ALBANY–MILLERSBURG

Talking Water GARDENS

a PARTNERSHIP *for* ENGINEERED *wetland* SCIENCE

ATI Wah Chang

Summary

Located on the banks of the central Willamette River, an American Heritage River, the Cities of Albany and Millersburg are invigorated by the important role the river has in the history and culture of their communities. In an effort to restore the Willamette River and the threatened salmonid species, the Oregon Department of Environmental Quality (DEQ) adopted a total maximum daily load (TMDL) for temperature along with bacteria and mercury. The discharge from the Albany-Millersburg Water Reclamation (WRF) facility did not meet the thermal load allocation set by the TMDL. In addition, local industry was required to relocate its point of discharge from a tributary stream to the Willamette River in the same proximity of the Albany-Millersburg WRF outfall diffuser. This requirement created a situation where yet another effluent diffuser would need to be permitted, constructed, operated, and maintained in the Willamette River.

In contrast with the typical engineering approach that focuses on identifying the least cost treatment technology solution to address the needs of individual dischargers to meet new regulatory water quality challenges, the Cities preferred to take a “value-focused” approach. The Cities saw an opportunity for a combined municipal-industrial solution that would produce greater overall environmental benefits for the area. This approach met an important economic goal of the Cities to create and sustain family wage through the retention and expansion of existing businesses and industries in the area. The development of socially, economically, and environmentally sustainable water and wastewater solutions for business and industries is a critical component to achieving this economic goal.

Assisted by CH2M HILL, the Cities of Albany and Millersburg, and local industry collaboratively developed a water reuse project that will in the first phase create 39 acres of new emergent wetlands on a 50-acre site, adjacent to the historic oxbow of the Willamette River and the combined water will be returned to the Willamette River with the existing Albany-Millersburg outfall diffuser. The water reuse project will be a significant public amenity and education opportunity in the Willamette Valley.

The Willamette Valley and Its River

Located on the banks of the Willamette River, the Cities of Albany and Millersburg are rich with history and culture. Albany and Millersburg are located about half way up the length of the 300-mile-long Willamette River, 118 miles from the confluence of the Willamette River and the Columbia River. The Willamette Valley watershed that feeds the mighty river includes 1,200 square miles of forest, meadows, lakes, and wetlands. The wetlands and river have been a lifeline in the Willamette River Basin for thousands of years. Prior to European settlement, the river and its lush riparian floodplain were an abundant source of food for the native Calapooya people. Then, as European settlers discovered the bounty and beauty of the area, river water was diverted into meadows to sustain crops and livestock.

Later, the industrial revolution enabled the Cities to become centers of productivity and manufacturing which were heavily dependent on the river for transport and water. The tremendous quantity of Douglas fir trees growing on the hillsides around the townships provided a seemingly endless source of timber, sustaining a thriving economy for many decades. More and more people came to settle the Willamette River Valley. Given all the timber needed for construction in the valley, it isn’t a surprise that Albany became a hub for mills and river transport.

Water sustained life in the river basin through all these stages of development. Now, past the time of the Calapooya settlements, past the heyday of the logging community, the river’s health is challenged. Channels straightened to facilitate the passage of larger ships and to protect riverside settlements from flooding contribute to the distress of ocean-going salmon and other aquatic animals. Impoundments provide drinking water, recreation, and hydropower but impede natural river flow, leaving oxbow meanders cut off and disjointed. The discharge of treated wastewater from human endeavors is causing the river to run warmer in some locations, which further impacts river habitat.

In an effort to restore the Willamette River, DEQ adopted a TMDL order. The TMDL includes limits on heat and other constituents carried by point-source discharges.

Development of the Concept

Development of Talking Water Gardens is driven by the need to meet TMDL requirements. The TMDL limits the Albany-Millersburg WRF waste heat load to an average of 111 million kilocalories per day (Mkcal/day) during low Willamette River flow conditions. The WRF effluent without any cooling carries approximately 10 percent more heat than allowed for discharge by the TMDL. Local manufacturers that discharge treated industrial wastewater to the river are also faced with TMDL limits on heat and other constituents.

In contrast with the typical engineering approach focused only on least cost technology selection to address new regulatory challenges, the adjacent Cities of Albany and Millersburg, preferred to take a value-focused approach. This approach started with identification of the Cities’ own desired outcomes, followed by identification of other stakeholder desired outcomes, and the needs of the environment, culminating in creation of solutions to achieve the greatest environmental and community benefits.

The Cities saw an opportunity to combine resources with local industries to create a sustainable solution that produces greater overall economic, social, and environmental benefits for the area. The approach helped meet the Cities' important economic goals to support the retention and expansion of existing businesses and industries.

The Cities' explored many options including technologies such as treatment plant upgrades, storage and cooling towers, refrigeration, land application reuse, new outfall diffusers, and treatment wetlands. Based on a screening of these technologies and alternatives, which included a preliminary cost comparison of individual wetland treatment systems with an integrated wetland treatment system, an integrated wetland treatment system was identified as the alternative that delivered the greatest benefits for the community.

Selection of a wetland treatment system afforded the opportunity for the Cities and industries to achieve discharge limits while simultaneously offering the community ancillary benefits. The natural environment of a wetland can be enhanced to include recreational and educational opportunities for area residents and visitors while also providing wildlife habitat.

Synergistic Effects of a Combined Discharge

In addition to the Albany-Millersburg WRF, two local manufacturers were assigned waste heat load allocations by the TMDL. These were ATI Wah Chang, which produces specialty metals, and the Weyerhaeuser paper mill. The waste heat load allocation varies according to the river flow at the point of discharge. The amount by which point source discharge must be cooled depends on the point source temperature, river temperature, and the point source flow.

