2010 Idaho Reuse Conference

Limits of Technology Nitrates and Aquifer Recharge

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HDR

Overview

- **Water Quality Protection**
  - Surface Water and Groundwater
- **Issues**
  - Groundwater Protection
- **Aquifer Recharge Practices**
- **Nitrogen Removal Treatment Technology**
  - Capabilities
- **Aquifer Recharge Example**

Idaho TMDLs with Low Phosphorus Wasteload Allocations

- **Spokane River**
- **Snake River/Hells Canyon**
  - Lower Boise River
- **Middle Snake River**
- **Portneuf River**
- **Paradise Creek**
- **Cascade Reservoir**
- **Others……..**

Convergence in Treatment Technologies Linked to Reuse

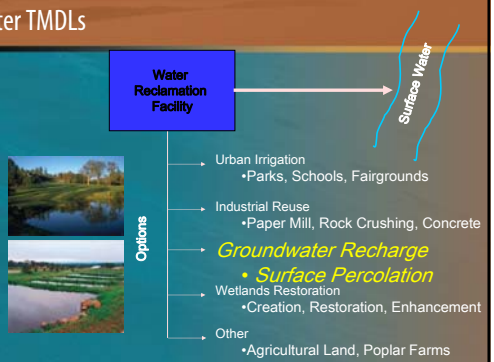
Low Phosphorus

- Biological Options
- Chemical Options
  - Effluent Filtration
  - Single and Multiple Stage Media Filtration
  - Membranes
- *Meets Reclaimed Water Standards*
- Technology Selections – Best Filter?

Low Nitrogen

- Biological Options
- Chemical Addition
  - Supplemental Carbon Source for Denitrification
- Effluent Filters?
  - Separate Stage Denitrification

Reclamation Options to Meet Restrictive Surface Water TMDLs



Aquifer Recharge as an Effluent Management Option

- **Effective Phosphorus Load Diversion from Restrictive Surface Wate Limitations**
  - Potential Soil/Aquifer Treatment
- **Aquifer Recharge to Supplement Groundwater Supplies**
- ***Nitrogen Loading to Groundwater***

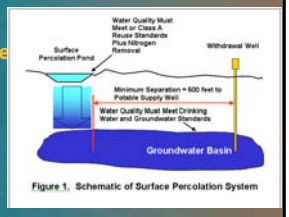


Figure 1. Schematic of Surface Percolation System

Water Quality Protection

Surface Water Quality (Emphasis on P[1])

- Beneficial Use Protection
  - WQ Standards
    - D.O. and pH
  - Narrative Nutrient Standards
  - *Future*
    - *Potential Numeric Nutrient Standards*
    - *Treatment Technology Standards*
- TMDLs to NPDES Permits
  - N and P

Groundwater Quality (Emphasis on N)

- Drinking Water Protection
  - Nitrate Nitrogen
  - Total Dissolved Solids
  - *Future*
    - *Trace Organics, EDCs, PPCPs*
- Special Resources
  - Groundwater Management Areas
    - Lower Boise/Canyon County Ground Water Quality Management Plan
    - Rathdrum Prairie Aquifer

[1] Caveats: Ignores potential surface water co-limitation N and P , NRDC petition for N&P Treatment Technology Stds, Reactive N Greenhouse Gas emissions, etc

Site Specific Analysis of Downgradient Groundwater Concentrations

- ***Groundwater Nitrate***
  - Idaho Groundwater Quality Rules
  - Required Wastewater Treatment Effluent Quality
    - Perhaps Effluent NO_3-N < 1 mg/l + Aquifer Concentration After Mixing Zone
- ***Groundwater Total Dissolved Solids***
  - Secondary Standard (IDAPA 58.01.11.400.02.a)
  - Required Wastewater Treatment Effluent Quality
    - Effluent TDS < 500 mg/l

Aquifer Recharge

Gilbert, Arizona Riparian Preserve

National Aquifer Recharge Practices

- **According to EPA; 1,200 Groundwater Recharge Projects**
  - Gilbert, Arizona Riparian Preserve
  - Scottsdale, Arizona Water Campus
  - Water Factory 21, Orange County Water District, CA
  - West Basin Municipal Water District, El Segundo, CA
  - Los Angeles County Sanitation Districts
  - Los Angeles DWP Harbor Project

Scottsdale, Arizona Water Campus

- Wastewater Reclamation
  - Microfiltration followed by Reverse Osmosis
- Colorado River Water
  - Microfiltration
- Recharge through Vadose-Zone Injection Wells
- Irrigation Reuse:
  - Golf courses served – 21.5 mgd
  - Average annual effluent delivery – 9,500 A.F.
- Indirect Potable Reuse (IPR):
  - Average annual effluent recharged – 3,300 A.F.
  - Average annual CAP water recharged – 3,200 A.F.
- Operation Since 1998

