Removing nitrate and phosphate from agricultural runoff or drainage

Collaboration:

- Richard Smith and Mike Cahn
- Tom Bottoms
- Cooperating growers

Funding:

- Leafy Greens Research Board
- CDFA - FREP

Surface water monitoring shows high NO_3-N is common…

= Good = Slightly Impacted = Impacted = Very Impacted = Severely Impacted

Irrigation and fertilization practices can be improved …


In-season soil NO_3-N testing


Upgrade irrigation efficiency


Grow winter cover *where practical*

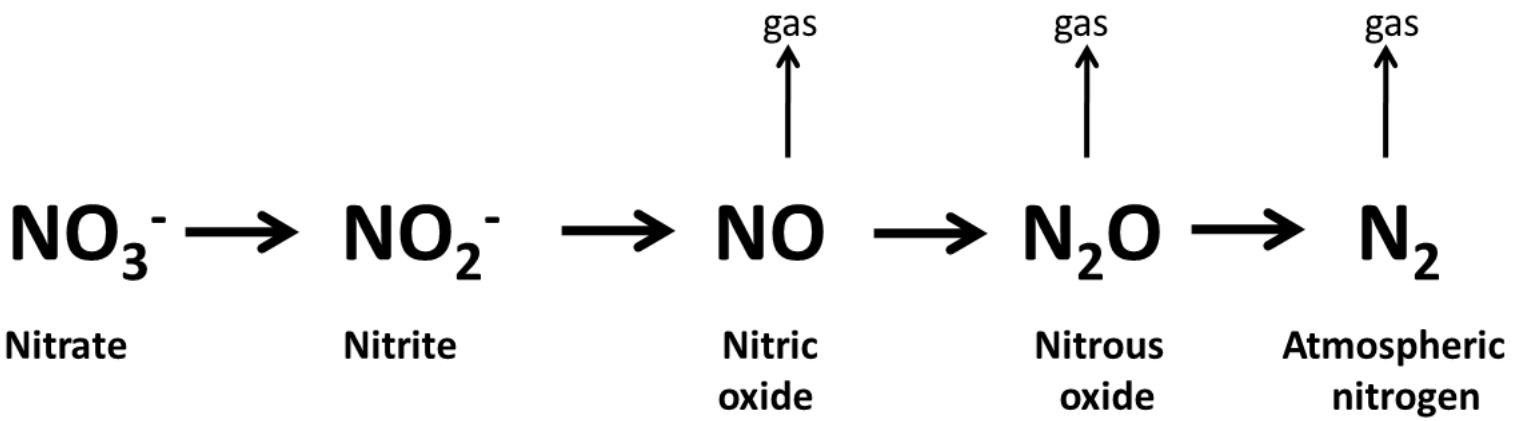
… but some wastewater remediation will likely be needed to consistently meet environmental targets

What remediation practices can remove soluble nutrients ?

- **Conservation practices that remove sediment are generally ineffective in removing *soluble* nutrients**

- **Biological denitrification has potential**

Biological denitrification :



