CONCENTRATE MANAGEMENT WETLANDS PILOT PROJECT

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Introduction

The Central Arizona Salinity Study (CASS) has predicted that reverse osmosis (RO) facilities in the greater Phoenix area will be producing approximately 80 million gallons of potable water daily from brackish ground water and effluent by the year 2025. Approximately 12 million gallons a day (mgd) of concentrate will be produced as a byproduct. CASS also predicts that by the year 2035, production of water using RO will have dramatically increased and as a result 28 mgd of concentrate will be created and need to be disposed. It will take innovative thinking to manage this volume of concentrate in an economical manner.

Managing concentrate through natural means would entail passing the concentrate through a vertical flow wetlands which would reduce a significant mass of the heavy metals, such as selenium and arsenic, and reduce other regulated ions below the maximum contaminant level (MCL). The concentrate minus the hazardous ions would then be blended with effluent from a local water reclamation facility and then surface discharged into the Gila River. The Gila River downstream of South Tuthill Road is high in total dissolved solids (TDS); in the range of 3000 to 3500 mg/L TDS. The concentrate/effluent mixture would match or be lower than the Gila River's TDS concentration and contain lower concentrations of regulated ions.

This innovative solution has many positive benefits such as; low cost low technology, guarantee of water to the habitat along the Gila River, reliable supply of water for irrigation districts downstream, and reduced energy consumption in managing concentrate. Computer modeling by CH2M Hill indicated that it may work and Reclamation felt that a pilot project was justified.

Natural Management of Concentrate

The city of Goodyear (City), Arizona, currently operates an advanced water treatment facility treating brackish groundwater. The product water from seven 0.5 mgd reverse osmosis (RO) skids produces 3.5 mgd of permeate which is blended into the City's potable water system. This facility also produces 0.5 mgd of concentrate as a byproduct. RO concentrate is classified as an industrial waste. The concentrate varies slightly in composition throughout the year as different groundwater wells are used. The information below was from an analysis of the concentrate taken 14 January 2010.

TDS	9190	mg/L
Arsenic	0.0240	mg/L
Selenium	0.0317	mg/L
Chromium	0.0460	mg/L
Nitrate-N	62	mg/L
Chloride	2910	mg/L

The concentrate, currently, is discharged into the sewer and is transported via the sanitary sewer system to the City's 197th Avenue Water Reclamation Facility (WRF). This small WRF is stressed by the saline concentrate. The concentrate contributes 10% of the hydraulic load and 25% of the salt load to the WRF. The effluent leaving the WRF has approximately 2000 mg/L TDS. This salinity level does not allow the effluent to be used by the City for irrigation of parks, schools or for the Cactus League professional ball fields located within a couple of miles of the WRF.

A concept to use nature to manage the concentrate has been devised. The concentrate will be conveyed to vertical flow wetlands located near the Gila River on the north side. In a vertical flow wetland untreated concentrate is introduced into the bottom of the wetlands via a PVC manifold system. The concentrate then travels vertically upwards to another PVC manifold system which whisks the water away. The surface is basically dry with the wetland plants reaching their roots into the media.

