

Project 6: Bureau of Reclamation – Goodyear Wetlands

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Background

City of Goodyear, AZ constructed the Bullard Water Campus Reverse Osmosis (RO) facility capable of treating 3.5 million gallons per day of brackish groundwater.

RO generates a concentrated solution as a by product and requires disposal.

- Potable drinking water – total dissolved solids TDS of < 500 mg/L
- Seawater – TDS around 35,000 mg/L.
- The influent concentrate (aka brine) – approximately 8,500 mg/L.

Project goal: Determine what factors improve the ability of artificial wetlands to treat the RO concentrate.

Goodyear Pilot Wetlands study

Sponsored by: *U. S. Department of the Interior, Bureau of Reclamation*

Lead author: Deborah Tosline

“.... vertical flow treatment wetlands have the potential to remove selenium, meet ADEQ discharge requirements, and provided valuable insights into *selenium* removal that may be used at a potential future demonstration scale facility. ”

This is a pilot project to design a larger (production) wetlands that will serve the Bullard facility and restore natural habitat.

Treated concentrate is also planned to increase flow in the nearby Gila River.

Bullard facility



Bin design

7 pilot-scale artificial wetlands, *bins*, were designed. Bins about the size of a construction dumpster.

Each "wetland" has an inflow and outflow source.



Figure: Bins 1, 2, and 3 (left) and 5, 6, and 7 (right)

Bin design (continued)

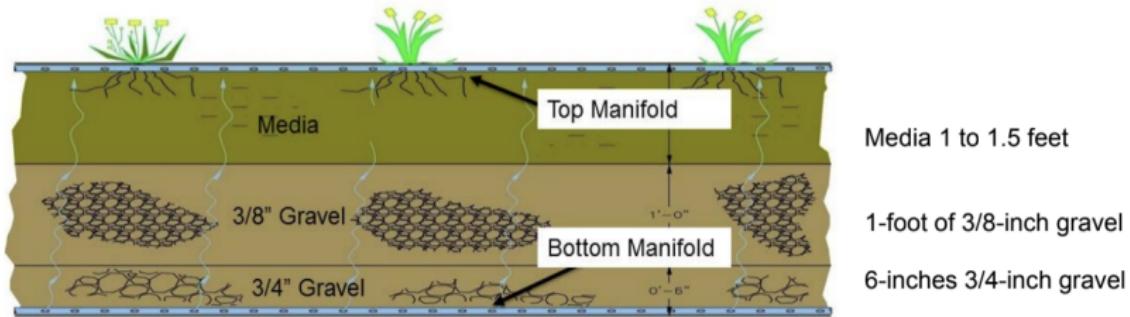


Figure 2. Schematic diagram of up-flow VFTW.

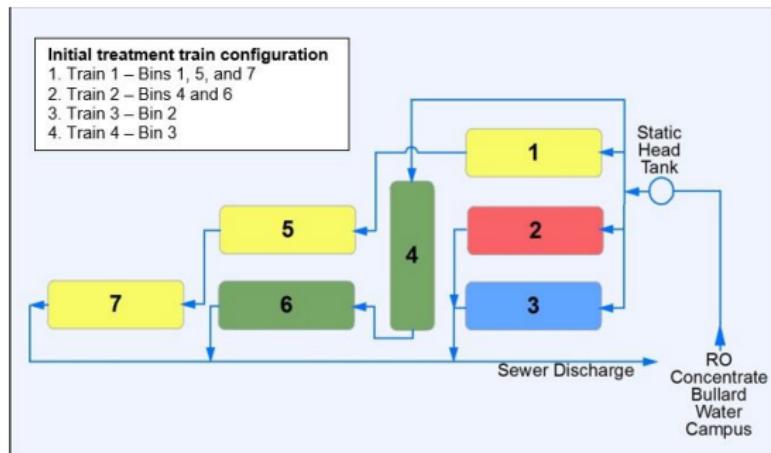
- Vegetation, inlets, and soil composition vary among these bins.
- Conditions of operation were also varied e.g. (A,B,C,D).

Inflow and outflows

Except for bin 7 the inflows are at the bottom!

Flow diagrams among bins

Some bins connected into *trains*.