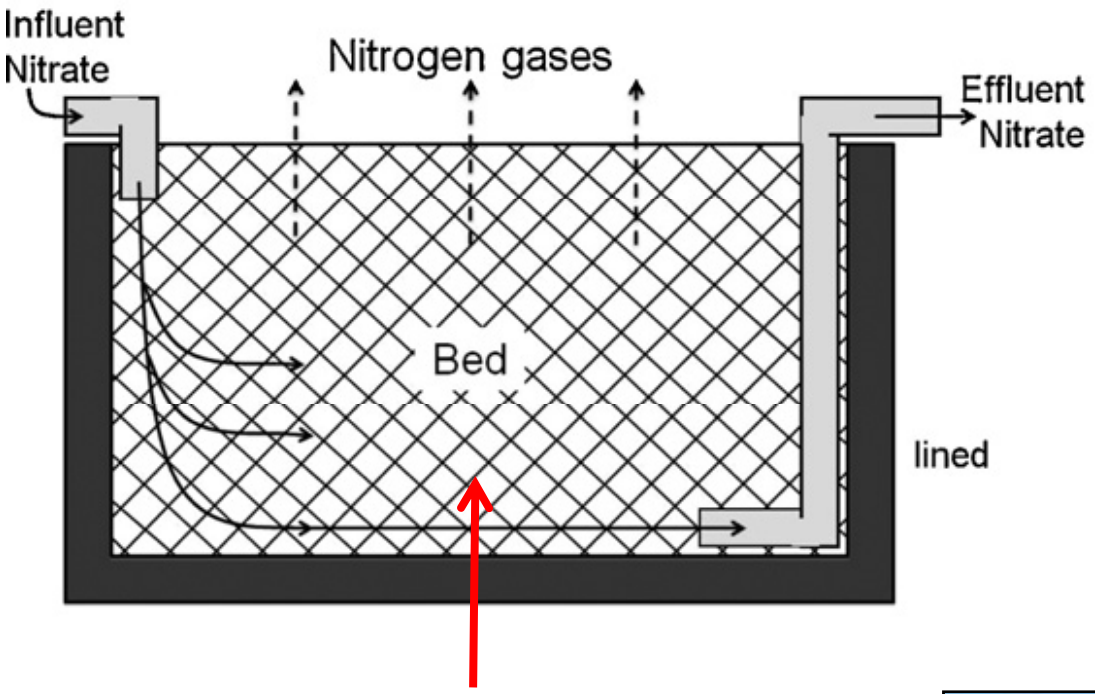
Requirements for denitrification:

- Anaerobic conditions
- Bacteria capable of reducing NO_3-N
- Labile (microbially-available) carbon to support the reaction

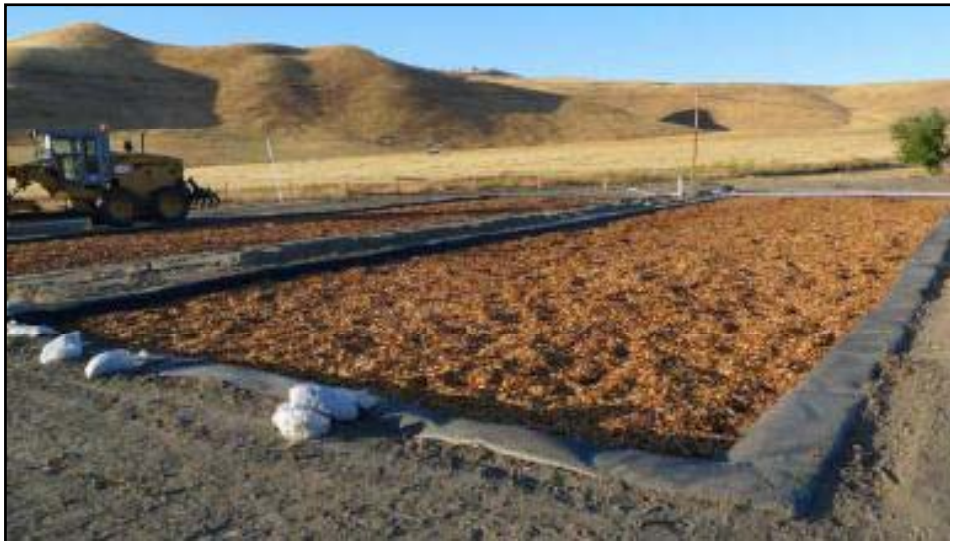
Denitrification occurs in wetlands, but …

- denitrification rate is usually limited by carbon availability, meaning that nitrate removal per unit land area is low
- wildlife attraction can raise microbial food safety concerns

Denitrification bioreactors (DBR) :



