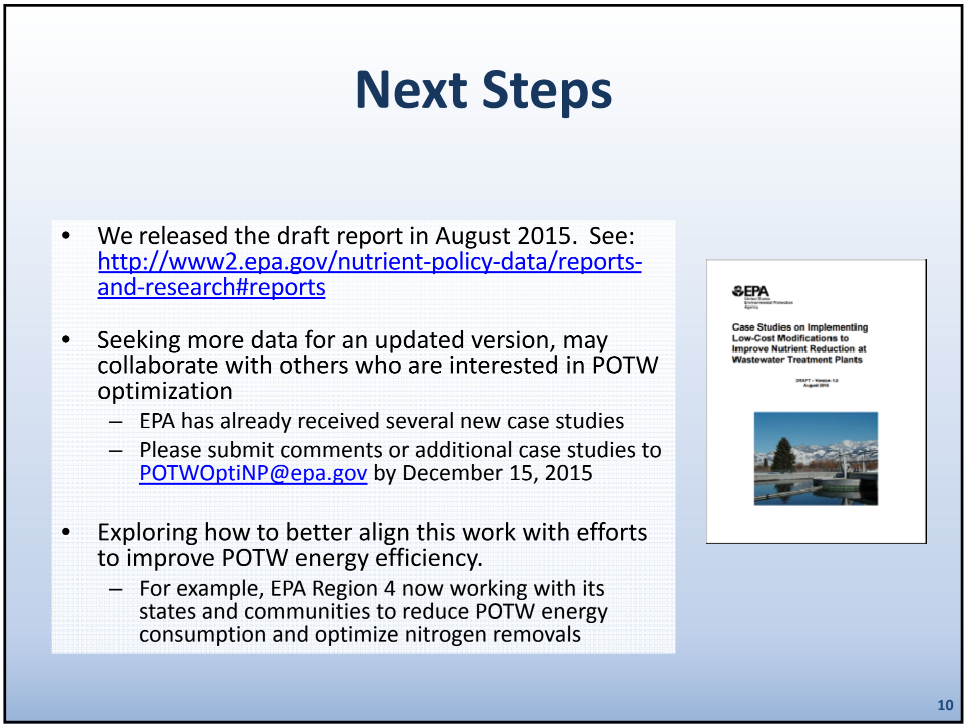
Town of Crewe, VA WWTP



What We Found

- Optimization for nutrient reduction is often feasible and cost-effective:
  - Low-cost activities can be implemented at existing WWTPs to significantly reduce nutrient discharges
    - Thus far, more examples found for nitrogen than for phosphorus
  - In many cases, energy efficiency increased, operational costs were reduced and process stability improved
- Low-cost nutrient reduction improvements, particularly for relatively basic treatment systems, are underreported in the literature
  - EPA seeks additional case studies to update this document

Victor Valley Wastewater Reclamation Authority



Next Steps

- We released the draft report in August 2015. See: http://www2.epa.gov/nutrient-policy-data/reports-and-research#reports
- Seeking more data for an updated version, may collaborate with others who are interested in POTW optimization
  - EPA has already received several new case studies
  - Please submit comments or additional case studies to POTWOptiNP@epa.gov by December 15, 2015
- Exploring how to better align this work with efforts to improve POTW energy efficiency.
  - For example, EPA Region 4 now working with its states and communities to reduce POTW energy consumption and optimize nitrogen removals

Case Studies on Implementing Low-Cost Modifications to Improve Nutrient Reduction at Wastewater Treatment Plants

DRAFT – Version 1.0
August 2015

Questions

TETRA TECH

Victor D’Amato

Senior Engineer, Tetra Tech Inc.

Case Studies on Implementing Low-Cost Modifications to Improve Nutrient Reduction at WWTPs

EPA
United States
Environmental Protection
Agency

Case Studies on Implementing
Low-Cost Modifications to
Improve Nutrient Reduction at
Wastewater Treatment Plants

DRAFT – Version 1.0
July 2015

- One of the first documented efforts to present **empirical** data of non-advanced WWTPs that have been optimized to improve nutrient reduction
- Compendium of case studies

Identifying Case Studies

- Internal EPA query to relevant Regional and state staff
- Broad grey and white literature review
- Review of existing EPA and other guidance documents
- Query of selected industry practitioners
- Supplemental search of Clean Water Needs Survey (CWNS) database

Case Study Selection Criteria

- Responsiveness to project objectives
  - relatively basic (non-advanced) treatment plants
  - improved nitrogen and/or phosphorus reduction using low-cost techniques
- Availability of monitoring and cost data
- Representative of a range of scenarios and nutrient optimization approaches

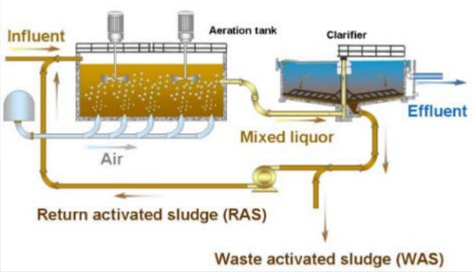
Case Study Selection

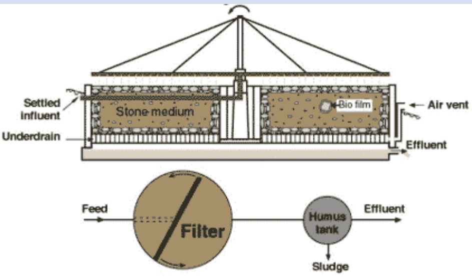
- From a master list of over 80 case studies, a total of 12 were summarized in report
- Of the 12 selected case studies, seven fully meet the main study criteria
- Other five provide useful information that might help target audiences understand nutrient reduction optimization approaches

Case Study Selection Findings

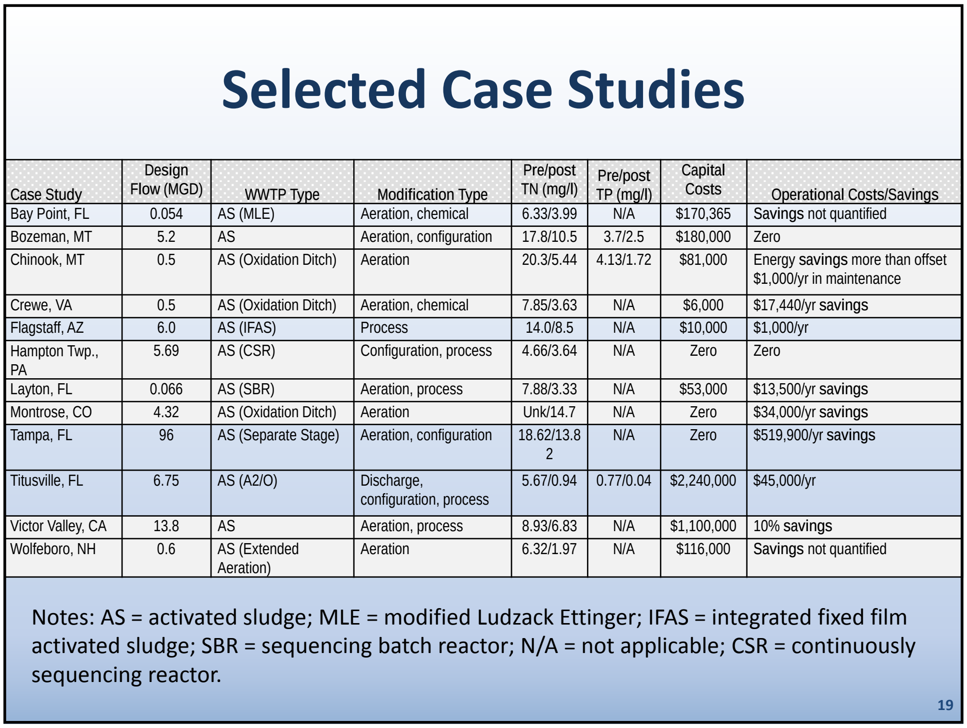
- Despite extensive efforts to identify and develop relevant case studies, few met the study criteria
- Most efforts at improving non-advanced plants appear to be unpublished or under-documented
- Most published literature focuses instead on optimizing existing enhanced nutrient removal (ENR) systems