Analysis of the WRF, Wah Chang, and Weyerhaeuser flows showed that peak effluent flows and temperatures occurred at different times of the day for each of the three point sources. This suggested an opportunity to combine effluents and therefore heat load allocations into one point source discharge, allowing a discharge of at single point source at a relatively constant temperature. Combining the effluents could also have synergistic effects on treatment of other constituents. Since the time of the initial evaluations, the Weyerhaeuser paper mill was purchased by International Paper, which closed the facility. The project concept was then adjusted to manage flows from the WRF and ATI Wah Chang.

Effective Cooling and Tertiary Treatment with Constructed Wetlands

The Talking Water Garden is designed to be a reliable, adjustable wastewater treatment process unit like the rest of the processes in the WRF. The 9.6 million gallons per day (mgd) of Albany/Millersburg effluent and the 3 mgd of Wah Chang effluent are both fully treated to meet river discharge standards and could be blended and discharged directly to the outfall if they were cooler. The wetland system is designed for the primary function of cooling. However, it has a huge capacity to provide additional treatment functions even beyond what is required for river discharge. In addition to cooling, wetlands provide a tertiary level of effluent treatment for both Albany/Millersburg and Wah Chang by removing thousands of pounds per year of nutrients and other elements that could by permit be discharged to the river. Because the Talking Water Gardens treatment unit is a complex of wetlands it also creates or enhances a host of natural wetland ecosystem functions as an ancillary benefit. Electricity is required to pump water from the WRF to the Talking Water Garden but the rest of the treatment processes are entirely natural. In wetlands the energy for operation comes from the sun, the wind, the soil, and the topography of the site.

Sun

Sun energy drives the photosynthesis that is the basis of plant life in the wetlands. A healthy plant system is required to support the rest of the organisms that provide the treatment. The plants are the superstructure that most other organisms live on. The immense surface area of a wetland full of plants that organisms can attach to and grow on can be over 10 times greater than the surface area of the pond bottoms and sides. The plants themselves consume large amounts of nitrogen, phosphorus, and potassium. However, plants also require 13 other basic elements: calcium, magnesium, sulfur, zinc, iron, manganese, copper, boron, molybdenum, chlorine, carbon, hydrogen, and oxygen. These elements are the basic building blocks of plant cells when captured by plant uptake to provide growth but are considered pollutants if they are dissolved in water above very low concentrations. When plant material dies and breaks down according to its natural cycle, these same elements are sequestered in the organic material that settles to the bottom of the wetland. This organic layer in turn supports another layer of life as a food source for decomposing organisms. This is the same growth and decay process that happens naturally in wetlands and along stream banks throughout the watershed.

The tall emergent wetland plants, floating aquatic plants, and trees on islands and around the perimeter create shade that blocks the sunlight and heat energy from warming the water during the day. The large surface water area of the wetlands allows for very efficient long wave radiant heat transfer to the atmosphere at night when ambient temperatures are coolest. The climatic conditions in western Oregon are ideal for cooling even during the hottest periods of summer. The night time air temperature is significantly lower than the daytime peak temperature, providing an average air temperature that is cooler than WRF effluent.

Evaporation of water is another mechanism of heat transfer from the wetlands to the atmosphere.

In a densely vegetated wetland, the plants shade the water and reflect or consume the sun’s heat energy so that the amount of heat transferred into the water during the day is less than the amount of heat lost from the water surface during the night. On average, with 2 nights of detention time through a densely vegetated wetland, effluent temperatures can be reduced to approximately average daily air temperatures during the summer months. This means the water temperature will drop by as much as 5°F in July and August, making it suitable for discharge into the Willamette River when cold water fish species are present. This is the same natural shading benefit that cools small streams and wetlands in the dense canopy of a forest or riparian area. The heat energy removed from the combined effluent flow is about 80 Mkcal/day in July and August when ambient temperatures are highest, and about 150 million kilo-calories per day in October when ambient temperatures have cooled. During the cooler weather in the fall the temperature of the water discharging from the wetlands will be up to 10°F cooler than the water from the treatment facilities.

The water entering the Albany-Millersburg WRF is warm primarily because of hot water heaters and is about 72°F in summer. The biological process and energy added with pumped air increases the effluent temperature by another 1°F so that the water entering the wetland from the WRF will be about 73°F in summer. The flow discharged to the wetlands from Wah Chang will have a similar temperature. The summer fish passage water temperature criteria that DEQ established in the TMDL for the Willamette River at Albany is 68°F.

The ability of constructed wetlands to effectively reduce effluent temperature in the Willamette Valley was documented at the Salem Wastewater Treatment Plant (WWTP) wetlands approximately 25 miles north of Albany. Analysis of these constructed treatment wetlands indicated that six acres of fully vegetated wetlands with a water depth of one foot cooled a flow of 1 mgd from 73°F to 64°F during the hottest month of July. More cooling was measured in other months when the air temperature is lower.

Wind

Wind energy moves the evaporated water away from the air/water interface to allow more water vapor to escape and more latent heat of evaporation to transfer heat energy from the water body to the atmosphere and off across the landscape. The dry winds of the Oregon summer drive high rates of evapo-transpiration, which remove heat from the water and plant leaf surfaces.

Wind also creates movement of the millions of tall emergent plants and creates a very efficient mixing zone around the submerged stems as they are pushed back and forth through the water like mixing spoons in a large bowl of soup. Mixing brings the food in the water into contact with the biofilm of organisms attached to plant stems and living at the bottom of the marsh.

