Nitrogen Issues with Subsurface Sewage Treatment Systems

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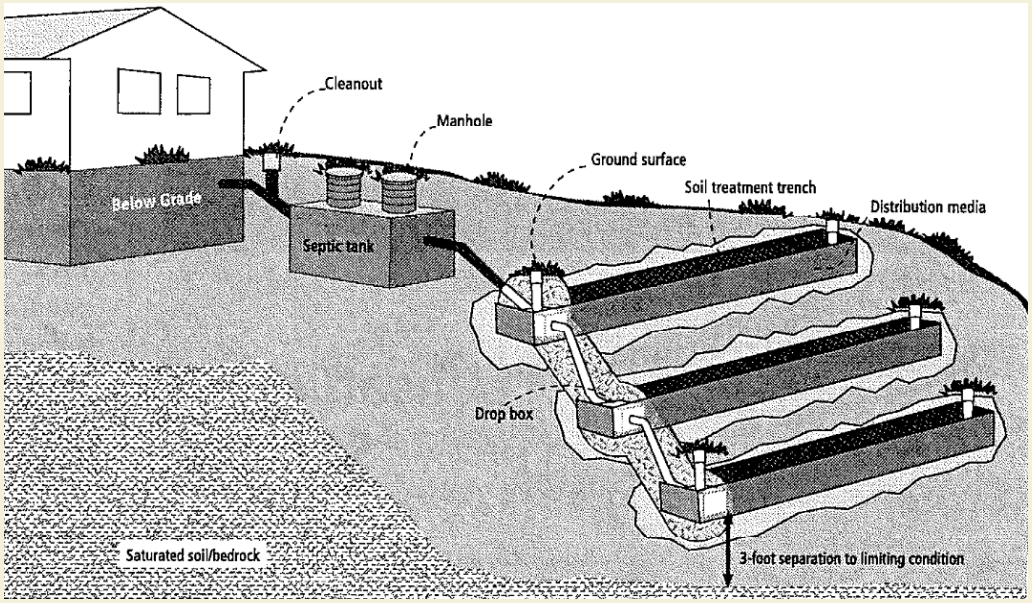
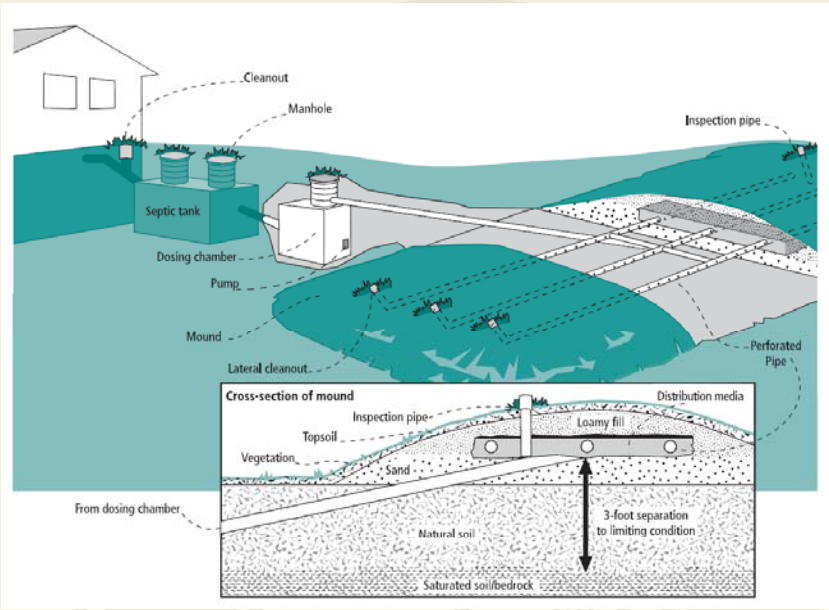
Introduction