Wastewater Treatment Primer





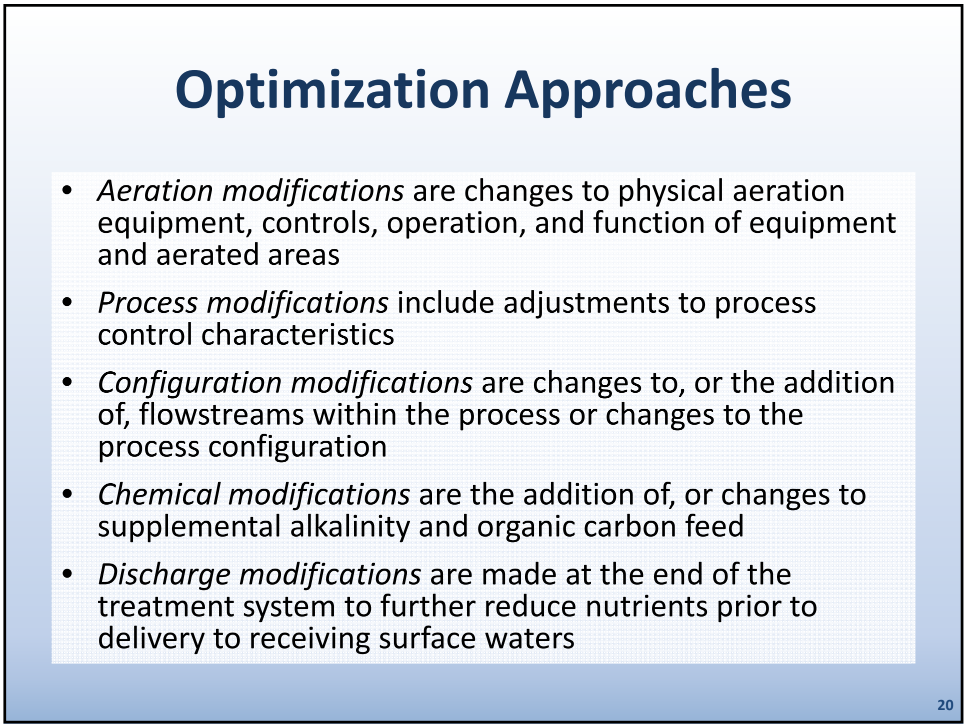
- Activated sludge: suspended growth in actively mixed/aerated reactors
- Lagoon: passive treatment
- Trickling filter: attached growth



Selected Case Studies

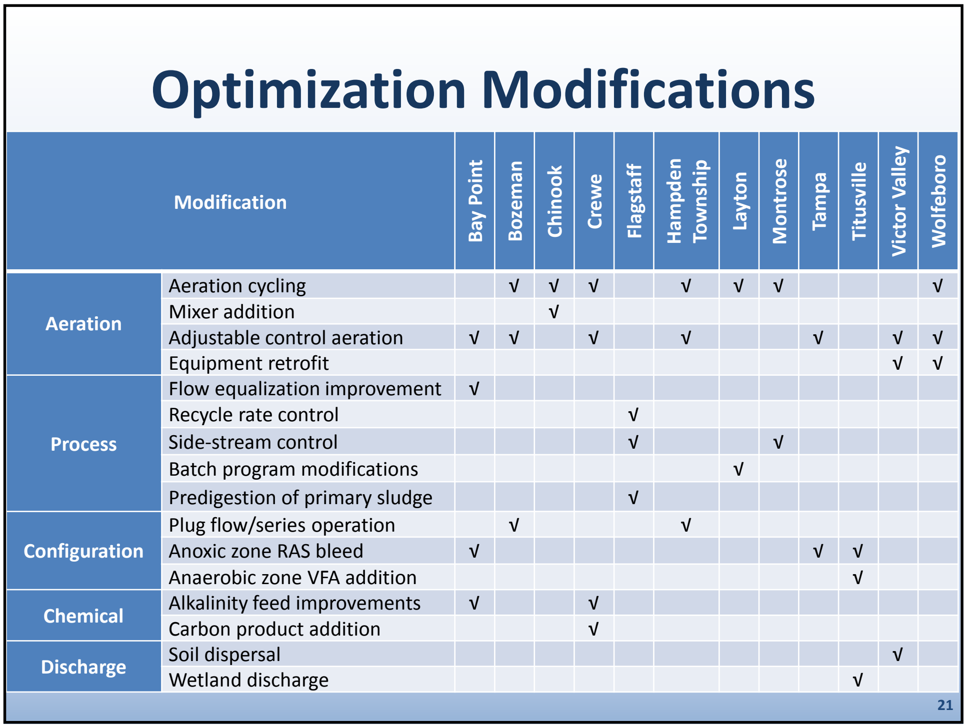
Case Study	Design Flow (MGD)	WWTP Type	Modification Type	Pre/post TN (mg/l)	Pre/post TP (mg/l)	Capital Costs	Operational Costs/Savings
Bay Point, FL	0.054	AS (MLE)	Aeration, chemical	6.33/3.99	N/A	$170,365	Savings not quantified
Bozeman, MT	5.2	AS	Aeration, configuration	17.8/10.5	3.7/2.5	$180,000	Zero
Chinook, MT	0.5	AS (Oxidation Ditch)	Aeration	20.3/5.44	4.13/1.72	$81,000	Energy savings more than offset $1,000/yr in maintenance
Crewe, VA	0.5	AS (Oxidation Ditch)	Aeration, chemical	7.85/3.63	N/A	$6,000	$17,440/yr savings
Flagstaff, AZ	6.0	AS (IFAS)	Process	14.0/8.5	N/A	$10,000	$1,000/yr
Hampton Twp., PA	5.69	AS (CSR)	Configuration, process	4.66/3.64	N/A	Zero	Zero
Layton, FL	0.066	AS (SBR)	Aeration, process	7.88/3.33	N/A	$53,000	$13,500/yr savings
Montrose, CO	4.32	AS (Oxidation Ditch)	Aeration	Unk/14.7	N/A	Zero	$34,000/yr savings
Tampa, FL	96	AS (Separate Stage)	Aeration, configuration	18.62/13.82	N/A	Zero	$519,900/yr savings
Titusville, FL	6.75	AS (A2/O)	Discharge, configuration, process	5.67/0.94	0.77/0.04	$2,240,000	$45,000/yr
Victor Valley, CA	13.8	AS	Aeration, process	8.93/6.83	N/A	$1,100,000	10% savings
Wolfeboro, NH	0.6	AS (Extended Aeration)	Aeration	6.32/1.97	N/A	$116,000	Savings not quantified

Notes: AS = activated sludge; MLE = modified Ludzack Ettinger; IFAS = integrated fixed film activated sludge; SBR = sequencing batch reactor; N/A = not applicable; CSR = continuously sequencing reactor.