Soil

Soil supports the plants and provides the nutrients that plants consume that may not be available in the water. Soil on a microscopic inspection is very much like a wetland, thriving with life of many forms from fungi to arthropods. Soil, like plant stems, is a superstructure matrix that life can attach to and draw sustenance from. The minerals in the Willamette silt loam that makes up much of the soil in the Talking Water Gardens wetlands footprint are the same as the minerals throughout the watershed. Some of these minerals are dissolved as water passes through these soils. The water gains a mineral signature similar to that of a natural wetland anywhere along the Willamette. The mineral signature is one of the mechanisms that fish sense as they work their way up a watershed passing many tributaries remembering the signature of the place where they were born. The water is further transformed to be more like the water in the river as it contacts the soil of the watershed in the wetland before discharging to the river.

Wetlands are great incubators for many levels of the aquatic food chain. The food currently discharged from the WRF outfalls is near the bottom of the food chain and is not readily available for fish. Much of the food that discharges from a wetland is far enough up the food chain that it is a direct source of food for fish. The water discharging from the wetlands will contain many levels of the aquatic food chain and will be transformed to be more like the water in the river.

Topography

Topography of the Talking Water Garden wetlands adds an additional dimension that most wetlands lack. Cascades and waterfalls provide added cooling and aeration. Many of the processes in the conventional WRF are rate limited by the amount of oxygen that can be provided to the bacteria that consume the waste. A large amount of energy is required to pump air into WRF tanks to support the biological treatment process. In wetlands with natural topography the drop from pool to pool can be utilized to increase the oxygen available for supporting biological growth and thereby increasing the treatment rate. Water falling and cascading from one wetland cell to another will dissolve air into the water which is needed by aquatic life. The turbulence of the rushing waterfalls and drops will mix the water like a mountain stream further dispersing nutrients and food throughout the aquatic food chain.

The Talking Water Garden has nine waterfalls ranging in height from 2 feet to 20 feet with an average drop of just under 10 feet and an average flow of about 4 mgd. Waterfalls are similar to small cooling towers where a cascade of water in a fine layer is dropped through a moving air column. The water discharged from the wetland will be cooled by natural processes to be more like the water in the river.

Why spend so much to cool the water when the river is so large and the effects of cooling the combined effluent won't cool the whole river very much? The wetlands project is located at the point where the combined temperature impact from all of the municipal and industrial discharges in the entire watershed is at its maximum. The wetlands project will discharge a plume of much cooler and cleaner water into the river. The cooler Albany wetlands water can provide a critical stepping stone that enhances fish passage from the cool waters at the confluence of the Santiam River downstream to the cool waters at the confluence of the Calapooia River upstream.

Technical Documentation to Support the Municipal/Industrial Partnership

Three analyses were undertaken to document the technical efficacy and net environmental benefits of the wetland treatment system. These analyses included a thermal reduction analysis, a wetland treatability test for reduction of waste constituents other than heat, and a net environmental benefits analysis to compare the wetland treatment system to a more conventional treatment system. These analyses were prepared assuming participation by the Albany-Millersburg WRF, Wah Chang, and Weyerhaeuser (the three entities).

Thermal Reduction Analysis

Several factors affect the thermal treatment capacity of a wetland system including hydraulic retention time, emergent vegetation density, climatic conditions, topographic and bank vegetation shading, channel cross section geometry, and influent temperatures. In order to account for all of these site specific factors, an existing stream temperature model, Heat Source version 7, was modified for this application and was used to evaluate the thermal treatment capacity of the proposed wetland complex.

Thermal Model Calibration

Heat Source version 7 is a numerical mass and energy transfer surface water model that has been validated extensively for prediction of stream temperature dynamics. However, before this effort, the model had not been validated for wetland temperature dynamics. As part of this work, the Heat Source version 7 code was modified to account for thermal dynamics within a wetland dominated by emergent vegetation. Using raw water temperature and flow monitoring data provided by the City of Salem for the Salem natural treatment wetlands, CH2M HILL and Watershed Sciences worked together to modify the Heat Source version 7 code and calibrate the model to reproduce measured wetland effluent temperatures. After calibration, the model predicted hourly wetland effluent temperatures over 20 months of data and under dramatically varied conditions of influent flow rates, temperatures, open water area, and climatic conditions with an correlation coefficient of 0.95 to 0.96 and a root mean square error (RMSE) of 1.0 to 1.3˚C.

Thermal Loading Evaluation

Six separate wetland physical configuration models were modeled to account for all effluent flow stream combinations. All wetland models predicted cooling of effluent throughout the entire year as expected.

Wetland effluent temperatures predicted by Heat Source were checked against TMDL waste load allocations using a spreadsheet tool provided by DEQ to the City of Albany. Results of this analysis indicated that the proposed wetlands are sufficient to meet the permit requirements of all three entities under the most conservative excess thermal load (ETL) analyses.

Results of the Heat Source model for the Phase 1 wetlands are shown in Figures 1 and 2. The Phase 1 wetlands will treat combined effluent from the Albany-Millersburg WRF and ATI Wah Chang; these are discussed in further detail in a later section of this case study.

Figure 1 shows the difference in temperature between wetland influent and wetland effluent.