Water Factory 21, Orange County Water District, CA

- 15 MGD Reclamation
  - Chemical Clarification, Multimedia Filtration, Granular Activated Carbon, Reverse Osmosis
- First Injected as Coastal Barrier in October 1976

West Basin Municipal Water District, El Segundo, CA

- Five different qualities of "designer" or custom-made recycled water
  1. Tertiary Water
  2. Nitrified Water
  3. Softened Reverse Osmosis Water
     1. Secondary treated wastewater pretreated by either lime clarification or microfiltration, followed by reverse osmosis (RO) and disinfection for ground-water recharge
  4. Pure Reverse Osmosis Water
  5. Ultra-Pure Reverse Osmosis Water
- Injected into South Bay's groundwater basin to prevent seawater intrusion

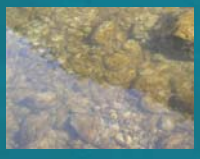
Advanced Oxidation Process (AOP) – Peroxide and UV

LOTT Alliance Hawk's Prairie

- **Lacey, Olympia, Tumwater and Thurston County, WA**
- **5 mgd Satellite Membrane Bioreactor**
  - **Effluent Diversion from Budd Inlet on Puget Sound**
    - **TIN 2 mg/l**
  - **8 acres of Groundwater Recharge Basins**

Wastewater Treatment Technology

Healdsburg, CA Membrane Bioreactor



Yakima River, WA

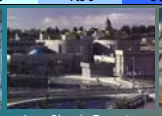
Concrete, WA MBR Effluent

Capabilities of Wastewater Treatment Technology

Parameter	Typical Municipal Raw Wastewater, mg/l	Secondary Effluent (No Nutrient Removal), mg/l	Typical Advanced Treatment Nutrient Removal (BNR), mg/l	Enhanced Nutrient Removal (ENR), mg/l	Limits of Treatment Technology, mg/l	*Typical In-Stream Nutrient Criteria, mg/l*
Total Phosphorus	4 to 8	4 to 6	1	0.25 to 0.50	0.05 to 0.07	*0.020 to 0.050*
Total Nitrogen	25 to 35	20 to 30	10	4 to 6	3 to 4	*0.3 to 0.600*

Las Vegas, NV (TP 0.170 mg/l)

Clean Water Services, OR (TP 0.100 mg/l)



Lacy, Olympia, Tumwater Thurston Co (LOTT), WA (TIN 2 mg/l)

Coeur d'Alene, ID (TP 0.050 mg/l)

Effluent Nitrogen Speciation

	Effluent Concentration
Nitrite + Nitrate	~0.5 – 3 mg/L
Ammonia	~0.1-0.5 mg/L
Particulate organic nitrogen	~0.01-1.0 mg/L
Dissolved organic nitrogen	~0.5-2 mg/L

Capabilities of Wastewater Treatment Technology – Nitrogen Speciation

Parameter	Typical Municipal Raw Wastewater, mg/l	Secondary Effluent (No Nutrient Removal), mg/l	Typical Advanced Treatment Nutrient Removal (BNR), mg/l	Enhanced Nutrient Removal (ENR), mg/l	Limits of Treatment Technology, mg/l
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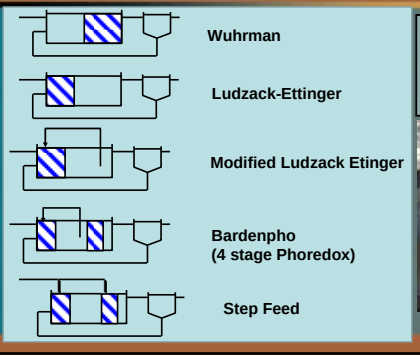
Total Nitrogen	25 to 35	20 to 30	10	4 to 6	3 to 4
Effluent Nitrogen Speciation					
Ammonia NH_4-N			~0.3	~0.1	~0.1
Organic-N			~2.5	~2	~1.5
Nitrate + Nitrate NO_3-N			~8	~4	~1.5

Nitrogen Treatment Process Types

- **Separate Stage**
  - Separate processes for nitrification, dentrification
  - Methanol (MeOH) Carbon Source Added
  - Filter (denitrification)
- **Combined**
  - Conventional, multiple cell BNR (MLE, Bardenpho, step feed, etc.)
  - Effluent filter (no MeOH)
- **Multiple Stage**
  - Conventional plus denitrification filter