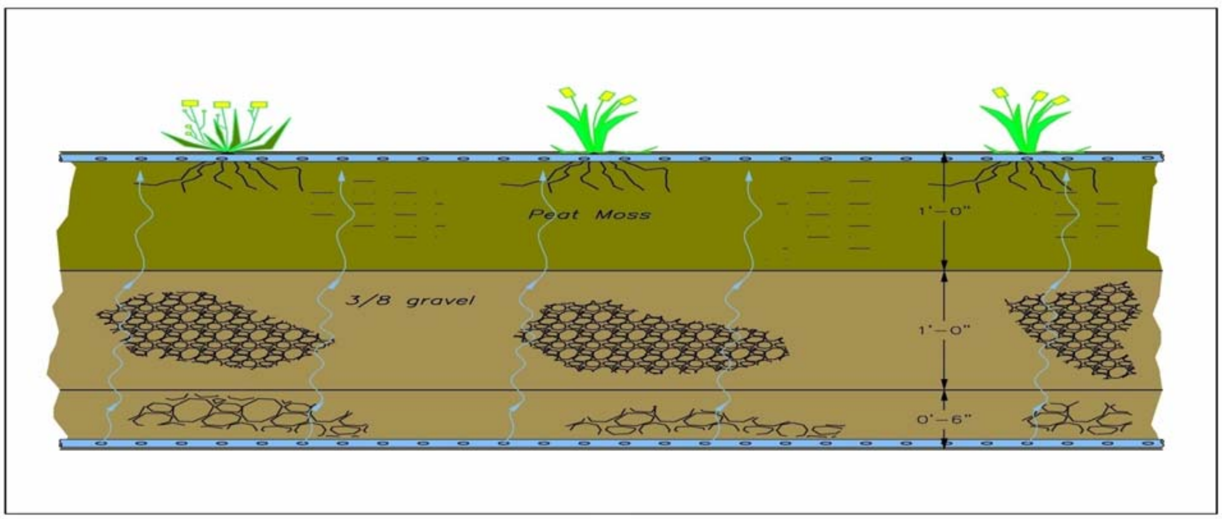

Figure 1. Vertical Flow Wetland cross section

The wetlands remove regulated ions through several mechanisms; physical settling, sorption, biological uptake and chemical precipitation. The treated concentrate will then be blended with effluent to match the TDS of the Gila River. Calculations indicate it will take 3 parts of effluent to 1 part of concentrate to match the TDS of the Gila River in this area.

The flow of concentrate/effluent blend would then be discharged to the effluent-dominated Gila River with the contaminants reduced below maximum contaminate levels (MCL). The discharge would rehydrate a portion of the Gila River, long modified by upstream diversion, thereby creating productive riparian and marsh habitat. Two different irrigation districts downstream of the point of discharge use the entire Gila River once again for crop irrigation. Water degradation cannot be allowed, all MCL's must be met and treated concentrate discharges must not contain more TDS than ambient conditions in the Gila River. Figure 2 shows a diagram of the scheme.

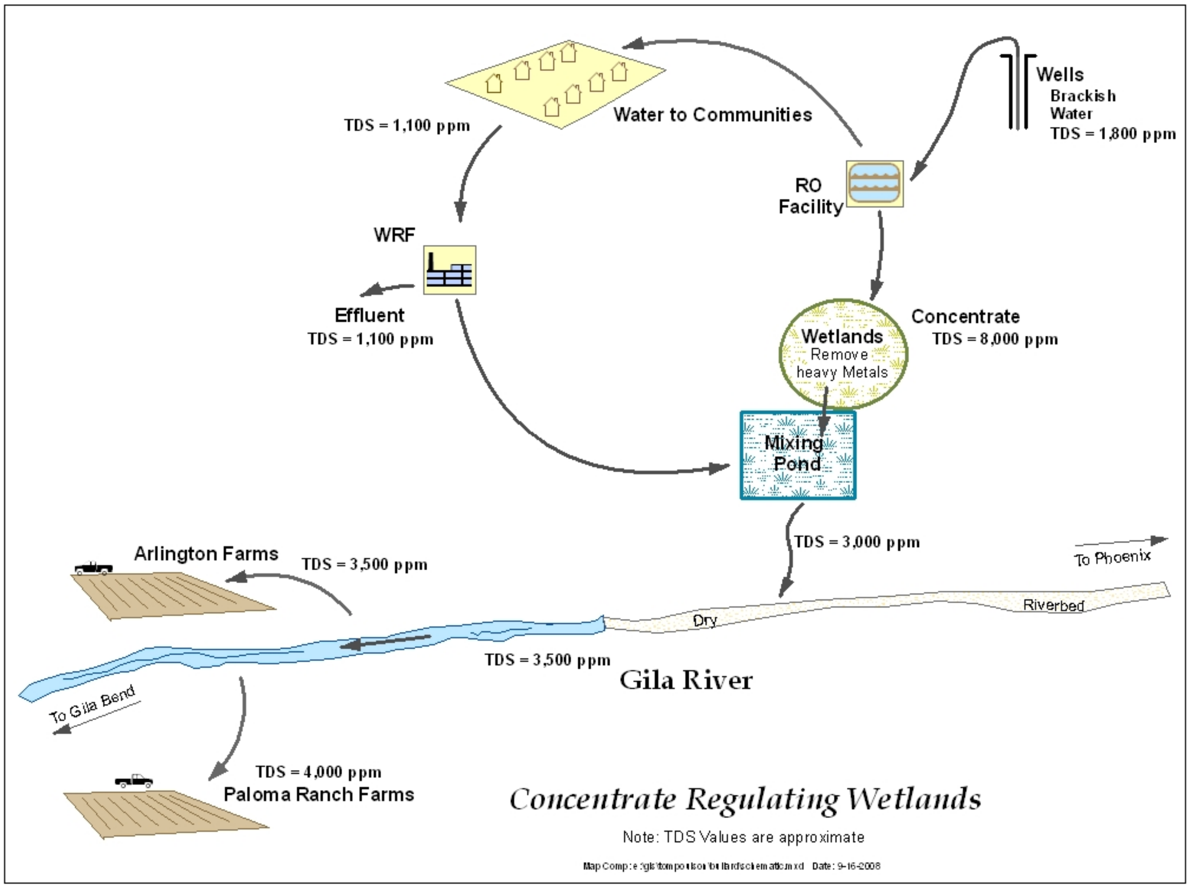

Figure 2.