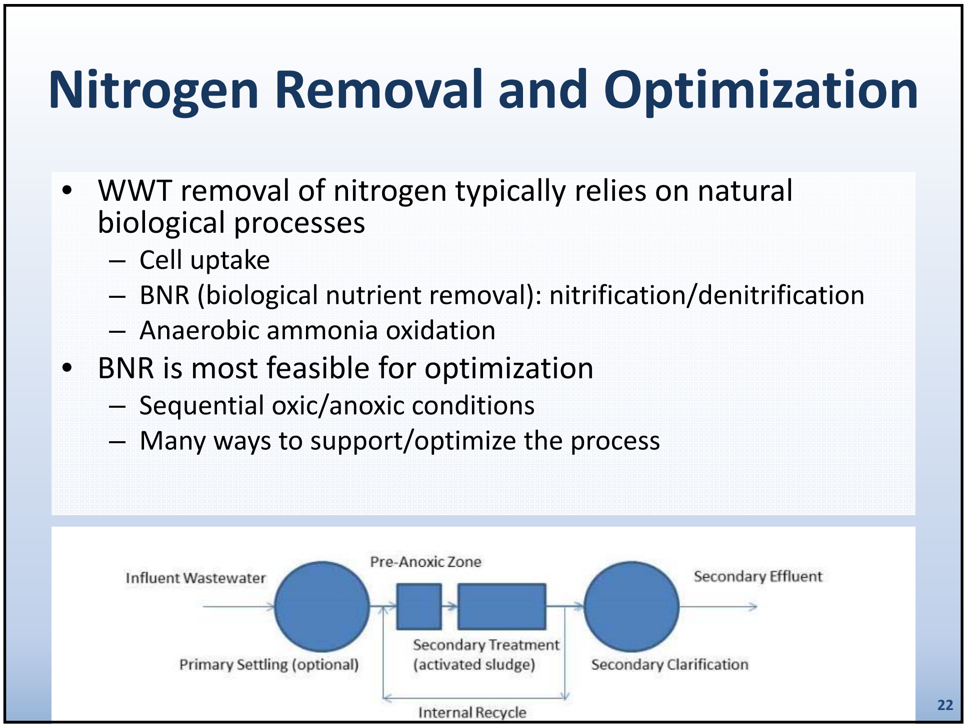
Optimization Approaches

- *Aeration modifications* are changes to physical aeration equipment, controls, operation, and function of equipment and aerated areas
- *Process modifications* include adjustments to process control characteristics
- *Configuration modifications* are changes to, or the addition of, flowstreams within the process or changes to the process configuration
- *Chemical modifications* are the addition of, or changes to supplemental alkalinity and organic carbon feed
- *Discharge modifications* are made at the end of the treatment system to further reduce nutrients prior to delivery to receiving surface waters



Optimization Modifications

Modification		Bay Point	Bozeman	Chinook	Crewe	Flagstaff	Hampden Township	Layton	Montrose	Tampa	Titusville	Victor Valley	Wolfeboro
Aeration	Aeration cycling		√	√	√		√	√	√				√
	Mixer addition			√									
	Adjustable control aeration	√	√		√		√			√		√	√
	Equipment retrofit											√	√
Process	Flow equalization improvement	√											
	Recycle rate control					√							
	Side-stream control					√			√				
	Batch program modifications							√					
	Predigestion of primary sludge					√							
Configuration	Plug flow/series operation		√				√						
	Anoxic zone RAS bleed	√								√	√		
	Anaerobic zone VFA addition										√		
Chemical	Alkalinity feed improvements	√			√								
	Carbon product addition				√								
Discharge	Soil dispersal											√	
	Wetland discharge										√		



Nitrogen Removal and Optimization

- WWT removal of nitrogen typically relies on natural biological processes
  - Cell uptake
  - BNR (biological nutrient removal): nitrification/denitrification
  - Anaerobic ammonia oxidation
- BNR is most feasible for optimization
  - Sequential oxic/anoxic conditions
  - Many ways to support/optimize the process

Phosphorus Removal and Optimization

- WWT removal of phosphorus is typically by sequestration in solids
  - Cell uptake
  - Enhanced Biological Phosphorus Removal (EBPR): increased cell uptake
  - Chemical precipitation/immobilization
- Chemical precipitation is most feasible for optimization
  - EBPR usually requires additional reactor(s)
  - Chemical treatment is easy, reliable and capable of low levels of effluent TP
  - Several drawbacks to chemical treatment

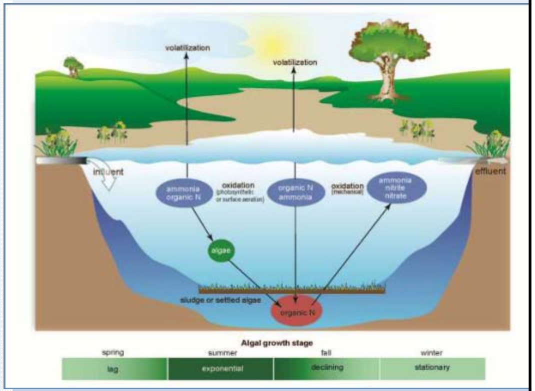
Typical WWTP Performance

Treatment System	Total Nitrogen (mg/l)	Total Phosphorus (mg/l)
Raw Wastewater	40	7.0
Primary Treatment	37	6.2
Activated Sludge (no ENR)	25	5.6
Facultative Lagoon	16	4.2
Trickling Filter	25	5.8

Sources: Metcalf and Eddy (1991, 2004); WEF (2003); USEPA (2011)

Lagoons

- Characteristics
  - Algae/wind aerate surface
  - Anoxic/anaerobic bottom layers
  - Relative long retention times
- Nitrogen removal mechanisms
  - Ammonia stripping to the atmosphere
  - Assimilation into biomass
  - Biological nitrification/denitrification
  - Sedimentation of insoluble organic nitrogen
- Phosphorus removal mechanisms
  - Physiochemical: adsorption, coagulation, and precipitation



Lagoon Optimization

- Controlled discharge
  - Coincide with times when effluent nutrient concentrations are lowest and/or when receiving water impacts will be lowest
  - Works well for non-discharge, since water demand is highest and receiving water sensitivity typically higher in summer
- Use non-discharge options, such as land application/soil treatment system
- Consider adding post-lagoon treatment
  - relatively passive constructed wetland systems
  - post-denitrification facilities such as biological filters
- **Documentation in literature is limited**

Trickling Filters

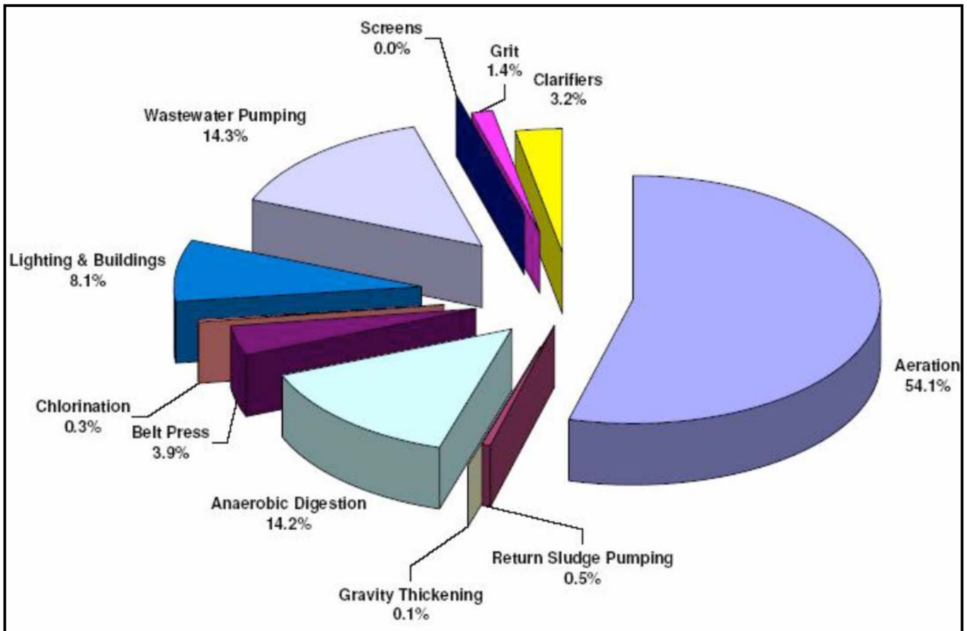
- Limited optimization options
  - Increase internal recycle rate
  - Aeration throttling/cycling for forced draft systems
  - Post-treatment or conversion to advanced secondary system
- **Documentation in literature is limited**

Author	Year	Location	TN	TP	Improvements
Dai et al.	2013	Australia	60%		Return nitrate-rich stream from secondary clarifiers back to primaries
Dorias and Baumann	1994	Germany	15 mg/l		Denitrification in trickling filter plants by covering filters for anoxic operation
Kardohely and McClintock	2001	Penn State			Added BNR plant to blend effluent prior to disposal or land application
Morgan et al.	1999	Australia			Conversion to MLE-type BNR by adding secondary reactors

Activated Sludge

Aeration

- *Aeration cycling* – includes on/off cycling of aeration, including the creation of dedicated anoxic and oxic zones, and associated controls.
- *Adjustable control aeration* – use of variable frequency drives to control aerator output and/or use of on-line monitoring tools to inform aerator operational mode.
- *Mixer addition* – addition of mixers to facilitate on/off cycling or maintain suspension of solids when aerators are turned down.
- *Equipment retrofit* – replacement with more efficient aeration equipment.



