



## Construction Experience with Wetland System Upgrades

By Archis Ambulkar, Stephen N. Zeller, and Neal S. Harris

Washington Township Authority, Dauphin County, PA, owns and operates a constructed wetland treatment system with a design hydraulic capacity of 50,000 gal/day and organic capacity of 120 lbs BOD/day for wastewater treatment.

The system was initially built in 1996 and consisted of two 350,000 gallon facultative lagoons, followed by two 150,000 free water surface (FWS) beds. These were followed by an intermediate pump station leading to two final subsurface flow (SF) stone-media filled beds of 150,000 gallons each. Effluent from these beds was passed through an ultraviolet disinfection system before ultimate discharge.

Historically, this plant had some operational issues including lack of dissolved oxygen in the wetlands and lagoons, sludge build up in lagoons and FWS, winter-time effluent BOD permit violations, a high groundwater table, a non-gravity treatment system requiring costly intermediate pumping, ponding surface water and weeds on subsurface beds, and vector issues including liner damage caused by borrowing mammals.

Brinjac Engineering Inc., retained municipal engineer for Washington Township Authority, helped the township obtain grants from the State of Pennsylvania through the Safe Drinking Water program and 2006 Pennsylvania Growing Greener Innovative and Alternative Grant Monies program to fund system upgrades.

### Upgrade Project

The proposed project consisted of two phases with Phase I completed in 2005. During Phase I, elevation of two partially excavated, non-constructed FWS wetland cells was raised, eliminating intermediate pumping needs. These wetland cells were redesigned to make one large FWS cell with a reduced length to width ratio for better treatment efficiency. A new 24-inch-deep re-aeration zone was added in the central section (approximately one-third of total area), and a heavier 40-mm HDPE liner was provided for beds.



Phase I involved design and construction of additional wetland bed areas that were only rough cut during original construction of the facility in 1996. Two smaller FWS wetland cells were added following this new larger FWS cell. These newly constructed beds ensured all wetland capacity required to meet design loadings. Heavy three inch stone was carefully added along all side slopes, to a depth of 6 inches on top of new heavy 40-mil geo-textile liner creating an impenetrable layer for borrowing mammals (a major problem with existing wetlands).



Acclimated wetland plants (tubers) from existing wetland cells were used to seed new wetland cells in Phase I, instead of using greenhouse wetland plants. Within 6 months, beds were ready for service (whereas normal time is > 1 year).

Phase II of the project was completed in April 2008 and included cleaning of accumulated sludge in existing FWS cells and their renovation and upgrade similar to the new design as in Phase I. Existing subsurface beds were modified with new influent and effluent manifolds to allow for more expansive water level control in the beds, enhanced treatment and to eliminate ponding. Intermediate pump station was eliminated, a new effluent flow meter for higher flows was installed and new effluent manifold was sized for additional flows from the wetlands beds.

One of the major additions to Phase I and II design was deeper re-aeration zones in the wetlands beds. They were provided to ensure the beds would remain well oxygenated and aquatic plants would not choke the beds out after a number of years as had occurred in the original FWS beds.

### **Construction Phase**

During the construction phase, wetland beds were excavated and converted to newer, deeper free water beds. Existing top soil was excavated to provide a suitable base. After excavation, base material of crushed shale and dirt was added to bring beds to about 6 inches from final grade. Bed elevations were set to ensure gravity flow.

Beds were then leveled for liner installation. Final grade leveling work was performed using 6 inches of fine silica sand screenings dust mixed with sand. Final base material used on this project was a recycled quarry screening fines with sand which compacted like cement. HDPE liner was placed on top of this material.

All pipe penetrations to the beds and headwalls were installed before the liner was placed in the beds. Headwalls were poured in place with forms. Effluent pipe was within 6" to 8" of the cell bottom.

Geo-textile was added to protect the liner bottom from rock, etc. A 40 mil HDPE liner was provided as a base for the lagoons/wetland cells. Each bed liner was run up to the sides of beds and anchor trenches were installed to ensure that liners did not move once in place.

HDPE liner penetrations were sealed with special boots and stainless steel bolts and clamps to ensure no leaks around any liner penetrations. All seams were tested to ensure proper seal. Each seam in HDPE liner was heat sealed.

Stainless steel screens were installed onto the effluent overflow units to control effluent TSS from beds resulting from algae and other material in the beds. Final treatment units had double mesh screens installed.

Geo-textile was added on all side slopes of the HPDE liner. Six inches of dirt for planting of wetlands plants into the free water beds was added on top of the HPDE liner.

The re-aeration zone was left without dirt so that no wetland plants could root. This area was kept free and open to allow for aeration of wetlands. Rock was added to side slopes on the wetlands cells to control burrowing animals. Wetland plants were placed 2 feet on center into 6" dirt covered with 1" of water to promote growth.

Since the wetland system upgrades, treated effluent has been monitored for BOD<sub>5</sub>, TSS, pH and nutrients (nitrogen and phosphorus). The system has kept in compliance with permit limits and previous WWTP operational issues have been overcome.

## Lessons Learned

Lagoon: The first stage of the aerated facultative lagoon or true facultative lagoon is critical for nutrient removal as BOD must be reduced and residual dissolved oxygen could be maintained in wetlands cells for nutrient removal.

Hydraulic retention time (HRT): HRT (minimum of about 30 days plus) in wetlands cells only along with the DO is critical in achieving nutrient removal. FWS cells are better at nitrification while subsurface cells are better at de-nitrification.

Energy Needs: Wetlands treatment is entirely passive with no pumps etc. and without any energy input except through sun, wind energy and plant growth.

Muskrats: Muskrats come irrespective of FWS cell design requiring maintenance cost of \$1000/yr for trapping. Subsurface wetlands eliminate trapping and control needs.

Rocks and Liners: Use of rocks on side walls of wetlands cells to deter borrowing animals promotes plant/weed growth. Use of a heavier liner (60-mil) is a better approach with no rocks.

Influent pipe location: Holes in influent piping should be minimum of 2" to 3" in diameter because frogs and turtles get into the influent pipes and are stuck and clog holes, plant growth clogs holes as well.

Water fowl: Large wetlands cells are great at attracting migratory water fowl (Geese, wood ducks, mallards etc.).

Acclimated Plants: Use of acclimated cattails resulted in rapid growth and wetland cells were ready for treatment in 6 months instead of 1 year with nursery plants.

Effluent Piping and Flow Metering: Wetlands cells have tremendous surface area which means that effluent piping and flow metering must be designed for rainfall amounts.

Algae Control: Subsurface cells are better at controlling algae through wetland systems resulting in minimal TSS in effluent.

Nutrient Removal: Average monthly effluent of 15.0 mg/l TN and 2.4 mg/l TP after upgrades compared to 25.0 mg/l TN and 4.0 mg/l TP before upgrades. **WW**

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### *About the Authors:*

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