Periodic floods down the Gila and Salt rivers have a renewing effect on the river by flushing away any accumulated salts.

The wetlands approach for managing concentrate would require a surface water discharge permit which is subject to approval by the Arizona Department of Environmental Quality (ADEQ). A major concern is that the concentrate/effluent blend will not be able to pass whole effluent toxicity testing (WET) because the chlorides will be too high. Chlorides above 300 mg/L have been known to cause failure of the WET test because one of the test animals, the water flea (*Ceriodaphnia*), can't tolerate high chlorides. The concentrate/effluent blend will have approximately 1220 mg/L of Chlorides.

Net Ecological Benefits (R-18-11-106) is a rule which allows exceptions to the regulations. It has been successfully used once in Arizona at the East Yuma Wetlands and should work in this situation also. It basically says "the good you are doing outweighs the bad you are doing". And since the water flea can't be living in the Gila River (Chloride level 1240 mg/L) the bad is negligible, and the good is: supplying water to Gila River habitat, improving effluent which can be used where potable water is now being used, reducing green house gases by reducing energy consumption on concentrate management and by producing a wetland habitat.

To establish the environmental safety, the feasibility of permitting this project and to test if the vertical flow wetlands can remove the regulated ions, Reclamation authorized a Pilot project, the Goodyear Wetlands Pilot Project.

Pilot Project

The pilot project is designed to test the ability of vertical flow wetlands to successfully remove regulated ions. Seven waterproof bins were manufactured which are 28 feet long, 7.5 feet wide and 4.5 feet tall. Six of the bins were planted as vertical flow wetlands, the seventh bin was created as a surface water wetland, which has a foot of earth at the bottom with a foot of water above it.

In the vertical flow bins the bottom 6 inches is filled with ¾ inch rock. In this zone a PVC manifold is installed where the concentrate is fed into the bin. Above the rock is a foot of 1/8 inch pea gravel. The function of the manifold, rock and pea gravel is to distribute the water. Above the pea gravel is the media in which the wetland plants are growing. Two media were selected; bins 1, 3, 5 and 6 contain peat and bin 4 contains green waste. At the top of the media just below the surface another PVC manifold pulls the water from the bin. The surface looks and feels dry.

It is a simple matter of measuring the flow and constituents going into a particular bin and measuring the flow and constituents leaving the bin to gather data. A multiply-week averaging approach will be used to calculate total mass reduction of the metals.

Four of the bins were planted with these grasses; Scratch Grass Muhly, Alkali Sacaton and Salt Grass. Also in those four bins were planted these salt tolerant plants; Creeping Spike Rush, Baltic Rush, Yerba Manza, Fourwing Salt Bush and Seep Willow. Most of the plants are thriving on the peat (Bins 1, 3, 5 & 6) and saline concentrate. Although, the Fourwing Salt Bush and the Seep Willows are not doing well at all. The plants planted in the green waste (Bin 4) are not thriving the growth is stunted compared to the peat bins. One of the vertical flow bins and the surface water bin were planted with Cattails, Olney's Three Square Rush and Soft Stem Rush. These plants are thriving and doing well.

The plants remove pollutants by; directly assimilating them into their tissue and more importantly their roots provide surfaces and a suitable environment for microorganisms to grow. Over time the microorganisms consume the oxygen and they form an anaerobic zone in the media. In this zone the microorganisms begin to transform Sulfate (SO_4--) to Hydrogen Sulfide (H_2S). Dissolved metals, such as Arsenic and Selenium, react with the Sulfide to form insoluble compounds which are retained in the wetland sediments.

Preliminary Results

The wetlands were planted on 3 September 2010. The plants flourished for the first month and then a cold winter (cold for Phoenix means it got down to freezing a couple of times) pretty much put the plants in hibernation. In the spring of 2011, the plants once again began to grow and an anaerobic zone has formed in Bins 4 and 6.   The analysis of the water samples taken in late 2011 show reductions in Arsenic, Selenium and Chromium.