Electricity Requirements for Activated Sludge Wastewater

Derived from data from the Water Environment Energy Conservation Task Force *Energy Conservation in Wastewater Treatment*

Activated Sludge

Process

- *Flow equalization improvement* – improving the influent flow to biological treatment process to improve performance consistency.
- *Recycle rate control* – modifying internal mixed-liquor recycle rate to optimize denitrification in primary anoxic zones.
- *Sidestream control* – modifying nutrient-rich internal plant return flows, such as sludge dewatering returns.
- *Pre-digestion of primary sludge* – modifying primary sludge wasting rate to facilitate biochemical oxygen demand (BOD) solubilization from settled sludge into secondary process influent.
- *Batch program modifications* - changes to SBR program settings.

Activated Sludge

Configuration

- *Plug flow/series operation* – conversion of complete mix reactor to plug flow to facilitate oxic/anoxic zonation.
- *Anoxic zone bleed* – introduction of influent wastewater or return activated sludge (RAS) into anoxic reactors to provide carbon for denitrification.
- *Anaerobic zone VFA addition* – introduction of RAS into anaerobic selector to provide carbon for enhanced biological phosphorus removal (EBPR).

Chemical

- *Alkalinity feed improvements* – modifications to alkalinity control systems to facilitate effective nitrification.
- *Carbon product addition* – addition of soluble BOD products to enhance denitrification or EBPR.

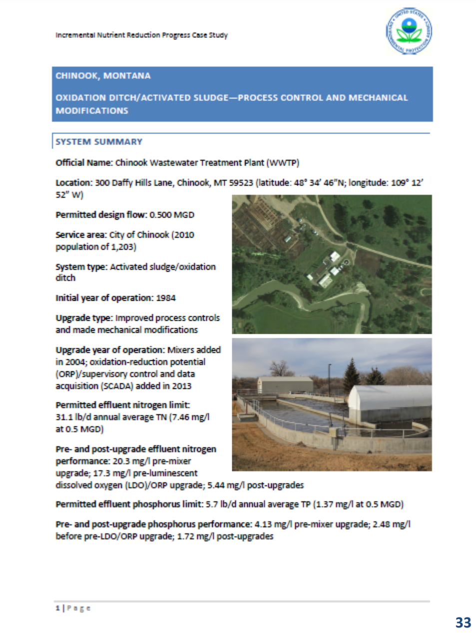
Discharge

- *Soil dispersal* – conversion of a surface discharging system into a soil discharging system.
- *Wetland discharge* – discharge into wetlands for further attenuation of nutrients prior to receiving water delivery.

WWTP type	Key questions to ask	Optimization efforts to consider
Activated Sludge	Is there excess plant capacity? - Is peak daily flow < 75% design capacity? - Are additional tanks/reactors available? - Is flow equalization provided?	Create anoxic zone(s) - On/off cycling for nitrification/denitrification in single reactor - Feed influent and internal recycle to dedicated tank - Denitrify in flow equalization with internal recycle
	Is there excess aeration capacity? - Can aeration be throttled? - Does aeration system have automatic control? - Can contents be mixed without aerating?	Facilitate anoxic environments - Maintain lower DO setpoint or dedicated anoxic zone - Install DO and/or ORP meters for auto control - Consider adding mixers
	Are process parameters sufficient? - Can nitrified liquor be returned to low DO zone? - Is alkalinity sufficient for full nitrification? - Is carbon available to drive denitrification?	Modify process parameters as warranted - Internal recycle to introduce nitrified liquor to anoxic - Add alkalinity - Consider step-feed, pre-fermentation additives
Lagoon	Is capacity available to store effluent?	Control discharge to take advantage of summer nutrient removal, while maintaining receiving water standards
	Is the lagoon mechanically aerated? If so, can it be controlled (see Activated Sludge rows above)?	Create anoxic zones for enhanced BNR
	Is a nondischarge alternative available?	Study alternative discharge methods
Trickling Filter	Does trickling filter currently nitrify?	Add post-denitrification unit

Case Study Summaries

- System Summary
- Rationale and Decision Process
- System Optimization Description
- Costs and Other Impacts
- Performance Discussion
- Challenges
- Future Improvements
- Contact Information
- Other Resources



Incremental Nutrient Reduction Progress Case Study

CHINOOK, MONTANA

OXIDATION DITCH/ACTIVATED SLUDGE—PROCESS CONTROL AND MECHANICAL MODIFICATIONS

SYSTEM SUMMARY

Official Name: Chinook Wastewater Treatment Plant (WWTP)

Location: 300 Daffy Hills Lane, Chinook, MT 59523 (latitude: 48° 34′ 46″N; longitude: 109° 12′ 52″ W)

Permitted design flow: 0.500 MGD

Service area: City of Chinook (2010 population of 1,203)

System type: Activated sludge/oxidation ditch

Initial year of operation: 1984

Upgrade type: Improved process controls and made mechanical modifications

Upgrade year of operation: Mixers added in 2004; oxidation-reduction potential (ORP)/supervisory control and data acquisition (SCADA) added in 2013

Permitted effluent nitrogen limit: 31.1 lb/d annual average TN (7.46 mg/l at 0.5 MGD)

Pre- and post-upgrade effluent nitrogen performance: 20.3 mg/l pre-mixer upgrade; 17.3 mg/l pre-luminescent dissolved oxygen (LDO)/ORP upgrade; 5.44 mg/l post-upgrades

Permitted effluent phosphorus limit: 5.7 lb/d annual average TP (1.37 mg/l at 0.5 MGD)

Pre- and post-upgrade phosphorus performance: 4.13 mg/l pre-mixer upgrade; 2.48 mg/l before pre-LDO/ORP upgrade; 1.72 mg/l post-upgrades

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Conclusions and Recommendations

- Optimization is often feasible and cost-effective: need a “champion”
- Some excess treatment capacity is ideal (though we didn’t specifically analyze this)
- Phosphorus removal is often complimentary to nitrogen removal
- Low-cost nutrient optimization is currently underreported
- Lagoon systems appear to have optimization opportunities
- Other approaches can also be considered on a case-by-case basis

Questions

John Hricko
Superintendent of Water
Utilities for the
Town of Crewe, Virginia

Town of Crewe, VA WWTP

- On January 1, 2007, the Town of Crewe WWTP began operating under the VPDES Watershed General Permit for Nutrient Discharges to the Chesapeake Bay.
- This permit placed restrictions on the amount of Total Nitrogen and Total Phosphorus discharged from the facility.
- This new permit would require treatment techniques be established, that previously, had never been employed.

