Kansas Wastewater Operator's School Energy Use and Nutrient Reduction Presentation

Kansas
Department of Health and Environment

Aeration Control for Nutrient Reduction

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Nutrient Reduction Requirements Are Now Being Placed into NPDES Permits

My Discussions will present the Regulatory Requirements for Nutrient Reduction and the Benefits of Aeration Control

Following me – Jerry Grant of Fort Scott Comm. College will be Presenting Case Studies of Operations Successes to Reduce Nutrient Discharges

Nutrients of Concern - Nitrogen

- Start with Basics – Kansas goal is to reduce Nitrogen and Phosphorus discharges to streams

- Nitrogen – can be treated and removed with typical activated sludge biological treatment processes to very low concentrations

- Nitrogen Reduction is easier with Operator Training, DO/ORP probes and monitors, VFDs, and computer controls

Nutrients of Concern - Phosphorus

- Phosphorus – is different.

- Typical activated sludge processes will treat to remove about 40% TP influent concentration. We need to remove another 40% (on average) to Meet Goals.

- To Meet Goals requires Bio-P activated sludge processes or chemical precipitation, or use both.

- Phosphorus reduction is not easy, not real expensive but not cheap either.

Impaired Streams – Examples

Impaired Reservoirs – Examples

Harmful Algal Blooms (HABs)

- Caused by Excessive Nutrients, and are Happening More Frequently
- Happening in More Lakes in Kansas
- Major Concern with Recreation
- Also a Concern to Drinking Water Supplies
- KDHE Finding HAB Toxins in Waterbodys
- Now Also Finding HAB Toxins in Raw Water Drawn from Lakes for Drinking Water Treatment
- No Toxins Found in Finished Drinking Water (Thank Goodness)

EPA New “2013” Ammonia Criterion

- As Proposed by EPA, and to be Adopted by Kansas Regulations, the Ammonia Criteria now also Considers Toxicity to Mussels and Snails
- Overall Impact is There will be Much More Stringent Numeric Criteria for Ammonia
- Expect NPDES Permit Effluent Limitations for Ammonia Concentration Reduced by 60%
- And many Permits Now With “Monitoring Only” for Ammonia will have Limits for Ammonia

EPA New “2013” Ammonia Criterion

- Kansas Population (2010) About 2,850,000
- About 80% of Kansas Population Served by Sewer Systems
- Kansas Mechanical WWTPs Serve 86% of Population on Sewers, About 2,000,000 People, about 120 WWTPs
- Of These, 75 WWTPs Serve 3,000 or Larger Population

EPA New “2013” Ammonia Criterion

- Most Mechanical WWTPs Can Meet These New Ammonia Limitations Based on the EPA 2013 Ammonia Criterion
- KDHE Estimates – 16 Mechanical WWTPs Major Expense Upgrades, 21 Mechanical WWTPs Operator Training & Minor Expense Improvements (Computer Controls); Letters have been sent to these WWTP Permittees
- And Then There are the 350 Discharging Lagoons

EPA New “2013” Ammonia Criterion and Lagoons

- If and When Act. Sl. Is Required to Replace a Lagoon, KDHE Will Require Biological Nutrient Removal (BNR) Treatment Process Upgrades to Reduce Nutrients and also Reduce Energy Use and Improve Operations Reliability
- EPA Provided a (Engr. Consultant) Contractor to Create a Small Flows Cost Curve for BNR Treatment Process Construction and Operations in Kansas

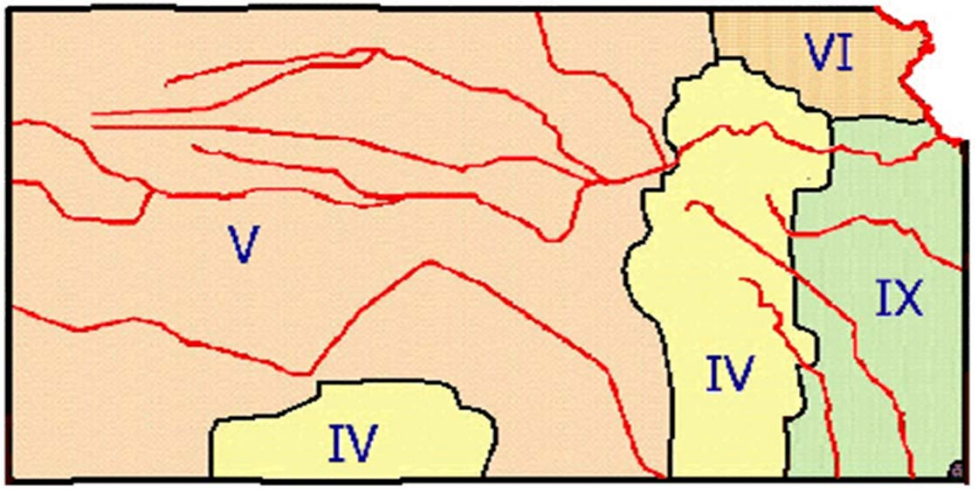
EPA New “2013” Ammonia Criterion and Lagoons

- No Doubt, Costs for BNR Act Sl are Beyond Financial Capability of Small Kansas Towns
- KDHE Has Now Developed a Multi Facility Variance (MVF) Review Procedure to Screen for Eligibility and Offer the Variance to NPDES Permittees Treating Domestic Strength Sewage with Discharging Lagoon Treatment Facilities

Example Change in Ammonia Criteria/Limits

Criterion – pH 8	1999 (Current)	2013 EPA
Acute – Daily Maximum - mg/l	8.40	3.9
Chronic – Monthly Average - mg/l	1.71	~0.78

EPA Eco Region Nutrient Criteria



Stream Criteria			
Region	**TN (mg/L)**	**TP (ug/L)**	**Chla (ug/L)**
IV	0.56	23.00	2.40
V	0.88	67.00	3.00
VI	2.18	76.25	2.70
IX	0.69	36.56	0.93

EPA Eco Region Nutrient Criteria

- EPA Published these recommended criteria numbers in the year 2001 – 15 Years Ago
- TN proposed criteria in-stream is as low as 0.56 mg/l
- TP proposed criteria in-stream is as low as 0.023 mg/l
- Best WWTP performance for TN in 2001 was about 3.0 mg/l, but some now do better with DO/ORP Controls
- Best WWTP performance for TP in 2001 was about 0.3 mg/l, but some now do better with DO/ORP Controls, and/or with Chemical Precipitation

Kansas Surface Water Nutrient Reduction Plan

- Document Prepared by KDHE Dated December 29, 2004
- Purpose was to consider ALL sources of nutrients – Municipal, Industrial, Agricultural, Stormwater
- Result for Municipal Wastewater Treatment was the 3 tiers of design for nutrient reduction – BNR, ENR, LOT
- First Phase Goals are BNR - 8.0 mg/l TN and 1.5 mg/l TP OR 10 mg/l TN and 1.0 mg/l TP – operator's choice, considering influent pollutant balance of BOD to TN to TP

Kansas 303(d) List of Impaired Streams, TMDLs, and Permit Limits

- TN Contributes to Impairments in 409 Stream Segments and Lakes
- TP Contributes to Impairments in 709 Lakes and Stream Segments compared to the Kansas "First Step" TMDL goal of 0.201 mg/l (201 ppb) in-stream concentration for TP

NPDES Permits and Nutrients

- Impaired Streams 2016 303(d) Listings – TN
  - Ammonia – 1 stream segment
  - Nitrate
  - pH (also TP)
  - Biology - Streams (also TP)
  - Eutrophication - Lakes (also TP)
  - Dissolved Oxygen due to WWTPs (also TP)
- Impaired Streams 303(d) Listings – TP
- TMDLs WLAs

NPDES Permits and Nutrients

- Impaired Streams 2016 303(d) Listings – TN
  - Ammonia – 1 stream segment, JoCo Nelson WWTP
  - Nitrate
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  - Eutrophication - Lakes (also TP)
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- Impaired Streams 303(d) Listings – TP
- TMDLs WLAs

NPDES Permits and Nutrients

- Impaired Streams 2016 303(d) Listings – TN
  - Ammonia – 1 stream segment, JoCo Nelson WWTP
  - Nitrate – 11 stream segments
  - pH (also TP)
  - Biology - Streams (also TP)
  - Eutrophication - Lakes (also TP)
  - Dissolved Oxygen due to WWTPs (also TP)
- Impaired Streams 303(d) Listings – TP
- TMDLs WLAs

NPDES Permits and Nutrients

- Impaired Streams 2016 303(d) Listings – TN
  - Ammonia – 1 stream segment, JoCo Nelson WWTP
  - Nitrate – 11 stream segments, 9 due to WWTPs
  - pH (also TP)
  - Biology - Streams (also TP)
  - Eutrophication - Lakes (also TP)
  - Dissolved Oxygen due to WWTPs (also TP)
- Impaired Streams 303(d) Listings – TP
- TMDLs WLAs

NPDES Permits and Nutrients

- Impaired Streams 2016 303(d) Listings – TN
  - Ammonia – 1 stream segment, JoCo Nelson WWTP
  - Nitrate – 11 stream segments, 9 Due to WWTPs, 6 have Permits w/ Limit for NO3+NO2 of 10 mg/l
  - pH (also TP)
  - Biology - Streams (also TP)
  - Eutrophication - Lakes (also TP)
  - Dissolved Oxygen due to WWTPs (also TP)
- Impaired Streams 303(d) Listings – TP
- TMDLs WLAs

NPDES Permits and Nutrients

- Impaired Streams 2016 303(d) Listings – TN
  - Ammonia – 1 stream segment, JoCo Nelson WWTP
  - Nitrate – 11 stream segments, 9 Due to WWTPs, 6 have Permits w/ Limit for NO3+NO2 of 10 mg/l, the other 3 are Wichita Plt. 1&2, Salina, and Emporia
  - pH (also TP)
  - Biology - Streams (also TP)
  - Eutrophication - Lakes (also TP)
  - Dissolved Oxygen due to WWTPs (also TP)
- Impaired Streams 303(d) Listings – TP
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NPDES Permits and Nutrients

- Impaired Streams 2016 303(d) Listings – TN
  - Ammonia – 1 stream segment, JoCo Nelson WWTP
  - Nitrate – 11 stream segments, 9 Due to WWTPs, 5 have Permits w/ Limit for NO3+NO2 of 10 mg/l
  - pH (also TP) – 44 stream segments
  - Biology - Streams (also TP)
  - Eutrophication - Lakes (also TP)
  - Dissolved Oxygen due to WWTPs (also TP)
- Impaired Streams 303(d) Listings – TP
- TMDLs WLAs

