Case Study – A Permeable Reactive Barrier for Denitrification
Overview

• Site Background
• Theory
• Permeable Reactive Barrier Design
• Photos
• Data
• Conclusions
Site Background

- Northern Alberta Site – Active Fertilizer distribution facility
- Nitrate plume traveling south, shallow groundwater velocity approximately 1.5 metres per year
- Nitrate concentrations up to 1,400 mg/L in shallow groundwater traveling offsite
Site Background

- Approximately 120 m south to nearest potable well from leading edge of plume
- Domestic Use Aquifer pathway eliminated
- Viterra wished to proactively address potential offsite liabilities
- Permeable Reactive Barrier (PRB) selected as a cost effective way to limit the nitrate flux traveling off-Site
Site Background
Nitrification Theory

- Requires Oxygen as electron acceptor
- Autotrophic, inorganic carbon (CO$_2$ and HCO$_3^-$) for growth
- Reduces alkalinity
**Denitrification Theory**

- Requires organic carbon
- Only occurs under anaerobic conditions
- Produces alkalinity

Nitrate $\text{NO}_3^-$ $\rightarrow$ Nitrite $\text{NO}_2^-$ $\rightarrow$ Nitric Oxide $\text{NO}$ $\rightarrow$ Nitrous Oxide $\text{N}_2\text{O}$ $\rightarrow$ Nitrogen $\text{N}_2$
Literature review

• Wood chips effective for long term denitrification – more than 25 years
• Largest volume for a PRB
• Highest influent nitrate levels of 100 mg/L
• Efficiencies between 50 and 80 %
• Initial spike in downstream levels
• Downstream reductions – double retention time
Design Considerations

Capped with 0.3 m clean clay

Influent nitrate concentrations
- Up to 1,200 mg/L
- Average ammonia influent concentrations 200 mg/L

Available Organic Carbon
- Retention Time = 1.3 years
- Volume = 960 m³

Midstream Concentrations
- Treatment Efficiency – 80%

Depth – 4 m
Width – 2 m
Length – 120 m

Placed under existing drainage ditch to ensure saturation

Carbon Source
- Pine wood chips
PRB Design

- Design life in excess of 20 years
- Hydraulic Conductivity of PRB was higher than surrounding soils based on slug tests
- Groundwater level an average of 0.8 metres below ground surface
PRB Design

• Reasons to go offsite to the south:
  - No disruptions to operations
  - Further nitrification of ammonia from 500 to 200 mg/L
  - Presence of drainage ditch would ensure PRB remained saturated
  - Land was unproductive due to drainage issues
PRB Preconstruction July 2011
PRB Design

• Benefits to adjacent landowner
  - Recycled metal, hauled debris away
  - Improved the drainage, landscaping of the area
  - “Reclaimed” about one acre of land, baled for the first time in summer 2013
PRB Construction June 2012
PRB Post Construction May 2013
Results
Results - Dissolved Organic Carbon

DOC, East Transect

Days Since Construction

DOC, mg/L

D1
D2
D3
Results – Alkalinity

Alkalinity, East Transect

Alkalinity, mg/L

Days Since Construction

D1
D2
D3
Results – Nitrate

Nitrate, East Transect

Days Since Construction

Nitrate, mg/L

D1
D2
D3
Results – Sulphate

Sulphate, East Transect

Sulphate, mg/L

Days Since Construction

D1
D2
D3
Nitrate - Center

Nitrate, Center Transect

Days Since Construction

Nitrate, mg/L

D4
D5
D6
Nitrate – West Transect

Nitrate, West Transect

Days Since Construction

Nitrate, mg/L

D7Up
D7
PMW6
Results

• PRB performing well
• Average Nitrate reduction of 95%
• Downstream nitrate concentrations have not yet shown a reduction – anticipated during 2014
• Sulphate reduction of 85% in east transect
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THANK YOU

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