High Rate Irrigation of Poplar Trees as a Nutrient Reduction System – The Oregon Garden Site

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'Putting Plants to Work'

for environmental sustainability and economic development

Mission:

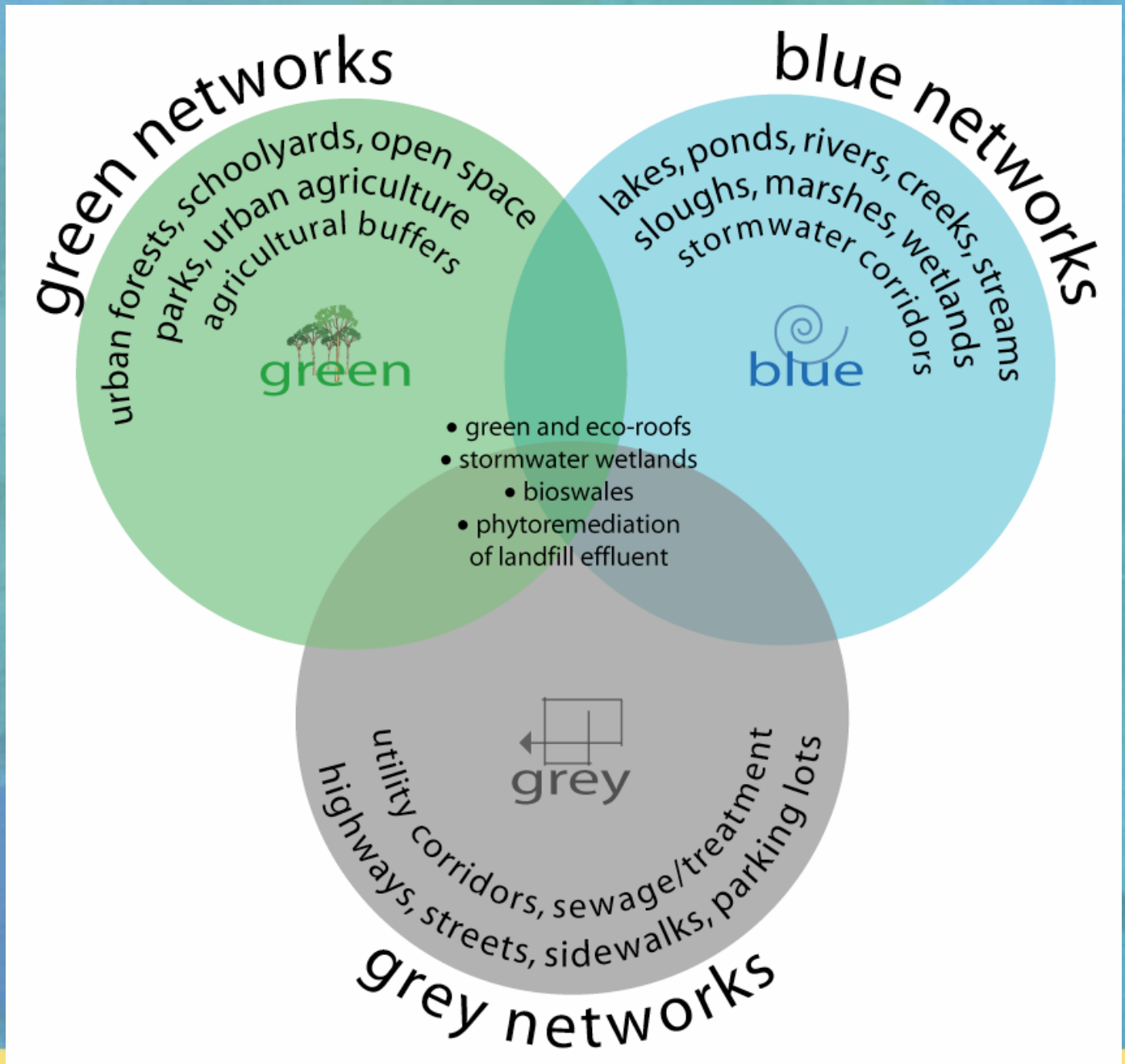
- To develop and promote the strategic use of plants (phytotechnology)
- To provide ecosystem services and solve environmental challenges in managed landscapes
- To serve as Oregon's phytotechnology resource center