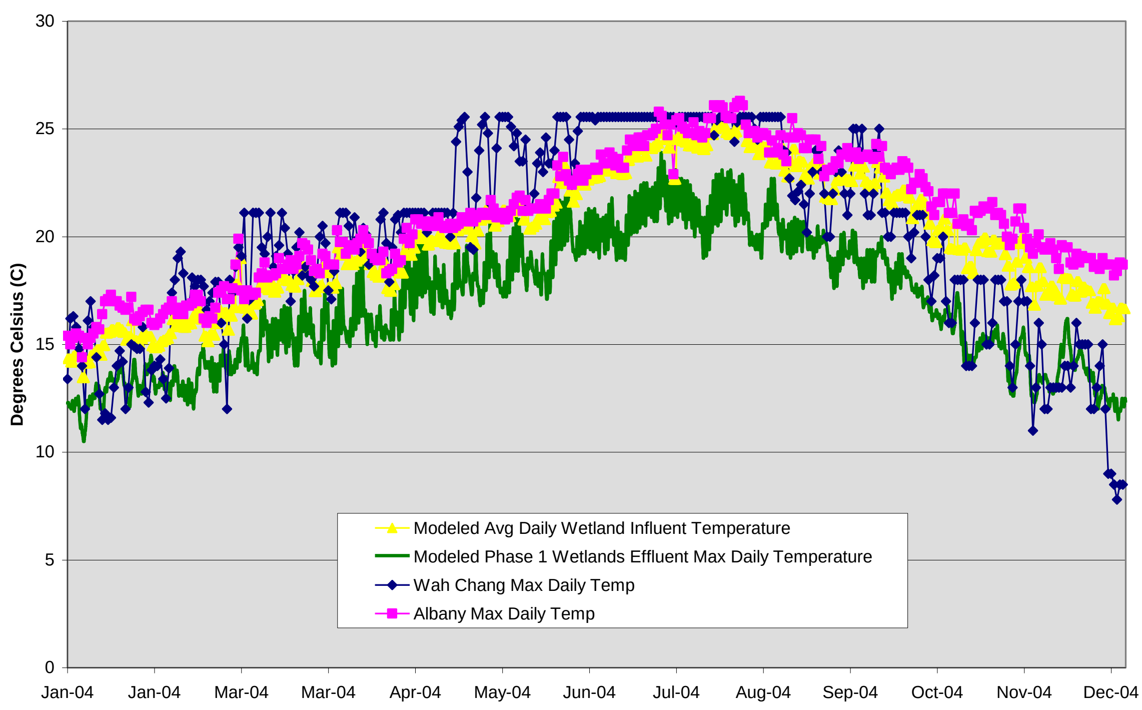

Figure 1. Results of Thermal Modeling of the Phase 1 Wetlands

The solid colored lines in Figure 2 show the thermal waste load allocation allowed by the TMDL for each year between 2001 and 2006. The dotted lines represent the excess thermal load carried by the combined Albany/Wah Chang effluent in 2004 without cooling in wetlands (light green line) and with cooling (light blue line). 2004 was used as a reference benchmark year because of the record high temperatures experienced in July. The figure shows that the Phase 1 wetlands effectively cool the combined effluent below TMDL limits, even in the hottest year on record.

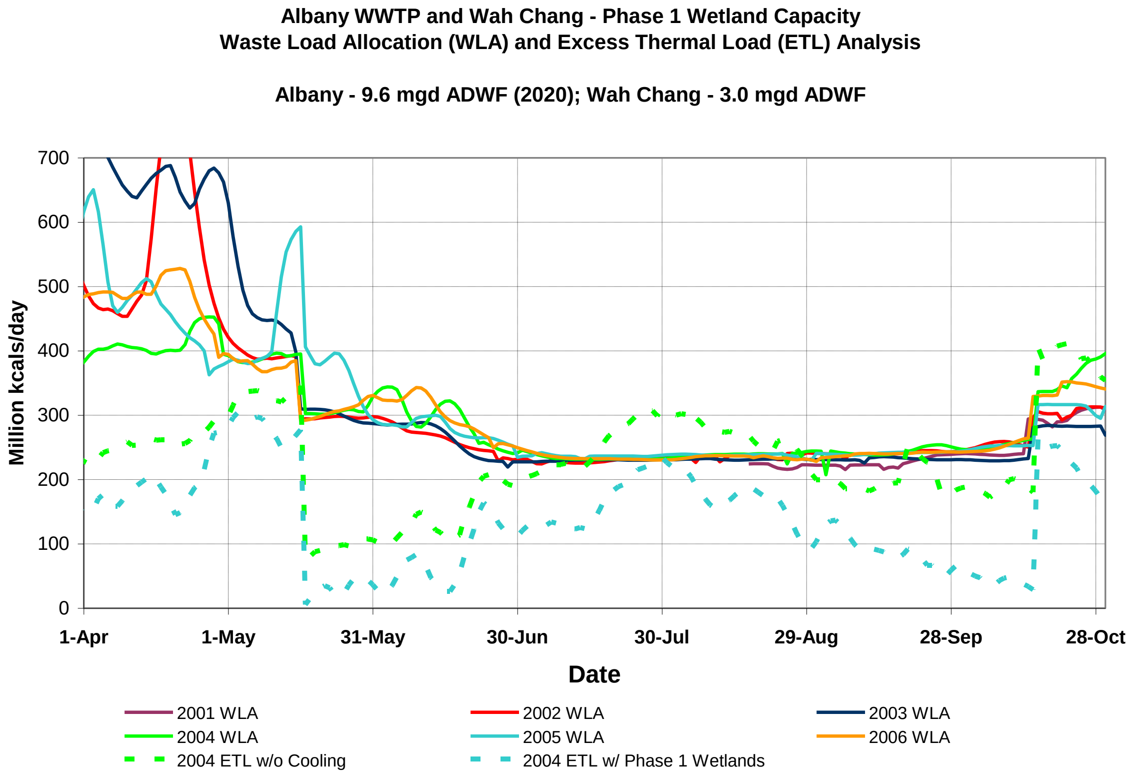

Figure 2. Results of Thermal Modeling of the Phase 1 Wetlands Compared to TMDL Limits

Overall, the thermal evaluation concluded that wetlands can provide a significant cooling benefit for effluent discharged by the three entities and can be used to comply with the new permit requirements for thermal discharge to the Willamette River.

Wetland Treatment of Other Constituents

Wetland Mesocosm Pilot Study

In order to test the treatment effectiveness of an integrated wetland system for waste constituents other than heat, a wetland mesocosm test was carried out at the Albany-Millersburg WRF.

