Denitrifying Bioreactor Design

Biological Systems Engineering

Virginia Tech *Invent the Future*

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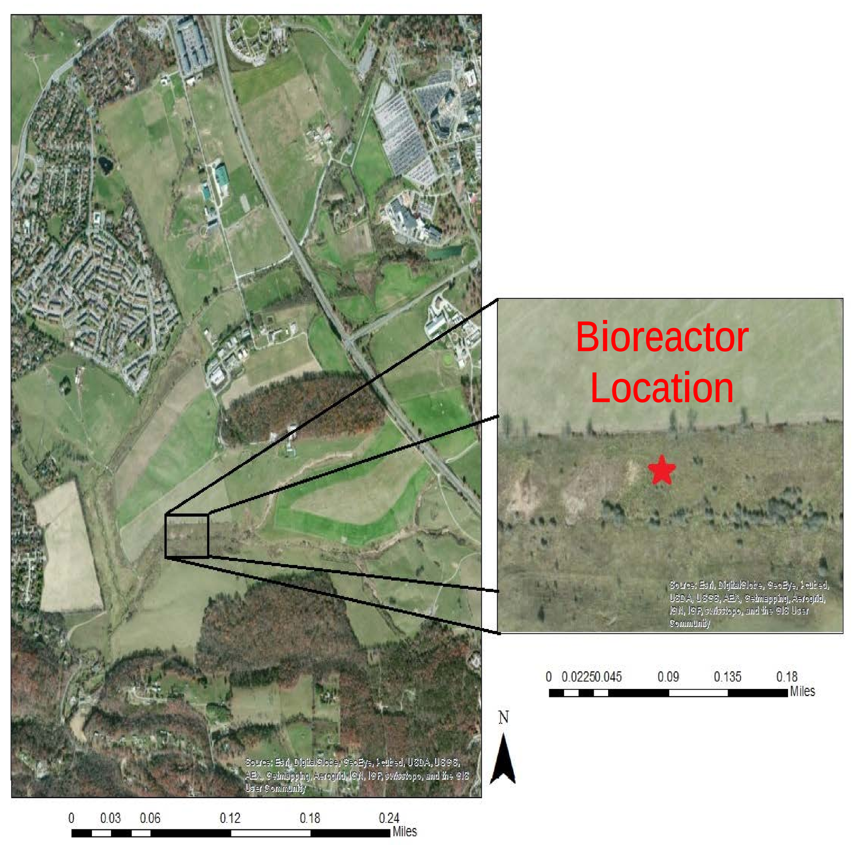
PROBLEM STATEMENT

Nitrogen (N), nitrate (NO_3^-) and phosphate (PO_4^{3-}) are critical water pollutants capable of causing eutrophication in receiving waters. In many regions agriculture can be an source of both N and P. Denitrifying bioreactors (DNBRs) are an emerging practice, which utilize a carbon substrate to support denitrifying microbes to remediate N and can be engineered to removed P in surface and groundwater.

OBJECTIVE

This project aims to design a denitrifying bioreactor (DNBR) for the Virginia Tech Stream Research, Education, and Management (VT StREAM) lab at the College of Agriculture and Life Sciences (CALS) farm. The bioreactor is being designed for a spring to treat groundwater with high nutrient levels, specifically nitrogen (N) and phosphorous (P). The criteria nutrient reductions for this design are 50% for N and 35% for P.