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  - pH (also TP) – 44 stream segments
  - Biology - Streams (also TP) -103 stream segments
  - Eutrophication - Lakes (also TP)
  - Dissolved Oxygen due to WWTPs (also TP)
- Impaired Streams 303(d) Listings – TP
- TMDLs WLAs

NPDES Permits and Nutrients

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  - pH (also TP) – 44 stream segments
  - Biology - Streams (also TP) -103 stream segments
  - Eutrophication - Lakes (also TP) – 248 lakes
  - Dissolved Oxygen due to WWTPs (also TP)
- Impaired Streams 303(d) Listings – TP
- TMDLs WLAs

NPDES Permits and Nutrients

- Impaired Streams 2016 303(d) Listings – TN
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  - pH (also TP) – 44 stream segments
  - Biology - Streams (also TP) -103 stream segments
  - Eutrophication - Lakes (also TP) – 248 lakes
  - Dissolved Oxygen due to WWTPs (also TP) – 2 stream segments, JoCo Blue, ~Coff.
- Impaired Streams 303(d) Listings – TP
- TMDLs WLAs

NPDES Permits and Nutrients

- Impaired Streams 2016 303(d) Listings – TN
  - Ammonia – 1 stream segment, JoCo Nelson WWTP
  - Nitrate – 11 stream segments, 9 Due to WWTPs, 5 have Permits w/ Limit for NO3+NO2 of 10 mg/l
  - pH (also TP) – 44 stream segments
  - Biology - Streams (also TP) -103 stream segments
  - Eutrophication - Lakes (also TP) – 248 lakes
  - Dissolved Oxygen due to WWTPs (also TP) – 2, JoCo Blue, ~ Coff.
- Impaired Streams 303(d) Listings – TP – Est. 350 Stream Segments Compared to EPA Eco-Region Criteria, w/o Lakes
- TMDLs WLAs

BOD Removal Bio-Chemistry

- CBOD is Carbonaceous BOD : (CBOD) $C_5H_7O_2N + O_2$ + microbes = $CO_2 + H_2O$ + N(gas) + more microbes
- BOD5 Includes both CBOD and NOD -- Nitrogenous Oxygen Demand – we use TKN Lab Test to Measure This -- which is Organic N (proteins) + Ammonia (NH_3)

Ammonia “Removal” Chemistry

- Nitrification:NH3 + O2 + microbes(nitrifiers) = N2O -> NO -> NO2 -> NO3(nitrate) + H20 + more microbes(nitrifiers); ~1% of MLSS
- EPA New Recommended Water Quality Criteria for Ammonia is about 40% of the Current Criterion
- Summer 1.2 mg/l -> 0.5 mg/l Mo. Ave.
- Winter 4.0 mg/l -> 1.4 mg/l Mo. Ave.

Ammonia and Total Nitrogen

- TN in raw sewage is TKN (NH3 + Org-N) – in the reduced forms
- TN in treated effluent is TKN (NH3 + Org-N) + (NO3+NO2) – BOTH reduced and oxidized forms of nitrogen
- Almost Every One of the Mech Plant NPDES permits in Kansas have Limits for Ammonia – Daily Max. and Monthly Average - mg/l

Ammonia and Total Nitrogen

- New Criteria for Ammonia proposed by EPA, Kansas has accepted these criteria, Kansas water quality standards regs have been developed and Public Hearings are to be held
- Expect Ammonia Limits Numbers to be Reduced by 60% as Compared to Current Permit Limit Numbers – that is, multiply any current number 0.4 to estimate the new monthly limit
- If Upgrade any WWTP for Ammonia, also Require TN and TP Reductions in the Design

Nutrient Removal – First TN

- Total Nitrogen – TKN (Organic N + NH3) + NO3 + NO2 = TN

- Total Phosphorus - TP

Current Recommendations to Reduce Total Nitrogen

- Kansas Surface Water Nutrient Reduction Plan – BNR - 8.0, ENR - 5.0, LOT - 3.0
- Current Recommendation Continues to be to use Biological Processes to meet More Stringent Ammonia Criteria/Limits, and also meet the goal of 10 mg/l Monthly Average TN with De-nitrification without Chemical Addition

Current Recommendations to Reduce Total Nitrogen

- We are Learning to do Better TN Reduction with Biological Processes with VFDs, DO/ORP Probes, and Computerized Aeration Controls
- But if you need carbon source to denitrify – Suggest avoid Methanol; Suggest also try Glycerin (or Glycerol)

Computer Controls of Aeration Processes

- Aeration Control can Substantially Reduce Total Nitrogen (and Total Phosphorus) in Effluent
- Aeration Control can Substantially Reduce Energy Costs – Note: 1 pound NO3-N = 2.9 lbs D.O.
- Computerization Control of Aeration Systems Reduces Electricity Use and Cost Savings can pay for Cost of Equipment within Months (not Years)

Computer Controls of Aeration Processes

- ORP is Shaping Up to be a Superior Process Control Technique as Compared to DO, As this Allows Computers to Measure Use of NO3 in Addition to DO
- Can Reduce Minimum D. O. Setpoint, or the ORP setpoints – Which Eliminates Over-aeration
- Any Activated Sludge Process can be Controlled to Fully Nitrify – NH3 + O2 -> NO2; NO2 + O2 -> NO3

Computer Controls of Aeration Processes

- And Controlled to De-nitrify - NO3 + BOD -> NO2; NO2 + BOD -> NO; NO + BOD -> N2 (gas)
- And Sometimes can also do Bio-P Reduction
- Computer Adjusts Aeration to Maintain DO or ORP Setpoint with Variations of Air Temperature, Mixed Liquor Concentration, Water Temperature, and Diurnal Flow – Greatly Improves Aeration Efficiency

Computer Controls of Aeration Processes

- Expected Reduction of Aeration Costs 30%, Overall Plant-wide Power Costs Expected Reduction of 15%
- Article in KRWA "The Kansas Lifeline" November 2013 – Buhler Oxidation Ditch - Reduced Total WWTP Electricity Use by 17%

Operations Technical Assistance

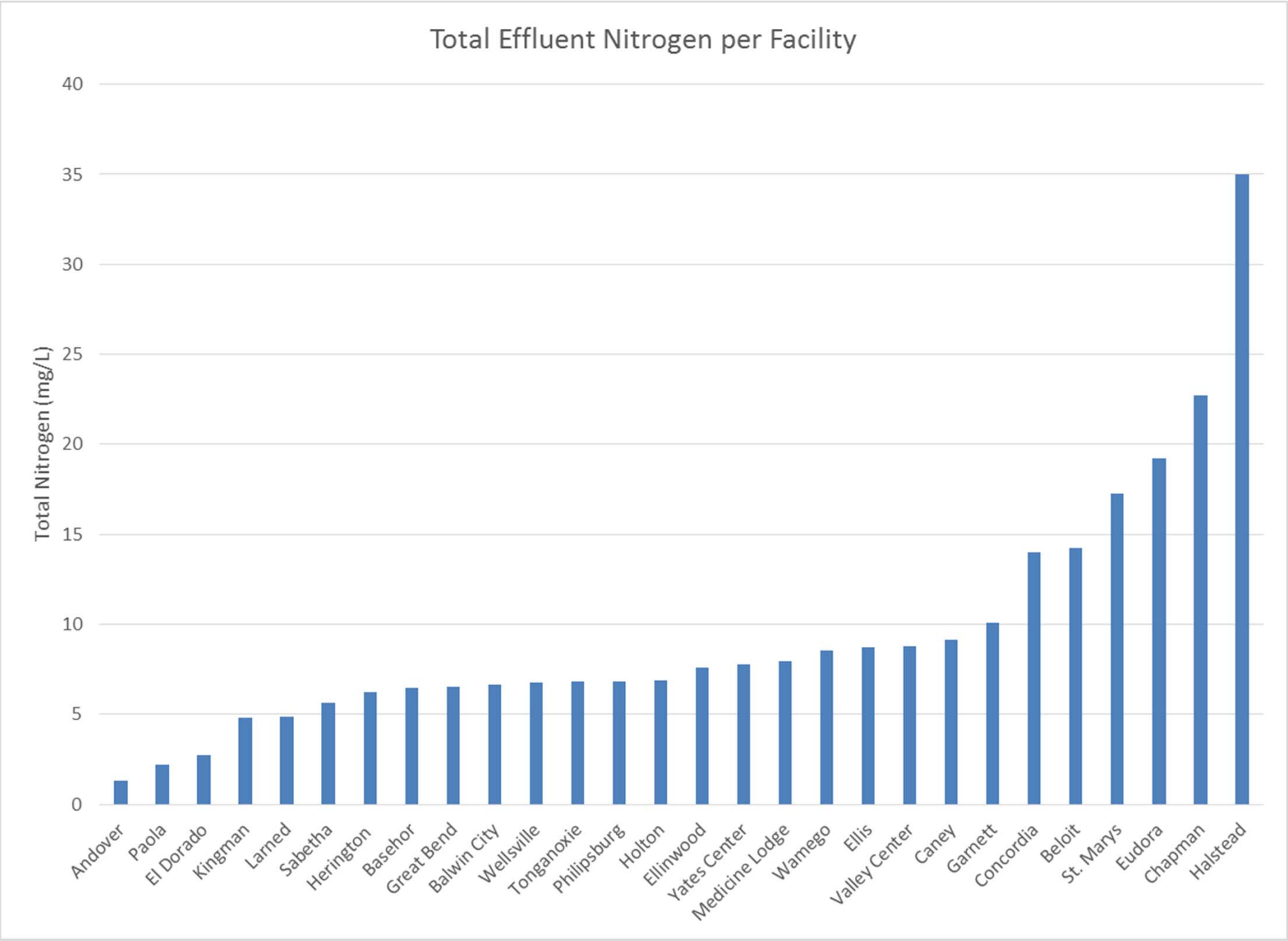
- KRWA Technical Assistance – Operations and Management Improvements to Resolve Non-Compliance at Small Mech Plants and Lagoons
- FSCC Technical Assistance – Operational Revisions to Reduce TN and TP in Effluent at Large WWTPs
- WSU Energy Audits – Facility and Operations Reviews to Reduce Energy and Oper. Costs at Small Mech WWTPs