Organic waste material to provide labile carbon

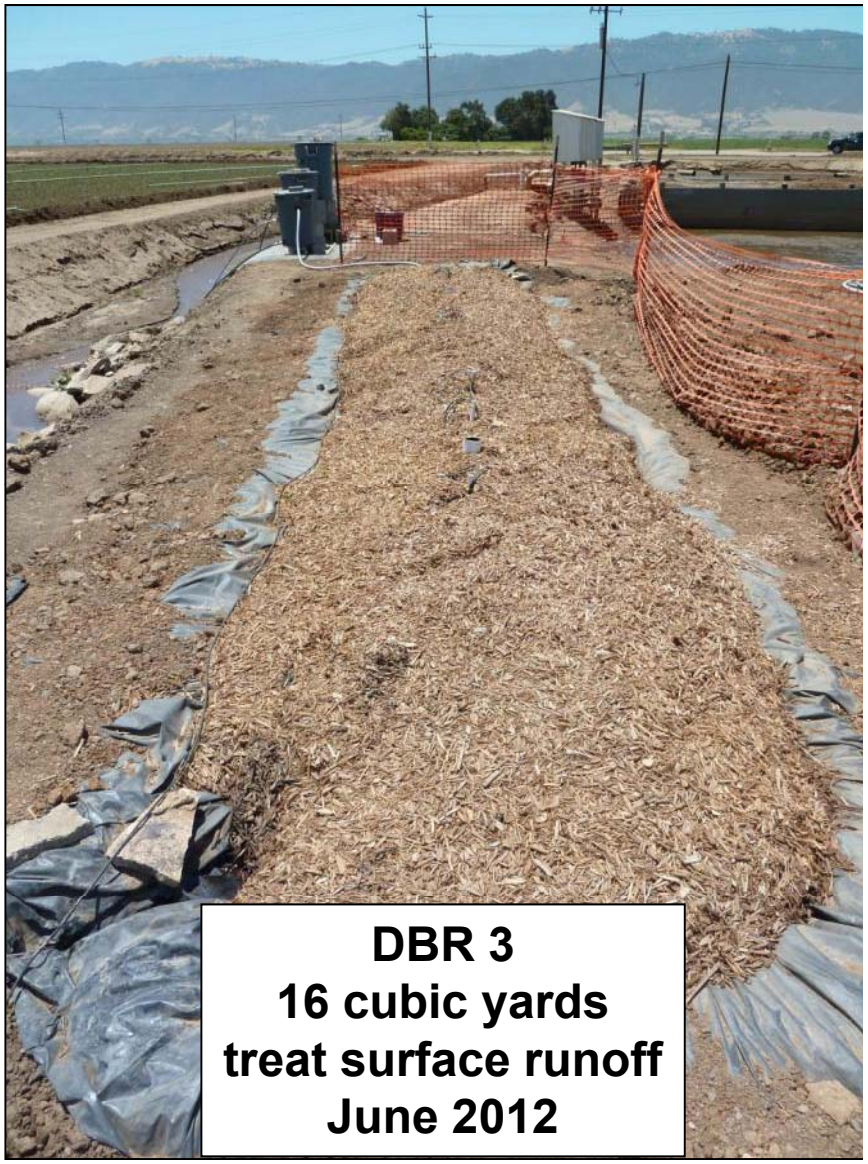


Building a DBR
Salinas Valley, 2011 :