SPROut integrates resource networks

Diagram by

Rene Kane

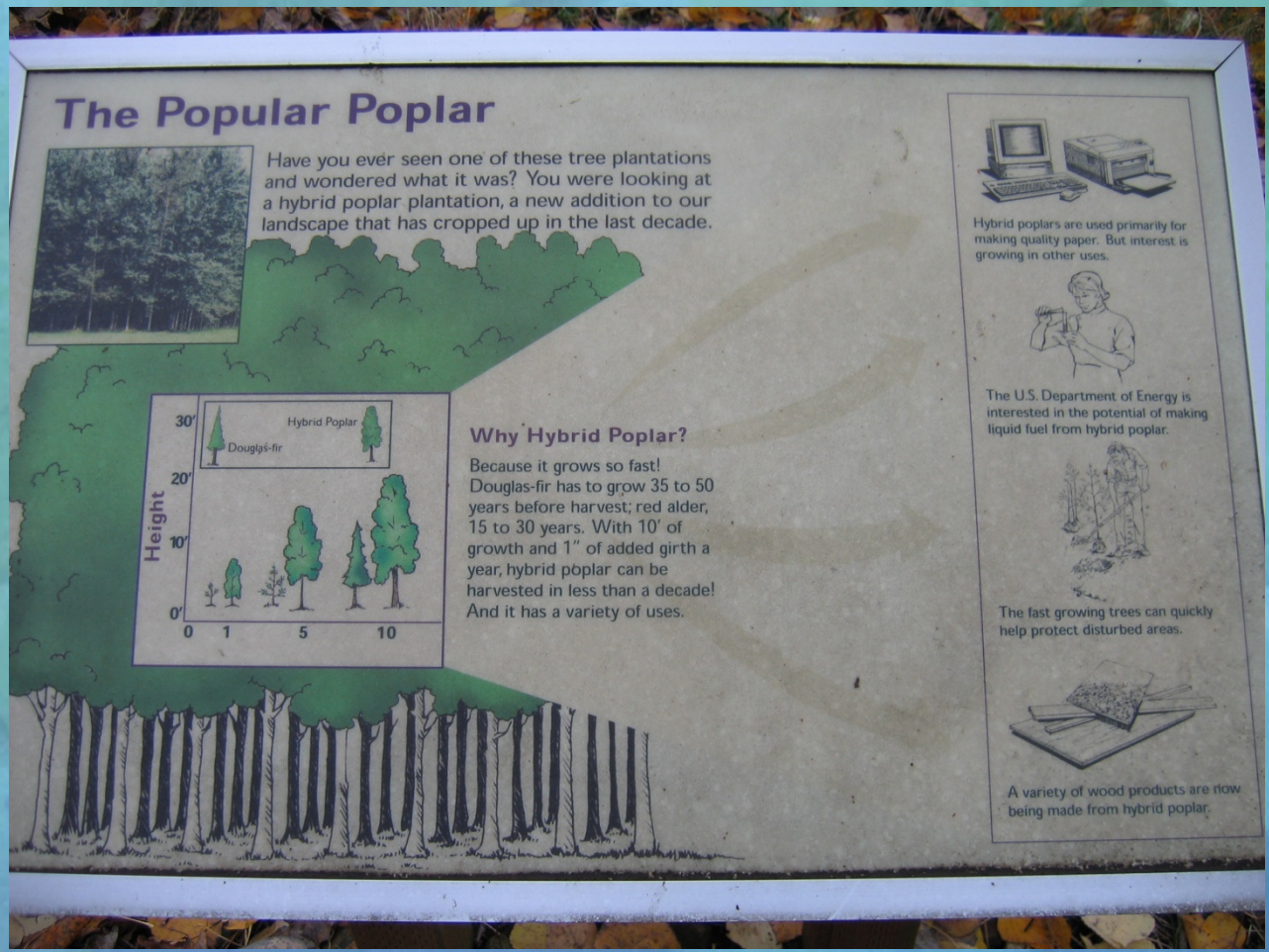
for SPROut



Objectives

- to evaluate the effectiveness of high rate irrigation of poplar trees as a process for polishing applied municipal effluent
- to remove nutrients and other contaminants to achieve water quality suitable for groundwater recharge
- to determine an optimal irrigation rate for beneficial reuse and groundwater recharge

Why Poplar?