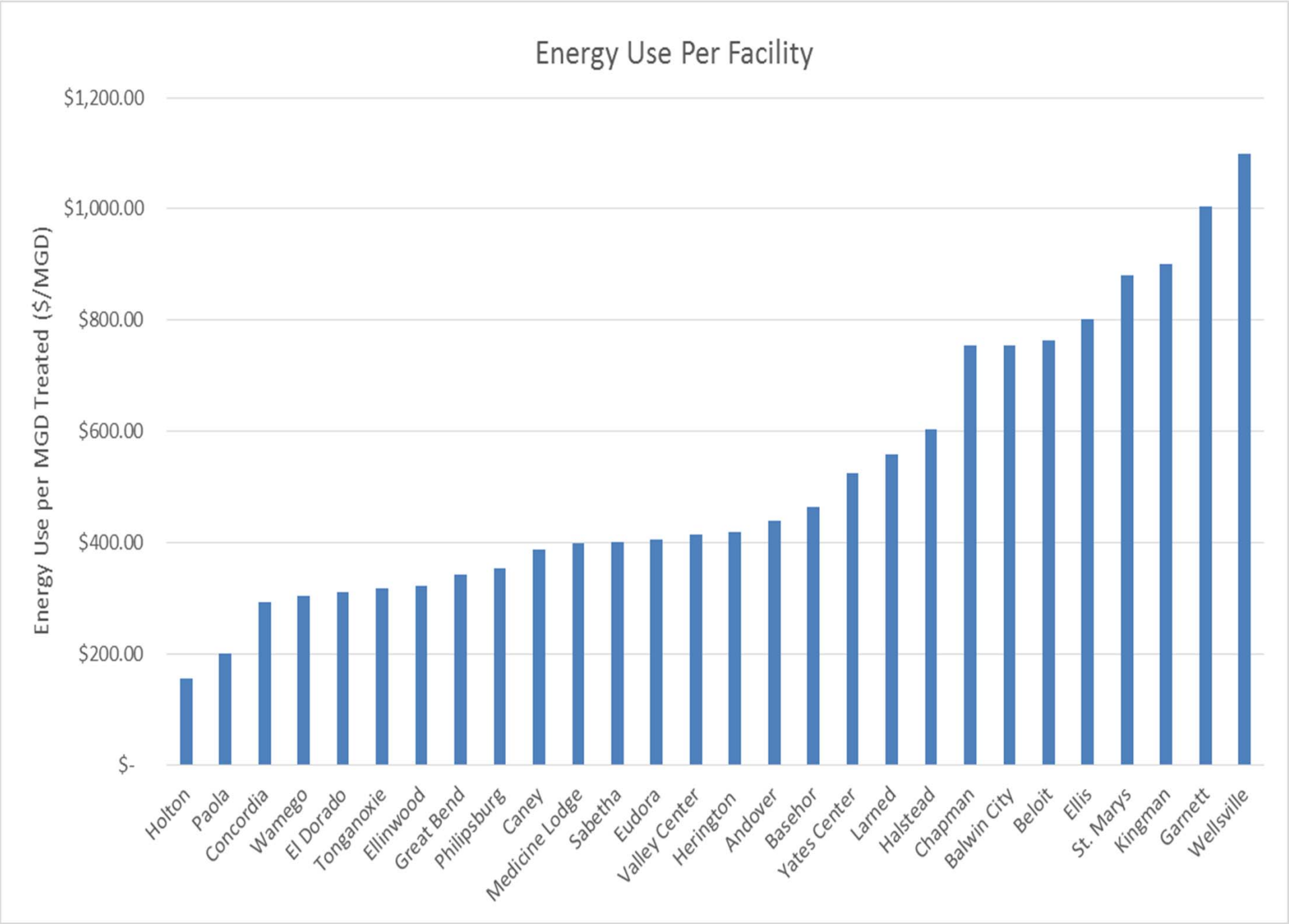
Operations Technical Assistance

- No Cost to City or Owner – Tech Assistance Contracts are paid by KDHE CW SRF Service Fees
- The Next Few Slides Present a Summary of Electricity Use at many Different Types of WWTFs Now in Use in Kansas as Provided by the WSU Efforts
- Electricity Use Varies from 2,500 kWh/MG Treated to 11,900 kWh/MG Treated

Electricity Usage

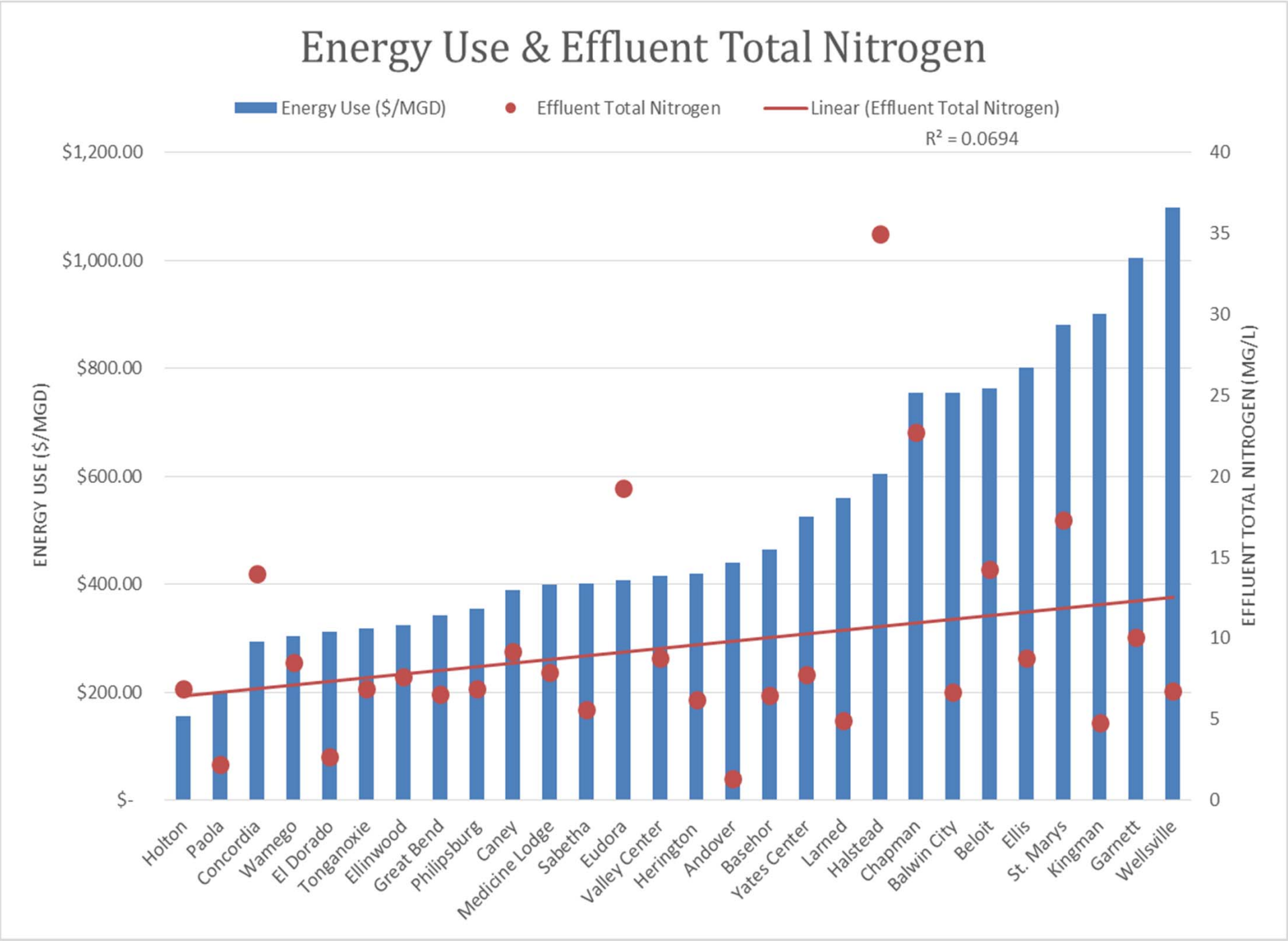
- At National Level - WERF Report “A Guide to Net-Zero Solutions for Water Resource Recovery Facilities” (2015)
- “Typical” Electricity Use BNR about 1,800 kWh/MG Treated
- “Best-Practice” Electricity Use BNR about 1,100 kWh/MG Treated
- We Have Opportunities to Improve


Total Effluent Nitrogen per Facility
Total Nitrogen (mg/L)
40
35
30
25
20
15
10
5
0
Andover
Paola
El Dorado
Kingman
Larned
Sabetha
Herington
Basehor
Great Bend
Balwin City
Wellsville
Tonganoxie
Philipsburg
Holton
Ellinwood
Yates Center
Medicine Lodge
Wamego
Ellis
Valley Center
Caney
Garnett
Concordia
Beloit
St. Marys
Eudora
Chapman
Halstead


Energy Use Per Facility
Energy Use per MGD Treated ($/MGD)
$1,200.00
$1,000.00
$800.00
$600.00
$400.00
$200.00
$-
Holton
Paola
Concordia
Wamego
El Dorado
Tonganoxie
Ellinwood
Great Bend
Philipsburg
Caney
Medicine Lodge
Sabetha
Eudora
Valley Center
Herington
Andover
Basehor
Yates Center
Larned
Halstead
Chapman
Balwin City
Beloit
Ellis
St. Marys
Kingman
Garnett
Wellsville

Reduce Electricity Usage

- Upcoming EPA "2013" Criteria for Ammonia Will Require Almost All WWTPs in Kansas to Fully Nitrify – Power Usage and Costs Will Increase
- First Thing to Reduce Power Costs, if Nitrify and do not De-nitrify, then Revise the Treatment Process to De-Nitrify and Utilize the NO3 (nitrate) Oxygen
  - Motors & Blowers– use VFDs (or AFDs)
  - Add Full Time OPR/DO Monitors
  - Computer Controls to Insure Minimum Power to meet DO Needs, and to De-nitrify (SCADA)