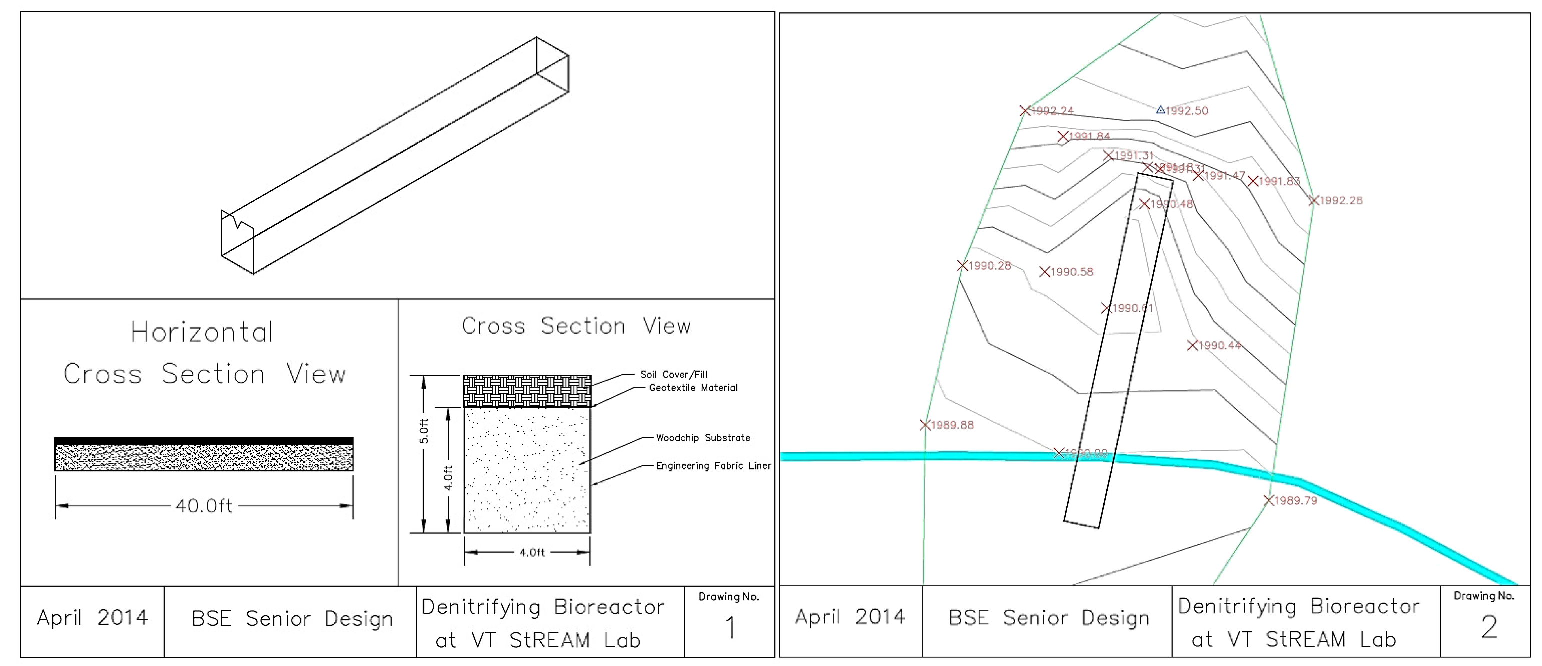
DESIGN CRITERIA & CONSTRAINTS

- Compliance with local, state and federal regulatory requirements
- Compliance with all Standards
- Nutrient reduction of N by 50% and P by 35% on average.
- Total design cost of no more than $5,000
- Annual future Operation and Maintenance costs of no more than $100.
- Minimal impact on surrounding lands and ecosystems.

STANDARDS

- NRCS (interim) Conservation Practice Standard Code 747: DNBR
- ASCE Comprehensive Transboundary Water Quality Management Agreement (33-09)
- NRCS Conservation Practice Standard Code 554: Drainage Water Management
- Dept. of Conservation and Recreation and Division of Soil and Water Conservation: Virginia Nutrient Management Standards and Criteria
- ASTM F449-02: Standard Practice for Subsurface Installation of Corrugated Polyethylene Pipe for Agricultural Drainage or Water Table Control

FINAL DESIGN



- Bioreactor size: 40 ft long, 4 ft wide and 4 ft deep.
- Only 80% of average flow (2574 CFD) is treated.
- With a land slope of 4%, an N removal rate of 50% and a P removal rate of 35%, a retention time of 4.2 hours was determined.
- The carbon substrate to be placed in the bioreactor is 90% woodchips and 10% biochar.
- An engineering fabric will be used to line the sides and bottom of the bioreactor, with a geotextile placed on top of the carbon substrate.
- Installation of emissions and water quality monitoring equipment is recommended to adjust DNBR performance after installation