chipped construction wood from Monterey Regional Waste Management District

DBR 1
34 cubic yards
treat tile drain water
May 2011

DBR 2
17 cubic yards
treat tile drain water
June 2011



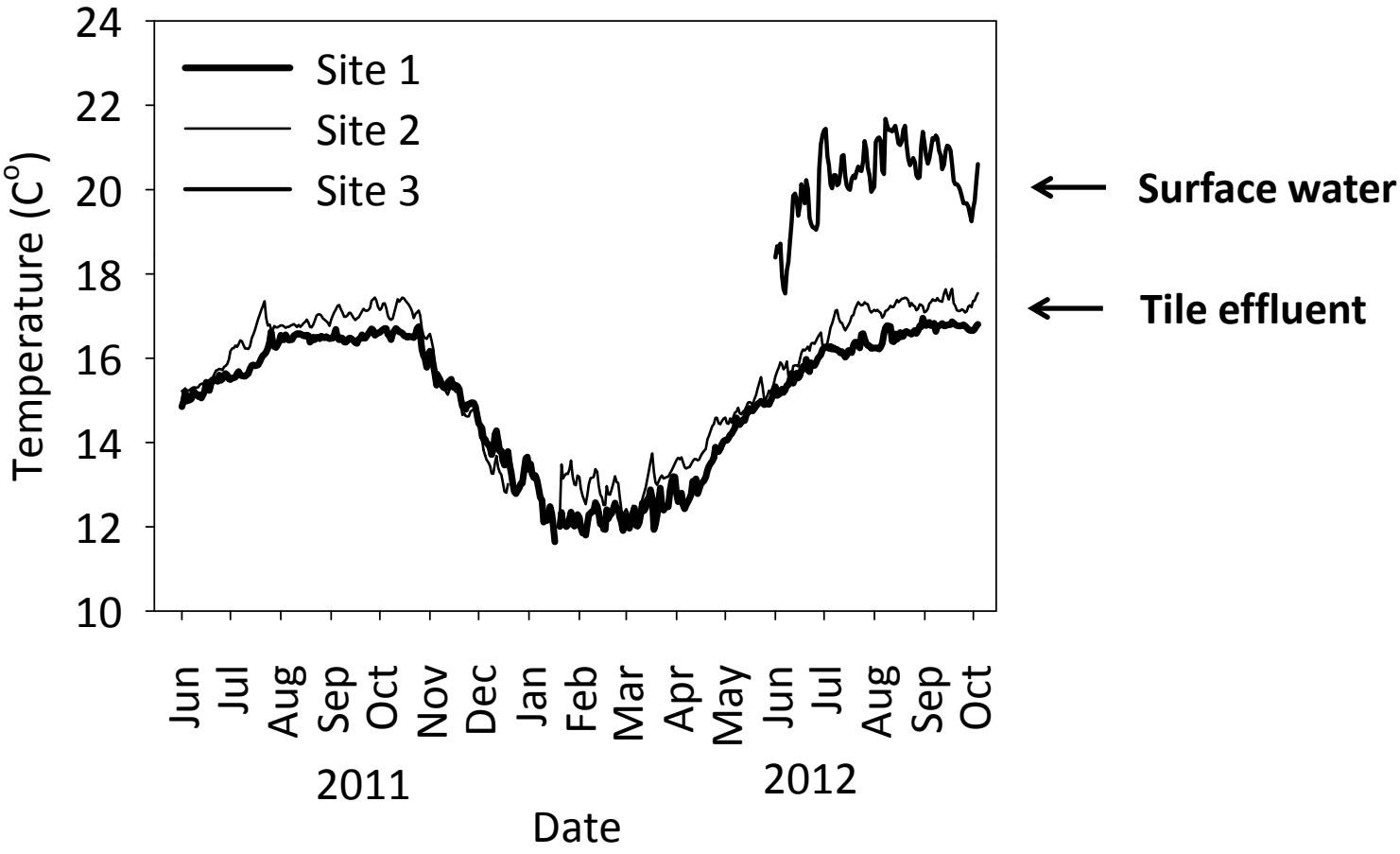
DBR 3
16 cubic yards
treat surface runoff
June 2012