The Popular Poplar
Have you ever seen one of these tree plantations and wondered what it was? You were looking at a hybrid poplar plantation, a new addition to our landscape that has cropped up in the last decade.
Hybrid Poplar
Douglas-fir
Height
30'
20'
10'
0'
0
1
5
10
Why Hybrid Poplar?
Because it grows so fast! Douglas-fir has to grow 35 to 50 years before harvest; red alder, 15 to 30 years. With 10' of growth and 1" of added girth a year, hybrid poplar can be harvested in less than a decade! And it has a variety of uses.
Hybrid poplars are used primarily for making quality paper. But interest is growing in other uses.
The U.S. Department of Energy is interested in the potential of making liquid fuel from hybrid poplar.
The fast growing trees can quickly help protect disturbed areas.
A variety of wood products are now being made from hybrid poplar.

Project Context

- Heat and nutrients limited by Willamette River 2006 TMDL
- However, some streams rely on effluent discharges to maintain flow during low-flow periods

Hypothesis

- irrigation at higher than agronomic rates can remain protective of groundwater quality
- soil treatment systems planted with poplar trees do not need to consume all of the water applied in order to consume nearly all of the nutrients applied
- water temperature is cooled through surface evaporation, crop shading, seasonal soil heat storage, and dilution with groundwater

Benefits to High-rate Irrigation

- Increased amount of treated municipal effluent that can be applied to a unit of land
- Natural tertiary treatment is lower cost than mechanical / chemical treatment for nutrient and temperature reduction
- Improved water quality effluent moving through the root zone to recharge groundwater
- Increased amount of water supporting the river flow from smaller area of land

Site Description

- Parallel sites at Woodburn Wastewater Treatment Plant and The Oregon Garden
- Woodburn 80 acres / TOG 1 acre
- Secondary effluent (Class D reuse in Oregon)
- Lysimeters for collection of groundwater sampling- 6 ft below ground surface

Oregon Garden

Oregon Garden

- one acre of land subdivided into four plots
- trees were 8-10 yrs old during study, with root depths of more than 6 ft
- trees are planted approx 10 ft apart in all directions
- ground slope is approx 16 % toward Brush Creek

Woodburn WWTP

Irrigation

- Agronomic= difference between rainfall and max ET rate for that crop (look-up tables)
- The study included irrigation at agronomic rate (28”) and irrigation at three increments above agronomic rate:
  - 140 percent = 1.4 x agronomic rate (39 inches)
  - 200 percent = 2 x agronomic rate (56 inches)
  - 400 percent = 4 x agronomic rate (112 inches)

  In winter, there is no irrigation under saturated conditions.