Energy Use & Effluent Total Nitrogen
Energy Use ($/MGD)
Effluent Total Nitrogen
Linear (Effluent Total Nitrogen)
R² = 0.0694
ENERGY USE ($/MGD)
EFFLUENT TOTAL NITROGEN (MG/L)
$1,200.00
$1,000.00
$800.00
$600.00
$400.00
$200.00
$-
40
35
30
25
20
15
10
5
0
Holton
Paola
Concordia
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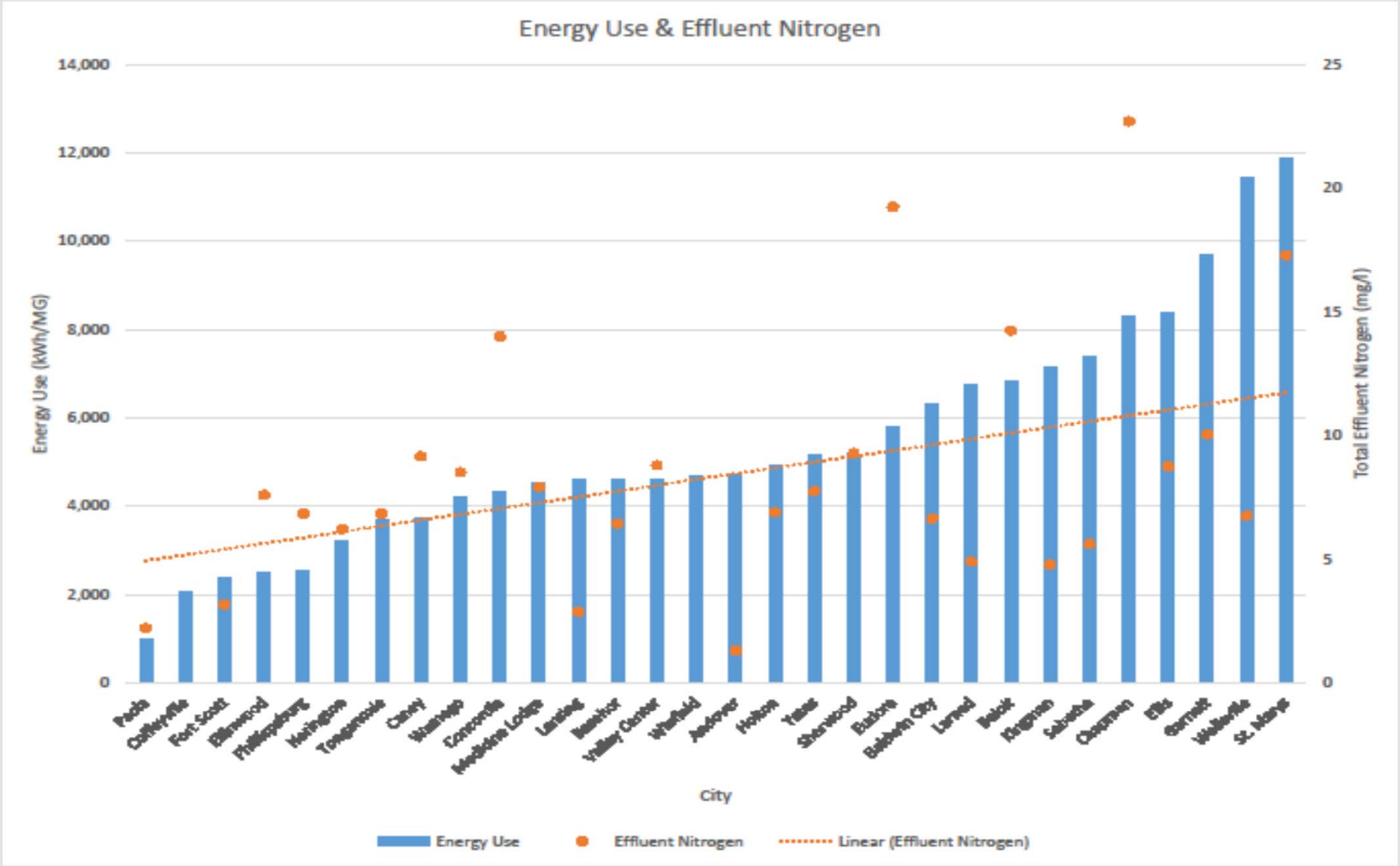


Energy Use & Effluent Nitrogen
Energy Use (kWh/MG)
Total Effluent Nitrogen (mg/l)
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
25
20
15
10
5
0
Paola
Coffeyville
Fort Scott
Ellinwood
Phillipsburg
Herington
Tonganoxie
Caney
Wamego
Concordia
Medicine Lodge
Lansing
Basehor
Valley Center
Winfield
Andover
Holton
Yates
Sherwood
Eudora
Baldwin City
Larned
Beloit
Kingman
Sabetha
Chapman
Ellis
Garnett
Wellsville
St. Marys
City
Energy Use
Effluent Nitrogen
Linear (Effluent Nitrogen)

Lessons Learned – Small Mech WWTP Reviews

- Aeration Control can Substantially Reduce TN (and TP) in Effluent by “Recovering” the Oxygen from Nitrate (NO3), by use of Computerized Control of Aeration Systems
- AND Effluent Quality Improves!!
- Minor Costs of Probes, Controls, Computer are Responsibility of City or Owner
- BUT!! Also we HAVE to Keep the Bugs Warm – Above 10 C or the Nitrifiers Lay Down on the Job

Continuing – Nutrient Removal - TP

- Total Nitrogen – TKN (Organic N + NH3) + NO3 + NO2 = TN

- Total Phosphorus - TP

Total Phosphorus

- Measured as both Ortho-phosphate (oxidized PO4) and Phosphorus (not oxidized)
- Oxidized Phosphorus (as PO4 – phosphate) can be in solids or in liquids
- The “Not oxidized” Phosphorus (as P) can also be in solids or in liquids
- Purpose of wastewater “treatment” is to change all liquid-form P into solid-form P, and remove the solid TP with the sludge

Total Phosphorus

- TP in Bio-P WWTP effluent and Sludge is more “bioavailable” than TP from mineral fertilizers, or NPS runoff
- Phosphorus is Everywhere – food, cleansers, fertilizers, toothpaste, dish soap, laundry soap, prep for painting, matchsticks, and on and on and on
- Phosphorus is in our teeth, its in our bones, its inside our eyeballs

Total Phosphorus

- History – EPA published the “Process Design Manual for Phosphorus Removal” in 1971, updated in 1976

- In 1971 “typical” TP in Raw Sewage was an Average ~ 11.5 mg/l, Median ~ 10.0 mg/l in that study

Total Phosphorus

- Today, in Kansas, information from the KDHE DMR/Oracle database – Raw Sewage Average TP is ~5.1 mg/l and Median ~4.5 mg/l
- Why the Decrease? EPA is working with industry to reduce/remove Phosphorus from Daily Use Products, and Having Good Success

Kansas 303(d) List of Impaired Streams, TMDLs, and Permit Limits

- Kansas is taking an “incremental” approach to TP control thru 303(d) Listings and implementation
- Phase 1 is 201 ppb in-stream concentration, and effluent limits of 1.5 - 1.0 mg/l for Mech Plants, and 2.0 mg/l performance expectation for lagoons – Annual Averages (Prior 12 months effluent data)

Kansas 303(d) List of Impaired Streams, TMDLs, and Permit Limits

- Phase 2 could be about ½ Phase 1 in-stream ppb (~100 ug/l) with effluent limits of 1.0 - 0.5 mg/l for Mech Plants and 2.0 mg/l performance expectation lagoons – Annual Averages
- Also Implement Non Point Source and MS4 Pollution Controls
- Implementation over next 40 Years or so
- Phase 3 do something more, where and if needed

Biological Phosphorus Removal

- Also Called “Luxury Uptake” as the microbes take in more P than they need to survive, and form ortho-phosphate “lipids” inside the sludge microbes
- Requires a “Balanced Diet” of Pollutants – 40:10:1
  200 BOD : 50 TKN : 5 TP -- Normal Domestic Strength Sewage in Kansas today
- New Designs Provide 3 to 5 Chamber Activated Sludge System – Anaerobic Tank, Anoxic Tank, Aeration Tank – and Well Trained Operator, with Computer Controls Really Helps

Biological Phosphorus Removal

- Sequencing Batch Reactors - Some can do Luxury Uptake, Some Can't – Detention Time
- But ANY Existing WWTF Design an Improve with Improved Operations Training and Computer Controls
- If Influent TP is over 7 mg/l, suggest look for high strength discharge – industry that paints, food or meat processing, soap or cleanser manufacturer, and require pretreatment to reduce TP to 1.0 mg/l

Biological Phosphorus Removal

- Also Consider Changing Sewer Use Ordinance, to NOT Surcharge high BOD and TSS, but Instead Surcharge high TP
- Bio-P Fails When the Microbes Run out of BOD
- Bio-P Activated Sludge Process uses lots of BOD to “capture and recapture” phosphorus into and out of the microbes

Recent Change to Emphasize TP over TN

- TP – Ks Nut Red Plan – BNR – 1.5 mg/l, ENR – 0.5 mg/l, LOT – 0.3 mg/l
- TP – Ks Nut Red Strategy – BNR/TMDLs – 1.0 mg/l – with Enforceable Limit as lbs per day, Prior 12 Month Annual Average
- Prior Guidance was to use Biological Processes, then Also use Chemical Addition (i.e., alum, ferric chloride), as Best the Community can Afford

Recent Change to Emphasize TP over TN

- New Emphasis Continues to be to Encourage Biological Processes, and/or also Chemical Addition as needed, goal is 1.0 mg/l Monthly Average
- And we can Reduce TP Further with Chemical Addition Following Bio-P Removal

Bio-P and Chem-P Phosphorus Removal

- Bio-P Process – P + O2 -> PO4 (oxidized); PO4 + BOD -> P (reduced) ; P + O2 -> PO4; PO4 + BOD -> P; over and over and over again
- Waste Sludge Volume Reduced by Denitrification, Waste Sludge Volume Slightly Increased by Bio-P Process

Bio-P and Chem-P Phosphorus Removal

- Chem-P Removal can use Alum or Ferric, and an Operations Scheme can add Chemical at Several Locations in Collection System (odor control, ties up H2S first then P) and/or Treatment Process
- Chem.-P Removal can use Many of the Different Forms of Alum or Ferric, can add Chemical to Several Locations, Into the Collection System (as odor control ties up H2S first, then P) and/or Into the Treatment Plant Processes