Nitrogen Removal Processes - Classic Zoned



Effluent
TN < 10
NH_4 < 1
NO_3 ~8

Tillmann WRP, Los Angeles

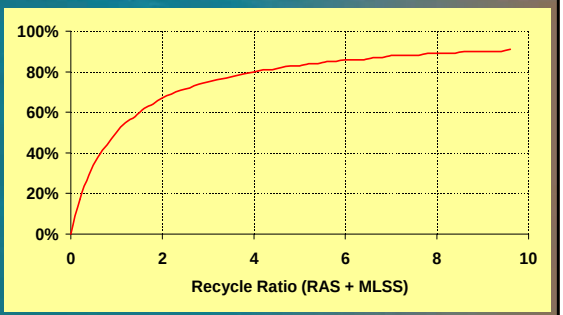
Example Final Effluent Nitrogen Levels (2005)

	Type	Flow (MGD)	PE BOD/TKN Ratio	PE NH_3-N (mg/L)	NH_3-N (mg/L)	NO_3-N + NO_2-N (mg/L)
Long Beach	Step	20	7.4	26	<1	6.6
Los Coyotes	Step	40	7.9	28	<1	5.9
San Jose Creek (East)	Step	59	8.4	23	<1	3.0
San Jose Creek (West)	Step	30	6.5	26	<1	6.3
Pomona	MLE	10	7.1	26	<1	5.9
Saugus	MLE	6	6.2	27	<1	3.3
Whittier Narrows	MLE	8	7.6	24	<1	6.2
Valencia	*	17	8.8	23	<1	4.5

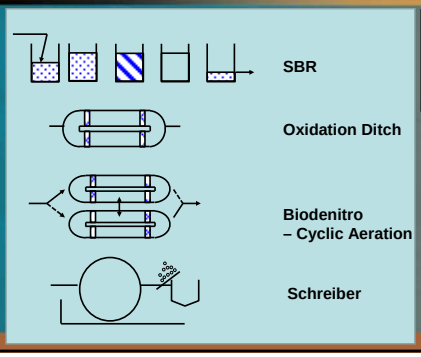
* Valencia WRP has three treatment units that are configured for MLE and two treatment units that can operate as either MLE of step-feed.

Jeff Weiss et al., Comparison of Three Nitrogen Removal Activated Sludge Processes, CWEA 78th Annual Conference, April 4 – 7, 2006; Sacramento, CA

Denitrification vs Recycle



Nitrogen Removal Simultaneous

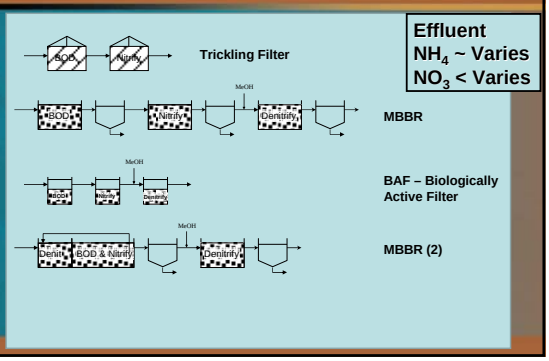


Effluent
TN < 6
NH_4 < 4
NO_3 ~4

Hamilton, MT Phased Nitrification/Denitrification Process Performance

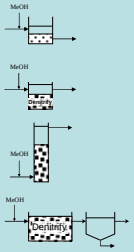
Parameter	Influent	Effluent
TKN	22.6	1.9
Ammonia	12.5	0.3
Total Nitrogen	22.9	3.5
Total Phosphorus	4.1	3.0
Alkalinity	320	220

Nitrogen Removal – Fixed Film



Effluent
NH_4 ~ Varies
NO_3 < Varies

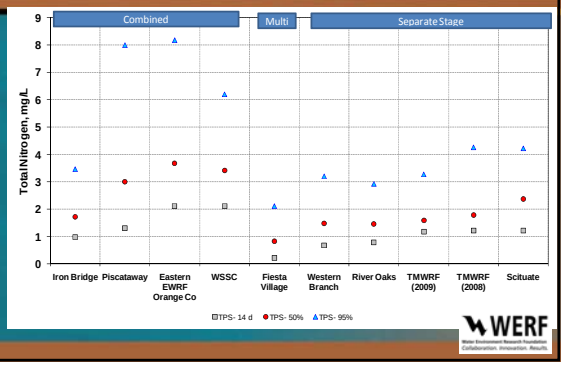
Tertiary Nitrogen Removal Options



Effluent
NH4 ~ Same
NO3 < Controlled

Truckee Meadows , NV
Denitrification Fluidized Bed

Effluent Total Nitrogen Treatment Performance Statistics (TPS) By Process



Spokane River TMDL Scenarios

Scenario	$CBOD_5$, mg/l	Ammonia-N Permit, mg/l	Ammonia-N Average, mg/l	TP Permit, mg/l[1]	TP Average, mg/l
1	5.0	1.0	0.71	0.050	0.036
2	5.0	1.0	0.71	0.070	0.050
3[a]	5.0	1.0	0.71	0.050	0.036