Town of Crewe, VA WWTP

- Prior to 2007, the only permit limitation with regards to Nutrients was for Total Kjeldahl Nitrogen (TKN).
- Total Kjeldahl Nitrogen is the sum concentration of Organic Nitrogen and Ammonia (NH_3-N)
- Control of TKN and NH_3-N is strictly an aerobic process and as such, treatment was designed to maintain regulatory compliance. (One “environment” with plenty of Free Available Oxygen) The end product of this treatment process (Nitrification) is Nitrate NO_3. One of the components of TN is the reduced form of nitrogen, NO_3.

Town of Crewe, VA WWTP

- In addressing compliance with new limitations on TN the treatment process would have to be upgraded to now create and maintain a treatment “environment” that would accomplish Denitrification (the reduction of Nitrate NO_3 to ultimately Nitrogen gas).
- This in simple terms meant creating, then maintaining, two very different environments with regards to dissolved oxygen, one with, and one without, free available oxygen.
- Without establishing these two different stages of treatment, *by some means*, compliance with new TN limits would be impossible.

Town of Crewe, VA WWTP

- Preliminary Engineering Reports estimated a necessary cost, to upgrade the facility at anywhere from $500,000 to over $800,000.
- This initiated our “in-house” work to determine if we could in fact, find treatment solutions that could meet our treatment goals while keeping capital costs minimized.
- Our case study in this written report details the steps we took in order to achieve our success.
- This presentation will summarize that case study.

Town of Crewe, VA WWTP

- All biological treatment processes have their success determined by creating and maintaining the proper “environment” or “habitat” for the target biological organism(s).
- This “environmental control” is mandatory in order to achieve treatment goals, whether we treat a flow of 0.5 MGD or 50 MGD. The scale, the equipment, the facility will be different, however, the treatment principles are the same.

Town of Crewe, VA WWTP

- Required “Environmental” or “Habitat” parameters for success in reduction of Total Nitrogen:
- Control of Dissolved Oxygen levels in different stages of treatment. Maintaining an aerobic (oxic) environment, sufficient free available oxygen, in one treatment stage, Nitrification. Eliminating free available oxygen (anoxic) in a separate treatment stage, Denitrification. Two distinctly different, yet equally important “environments” mandatory in order to achieve Total Nitrogen reduction.
- Control (maintaining) pH and Alkalinity requirements.
- Control (maintaining) sufficient carbon source availability.

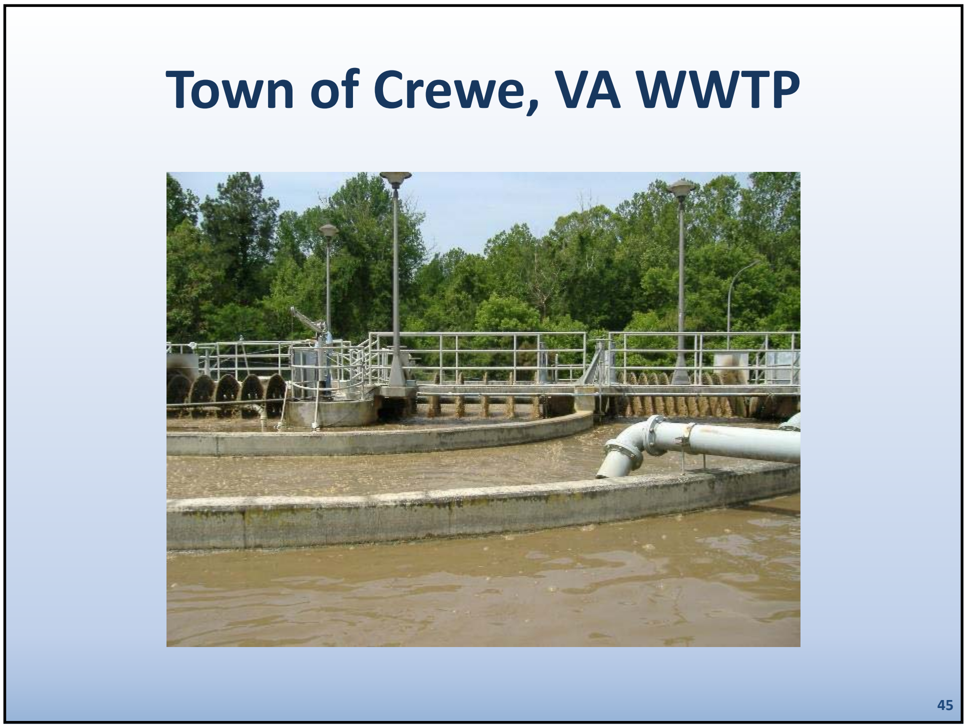
Town of Crewe, VA WWTP

- The BIG question?

- Can WE achieve these controls with our existing facility, structures and equipment?
- If so, HOW?

Town of Crewe, VA WWTP

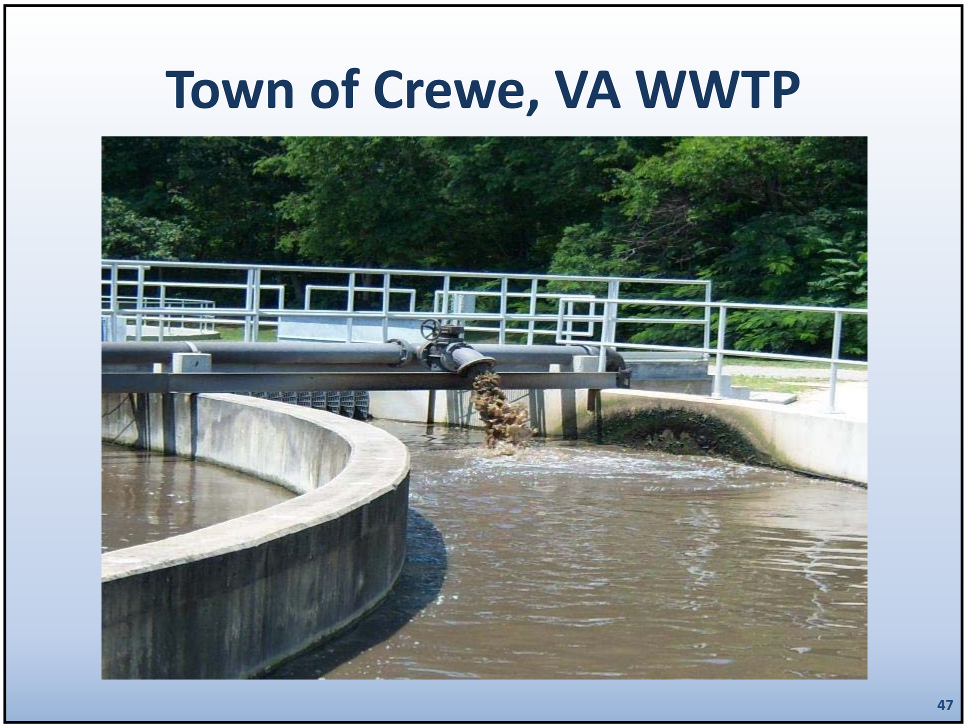
- The biggest challenge would be creating and maintaining the two necessary dissolved oxygen “environments” with the *existing* equipment.
- We visited a number of facilities here in Virginia that were practicing BNR to see what specific treatment techniques they were employing. We may not be able to afford the same equipment, but we could try to mimic the treatment technology.
- Because the treatment is all about “environment”, looking at facilities here in Virginia was paramount.