MATERIALS LIST & COST ANALYSIS

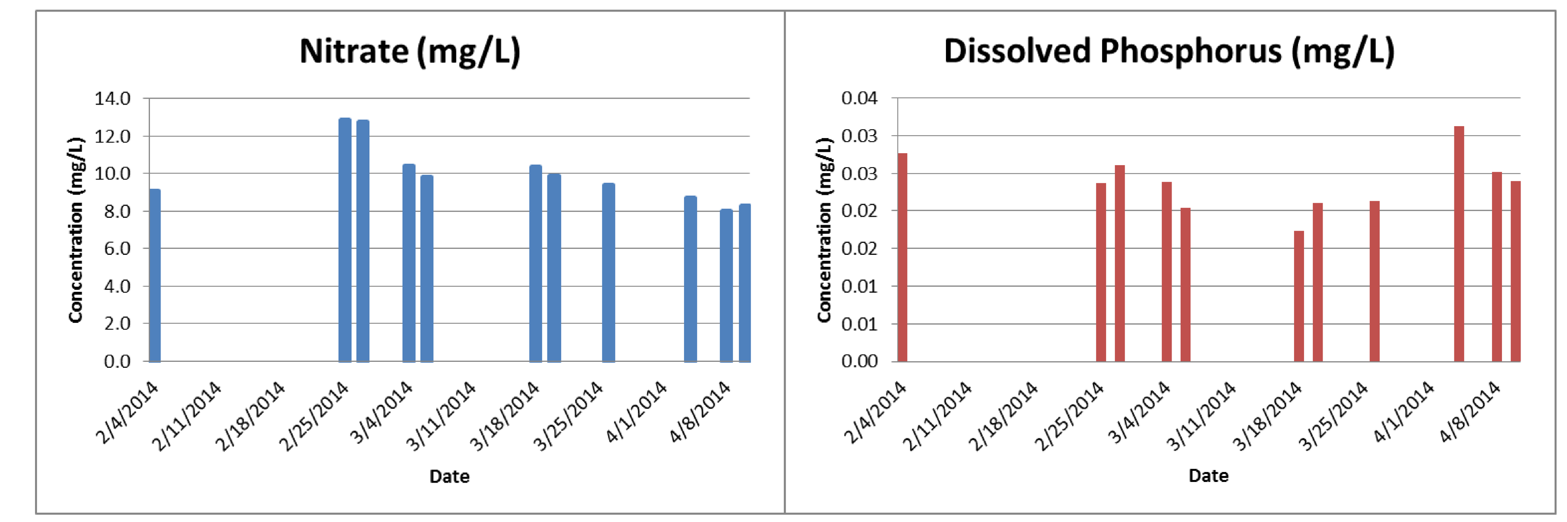
Component	Cost
Wood Chips	426.60
Total woodchips volume: 23.7 yd^3	
Engineering Fabric liner	85.50
Total Surface Area: 512 ft^2 = 57 yd^2	
Cost : $1.50 per yd^2	
Geotextile cover	30.32
Total surface area: 160 ft^2	
Cost: $15.16 per 150 ft^2	
Water table control structure	1600.00
Lab work	107.77
Trenching and installation	1,500.00
Additional expenses	549.81
Total	$ 4,300.00

NEXT STEPS

Bioreactor construction and implementation is slated to begin in Summer 2014. Yearlong monitoring of weather conditions, temperature, discharge volume, and bioreactor efficiency is recommended to adjust and optimize bioreactor design.