Measurements

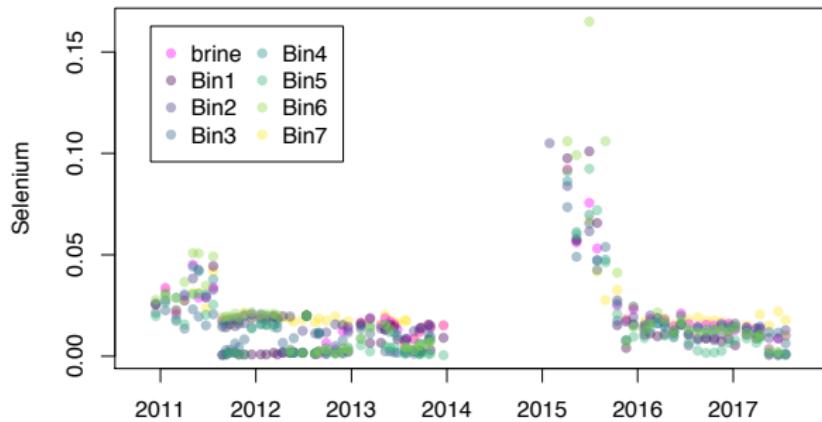
Both insitu and lab measurements on concentrate and bin flows on a weekly time scale.

- physical variables: inflow, outflow, temperature, pH
- Water quality variables: DO, conductivity, TDS, COD, ...
- Inorganics: Sulfate, Selenium, Chromium, ...

These are combined into a single R data frame goodyear.

Overveiw of study data

Selenium concentrations at bin outflow and RO (brine)



Performance periods

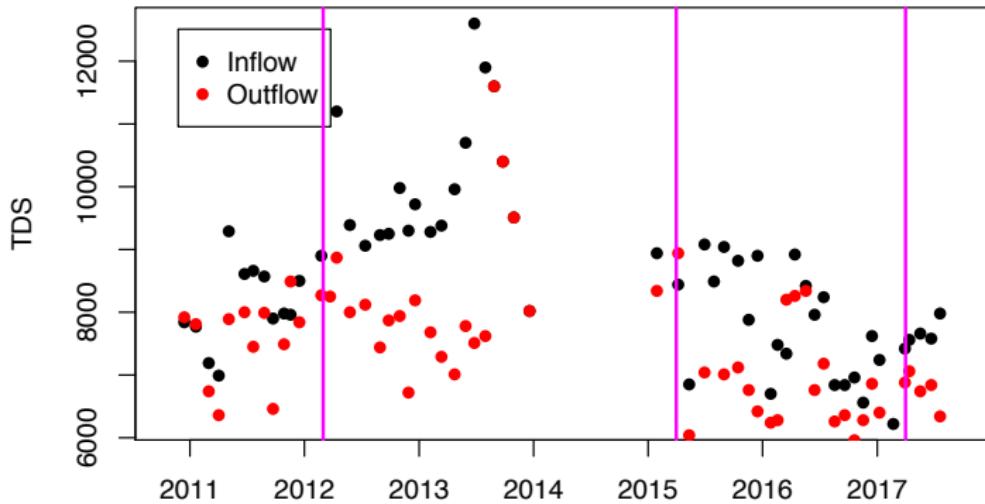
These are different conditions for the bin operation.

For bin 1:

- (A) operation of Bin 1 (influent to Bin 5) after first media and plant installation – December 2010 to March 2012
- (B) operation after replacement of Bin 1 (influent to Bin 5) and phase-in of the new Bin 1 media and plants – March 2012 to April 2015
- (C) operation during the mature phase of the 2nd media and planting of Bin 1 (influent to Bin 5) – April 2015 to April 2017
- (D) operation during the more controlled portion of the study and carbon dosing – April 2017 to June 2018

Example: Bin1 removal of TDS

Figure 17 --- Bin1 TDS



A, B, C, and D performance periods.

Questions

- How effective are the treatment trains as function of different performance periods?
- How well do these systems remove Selenium and other inorganics that are of particular concern to the Goodyear facility?
- Does the efficiency of the system depend on covariates, e.g. temperature or pH? Are there correlations among inorganic constituents more easily measured variables?
- Are there conclusions in the study report that can be modified or sharpen using a more statistical analysis?

In general the study does not address multivariate relationships of the measured variables or rely on regression analysis for fitting models.

Data subsetting

```
temp<- subset( goodyear, goodyear$ID=="Bin1")  
plot( temp$date, temp$TDS,xlab="date", ylab="TDS")
```

- ID is a factor.
- time as a date object
- Can streamline analysis using tidyverse tools ...

Thank you!

Goodyear, AZ