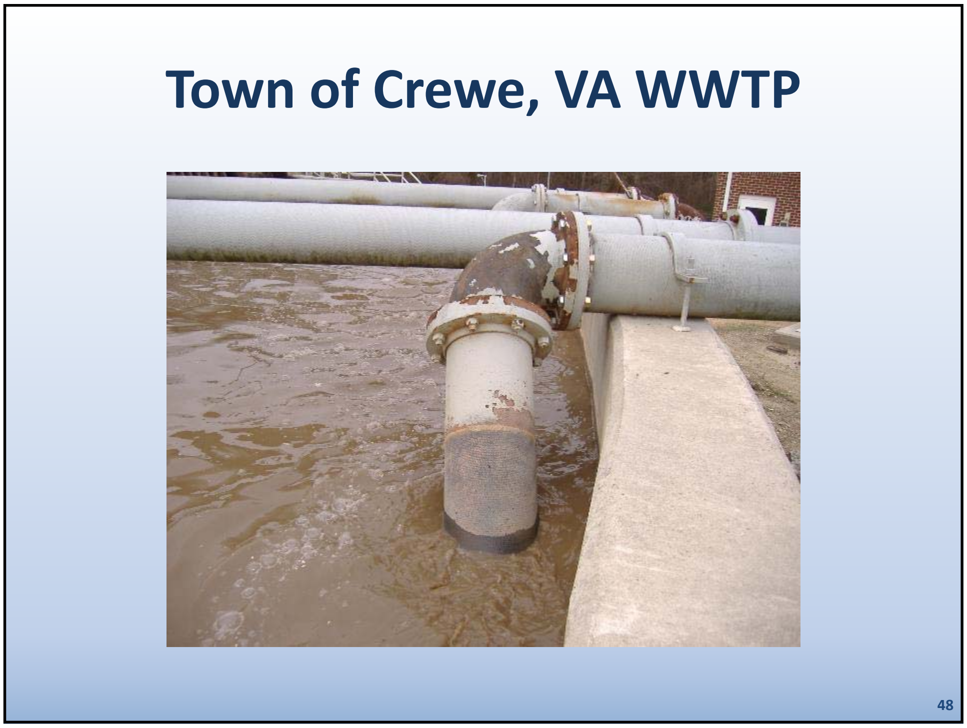
Town of Crewe, VA WWTP

Town of Crewe, VA WWTP

- Alter disc configuration.
- Manual On-Off cycling.
- 24 hour programmable timer (On-Off Auto Control with NO response to changes in flow and temperature)
- On-line Dissolved Oxygen probe with Low-High Auto Control. This system responds to changes in both plant flow and temperature.
- Results were good…yet not good enough!
- Too much free available oxygen in the anoxic zone.



Town of Crewe, VA WWTP

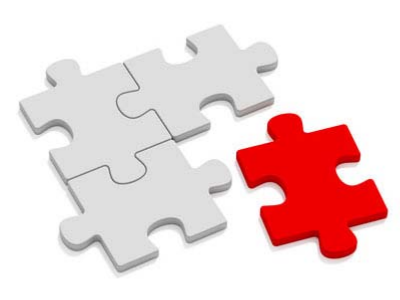


Town of Crewe, VA WWTP

Town of Crewe, VA WWTP

- Once the two opposing dissolved oxygen “environments” were established, it was determined that a supplemental carbon source would have to provided.
- A series of product trials over the course of two years demonstrated that a molasses product would provide the most “bang for the buck”.
- In 2011 the facility began using a liquid molasses product specially formulated to enhance BPR. This product provided excellent results for both TN and TP removal, and allowed for a reduction in liquid alum usage of 50%. (Liquid alum was the sole method of TP reduction previously used in treatment.)

Town of Crewe, VA WWTP



The final piece to the puzzle was management of sidestream contributions to TN in the form of Nitrates.

Town of Crewe, VA WWTP

	*2005	*2006	2007	2008	2009	2010	2011	2012	2013	2014
Annual Average Flow, MGD	0.27	0.26	0.23	0.22	0.26	0.27	0.22	0.18	0.27	0.28
TN Annual Avg. mg/L	**7.11**	**8.59**	4.05	3.45	3.91	3.56	3.36	3.83	3.26	3.52
TN Annual Limit mg/L	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00
Annual Average +/- % change	+18.5%	+43.2%	**(34.2%)**	**(42.5%)**	**(34.8%)**	**(40.7%)**	**(44.0%)**	**(36.2%)**	**(45.7%)**	**(41.3%)**
TN Discharged Lbs/Yr	5689	6790	2773	2273	2929	2572	1991	1986	2414	2849
TN Annual Waste Load Allocation, Lbs.	9137	9137	9137	9137	9137	9137	9137	9137	9137	9137
Annual TN Lbs. +/-	(3448)	(2347)	**(6364)**	**(6864)**	**(6208)**	**(6565)**	**(7146)**	**(7151)**	**(6723)**	**(6288)**
Annual TN Lbs. +/- % change	(38%)	(26%)	**(70%)**	**(75%)**	**(68%)**	**(72%)**	**(78%)**	**(78%)**	**(74%)**	**(69%)**

Town of Crewe, VA WWTP

	*2005	*2006	2007	2008	2009	2010	2011	2012	2013	2014
Annual Average Flow, MGD			0.23	0.22	0.26	0.27	0.22	0.18	0.27	0.28
TP Annual Avg. mg/L			0.06	0.07	0.05	0.04	0.04	0.07	0.09	0.06
TP Annual Limit mg/L			0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Annual Average +/- % change			**(88%)**	**(86%)**	**(90%)**	**(92%)**	**(92%)**	**(86%)**	**(82%)**	**(88%)**
TP Discharged Lbs/Yr			42	51	48	32	22	36	73	48
TP Annual Waste Load Allocation, Lbs.			761	761	761	761	761	761	761	761
Annual TP Lbs. +/-			**(719)**	**(710)**	**(713)**	**(729)**	**(739)**	**(725)**	**(688)**	**(713)**
Annual TP Lbs. +/- % change			**(94%)**	**(93%)**	**(94%)**	**(72%)**	**(96%)**	**(95%)**	**(91%)**	**(94%)**

Town of Crewe, VA WWTP

	*2005	*2006	2007	2008	2009	2010	2011	2012	2013	2014
TKN Annual Avg. mg/L	< 0.50	< 0.50	0.78	0.88	1.00	0.67	0.82	0.90	0.88	0.71
N + N Annual Avg. mg/L	7.11	8.59	3.27	2.57	2.91	2.89	2.54	2.93	2.38	2.79
TN Annual Avg. mg/L	**7.11**	**8.59**	**4.05**	**3.45**	**3.91**	**3.56**	**3.36**	**3.83**	**3.26**	**3.52**

Town of Crewe, VA WWTP

Cost Comparison of Crewe VA's Nutrient Control Methods						
EnhanceBioP						
Cost per ton	$425					
Gal of EHB-P weights	11.5					
Gallons Dosed	24.00	gpd				
Cost per gal	$2.44					
Total cost per day				**$58.65**		
Total Annual EnhanceBioP Cost					$21,407.25	
Alum Dose, annual average (Summer/Fall/Spring 75/Winter 45)	50	ml/min				
Alum Dose	0.79252	gph				
Alum Cost	$1.25	Cost per gal of Alum				
Alum Cost per day				**$23.78**		
Total Annual Alum Cost					$8,678.05	
Total EnhanceBioP/Alum Cost per Year						$30,085.30
Previous Dry Molasses feed rate	300	lbs per day				
Pecent sugar of dry feed	38.0%					
Lbs sugar per gal used	114	lbs per day				
Cost per 50 lbs dry	$16.00					
Dry Molasses Cost per day				**$96.00**		
Total Annual Dry Molasses Cost					$35,040.00	
Alum Dose, annual average (Summer/Fall/Spring 115/Winter 75)	105	ml/min				
Alum Dose	1.66428	gph				
Alum Cost	$1.25	Cost per gal of Alum				
Alum Cost per day				**$49.93**		
Total Annual Alum Cost					$18,223.91	
Total Dry Molasses/Alum Cost per Year						$53,263.91
					Saving/year:	**$23,178.61**
NOTE: Plus Increased Sale of Nitrogen Credits						***$5,000.00***
					Total Savings	**$28,178.61**