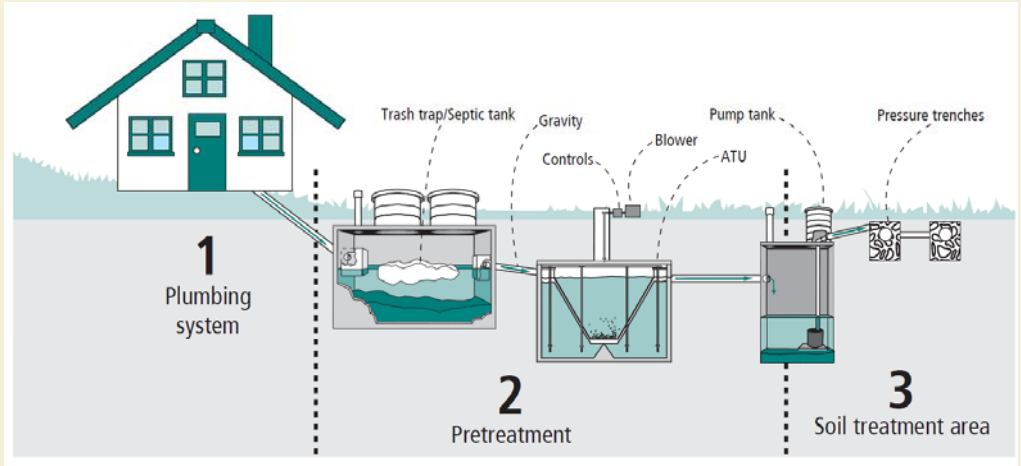
- Objectives
  - Present current MPCA requirements for nitrogen treatment in SSTS (subsurface sewage treatment systems)
  - Describe challenges associated with nitrogen compliance for SSTS
  - Discuss treatment options and technologies
  - Case study – Small Sanitary District

Introduction

- Subsurface Sewage Treatment System (SSTS)







Figures from University of Minnesota OSTP Manual

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Introduction

- SSTS Permitting
  - <10,000 gpd – Permitted by County, Regulated under MPCA Rules, Ch. 7080-7083
    - 0-5,000 gpd – ISTS (Individual Subsurface Sewage Treatment System)
    - 5,000 – 10,000 gpd – MSTS (Midsized Subsurface Sewage Treatment System)
    - Licensed MPCA Designer/Advanced Designer Required (Licensed P.E. not required)
  - >10,000 gpd – Permitted by MPCA (SDS Permit)
    - LSTS (Large Subsurface Sewage Treatment System)
    - Licensed P.E. required