METHODS AND SAMPLING RESULTS

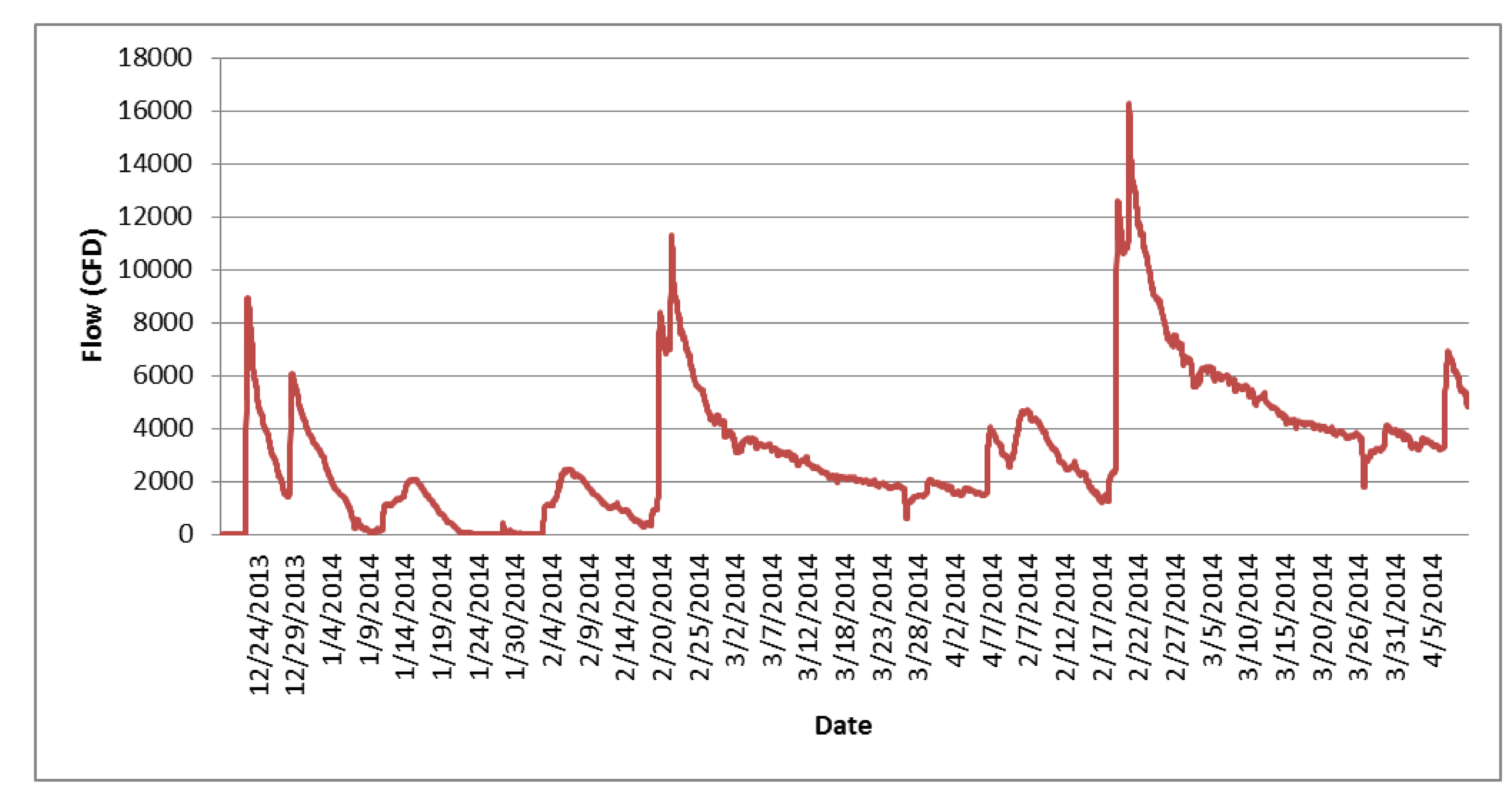
- 0.5 ft H-flume was installed at spring to measure flow and calculate stage
- Samples were collected to find average nitrate and phosphate levels for goal reduction calculation



Average nitrate concentration = 9.8 mg/L
Goal nitrate concentration = 4.90 mg/L

Average phosphate concentration = 0.02 mg/L
Goal phosphate concentration = 0.01 mg/L

FLOW ANALYSIS



Min = 5.30 CFD   Max = 16268.71 CFD   Avg = 3217.77 CFD

ACKNOWLEDGEMENTS

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