Chem-P Phosphorus Removal

-Chem-P Treatment Significantly Increases Waste Sludge Volume, Each WWTP Unique, Est. 20% to 40% Increase in Sludge Solids Volume to Reduce TP from 5 mg/l Influent to TP to 1 mg/l Effluent

-Always do Jar Tests as Part of Design Services or Testing Operations Changes

Chem-P Phosphorus Removal

-Recent Article in KRWA Magazine – March 2015 – Regarding Chem-P Operations

-There is no “Economy of Scale” for Chem-P Removal

-It takes10 pounds of Alum to Capture 1 pound of TP, whether in Abilene or Wichita (and this is AFTER nitrification and denitrification treatment has “reworked” phosphorus to be efficiently removed by Chemical Addition), to Reduce TP from 5.0 to 1.0 mg/l

Phosphorus Removal is Different

EPA Report-

Advanced Wastewater Treatment to Achieve Low Concentration of Phosphorus, EPA 910-R-07-002 April 2007

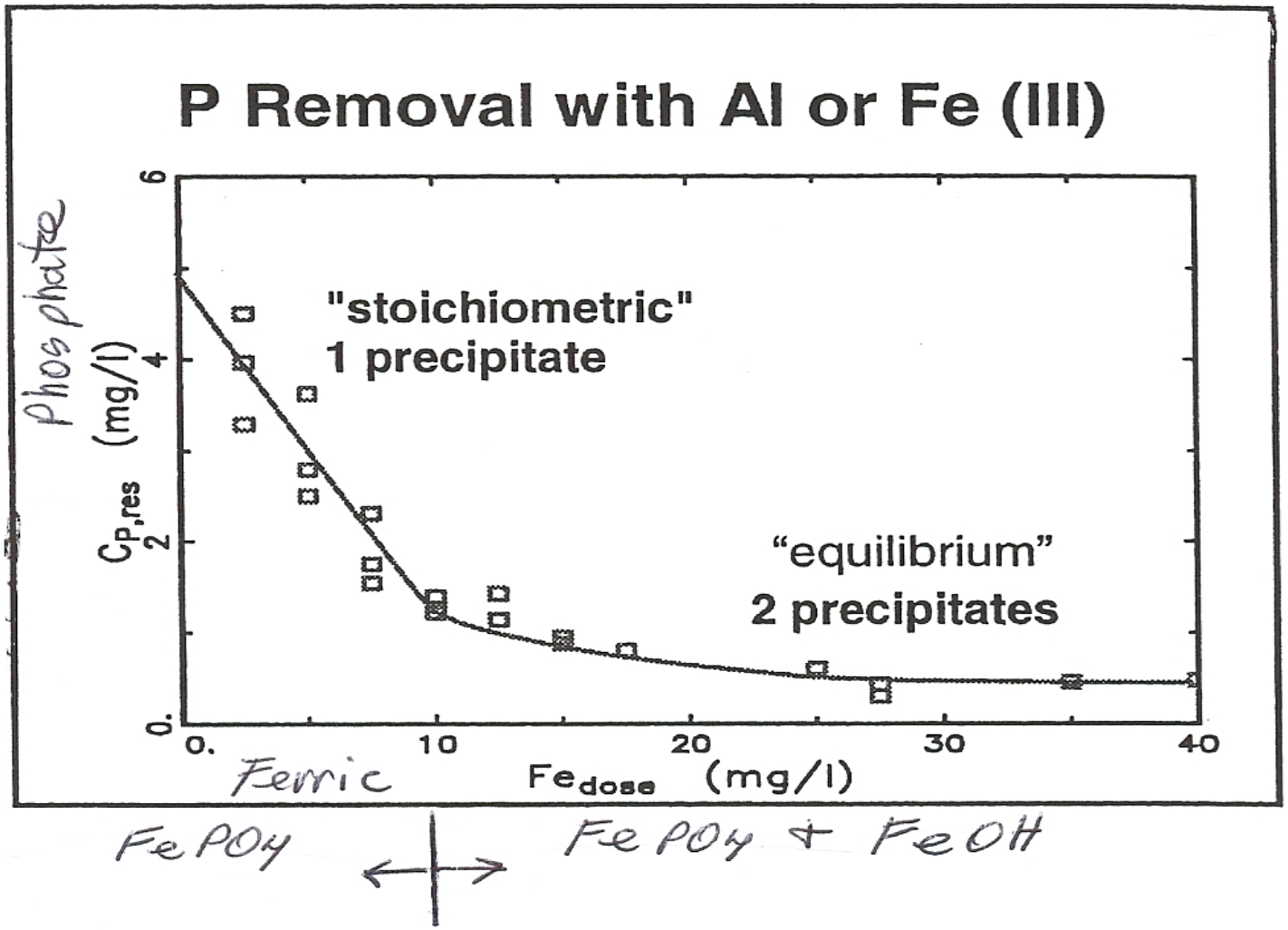
Factoid from the Report-

Effluent TP Concentrations can be Reduced to 0.10 mg/l by Addition of Alum to a BNR Effluent at 135 mg/l Followed by Filtration – Effluent pH Adjustment Then Also Required

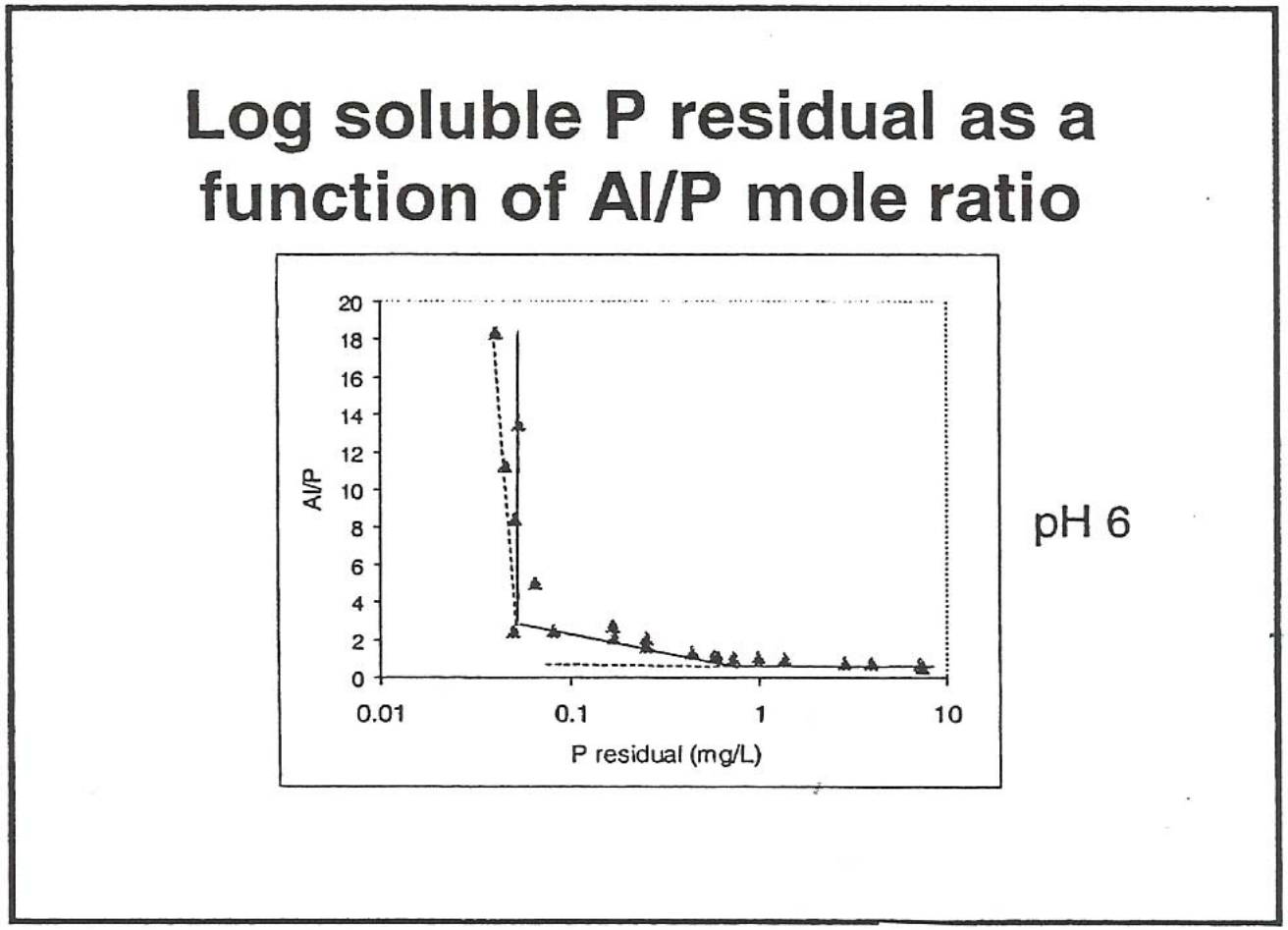
Giving Credit….