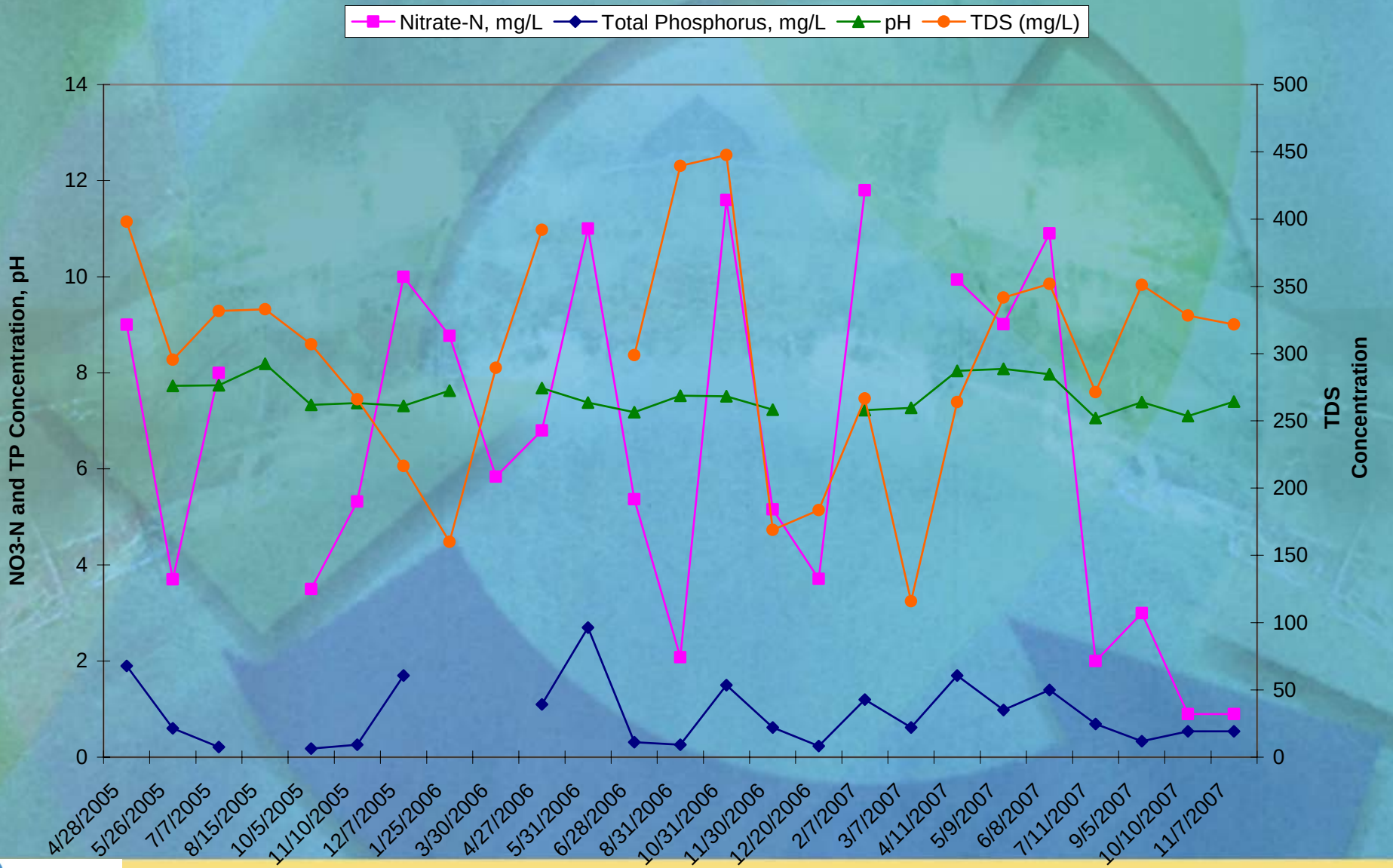
Water Quality Monitoring – Why? and When?

- To compare irrigation water quality to soil water quality
- Gage effectiveness of poplar tree system to remove or reduce concentrations of various constituents
- Study period January 2006 – December 2007