Introduction

- Nitrogen is an issue
  - Drinking water standard for nitrate is 10 mg/l

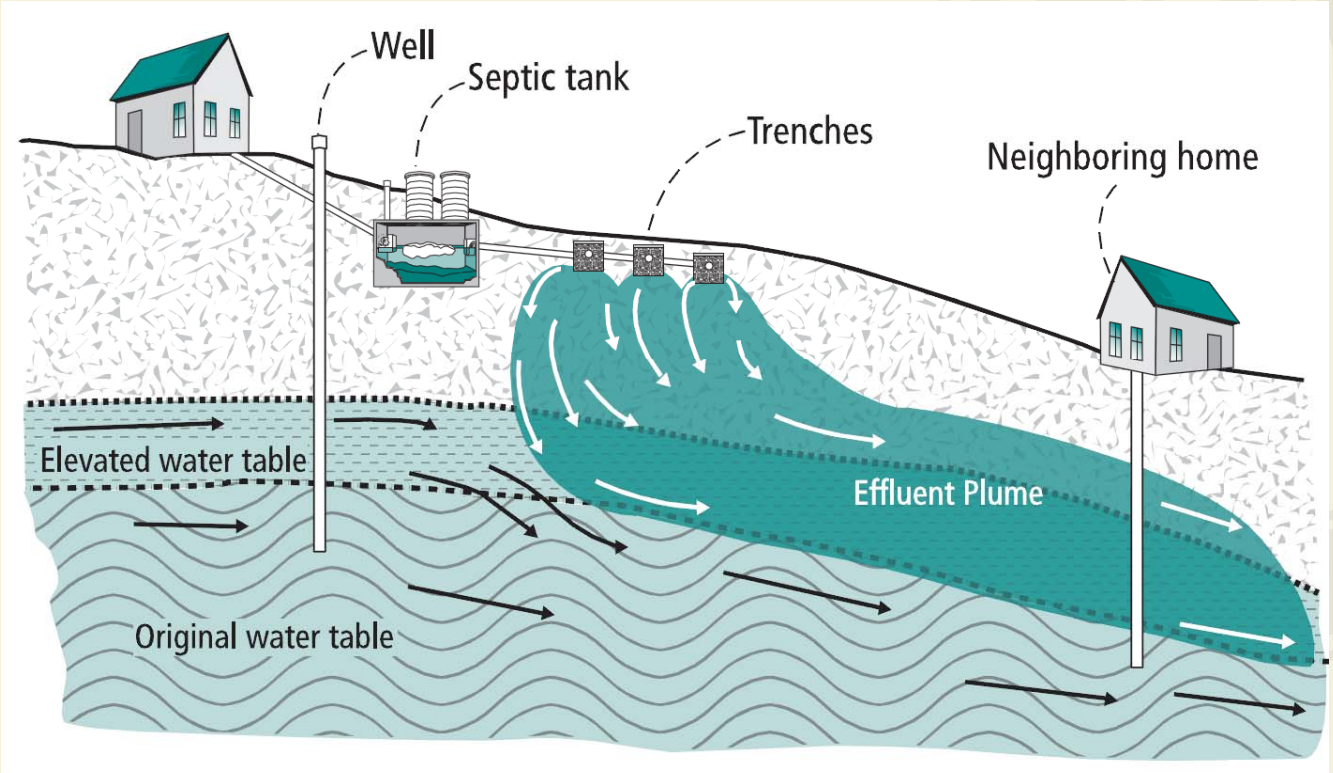


Figure from University of Minnesota OSTP Manual

Introduction

- Typical Nitrogen Concentrations in SSTS

TABLE 5.7 Unsaturated Flow During Soil Treatment of Septic Tank Effluent

parameter	raw waste	septic tank effluent	one foot below trench bottom	three feet below trench bottom
Nitrogen (mg/L)				
total	100-150	50-60	—	—
NH_4^+	60-120	30-60	*B-60	*B
NO_3^-	<1	<1	*B-40	*B-40

* B = background
Magdorf et al., 1974 and Metcalf and Eddy, 1991

Table from University of Minnesota OSTP Manual

MPCA SSTS Nitrogen Policy

- ISTS with flow 2,501 – 5,000 gpd
  - Must do aquifer assessment
  - If aquifer is adversely impacted, must implement nitrogen BMP

MPCA SSTS Nitrogen Policy

- ISTS with flow 2,501 – 5,000 gpd
  - Assessment
    - Site not suitable if within 200-ft of public water supply well
    - Aquifer is considered adversely impacted if:
      - Private water supply well within 200-ft
      - Potential for future private water supply well within 200-ft
      - System within a drinking water supply management area with high sensitivity rating
      - Web Soil Survey "Aquifer Assessment" rating is sensitive for majority of land area within ¼ mile of system
      - Sensitivity rating for any published aquifer sensitivity rating is "sensitive" for majority of land area within ¼ mile of system
      - Soil texture 6-ft below bottom of system is sand

MPCA SSTS Nitrogen Policy

- ISTS with flow 2,501 – 5,000 gpd
  - BMP's
    - Black water separation with only grey water discharging to system
    - Recirculating media filter
    - Mound system on loamy or finer textured topsoil with medium or high organic content
    - Registered treatment product, reduce TN to 20 mg/l end of pipe
    - Known natural nitrogen reduction in soil or groundwater, or use dilution
    - Detailed hydrogeologic assessment that shows aquifer impact does not exist (Licensed P.E., P.G.)

MPCA SSTS Nitrogen Policy

- MSTS (5,001 – 10,000 gpd)
  - TN must not exceed 10 mg/l at the property boundary or nearest receptor, whichever is closer
  - Site not suitable if within 200-ft of any drinking water supply well
  - Constraints must exist to prevent future drinking water supply well within 200-ft of site
  - Site must not be within a drinking water supply management area with a high or very high sensitivity rating

MPCA SSTS Nitrogen Policy

- MSTS (5,001 – 10,000 gpd)
  - How to determine TN concentration at property boundary or receptor
    - Conduct detailed hydrogeologic assessment (Licensed P.E., P.G.)
    - Complete MPCA prescriptive methodology

MPCA SSTS Nitrogen Policy

- MSTS (5,001 – 10,000 gpd)
  - MPCA Prescriptive Methodology
    1. Employ MPCA registered nitrogen treatment device
    2. Evaluate TN reduction in soil

Table 1.
System Located South of St. Cloud - Receiving Septic Tank Effluent

	Total N concentration remaining at the depths below the system (in decimal percent)		
	3 feet	4 feet	6 feet
Coarse sand, sand	1.00	1.00	1.00
Fine sands	1.00	1.00	0.98
Loamy sand	1.00	0.90	0.84
Sandy loams	1.00	0.90	0.46
Loam	1.00	0.90	0.46
Silt loam	1.00	0.88	0.40
Clay loams	1.00	0.78	0.00

Table 2.
System Located St. Cloud and North - Receiving Septic Tank Effluent

	Total N concentration remaining at the depths below the system (in decimal percent)		
	3 feet	4 feet	6 feet
Coarse sand, sand	1.00	1.00	1.00
Fine sands	1.00	1.00	1.00
Loamy sand	1.00	1.00	0.94
Sandy loams	1.00	1.00	0.84
Loam	1.00	1.00	0.82
Silt loam	1.00	1.00	0.80
Clay loams	1.00	0.96	0.58