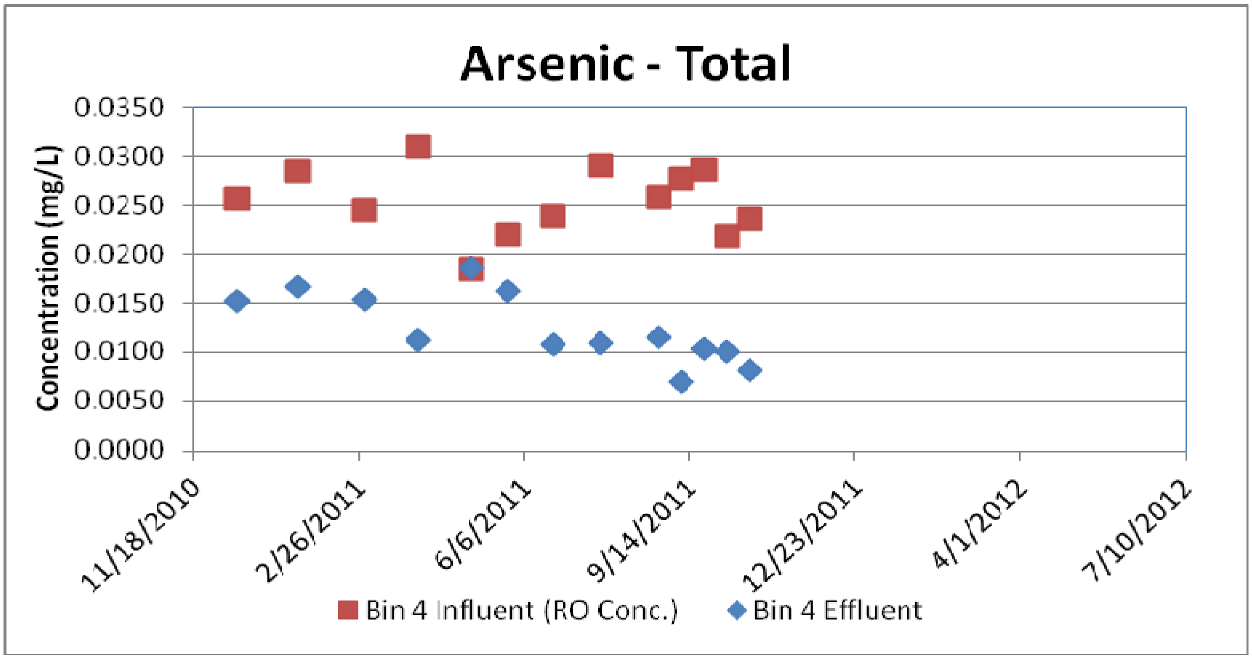

Figure 3. Arsenic Reduction

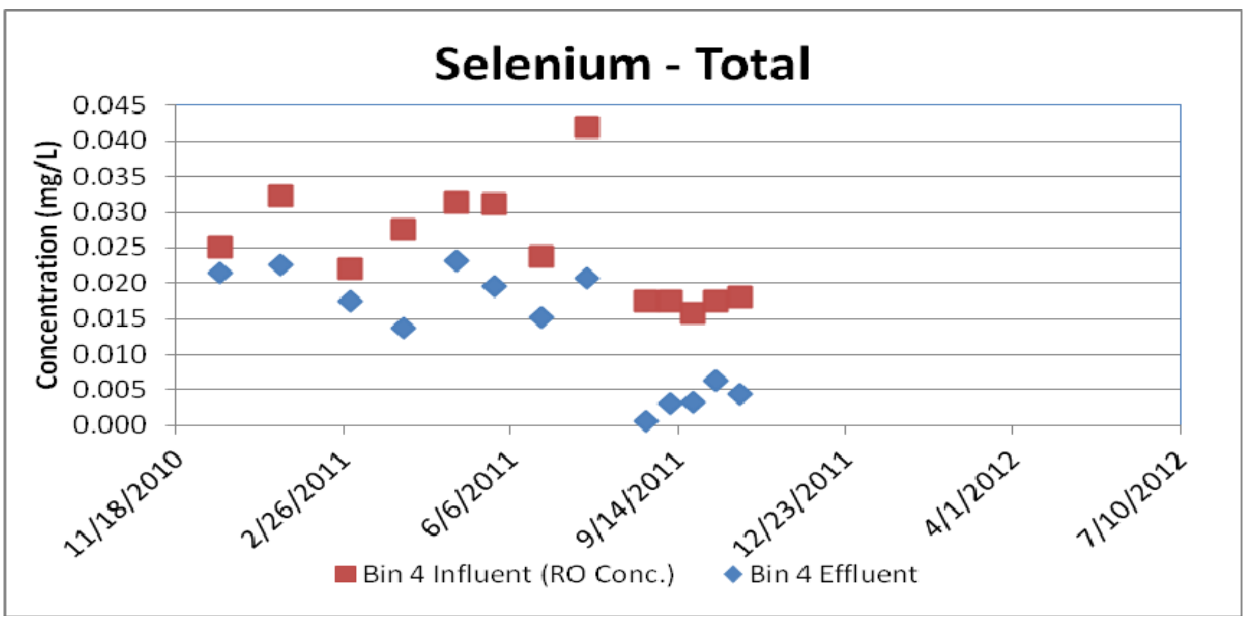

Figure 4. Selenium reduction

The data look good with the arsenic and selenium graphs. Bin 6 which is in series with Bin 4 reduces Arsenic and Selenium to non-detect.   Arsenic and selenium are only being removed in the bins which have formed an anaerobic zone. On the other hand, a different mechanism is at work to remove chromium. Chromium is being removed to non-detect levels in all of the vertical flow bins even the bins which have not formed an anaerobic zone.

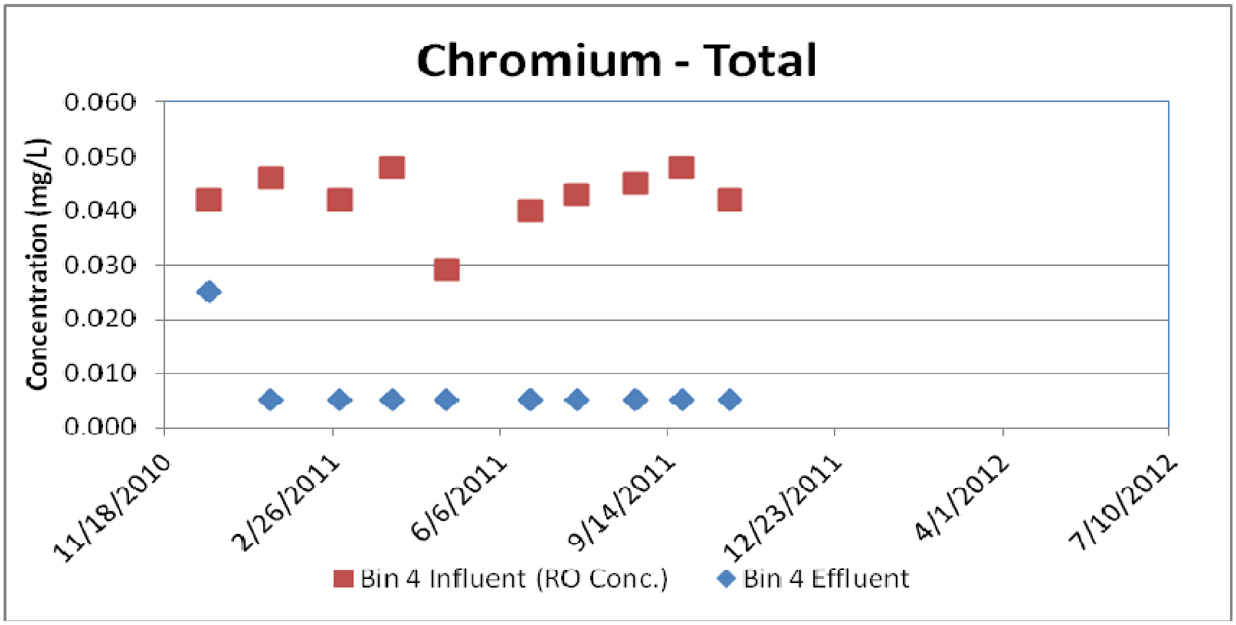

Figure 5. Chromium Reduction

When the media can no longer hold any more heavy metals it will be removed to a landfill and a new wetland will be planted. Part of the pilot is to discover how long that will take.

Conclusion

This idea of managing concentrate through natural means is a complete shift in thinking from conventional concentrate management. Instead of using lots of energy and highly engineered systems, we can use natural means to process the concentrate, removing the harmful constituents and return the benign salts back to nature, with the added bonus of water for the environment.

While the preliminary results look very encouraging there is a lot more work to do before ADEQ, environmentalist and the water community are convinced that this process just may work in the southwest Valley of the Sun.