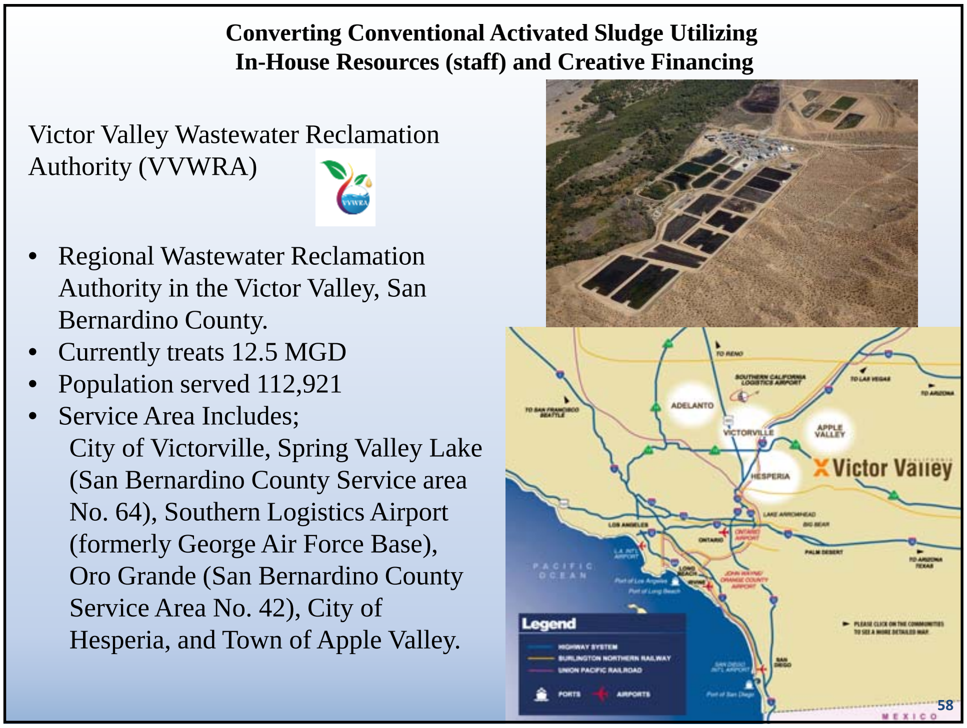
Town of Crewe, VA WWTP

- In 2012 the Towns membership in the Virginia Nutrient Credit Exchange Association began paying dividends. As a result of the plants success in TN and TP reduction, our surplus treatment credits have become a source of revenue for the Town.
- With the additional savings in liquid alum use, the BNR program put in place not only insures compliance with Nutrient Discharge Limits but allows for positive cost impact as well.

Questions

Converting Conventional Activated Sludge Facility to Biological Nutrient Removal Utilizing In-House Resources (staff) and Creative Financing

Gilbert Perez
Director of Operations
Victor Valley Wastewater Reclamation Authority



Converting Conventional Activated Sludge Utilizing In-House Resources (staff) and Creative Financing

Victor Valley Wastewater Reclamation Authority (VVWRA)

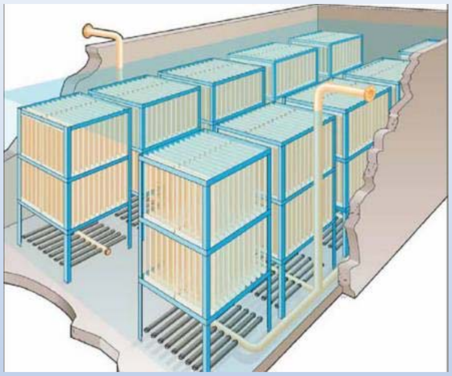
- Regional Wastewater Reclamation Authority in the Victor Valley, San Bernardino County.
- Currently treats 12.5 MGD
- Population served 112,921
- Service Area Includes;
  City of Victorville, Spring Valley Lake (San Bernardino County Service area No. 64), Southern Logistics Airport (formerly George Air Force Base), Oro Grande (San Bernardino County Service Area No. 42), City of Hesperia, and Town of Apple Valley.

Converting Conventional Activated Sludge Facility to Biological Nutrient Removal Utilizing In-House Resources (staff) and Creative Financing

- In Feb. 2008 the RWQCB finalized the VVWRA NPDES permit with a total nitrogen limit of 10.3 mg/L and ammonia nitrogen of 0.54 mg/l.
- The VVWRA facility was designed as an 18 MGD conventional activated sludge plant and was faced with making significant modifications to convert to biological nutrient removal (BNR) process for nitrification and denitrification.
- Due to stringent nitrogen limitation the VVWRA facility capacity was reduced to 13.8 MGD. **This equates to a loss of $42,000,000.00 in equity!**

Converting Conventional Activated Sludge Facility to Biological Nutrient Removal Utilizing In-House Resources (staff) and Creative Financing

- Engineer estimates of $13.4M to install a fixed IFAS media system into the existing aeration tanks to comply with nitrogen limitations at 14 MGD without having to build additional new structures for biological treatment was proposed due to time and funding constraints.



Converting Conventional Activated Sludge Facility to Biological Nutrient Removal Utilizing In-House Resources (staff) and Creative Financing

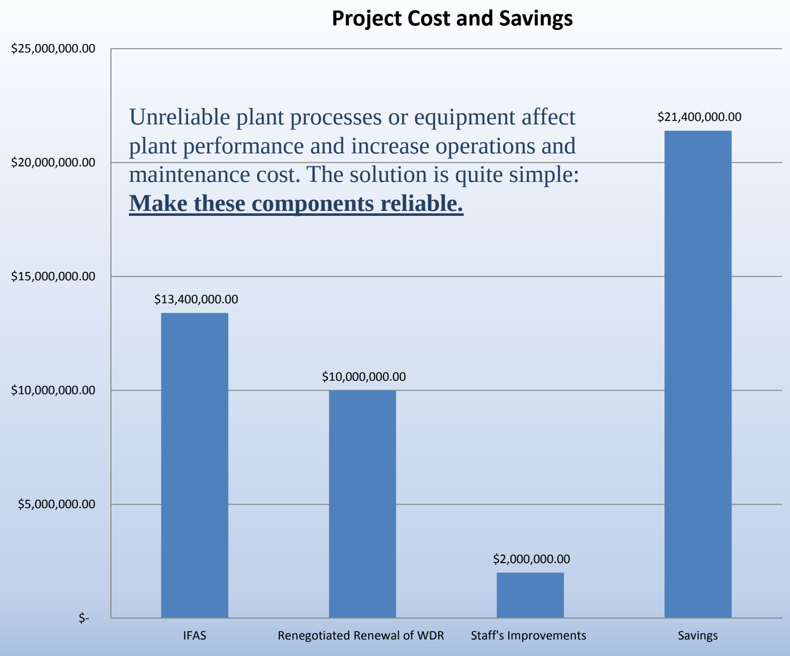
- Staff worked diligently to improve the operational efficiency of the aeration basins to improve their reliability and nitrification/denitrification capabilities. This was a three step process which required:

- Improved instrumentation for monitoring. (D.O., Air Flow, Ammonia and Nitrate concentration).

- Improved aeration diffusion in the water for improved efficiency. (Repaired/Replaced inefficient diffusers, repaired air leaks).

- Structural enhancements to provide system reliability. (Installed Internal Recycle Pumps).

- Once all three project elements were complete staff were able to meet their objective in meeting permit requirements and improving ground water quality.



Unreliable plant processes or equipment affect plant performance and increase operations and maintenance cost. The solution is quite simple: **Make these components reliable.**

Converting Conventional Activated Sludge Facility to Biological Nutrient Removal Utilizing In-House Resources (staff) and Creative Financing

Phase II of Project involved additional challenges.