Tables from MPCA SSTS Advanced Design Guidance

MPCA SSTS Nitrogen Policy

- MSTS (5,001 – 10,000 gpd)
  - MPCA Prescriptive Methodology
    3. Evaluate potential for nitrogen reduction through dilution
  - Any combination of 1-3 can be used to show 10 mg/l at boundary

MPCA SSTS Nitrogen Policy

- LSTS (>10,000 gpd)
  - TN must not exceed 10 mg/l at the property boundary or nearest receptor, whichever is closer
  - MPCA State Disposal System (SDS) Permit
  - Two Permitting Options
    1. Treatment system to reduce TN to 10 mg/l end of pipe
    2. Conduct complete hydrogeologic assessment. Base end of pipe limit on study results for nitrogen reduction in soil

MPCA SSTS Nitrogen Policy

- LSTS (>10,000 gpd)
  - New and expanding LSTS are subject to policy
  - Existing LSTS handled on a case-by-case basis based on potential impact to environment or human health

Challenges

- Natural nitrogen reduction through soil or groundwater dilution
  - Sandy soils have minimal capacity for nitrogen removal
  - Small sites have limited potential for dilution from precipitation
  - Detailed hydrogeologic assessment can be expensive – do I invest in a study to determine I need to spend money on pre-treatment or do I just spend the money on the pre-treatment up front?

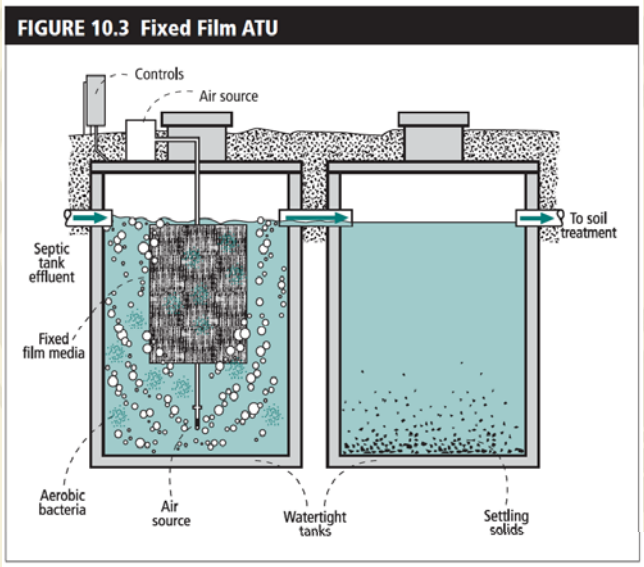
Challenges

- Some sites will dictate the need for treatment devices
- Treatment Devices
  - MPCA has registration process for treatment products
  - For nitrogen removal, products must achieve minimum of 20 mg/l TN end of pipe-must submit 3rd party testing data
  - Currently there are no registered products that meet 10 mg/l end of pipe*

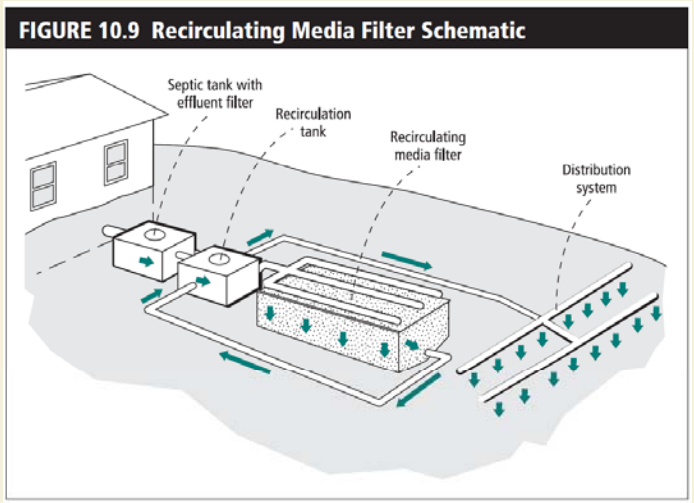
*Update – 1 product is now registered (as of 11/30/11)

Challenges

- Treatment Devices
  - Current registered treatment products for TN include:
    - Aerobic treatment units
    - Textile filters
  - Public Domain Technology
    - Recirculating sand filters