Continuous pumping into DBRs from tile drain sump or tailwater pond

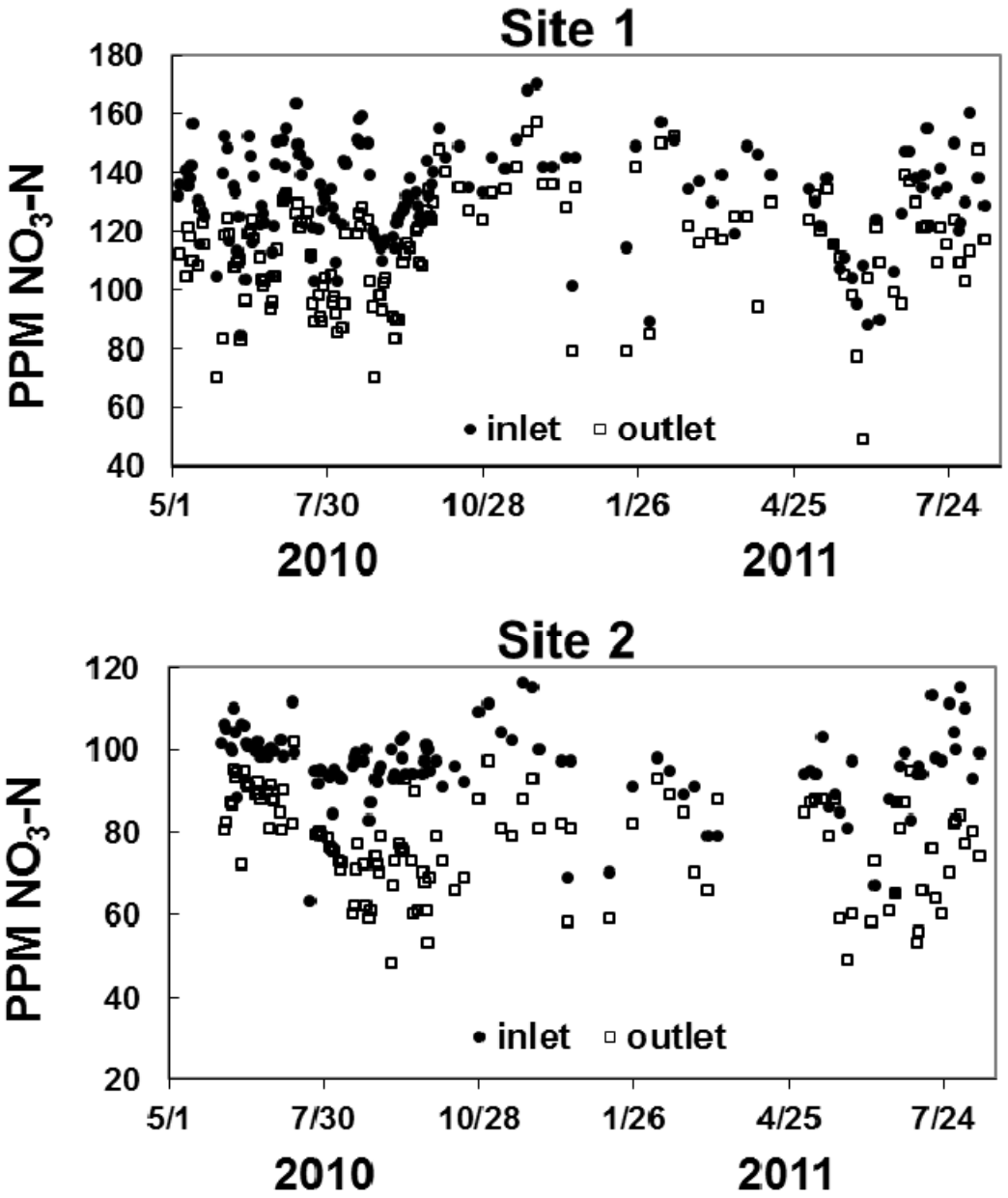
DBR outlet drains into surface ditch
after approximately 2 days of residence time

- **Surface water pretreated with polyacrylamide (PAM) to keep sediment out of the bioreactor**

Moderate temperature allows denitrification all year :



DBR performance on tile drain effluent :