The Next Two Slides are taken From a Presentation by Dr. David Jenkins, Professor in the Graduate School University of California at Berkeley, entitled “Principals of Phosphate Removal by Chemical Precipitation” presented at the WEFTEC Technical Workshop “Phosphorus Removal to Very Low Levels”, October 22, 2006, in Dallas, TX

Phosphorus Removal is Different



Phosphorus Removal is Different



“Excess Alum Softening”

- The Addition of Excess Alum or Ferric Will “Dilute” the Phosphorus Concentration Within the Chemical Precipitation Solids with Hydroxide Compounds
- pH Adjustment of the Effluent is Required Prior to Discharge

“Excess Alum Softening” con’t

Assuming 1 mg/l TSS in Effluent

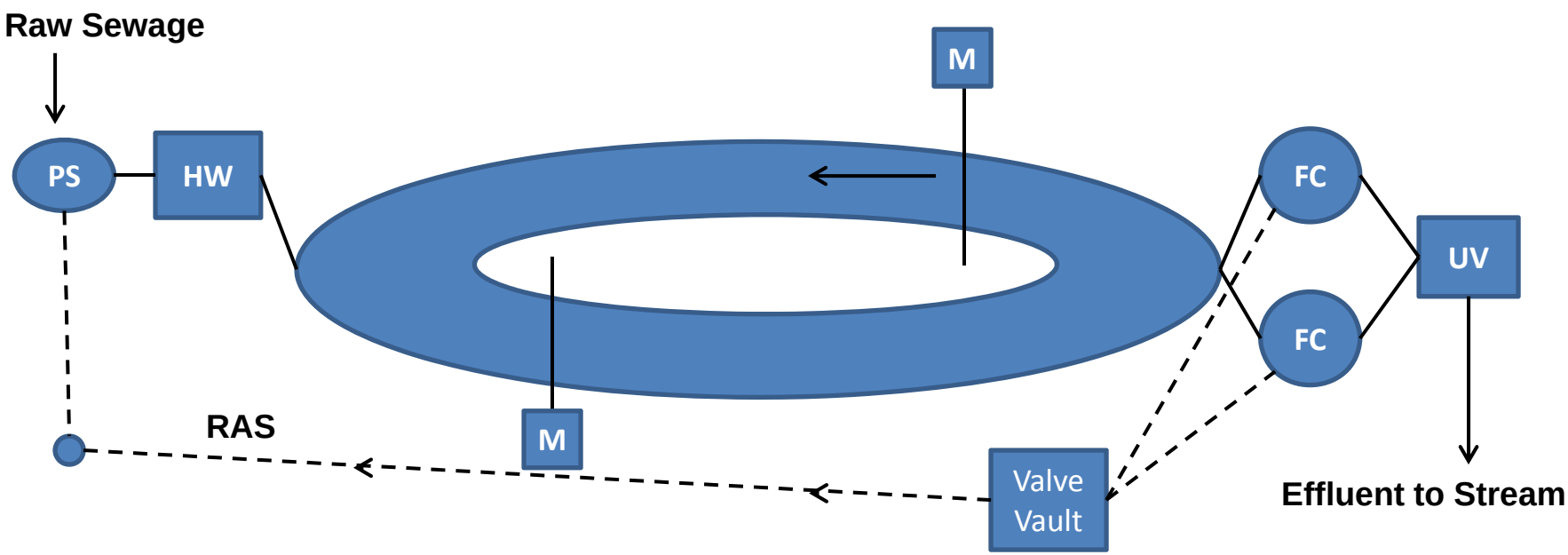
- Al to P Ratio for TP >= 0.5 mg/l is 1 to 1
- Al to P Ratio for TP =< 0.1 mg/l is 4 to 1
- Al to P Ratio for TP =< 0.03 mg/l is 10 to 1
- Al to P Ratio for TP =< 0.01 mg/l is 30 to 1

Note Alum is About 10% Aluminum

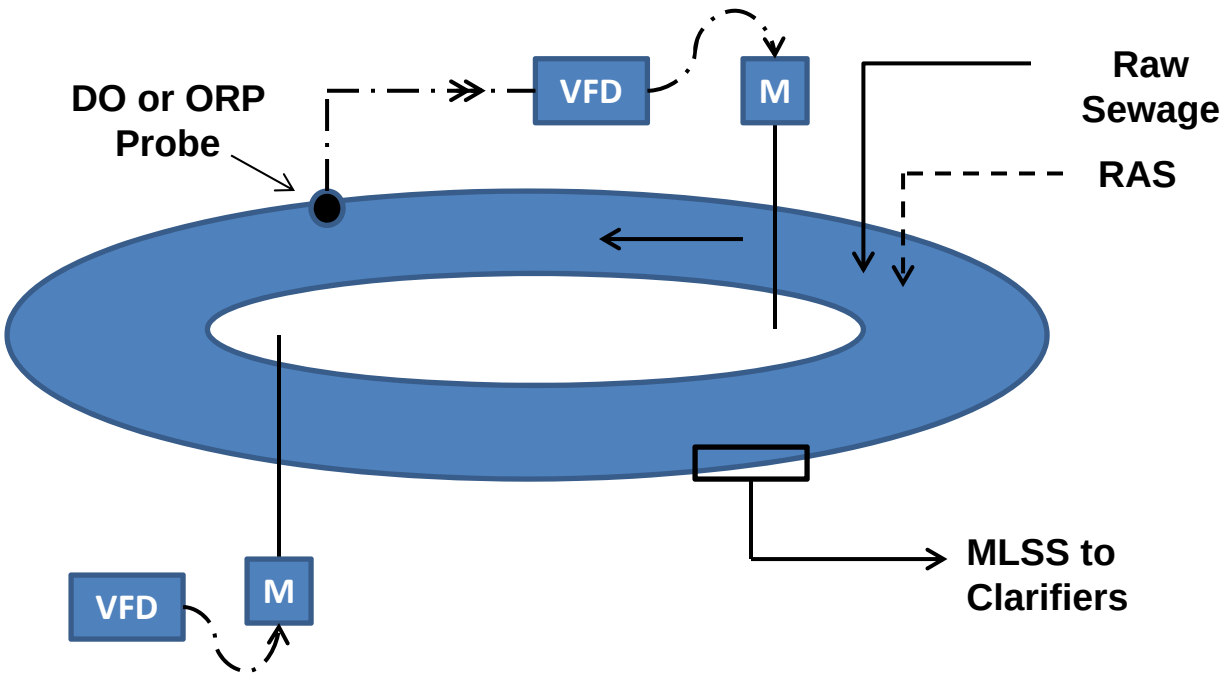
Diversity of Treatment in Kansas

- Example: Connecticut – 90 WWTPs (all alike??)
- Kansas – Seems Like Every WWTP is Different
    - ABCs of Equipment and Designs
    - Aero-mods
    - (sequencing) Batch Reactors
    - “Carousel” (“racetrack”) [Vertical Turbine Mixers]
    - Oxidation Ditches [Horizontal Rotors]
    - Schreiber Designs
    - Unique Designs