Figures from University of Minnesota OSTP Manual



Challenges

- TN reduction to 20 mg/l at end of pipe is not difficult, under ideal conditions
- Reducing TN to 10 mg/l end of pipe is more difficult, even under ideal conditions
- Ideal conditions are not typical with large SSTS
- Regardless of desired treatment level, system requires careful design and management

Challenges

- Nitrogen Treatment
  - Nitrification
    - Organic Nitrogen→Bacterial Decomposition→Ammonia
    - Ammonia + Oxygen + Nitrifying Bacteria →Nitrite
    - Nitrite + Nitrifying Bacteria → Nitrate
  - Denitrification
    - Nitrate + Carbon Source (anoxic, no oxygen) → Nitrogen Gas
  - Nitrification/Denitrification reaction is very sensitive
    - Flow dependent
    - BOD depended
    - pH dependent
    - Temperature dependent
    - Alkalinity dependent
    - May need added carbon source to achieve denitrification, either recirculated WW or often added source (methanol, Micro-C)

Challenges

- Flows to SSTS are often highly variable
  - Inflow and infiltration
  - Seasonal/weekend residences
- WW temperature is often highly variable
  - Flow variations, systems sized for peak flow in summer or future growth
  - Shallow depth systems, low flow, freezing is an issue
- WW strength is often variable
  - Inflow and infiltration
  - Seasonal usage

Challenges

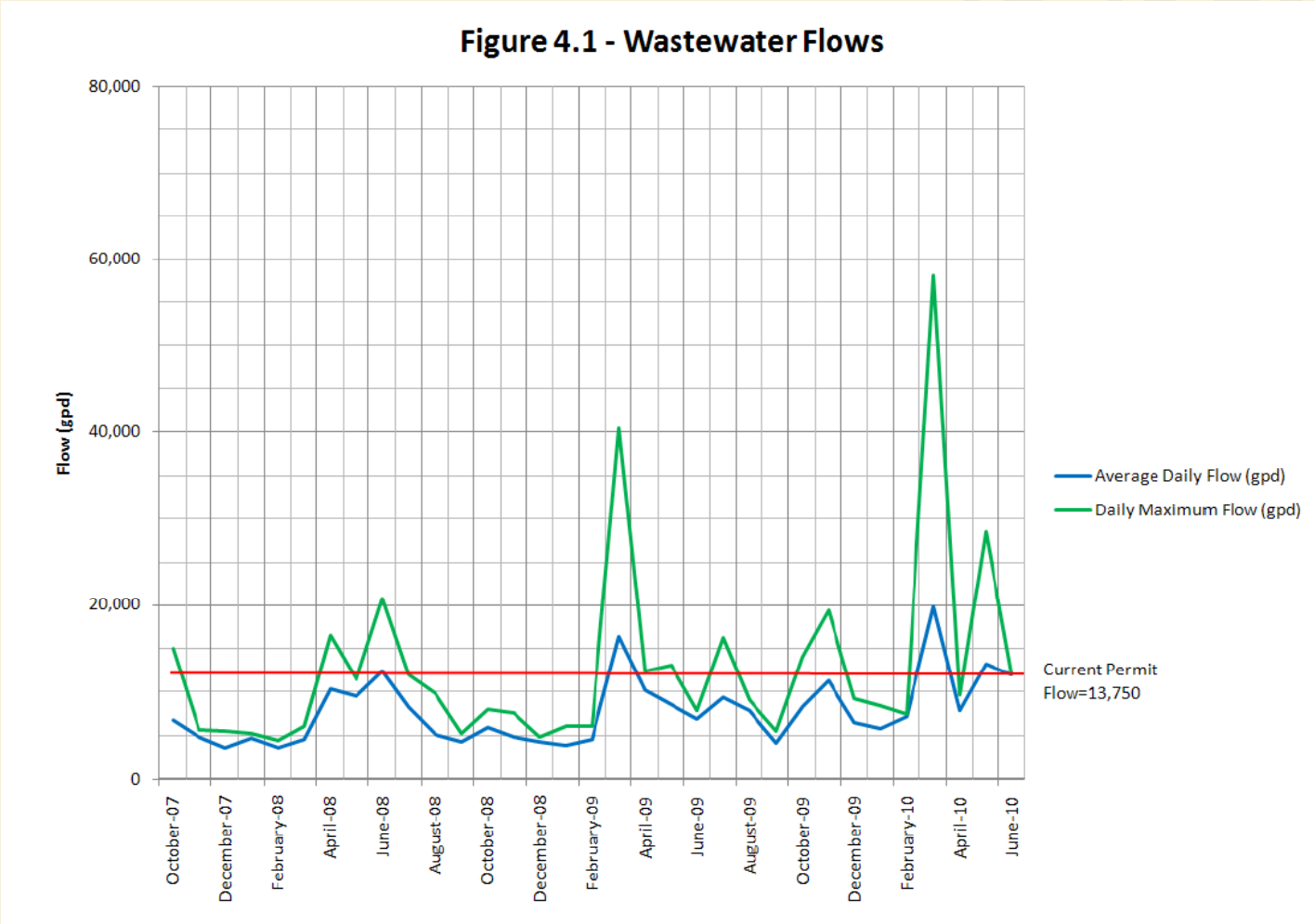
- Systems can be designed to overcome these issues, but are expensive
- Operation and maintenance, monitoring, management is critical for the system to operate properly
- SSTS owners usually not equipped to properly operate and manage such systems
- Professional O&M is a solution and in many cases required by permit
  - Requires O&M budget and supporting utility rate structure