The tests involved setting up a series of nine treatment cells containing mesocosms of wetland soil and plants. The cells were established at the WRF in empty open-top polyethylene shipping totes (3 × 3 x 3 foot cubes) with a volume of approximately 1 cubic yard. Different mixtures of wastewater from the three entities were added as batches to the treatment cells and water samples were collected over time to test the ability of wetlands to remove pollutants. Wastewater samples were tested for analytes such as biochemical oxygen demand (BOD), ammonia, nitrate, metals, total dissolved solids (TDS), and methyl isobutyl ketone. Tests were conducted in three separate runs with wastewater from the previous run drained before initiating the next run.

The mesocosms were set up to represent the range of scenarios for treatment wetland operations including each wastewater being treated individually and potential combinations of wastewater from possible combined treatment schemes.

Table 1 describes the source of the wastewater in each tote and test duration during the three test runs.

TABLE 1. *Source of Wastewater added to Treatment Wetland Mesocosms*

Tote	**Run 1** **6/7/06 → 6/13/06**	**Run 2** **7/10/06 → 7/13/06**	**Run 3 High BOD** **7/25/06 → 8/1/06**
1.	Control (potable water from Santiam River treatment plant)		
2. Albany-Millersburg only	100% Albany Wastewater		
3. Wah Chang only	100% Wah Chang Wastewater		
4. Weyerhaeuser only	100% Weyerhaeuser Wastewater		
5. Albany-Millersburg & Wah Chang	70% Albany-Millersburg/ 30% Wah Chang	80% Albany-Millersburg / 20% Wah Chang	
6. Albany-Millersburg & Weyerhaeuser	41% Albany-Millersburg / 59% Weyerhaeuser	55% Albany-Millersburg / 45% Weyerhaeuser	
7. Wah Chang & Weyerhaeuser	23% Wah Chang / 77% Weyerhaeuser		
8. & 9. (replicates) Albany-Millersburg, Wah Chang & Weyerhaeuser	35% Albany-Millersburg / 15% Wah Chang / 50% Weyerhaeuser	49% Albany-Millersburg / 12% Wah Chang / 40% Weyerhaeuser	

Wetland Mesocosm Construction and Testing

The wetland mesocosms were constructed from clean, open-top polyethylene totes in wire support frames capable of being moved with a fork lift when full of fluid. Topsoil from one of the potential full-scale wetland sites was used for the base 1 foot of soil in each of the nine mesocosms. The topsoil used came from the top 1 foot of the proposed full-scale wetland site but did not include significant vegetation such as grass and shrubs, although roots and organic matter were allowed. The mesocosm wetlands were inoculated with a 2-inch layer of wetland sediment from a municipal effluent treatment wetland at nearby "The Oregon Garden" to provide immediate availability of micro and macro organisms acclimated to wastewater effluent.

Approximately 10 mature cattail tubers were planted in each mesocosm tote amongst other wetland plants such as hydrocotyle, duck weed, and Mexican water fern to provide approximately 80 percent cover of the water surface for shade. Water from the treatment wetland was added to saturate the soil and provide 1 inch of depth.

The totes were placed in a full sun location where they remained undisturbed for the duration of the three test runs. The totes were allowed to stand for 2 days before effluent was added to allow consolidation of the sediment and soil. Approximately 18 inches of effluent was added to each tote at the beginning of each run. Water level was measured daily to track evaporation losses. Figure 3 illustrates the primary features of each of the nine wetland mesocosm cells used in the test.

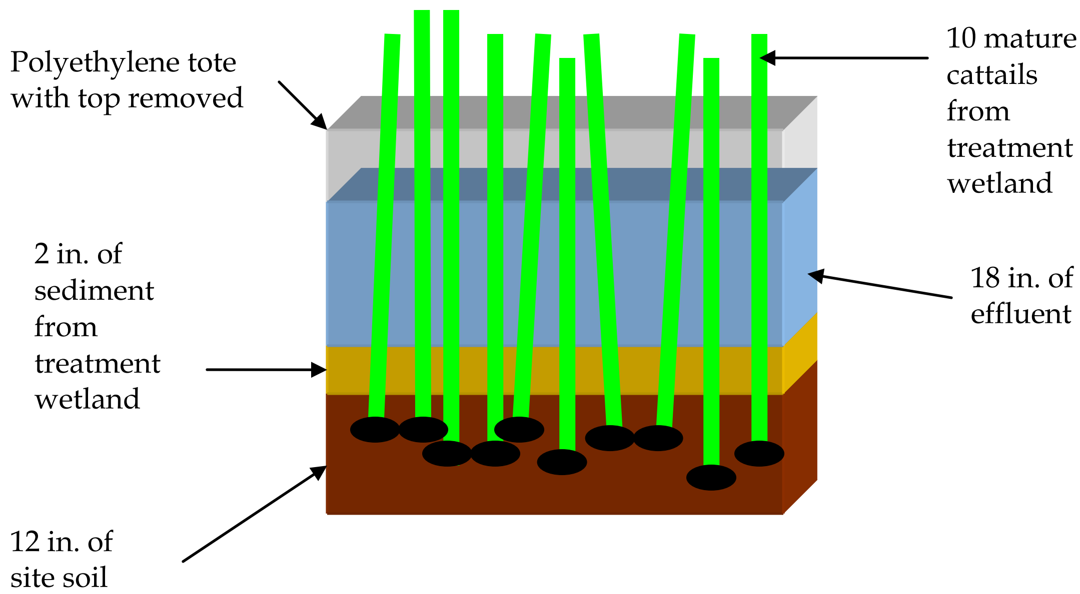

Figure 3. Wetland Mesocosm Test Unit Schematic

Primary samples were analyzed for TDS, electrical conductivity, total suspended solids (TSS), BOD, total Kjeldahl nitrogen (TKN), NH_4-N, NH_3-N, NO_2-N, NO_3-N, total phosphorus (P), temperature, dissolved oxygen (DO), pH, chloride, sulfite, sulfate, and total residual chlorine. Some analyses were not completed for every test and many results were below detection limits. However, the resulting data provide a much improved understanding of the treatability of the effluents individually and combined in likely mixes.