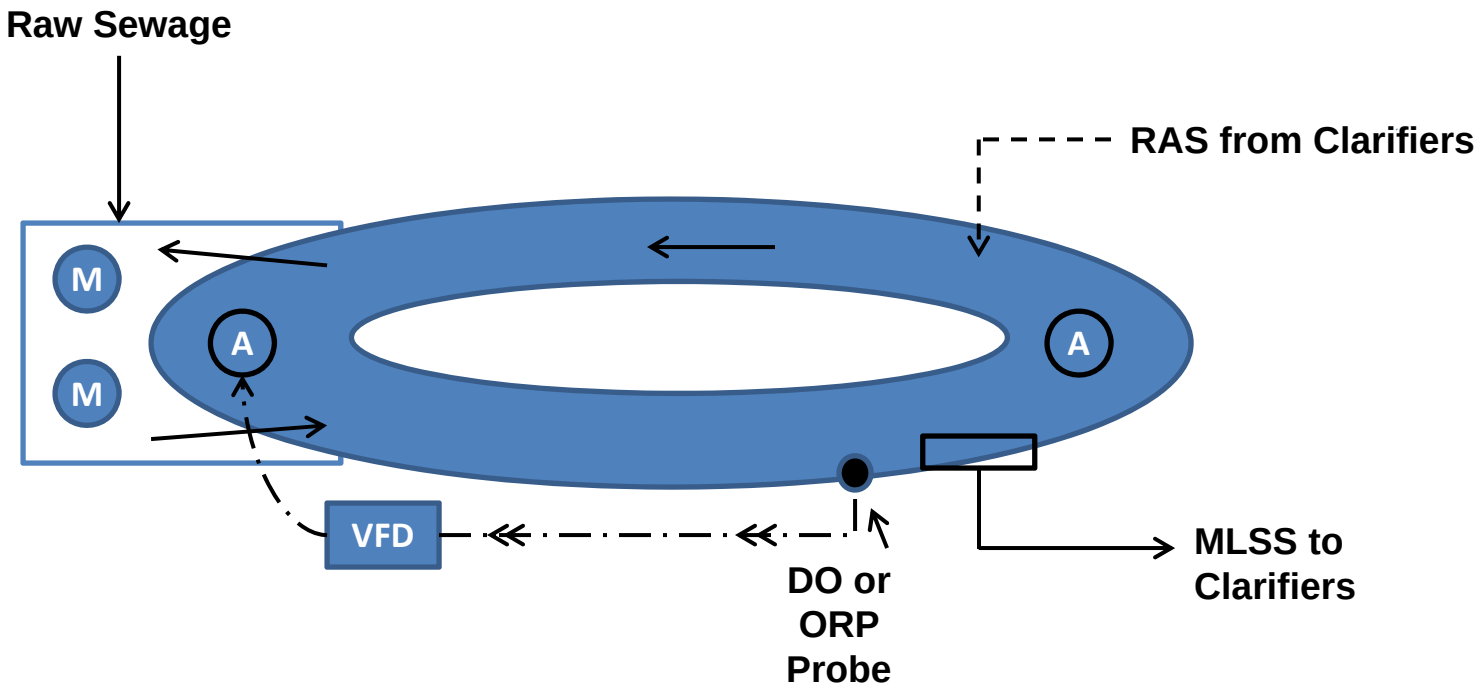
Oxidation Ditch



Oxidation Ditch Nitrification-Denitrification Process

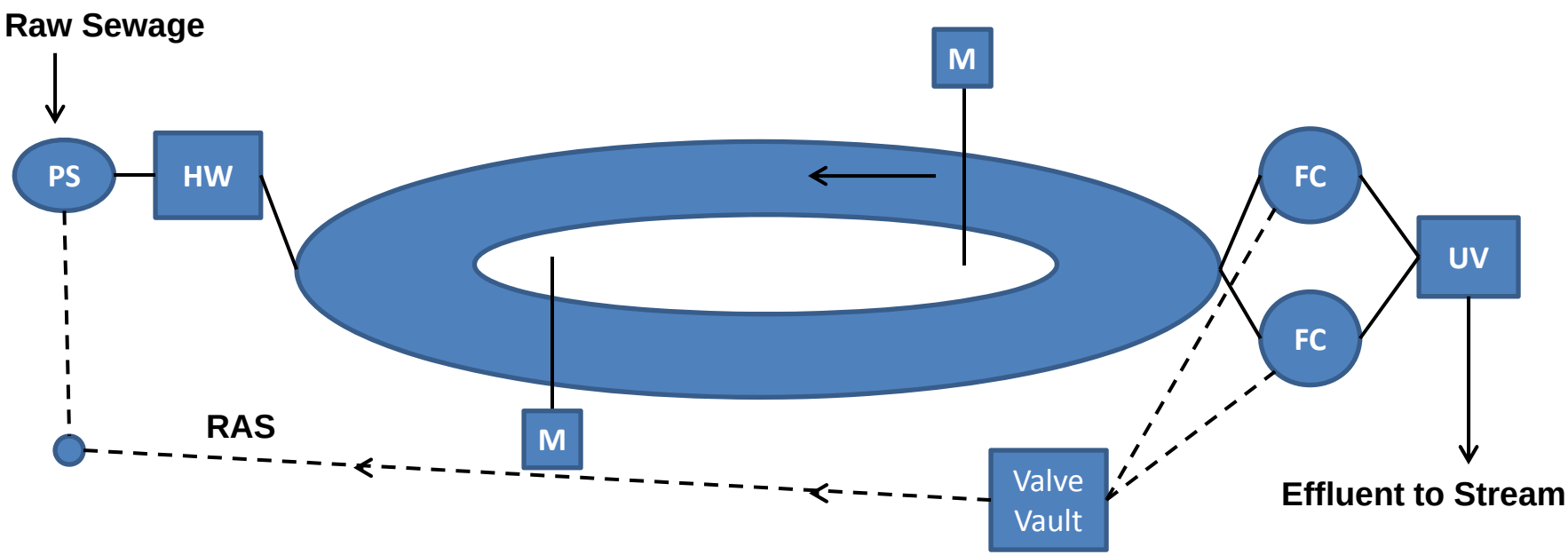


O. D. Nitrification-Denitrification and Bio-P Process



Buhler Oxidation Ditch

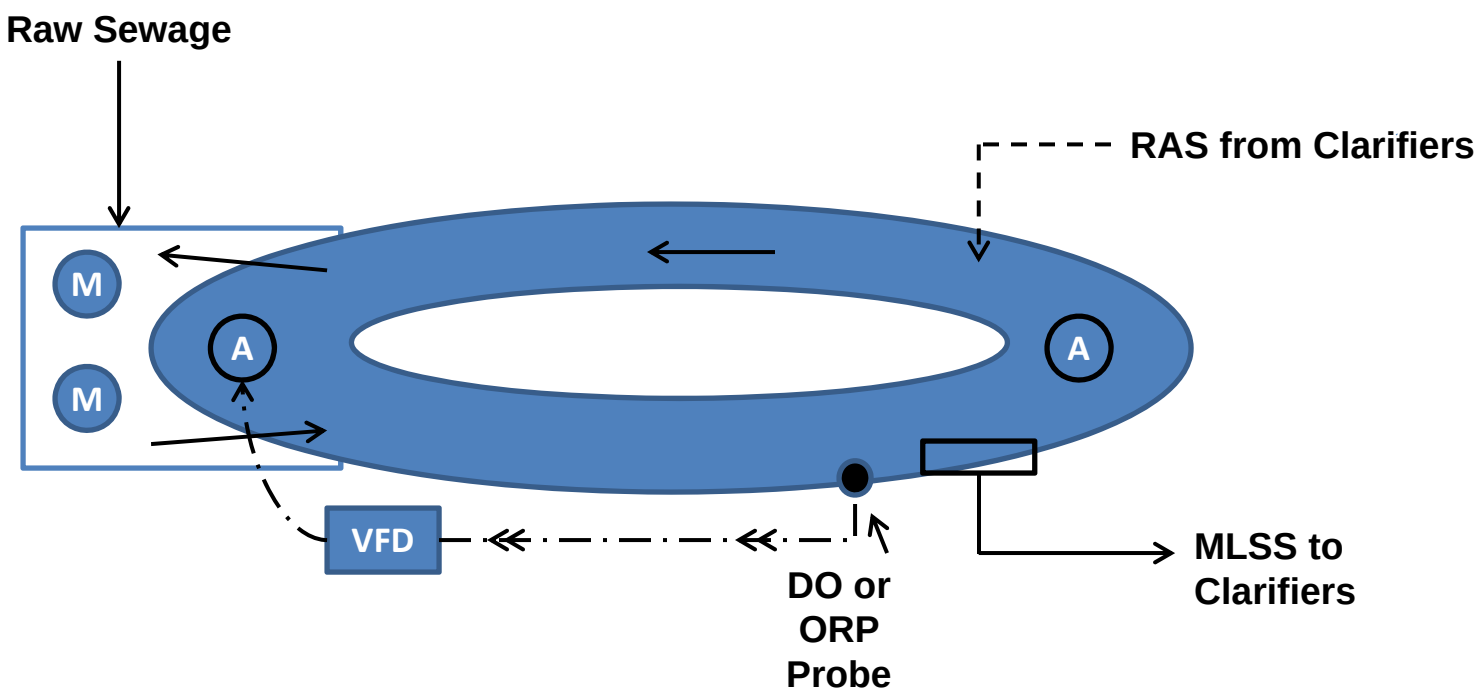
Oxidation Ditch – Chem-P



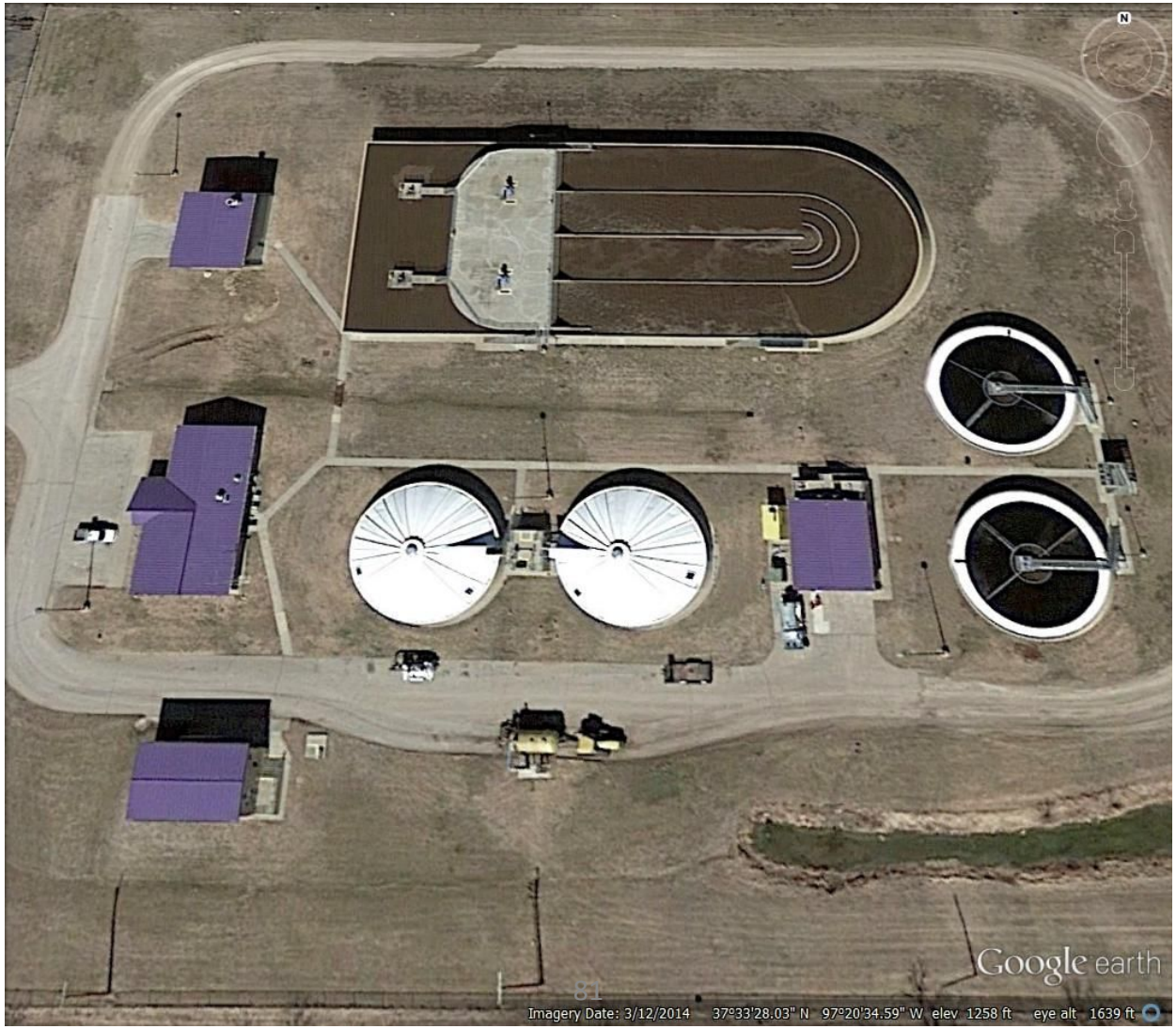
Edgerton Chem-P System

Edgerton Chem-P System cont.