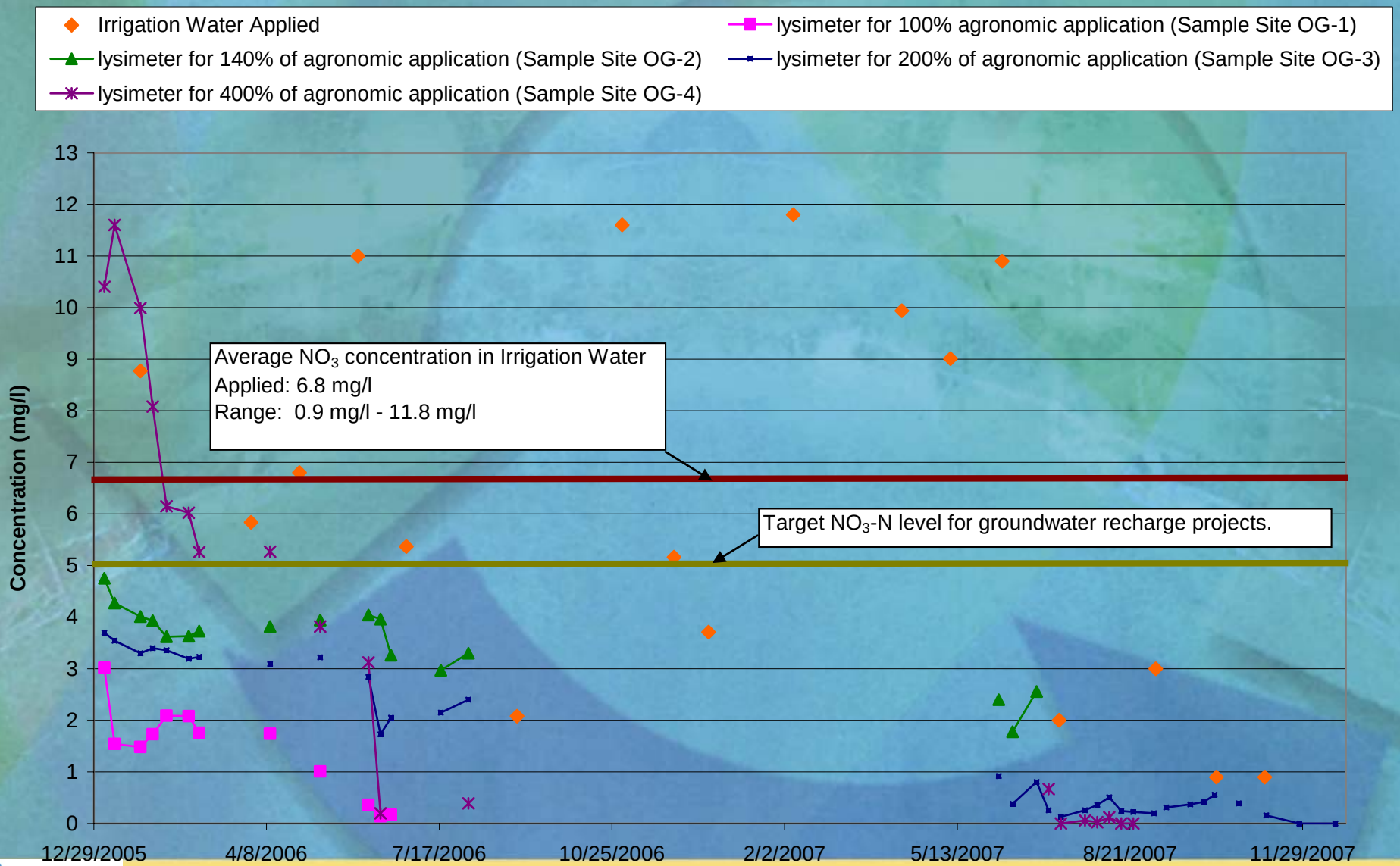
Water Quality Monitoring – What?

- Irrigation Water
  - Tested for nitrate, total P, pH, turbidity, conductivity, temperature, DO
- Average values of parameters of irrigation water
  - Nitrate 6.40; Total P 0.92
  - pH 7.48; temp 15.09 C
  - Turbidity 2.87; conductivity 438
  - Dissolved oxygen 9.40
- Soil Water from Lysimiters
  - Tested for nitrite, nitrate, ammonia, TKN, TDS, total P, and pH