Some samples were additionally analyzed for *Escherichia coli*, total residual chlorine, lead, copper, silver, mercury, fluoride, and zinc. The samples containing any amount of Wah Chang effluent were analyzed for ammonium thiocyanate, methyl isobutyl ketone, and free and total cyanide at these same time intervals. The sampling and analysis methods and procedures match the methods and procedures currently used for DEQ permit compliance reporting.

Results of the Wetland Mesocosm Tests

The resulting removal rate constants for BOD, ammonia, and nitrate were higher than predicted from a national data base of representative treatment wetland performance, as summarized in Table 2.

Table 2. Removal Rates

	BOD	**NH_4-N**	**$NO_{2\text{-}3}$-N**
Pilot areal rate constant, 20°C	143	51	42
Literature areal rate constant, 20°C	34	18	35
Effluent concentration (mg/L) with pilot K	6.5	1.1	2.2
Effluent concentration (mg/L) with literature K	12.3	1.9	2

The removal rate for the combined wastewaters was significantly greater than predicted and was greater than any of the individual wastewaters. This symbiosis of combined wastewaters indicates a reaction between wastewater constituents and a more balanced ratio of constituents available for higher-rate microbial consumption. These findings are illustrated in the nitrate removal curve shown in Figure 4.

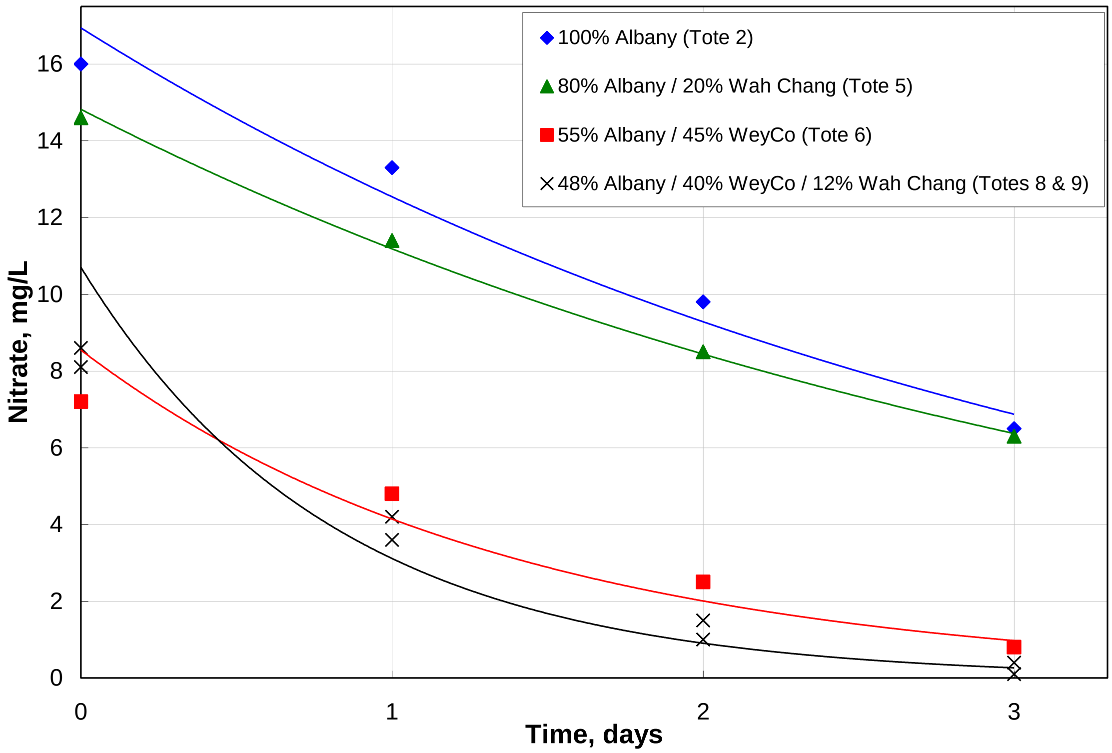

Figure 4. Nitrate Removal in Blended Effluent

Wetland Treatment Model Predicts Removal of Priority Pollutants and Other Constituents

A proprietary treatment model based on current wetland science was used to estimate removal of a wide variety of pollutants. Removal constants used in the model for BOD, ammonia (NH_4), and nitrate and nitrite ($NO_2/_3$), were derived from data developed in the wetlands mesocosm pilot study. The model estimated that the Phase 1 wetlands will reduce the concentration of several constituents below the most stringent regulatory limit. These include removal of the priority pollutants copper, cyanide, and lead below the Oregon Water Quality Toxic Criteria. The excess percent removal above the most restrictive limit is summarized in Table 3.

Table 3. Phase 1 Talking Water Gardens Excess Percent Removal over Most Restrictive Limit

	BOD	TSS	NH_4	Pb	Ni	Zn	Cu	Cr	Hg	Oil & grease	Sb	Cd
Excess % Removal	60%	16%	18%	81%	94%	52%	31%	73%	51%	84%	100%	56%
Most Restrictive Limit, mg/L	10	10	2.5	0.0032	0.16	0.11	0.012	.011	0.000012	10	0.146	0.0011

The percent removals shown in Table 3 translate to thousands of pounds of waste material being kept out of the river on an annual basis. Annual load reductions for BOD, TSS, and NH_4-N are summarized in Table 4.