Case Study

- Small Sanitary Sewer District
  - 75 homes on a lake, northern MN
  - Some seasonal, some permanent
  - Originally constructed in 1976, upgraded in 1980
  - MPCA SDS Permit
  - Simple gravity collection, septic tank, gravity fed drainfield trenches – no pre-treatment
  - Sandy soils
  - Permit flow – 13,750 gpd
  - GW monitoring wells, nitrogen limit of 10 mg/l

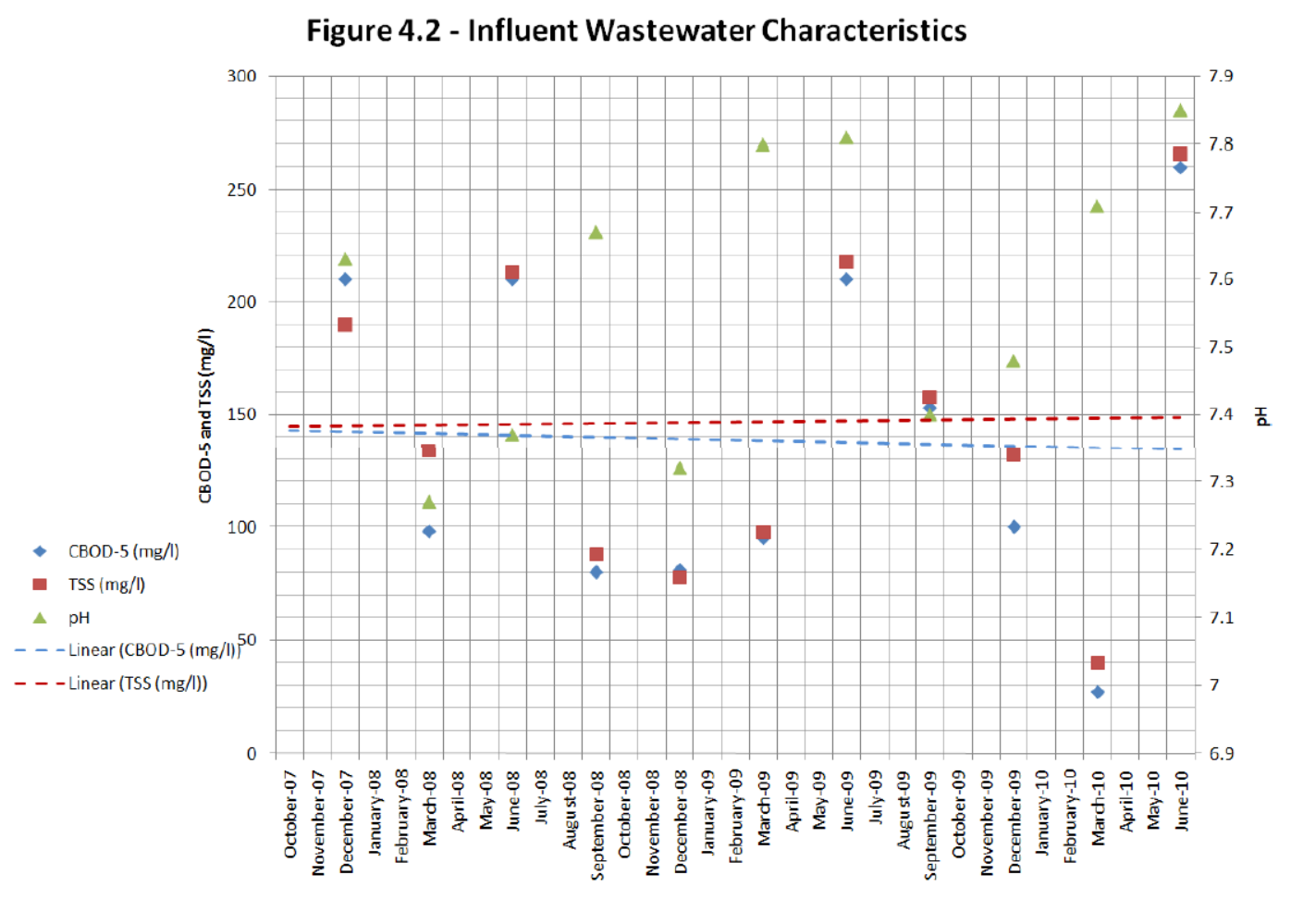
Case Study

- Issues
  - Highly variable flows (I&I and seasonal use)



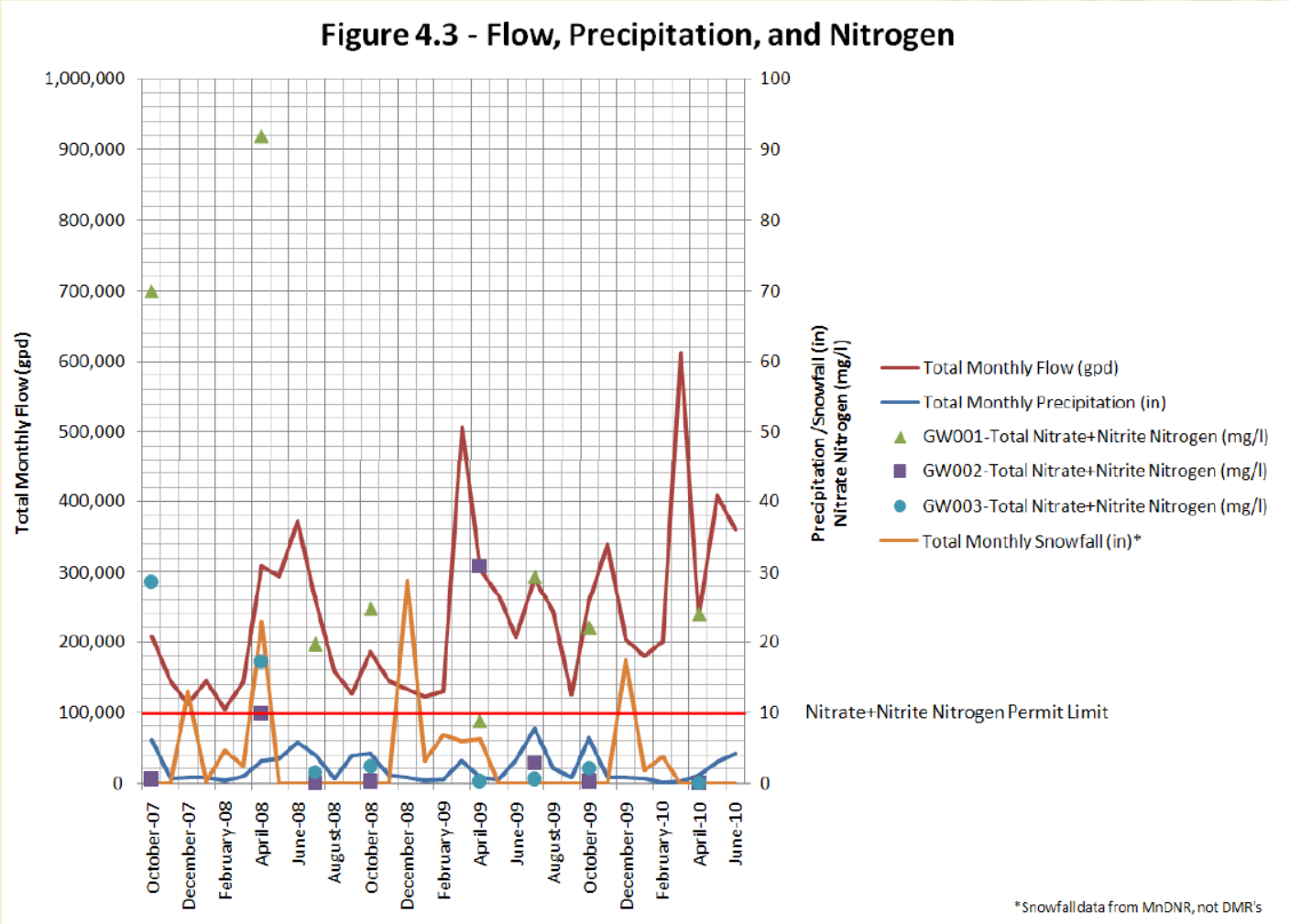
Case Study

- Issues
  - Variable wastewater strength



Case Study

- Issues
  - High nitrogen down gradient (GW001)