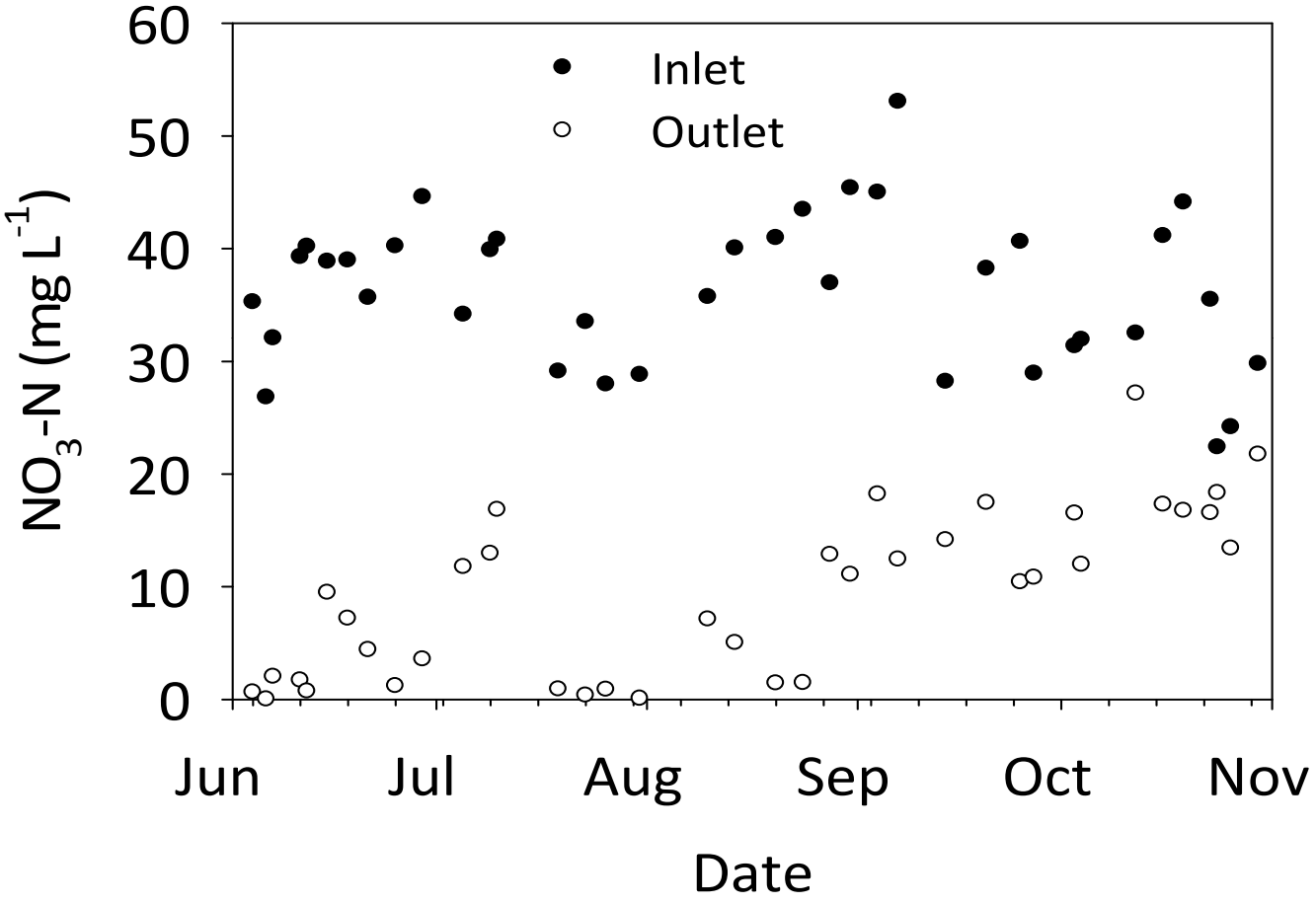


Denitrification rates achieved

Summer average:
≈ 8 PPM NO_3-N / day

Winter average:
≈ 5 PPM NO_3-N / day

DBR performance on surface runoff :