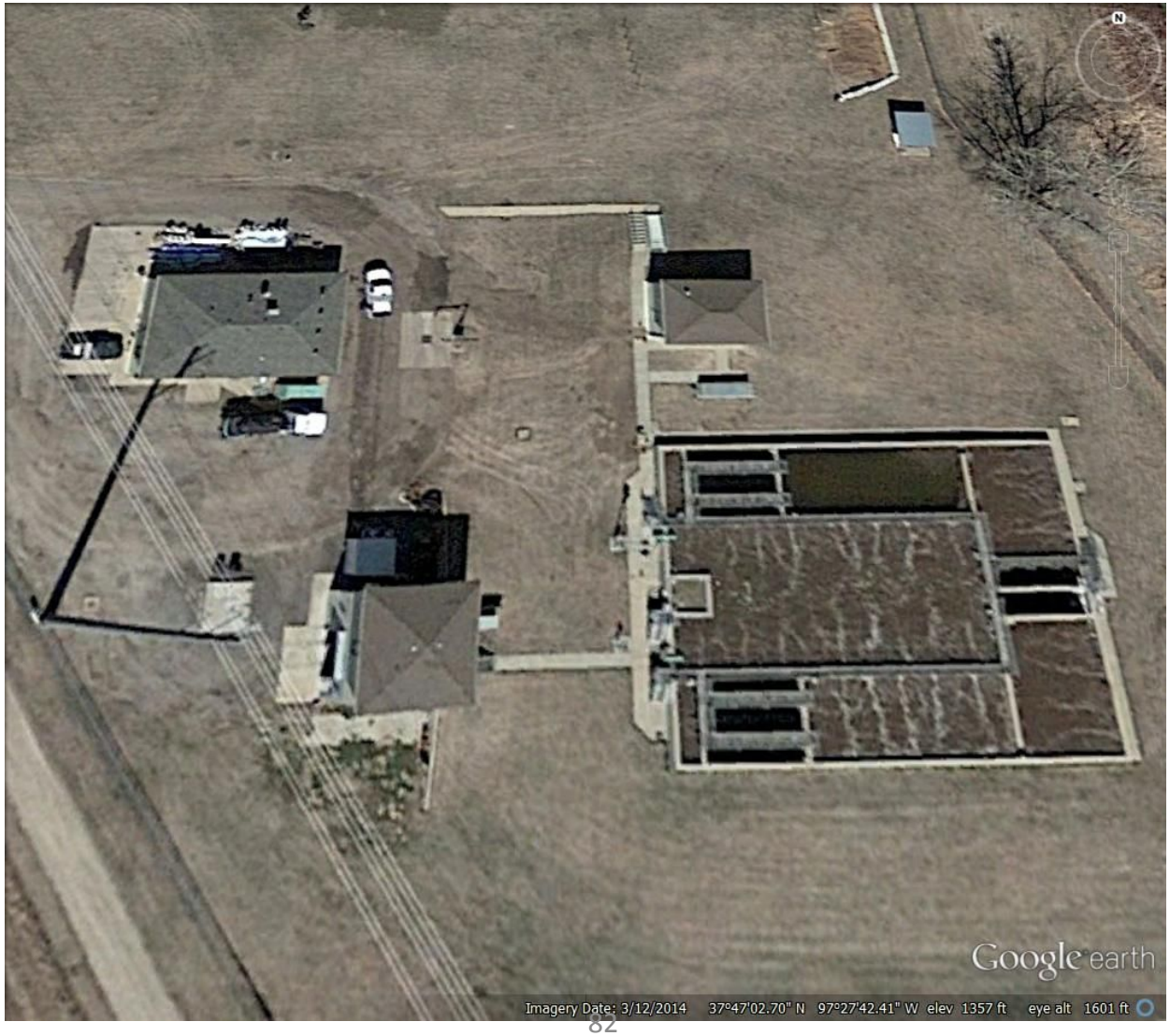
“Carousel” Nitrification-Denitrification and Bio-P Process



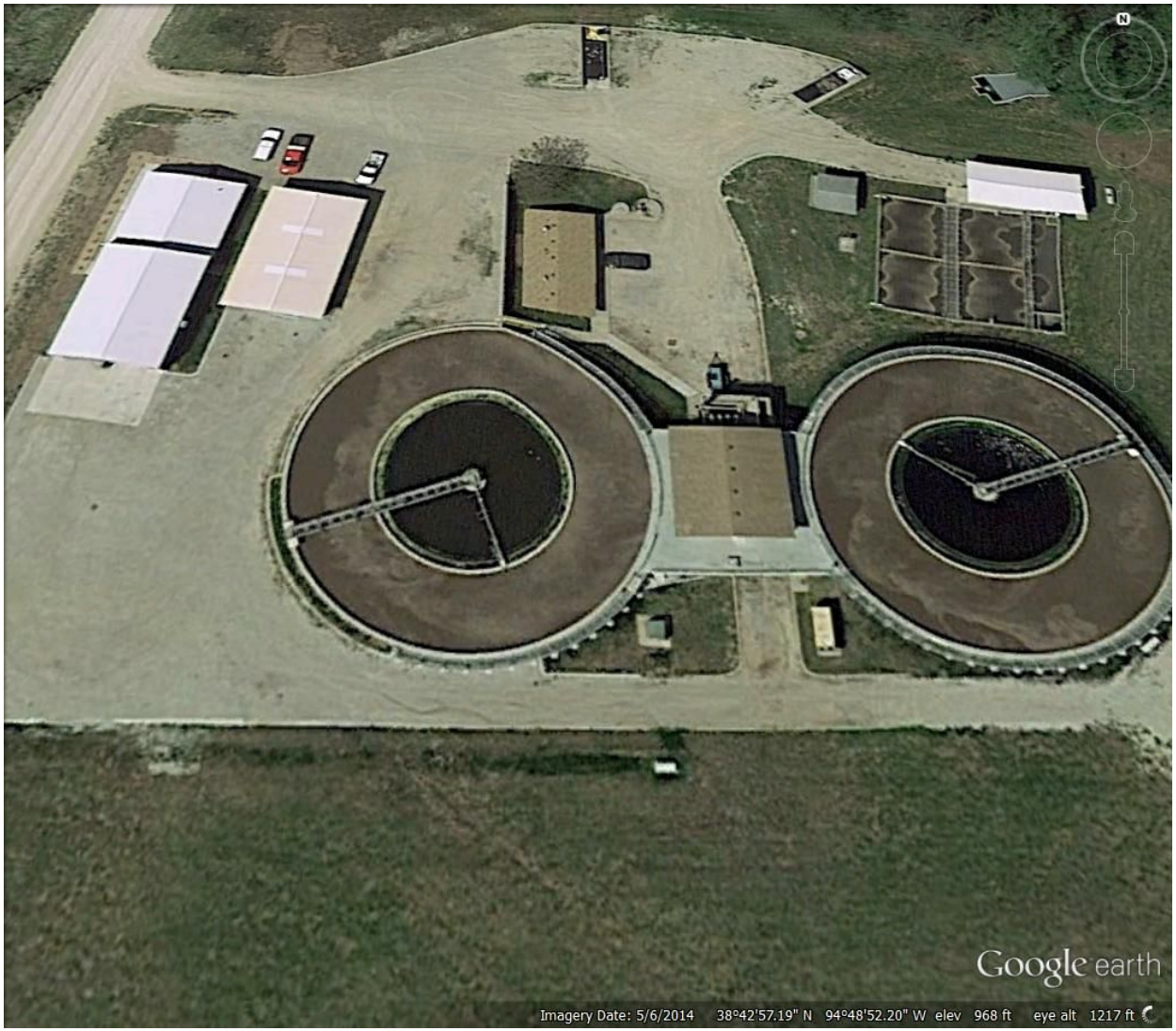
Haysville “Carousel”



Maize Aeromod



Spring Hill Schreiber



Abilene SBR

Google earth
Imagery Date: 4/8/2014 38°53'59.22" N 97°12'03.76" W elev 1143 ft eye alt 1585 ft

Chanute Unique Trickling Filter

Salina Unique

Poundages, Flow Measurement and Effluent Reuse

- Reporting Daily Poundage Discharges is required by TMDL/Waste Loan Allocations, Which Requires Effluent Flow Measurement
- Effluent Reuse, such as Irrigation, Provides an Alternate Path for Effluent Other than Discharge to the Receiving Stream
- KDHE is Now Also Reviewing Permits to Require Flow Measurement of Effluent to Irrigation or Other Reuse Methods
- Effluent Reuse is Encouraged, as this Reduces Pounds of Nutrients Discharged to Streams

Reuse of Effluent to Reduce Discharge Volumes and Costs

Agricultural Irrigation

- 130 Muni, Comm, Ind WWTP Permits Allow “Optional” Irrigation, with no Additional Disinfection Required, about 10 Permits Have “Mandatory” Reuse

Golf Course Irrigation

- 24 Muni & Comm Permits, Additional Disinfection is Required to Protect Public Access Areas

Industrial Reuse – Typically Cooling

- 5 to 10 Permits Allow This

Less Stringent Treatment Required to Reuse Effluent Than to Discharge to Stream

Reuse of Effluent to Help Meet Nutrient Reduction Goals

- Example – Ks Nutrient Goals of 8 mg/l TN & 1.5 mg/l TP are Annual Averages
- 1.0 MGD effluent flow X 8 mg/l TN X 8.34 (conversion factor) = 66.7 #/da X 365 day/yr = 24,353 #/yr
- If Irrigate Golf Course 30 da/yr @ 1 mgd/day, then TN Discharged to Stream is (365-30=335 days) 24,353/335 = 72.7 #/da Allowed When Discharging, or 8.7 mg/l

Summary

- KDHE Nutrient Reduction Efforts Today are to Establish Goals (10 and 1) and Offer Training to Operators (Fort Scott CC, KRWA, WSU)
- Perhaps Nearly Every Activated Sludge WWTP in Kansas can be Upgraded to produce 3 mg/l TN with DO Probes and VFDs and Computer Controls, AND Save Electricity
- Perhaps Bio-P can be Added to Activated Sludge WWTPs to Produce 1.0 mg/l TP, but expect Construction Upgrades

Summary

- Certainly Chem-P can Produce 1.0 mg/l TP with small capital cost (if sludge handling can take increased load) but with large operations (chemical) costs

- There is no “Economy of Scale” for Chem-P Removal

Summary

- It takes10 pounds of Alum to Capture 1 pound of TP, whether in Abilene or Wichita, and this is AFTER nitrification and denitrification treatment has “reworked” phosphorus to be efficiently removed, to Reduce TP from 5.0 to 1.0 mg/l

- Operators Should Experiment with Jar tests and Chemical additions, to Determine Quantities of Chemical Needed and Sludge Produced

Summary

- For Larger Design Flow WWTPs – Bio-P is Often Cheaper, Process Design in Conjunction With Ammonia Removal
- Costs?? Each WWTP is Unique. Expect Chem-P to cost $1 to $2 per month per household for chemical purchase and feeders/storage, AND this assumes no upgrade needed to solids handling facilities

Summary

- Major WWTPs in Kansas can be Expected to Consider Implementing Bio-P Reduction with Chem-P “Trim” of Effluent Phosphorus Concentration

- Overall Statewide Goal is Every Municipal Mechanical WWTP Meet 1.0 mg/l Total Phosphorus in the Effluent, or less, Constantly and Consistently

- Electronic Measurement of TP and Monitoring Systems are Now Available, including Systems to Control Chemical Addition to “Trim” TP to Meet Effluent Limits and Goals

Bottom Line

- Significant push to reduce nutrients
- Kansas – will utilize an incremental reduction strategy
  - Reduce now, criteria later
  - May need tweaking, but still the framework for reduction
  - EPA and environmental groups acknowledge progress
    - Want to see more results more quickly
- Non Point Source reduction is a long process
  - Probably 1-4 decades depending on watershed size
- Point Sources can take measured steps now
  - We do see impacts from Point Sources (wastewater trmt. plants)
  - Failure to do so would invite intervention by others
    - Most likely, very stringent criteria = stringent permit limits

Questions

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