Case Study

- Issues
  - Typical Septic Tank effluent TN is 50-60 mg/l
  - Dilution due to I&I, sandy soils
  - TN reduction shown is not likely due to natural soil denitrification

Table 5.1 – Monitoring Well Nitrogen Data[3]

	GW001-Downstream Well				GW003-Upstream Well				Assumed) SSTS Influence			
Month	Ammonia Nitrogen (as N) (mg/l)	Total Kjeldahl Nitrogen (mg/l)	Nitrate+ Nitrite Nitrogen (mg/l)	Total Nitrogen (mg/l)	Ammonia Nitrogen (as N) (mg/l)	Total Kjeldahl Nitrogen (mg/l)	Nitrate+ Nitrite Nitrogen (mg/l)	Total Nitrogen (mg/l)	Ammonia Nitrogen (as N) (mg/l)	Total Kjeldahl Nitrogen (mg/l)	Nitrate+ Nitrite Nitrogen (mg/l)	Total Nitrogen (mg/l)
July-08	0.1	1.4	19.6	21.1	0.1	1.0	1.5	2.6	0.0	0.4	18.1	18.5
October-08	0.2	1.4	24.6	26.2	0.2	1.1	2.4	3.7	0.0	0.3	22.3	22.6
April-09	0.2	1.9	8.8	10.9	0.1	1.1	0.4	1.6	0.1	0.8	8.4	9.3
July-09	0.1	2.5	29.3	31.9	0.1	0.7	0.6	1.4	0.0	1.8	28.7	30.5
October-09	0.1	1.3	22.0	23.4	0.1	0.9	2.1	3.1	0.0	0.4	19.9	20.3
April-10	0.1	1.1	23.9	25.1	0.1	0.4	0.1	0.6	0.0	0.7	23.9	24.6

Case Study

- Issues
  - District mindset
    - Current O&M is virtually non-existent
    - Current fee structure is minimal
    - Flush it and forget it, water goes away, what's the problem?
    - Let's just put in a new drainfield, that will fix it, right?
    - Permanent residents, active and involved, fixed incomes
    - Seasonal residents, not involved, could afford more?

Case Study

- Solutions
  - Upgrade SSTS
    - MPCA Permitting Options
      1. Conduct hydrogeologic study
         - » Data indicates minimal natural soil denitrification or downgradient dilution
         - » Fix I&I, discharge TN concentration would increase
         - » Study would tell us what we already know?
      2. Treat TN to 10 mg/l end of pipe
         - » Expensive, capital costs and O&M
         - » Operational issues, variable flows, variable temperatures, variable WW strength

Case Study

- Solutions
  - Regionalize with nearby community, 2.8 miles away
    - Fix I&I in collection system, install lift station & forcemain
    - Lower capital cost, lower O&M, eliminates operational issues with TN removal
    - District loses independence

Case Study

- Estimated Costs

Table 6.3
Additional O & M Costs

Item	SSTS Upgrade	Regionalization (1)
Utilities	$3,400	$1,000
Chemicals	$3,700	$0
Salaries and Benefits	$33,000	$11,000
Testing, Equipment Replacement, etc.	$1,600	$4,000
Drainfield Replacement Fund(2)	$3,100	$0
User Cost	---	$10,500
TOTAL	**$44,800**	**$26,500**

(1) Rate based on assumed [illegible] residential charge of $3.64/1,000 gal, 75 hookups, 3,200 gal/month per hookup.
(2) Assumes 20-yr drainfield life, $62,000 replacement cost

Case Study

- Estimated Costs

Table 6.4
Estimated Cost Effective Summary for Alternatives

Item	SSTS Upgrade[1]	Regionalization[1]
Capital Costs	$ 828,000	$ 655,000[3]
Annual Equivalent Costs	$56,000	$44,000
Additional O&M Costs	$44,800	$26,500
TOTAL ANNUAL COSTS	**$100,800**	**$70,500**

[1] Assume 3.0%, 20-year financing of capital costs.

[2] Does not include user charges of regional facility.

[3] Assumes Route and no alternate items.

Case Study

- Conclusion
  - Regionalization option has lower annualized costs
  - Also has potential for cost sharing if additional users can be added to system along the way
  - District was shocked by cost associated with compliance with MPCA nitrogen policy
  - Currently evaluating options

Questions?

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