- **Improve treatment efficiency and reliability**
- **Energy savings**
- **Eliminate expensive chemicals for alkalinity augmentation.**
- **Financial Challenges**

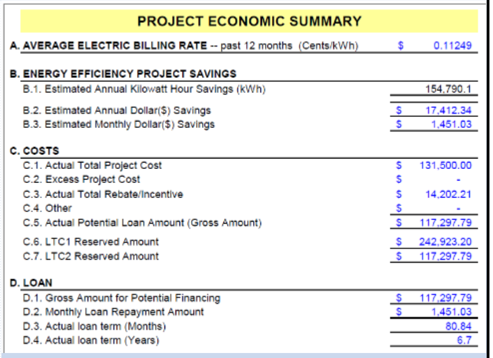
Converting Conventional Activated Sludge Facility to Biological Nutrient Removal Utilizing In-House Resources (staff) and Creative Financing

- **Staff were able to overcome these challenges by working with Edison to identify challenges with current equipment.**
- **Edison educated staff about creative financing options such as On Bill Financing and financial incentives for energy efficient Projects.**
- **Edison provided:**
  - **Engineering calculations**
  - **Equipment / Materials selection**
  - **Funding**

Converting Conventional Activated Sludge Facility to Biological Nutrient Removal Utilizing In-House Resources (staff) and Creative Financing

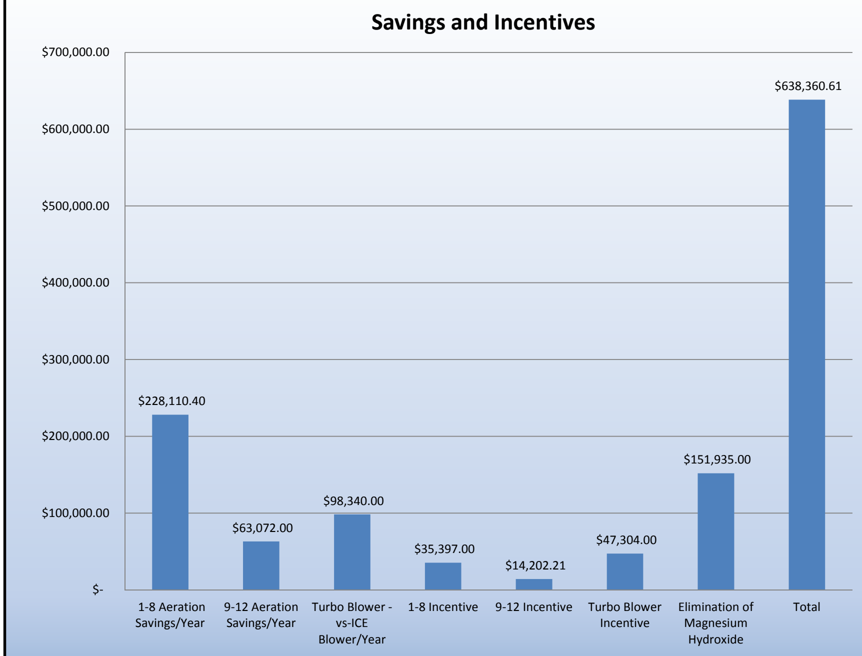
On-Bill Financing (OBF)

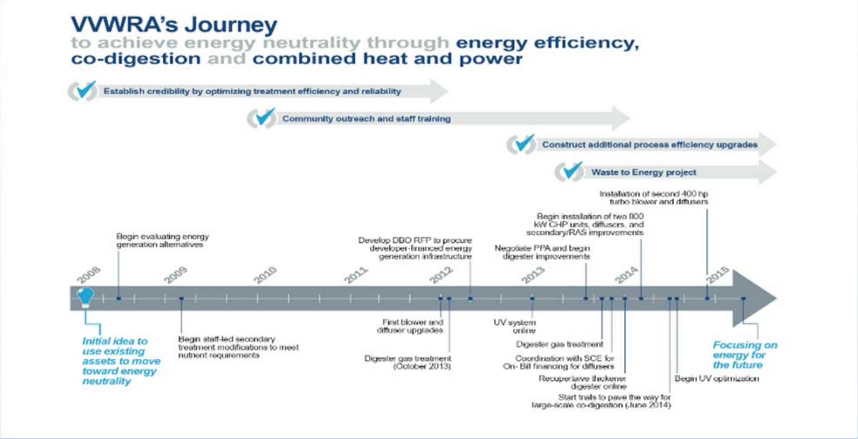
- Finance qualifying energy efficiency projects.
- Repay the loan in monthly installments which would be added as a line item on your bill.
- Fund your qualified energy efficiency project for zero interest and no fees,
- Reduce your monthly electricity usage,
- Receive financial incentives for installing qualifying energy efficient equipment.



PROJECT ECONOMIC SUMMARY

A. AVERAGE ELECTRIC BILLING RATE -- past 12 months (Cents/kWh)	$	0.11249
B. ENERGY EFFICIENCY PROJECT SAVINGS		
B.1. Estimated Annual Kilowatt Hour Savings (kWh)		154,790.1
B.2. Estimated Annual Dollar($) Savings	$	17,412.34
B.3. Estimated Monthly Dollar($) Savings	$	1,451.03
C. COSTS		
C.1. Actual Total Project Cost	$	131,500.00
C.2. Excess Project Cost	$	-
C.3. Actual Total Rebate/Incentive	$	14,202.21
C.4. Other	$	-
C.5. Actual Potential Loan Amount (Gross Amount)	$	117,297.79
C.6. LTC1 Reserved Amount	$	242,923.20
C.7. LTC2 Reserved Amount	$	117,297.79
D. LOAN		
D.1. Gross Amount for Potential Financing	$	117,297.79
D.2. Monthly Loan Repayment Amount	$	1,451.03
D.3. Actual loan term (Months)		80.84
D.4. Actual loan term (Years)		6.7





Converting Conventional Activated Sludge Facility to Biological Nutrient Removal Utilizing In-House Resources (staff) and Creative Financing

Operational benefits

- Simpler plant – reducing operating problems and related costs
- Eliminate chemical handling
- Improved air transfer efficiency – improved nitrification
- Reduces mixed liquor recycle rate – improved denitrification
- Increases detention time in BNR system enhancing microbes ability to effectively oxidize and convert carbon and nutrients
- Simpler plant – reducing operating problems and related costs

Economic benefits

- Provides an aeration system which is more efficient than current system
- Lower overall electricity at the plant **($291,182.40/Year)**
- Alkalinity recovery eliminating magnesium hydroxide usage **($151,935/Year)**
- Reduced O&M man hours – shift resources to other areas of the plant to improve efficiency and economic benefits
- Financial Incentives **($96,903.21)**
- Eliminate installation of fixed media, negotiating WDR no need to construct dewatering facilities **($21,400,000.00)**

Other benefits

- Increases plant hydraulic capacity
- Value from avoiding fines for non-compliance
- Potentially increase organic and nutrient treatment capacity

Converting Conventional Activated Sludge Facility to Biological Nutrient Removal Utilizing In-House Resources (staff) and Creative Financing

Gilbert Perez
Director of Operations

Victor Valley Wastewater Reclamation Authority

20111 Shay Rd. • Victorville, California 92394
760-246-2882 • Fax 760-246-5194 • Cell 760-927-1321
Website: www.vvwra.com • E-Mail: gperez@vvwra.com

Speaker Contact Information

Victor D'Amato
Senior Engineer, Tetra Tech Inc.
(919) 485-2070
Victor.D'Amato@tetratech.com

John Hricko
Superintendent of Water Utilities for the Town of Crewe, VA
(434) 645-9436
(434) 390-4438
hricko@hovac.com

Gilbert Perez
Director of Operations, Victor Valley Wastewater Reclamation Authority (VVWRA), CA
(760) 246-2882
gperez@vvwra.com

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Questions