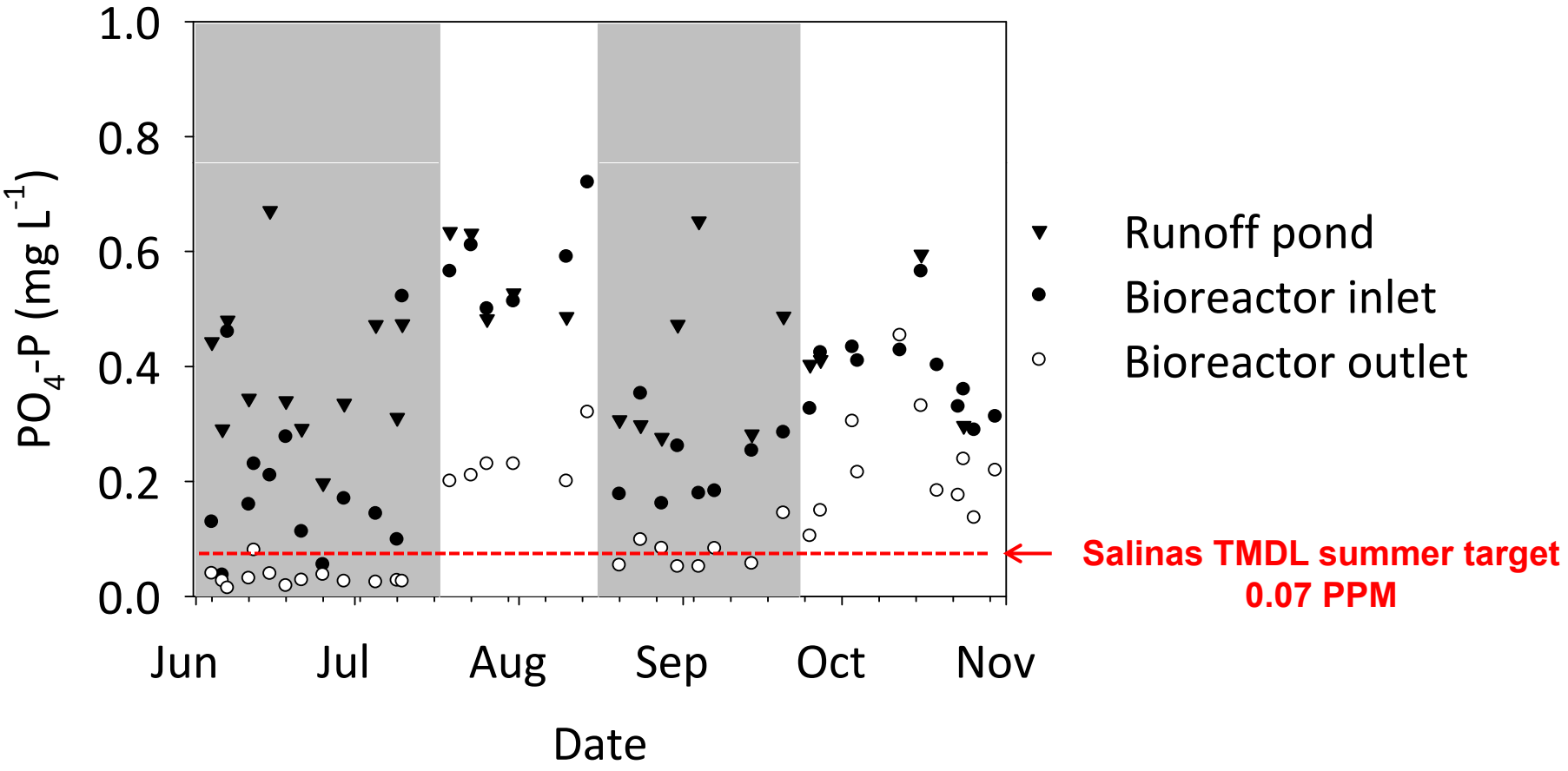


Irrigation season average:
≈ 11-13 PPM NO_3-N / day

DBR performance on surface runoff :

What about PO_4-P ?

- **Aluminum sulfate (alum) was injected during portions of 2012 (shaded area)**



- **Both alum and bioreactor treatment appear to remove PO_4-P**

Are there environmental issues with DBRs ?

- nitrous oxide (N_2O) release
  - high per unit land area, small as a % of N denitrified
- dissolved organic carbon (DOC) and tannins in DBR effluent
  - effluent may need to be recycled on-farm in the initial weeks of operation

Are there microbial food safety implications?

- **No exposed water = no wildlife attraction**

Is a commercial scale DBR feasible ?

Based on a year-around operation:

- **at an average of 6 PPM NO_3-N removal per day of residence time, a DBR has the *theoretical* capacity to remove about 3 lb N / yd^3 of volume annually; *operational* capacity probably less**
- **under commercial conditions, a DBR 50 x 100 x 5 ft could probably remove at least 2,000 lb N annually**
- **costs are probably between $1 - 4 per lb of NO_3-N denitrified**
- **management practice changes would still be needed to come close to meeting environmental goals, particularly with tile drain effluent**