Table 4. Comparison of Loads Before and After Wetland Treatment

	$CBOD_5$	TSS	NH_4-N
Before treatment (lb/day)	528	1,066	322
After treatment (lb/day)	337	715	159
Reduction in Load (lb/day)	191	351	162
Annual Reduction in Load (lb/yr)	69,563	127,984	59,296

Net Environmental Benefit Analysis

The project area historically contained braided channels, back waters, and alcoves. Before 1850, the river had more secondary channels, sloughs, islands, and riparian forests than there are today. A reconnaissance study of the river by the U.S. Army Corps of Engineers done at periodic intervals since 1850 indicates that the mainstem of the river has not strayed far from its original oxbow channel just north of Albany, although there has been a loss of perennial surface water connection to many sloughs and side channels just east of the river including Cox Creek Slough, and Second, Third, and Fourth Lakes in the intervening years (Willamette River Basin Atlas, 2nd Edition). Creating and restoring wetlands can greatly benefit the ecosystem proximate to the Albany-Millersburg WRF, Wah Chang, and Weyerhaeuser, and adjacent to the Willamette River and tributary lakes.

A preliminary Net Environmental Benefits Analysis (NEBA) was performed to compare the relative ecological performance of constructed wetlands treatment versus conventional wastewater treatment. NEBA quantitatively estimates the losses and gains of valued ecosystem services, and is a tool for selecting and defending the preferred treatment alternative. The analysis was based on the following attributes of the existing (baseline) landscape and the future landscape under each of the two treatment alternatives:

- Wetland acres
- Hydrology
- Horizontal interspersion or diversity of habitat
- Connectivity to river system
- Sediment removal
- Primary production and organic export
- Native plants
- Vertical stratification
- Groundwater recharge
- Habitat disturbance

The NEBA did not attempt to value other important performance objectives such as water quality and aquatic habitat improvements or construction costs, among alternatives; instead, these values were assumed to be equal among the considered options.

Comparative analysis showed that the constructed wetlands treatment alternative would provide about a 2.5 times greater amount of valued ecological services than the conventional wastewater treatment alternative. The implication of the analysis is that landscape changes under the constructed natural wetlands treatment option would produce more ancillary environmental benefits than conventional treatment would, at least for the ecological functions and assigned values used in the analysis. Because of high value forests identified in the NEBA, the original wetland footprint was relocated to preserve both riparian and oak savannah forest habitat.

This integrated wetland project is expected to provide greater overall environmental benefits than traditional approaches. It will function to educate and inform the public and the regulatory community about the benefits of wetlands treatment to reduce thermal loads and other pollutants. It will also demonstrate the overall environmental benefits that can be realized when several dischargers in a watershed work together to develop more effective treatment solutions.

Combining Effective Treatment with a Public Amenity: Phase 1 Treatment Wetlands

Based on the wetland treatability tests for reduction of heat and other waste constituents and the net environmental benefits analysis, the integrated wetland system emerged as the most sustainable, effective long-term solution. Further development of the idea resulted in the first phase Talking Water Gardens at Simpson Park.

The first phase will treat combined effluent from the Albany-Millersburg WRF and ATI Wah Chang. The Phase 1 wetlands are projected to provide capacity for thermal load compliance through 2020 with an average dry weather flow of 12.6 mgd. The Phase 1 wetlands provide approximately 1.6 days of detention time for effluent cooling.

Operational factors important to providing wetland performance to meet these projections include the following:

- Flows must be well balanced through all wetland cells to provide uniform HRTs across the site especially during peak ETL periods.
- Open water surfaces need to be maintained at 10 percent or less through ongoing vegetation management.

The natural treatment system will be developed on 50 acres surrounding the old Simpson Lumber Mill site, providing a direct connection to the history and culture of the Cities. Complete design criteria for the Phase 1 wetlands are provided in Table 5.

Table 5. Design Criteria

Item	Description	2010	2020	2030
Flow Summary				
	Albany-Millersburg WRF Peak Hour (mgd)	14	14	21
	Albany-Millersburg WRF Minimum Hour (mgd)	3	-	-
	Albany-Millersburg WRF Avg. Dry Weather (mgd)	8.6	9.6	12.3
	Wah Chang Effluent Peak Hour	6	6	6
	Wah Chang Effluent Minimum Hour (mgd)	0.7	0.7	0.7
	Wah Change Effluent Average (mgd)	3	3	3
Design Storms				
	Temperature Compliance	2 yr		
	Conveyance	25 yr		
	Check Storm	100 yr		
Berms/Trail System				
Primary Pedestrian Trails				
	Side Slope	3: 1 H:V		
	Top Width	8 ft		
	Maximum Longitudinal Slope	5%		
Pedestrian Trail to Southern Influent Mound				
	Side Slope – Bound by Handrails	2: 1 H:V		
	Top Width – 2' buffer edges @5%	8 ft (12 ft total w/ buffers)		
	Maximum Longitudinal Slope	5%		
Maintenance Access Pathways				
	Side Slope	2: 1 H:V		
	Top Width	8 ft		
	Maximum Longitudinal Slope	30%		
Pressure Pipe from WRF to Wetland				
	Maximum Velocity	7 ft/s		
	Minimum Diameter	30 inches		
All Other Influent Conveyance Pipes				
	Flow	Convey maximum flow with available head pressure only		
	Maximum Velocity	≤ 8 ft/s		
Stilling Basins/Inlet Control Weirs				

Table 5. Design Criteria

Item	Description	2010	2020	2030
	Approach Velocity	< 3 ft/s		
Outlet Weirs for Water Surface Control				
Limit diurnal fluctuation to 3 inches				
Maintain adequate freeboard during conveyance storm				
GENERAL NOTES AND CONSTRUCTION INFORMATION				
Earthwork				
	Wetland Grading Tolerance	+/- 0.15ft		
	Berm Grading Tolerance	+ 0.3 ft, - 0 ft		
	Berm Compaction	95% of maximum at optimal moisture		
	Berm Compaction Tolerance	+/- 2%		

Phase 1 of the project includes 37 acres of constructed wetlands, linked by a series of interpretive trails enhanced by the presence of educational signs and local art. Trails of various lengths are designed to accommodate a wide range of visitors, including toddlers, senior citizens, and wheelchair assisted individuals. New trails at the Gardens tie into the existing Waverly Lake and Simpson Park trails. Later phases will include more wetland area and more trails.