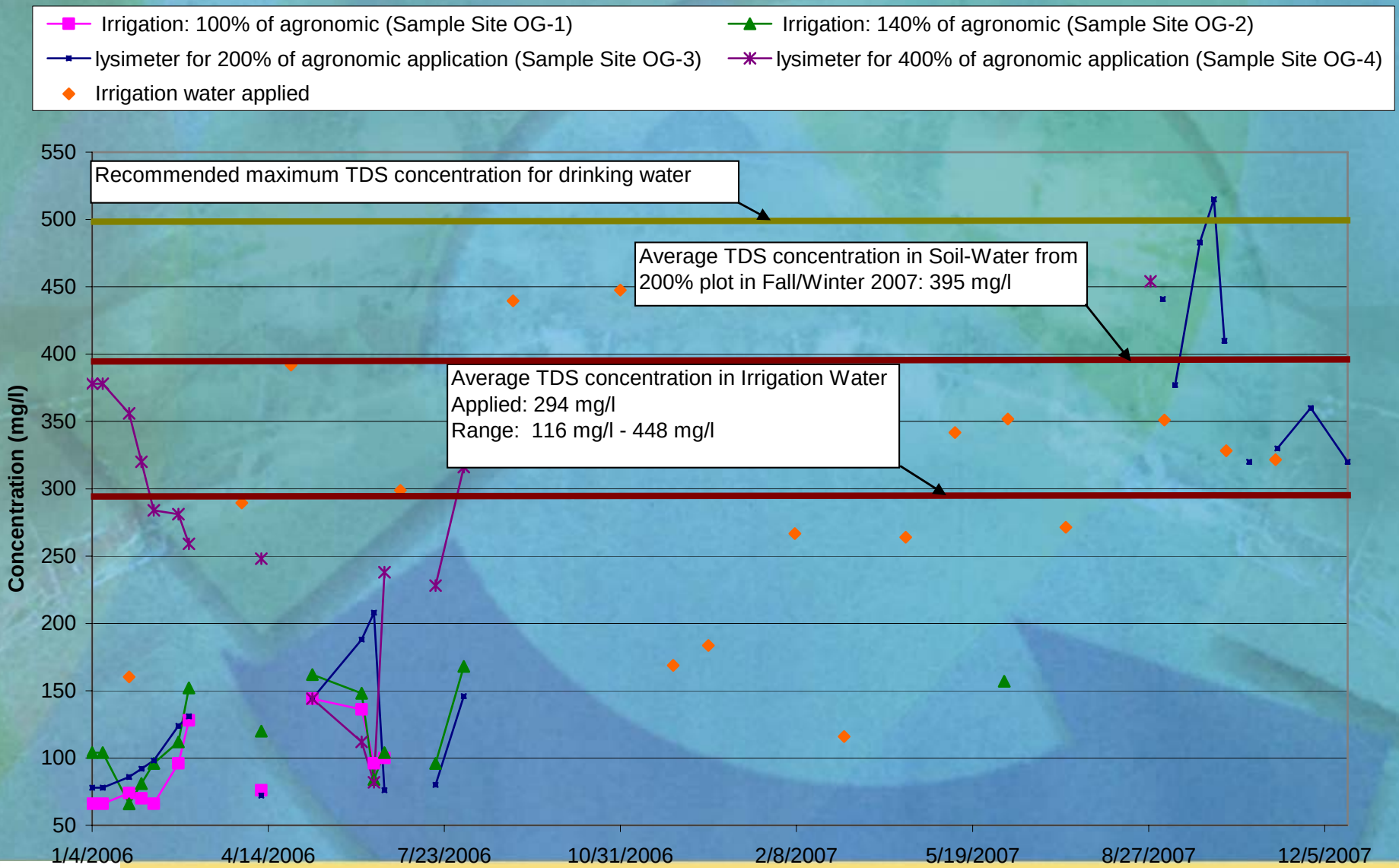
Irrigation Water Quality



NO_3-N Concentration



TDS Concentration



Total Phosphorus

- Irrigation water range 0.23 mg/l to 2.7 mg/l
  - Average 0.92 mg/l
  - Maximum P-load of 26 pounds per acre in 400% plot
- Phosphorus detected in soil-water in only 3 out of 36 tests
  - Maximum 0.07 mg/l in the 200% plot
  - Minimum 0.023 mg/l in the agronomic plot
- Low P likely a result of adsorption to clay soils

pH

- Irrigation water range 7.06 to 8.08
  - Average 7.6
- pH of soil water approximately 5.5 in all plots
- Water moving through the soil is buffered by the soil to match the soil pH
- Discharge to groundwater or stream at same pH as the soil

Conclusions

- High rate irrigation of poplars remove NO_3-N to below federal maximum contaminant load and Oregon groundwater recharge target

Conclusions

- NO_3-N, total P, and pH similar in all test plots
  - Up to 400% agronomic rate is viable method for polishing secondary effluent while remaining protective of groundwater quality

Conclusions

- Soil water from 6 feet deep is of higher quality than secondary effluent
  - Further treatment of total N, total P, and pH is likely as the water travels through the soil for eventual discharge
  - Soil reactions could also immobilize some constituents of TDS such as calcium

Conclusions

- High rate irrigation of poplars at up to 400% agronomic rate can be protective of groundwater and can result in increased availability of groundwater and discharge to the stream

Recommendation for Further Study

- Results of this study to be compared to Woodburn poplar site to assess consistency of conclusions at different sites in the Willamette Valley

Comments or Questions?