[1]Maximum Month Limits for Phosphorus Based on Assumed Relationship Between Max Month and Long Term Average from BOD Data Set
[a] Scenario 3 Same as Scenario 1 Except for Hayden Summer Reuse (Mar-Jun TP = 0.150 mg/l and July-Sept 0.010 mg/l)

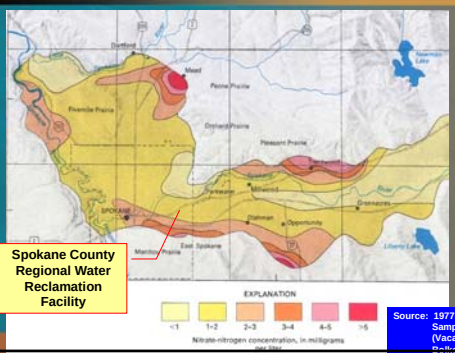
- Ecology Selected Scenario 1 for TMDL Wasteload Allocation (WLA) in Washington
  - Revised Idaho Permits to Ensure Compliance with Washington Standards

Spokane County Regional Water Reclamation Facility

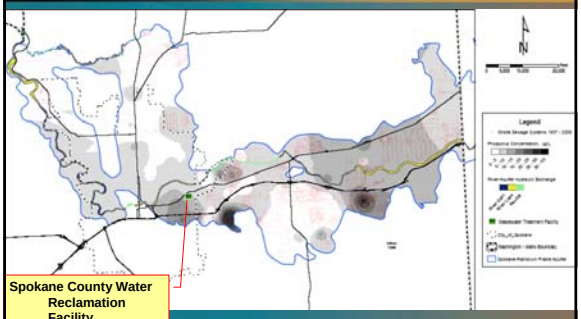
Chemically Assisted Primary Treatment	Nitrification / Denitrification	Membrane Treatment	Disinfection
Suspended Solids & Phosphorus Removal	Organic, Ammonia & Nitrate Removal	Removal of all Particles Larger than 0.4 Microns	Inactivates Protozoa, Bacteria and Viruses

100% Meets Washington Class A Reclaimed Standards

Nitrate-Nitrogen Concentrations in SVRP Aquifer



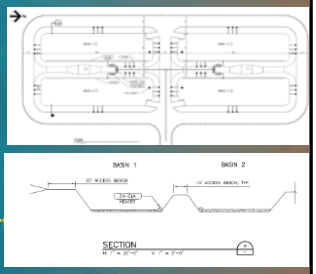
Total Phosphorus Concentrations in SVRP Aquifer



Spokane County Water Reclamation Facility

Spokane County Aquifer Recharge Pilot Study

- **Proposed 2 mgd Study**
  - **Effluent Quality**
    - **TP 0.05 mg/l**
    - **CBOD 2 mg/l**
    - **TN 10 mg/l**
    - **NH_3N 1 mg/l**
  - **Fate and Transport of N and P**



Spokane County Regional Water Reclamation Facility

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Nitrate + Nitrate NO_3-N			~8	~4	~1.5

Effluent TP 0.05 mg/l

Effluent TN 10 mg/l

EPA's Municipal Nutrient Removal Technologies Reference Document (Sept 2008)

- **Technical and Cost Information**
  - **40 Process Trains for N and P Removal**
  - **Performance Data Analysis 30 Operating Facilities**
  - **In-depth Case Studies 9 Operating Facilities**

Cost Estimates for Expansion Technologies for 10 mgd

Effluent Target	Capital $/gpd	O&M $/MG treated	Life-cycle $/MG treated
TN 5 mg/l TP 1 mg/l	$1.36 - $2.05	$299 - $436	$625 - $925
TN 5 mg/l TP 0.5 mg/l	$2.19 - $2.45	$452 - $456	$975 - $1,040
TN 5 mg/l TP 0.1 mg/l	$0.83 - $1.87	$259 - $387	$456 - $834
TN 3 mg/l TP 0.1 mg/l	$0.75 - $2.48	$448 - $477	$626 - $1,070