Several wildlife species are expected to find a home in the varied habitats. Throughout the site, willow trees provide shade over open water areas, while dense wetland vegetation provides shade as well as nesting habitat for migratory and resident birds. The variety of vegetation that will be used at Talking Water Gardens is shown on the landscaping plan in Figure 5.

Figure 5. Landscaping Legend for Talking Water Gardens Phase 1 Treatment Wetlands

Natural topography of the site adds visual interest and a variety of overlooks and viewpoints. Wetland berms are more sinuous than those typically found at constructed wetlands to provide a more natural feel to the park. Cool Creek, a naturally shaped constructed channel, moves water out of the wetland system and back to the WRF river diffuser outfall. Cool Creek runs parallel to a trail, above the Cox Creek Slough and Willamette River. Eventually the creek will connect directly to Cox Creek Slough.

A 3-D earthwork model was developed during the design phase. Figure 6 shows a computerized rendering of how the wetlands will look after the vegetation is fully established. This rendering was generated by superimposing a colored pencil overlay on the 3-D earthwork model to accurately illustrate the design topography and plant communities.

Figure 6. A colored-pencil overlay on the3-D earthwork model shows variation in topography at the Gardens.

Talking Water Gardens is named for the sound of the influent waterfall, a focal point of the landscape, which provides aeration as the water cascades over rocks. The influent waterfall, as conceptualized by the landscape architect who will oversee the building of the waterfall, is shown in Figure 7.

Figure 7. The Influent Waterfall as Envisioned by the Landscape Architect, Kurisu International

Eventually, a visitor's center will provide an opportunity for visitors to learn about the Gardens, the Willamette River, the water cycle, and the way that water and history are intertwined in the basin.

Water Blending and Monitoring

Storage and flow pacing of the treated water from Wah Chang, which is produced at a relatively constant rate of 3 mgd, will allow delivery to the wetlands to be at a variable rate that matches the diurnal flow rate of the WRF. The WRF flow rate can fluctuate from 3 to 10 mgd even on an average day, with low flows at night and high flows during the day. Delivering water from both treatment facilities at rates that fluctuate together allows the waters to be blended at a relatively constant ratio. Monitoring for permit compliance for the Wah Chang water will be at the Wah Chang WWTF. Compliance will be met for all discharge parameters except temperature and TDS before delivery to the wetlands. The Albany-Millersburg WRF water will be monitored for all discharge permit parameters and meet discharge standards for all monitored parameters except temperature before discharging to the wetlands. The Wah Chang water contains TDS or salt that can be easily monitored and used as a tracer to control blending rates. The Wah Chang water has about 5,000 mg/L of TDS and the WRF water has about 400 mg/L TDS.

The wetland complex includes nine wetlands cells connected as three parallel treatment trains so that three different blends of Wah Chang and WRF water can be used. The target blend ratios will result in the northern wetlands having a TDS concentration of 2,500 mg/L, the central wetlands having a TDS concentration of 1,500 mg/L, and the southern wetlands having a TDS concentration of about 800 mg/L. All of the water is blended together after wetlands treatment before discharging to the river through the existing WRF outfall diffuser, which provides over 500:1 dilution in the mixing zone of the river.

Project Cost and Funding

Talking Water Gardens total project cost for Phase 1 is $13.75 million. This includes engineering design and construction management, land acquisition, and the construction of the wetlands including the internal pipelines and earthwork, pump stations and pipelines required to transport water, plantings, and flow control structures. The project received $8 million in federal funding via the American Resource and Recovery Act of 2009, administered in Oregon via the Clean Water State Revolving Fund. The Cities contributed $2.5 million and ATI Wah Chang contributed $3.25 million for its share of the project. The company is also making other significant improvements to its treatment facilities.

Recreational amenities, public art, kiosks, additional landscaping, and a potential visitor's center are planned to be added in the future as funding becomes available, and are expected to cost an additional $5 million.

Project Status

The groundbreaking ceremony for the Phase 1 wetlands was on February 12, 2010. The project is currently under construction and is expected to be completed by May 2011. The wetland vegetation is expected to be fully grown and providing maximum benefit by May 2012. The Talking Water Garden will use treated effluent during construction for compaction and plant establishment. Flow at a reduced capacity will be introduced to the wetlands on a regular basis starting in May 2011 to grow healthy plants. WRF water will continue to irrigate about 13 acres of upland landscaping on the wetlands perimeter as a beneficial reuse for urban park irrigation. In 2012, the natural treatment system will perform at full capacity and Talking Water Gardens will be opened to the public.

The Connection to Community

The Talking Water Gardens at Simpson Park reconnect the Cities to their common water heritage. The Gardens revitalize the Simpson Lumber Mill site and connect to the existing park and trail system.

This project is exceptional in several ways. It is original in concept, it employs new techniques in modeling of treatment wetlands for temperature reduction, it incorporates and turns to advantage the natural complexity of the topography and oxbow lakes adjacent to the various facilities, it forges a mutually beneficial partnership between two municipalities and industry, and it results in a treatment system that effectively addresses new regulatory challenges while creating ancillary social, environmental, and economic benefits.

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This project reflects years of collaboration and cooperation amongst a diverse group of participants. Thanks for the successful design and implementation of this project goes to:

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