Florida Department of Transportation
Aviation and Spaceports Office

Technical Report on the Water Management Performance of the FAA Pond at Naples Municipal Airport

FAA Pond Post-Construction Monitoring

Contract C9889

Task Order #7

January 2016

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EXECUTIVE SUMMARY

The Naples Municipal Airport (APF) water management system was retrofitted through a multi-phase, multi-agency cooperative effort addressing stormwater management. As part of a public transportation facility, the stormwater system must provide safe, effective water management. With environmental and ecological interactions, the system must meet regulatory requirements to control water chemistry loads, limit or prevent flooding, and minimize wildlife attractant features.

The current 2014-2015 Phase III study is a culminating study from two previous studies that focused on the APF water management system. These studies included a retrofit design for existing pond 212 at APF which is the focus of the current Phase III study that examines the hydrodynamic and load-response of retrofitted pond 212. In the 2012-2013 APF Phase I study, four retrofit gabion (from 7 to 17) design scenarios were developed and modeled for pond 212 using computational fluid dynamics (CFD). Retrofit design constraints focused on (1) minimizing wildlife attractants by maintaining the existing water surface area and eliminating several littoral areas, (2) maintaining the existing pond hydraulic capacity as an on-line conveyance for the existing drainage system, (3) maintaining the context sensitive nature of the pond as a landside water amenity for the local Naples environs, and (4) providing load reduction by the retrofit. In 2013, the final design of 12 internal subsurface gabions was chosen by stakeholder review and the retrofit subsequently constructed in the first half of 2014 during Phase II. With the retrofitted pond 212 meeting design constraints 1, 2, and 3; Phase III examined the hydrodynamics and load-response behavior for particulate matter (PM, as total suspended solids, TSS), total phosphorus (TP) and total nitrogen (TN) for 10 monitored storms during the latter half of 2014 and into 2015.

A summary of the loading context for pond 212 is critical. Pond 212 is a small on-line conveyance pond (surface area < 2% of watershed area) subject to significant, multiple and continuous hydraulic, watershed and ambient loads. The pond has a complex hydraulic connectivity to up-gradient, down-gradient, groundwater and offsite irrigation flows. The pond conveys four separate stormwater pipe inflows from watershed catchments, unconfined groundwater above a limestone cap just below the pond invert, offsite irrigation interflows, and a relatively small volume of sheet flow from peripheral areas. Pond 212 is directly connected to pond 208 through multiple 5x8 ft. box culverts. Pond 208 controls the conveyance from pond 212 and there are re-circulating flows between ponds 208 to 212. Pond 212 and 208 function as one hydraulically-contiguous pond of two cells with direct hydraulic interactions. There is one surface weir and orifice point discharge from pond 208 to Rock Creek but the system can be subject to occasional tidal influence based on salinity gradients. This weir is the only point surface discharge except during tidal influence.

Retrofitted pond 212 has a 3.2 acre mean water surface area and 33 acre-feet of volume and is loaded by approximately 170 acres of commercial off-site and APF catchments. The pre- and post-retrofit pond 212 area/volume conditions were not changed with internal underwater gabions. Physical and CFD-SWMM modeling of pond 212 hydrodynamics in the form of residence time distribution (RTD) results produced a transit time (from initial inflows and outflows) on the order of one day with an elution of approximately five days. The major inflow from the northeast (NE) 54-inch equivalent diameter pipe conveyance produced continual, albeit stochastic hydraulic loadings to pond 212. Proximate to, and of the same size as the NE, the north (N) conveyance from APF pond 214 through the grassed north ditch along Airport-Pulling road, conveys more discernable storm-based flows to pond 212. The smaller east (E) and west (W) pipe conveyances, 15-inch and 18-inch respectively generate only storm-based flows from their smaller and shorter lag time catchments. The storm-based flow component from the NE conveyance is approximately equivalent to the combined storm-based flows from the N, E and W conveyances into pond 212.

Storm events from 12 September 2014 (event 1) to 24 July 2015 (event 10) had rainfall from 0.74 to 3.18 inches and median of 1.26 inches. Event-based combined inflows (NE, N, E, W irrespective of inflows from pond 208) ranged from 14.7 acre-feet to 51.3 acre-feet and median of 27.2 acre-feet. Event-based net outflows (from SE, SM and SW box culverts connecting pond 212 and 208) ranged from 4.5 acre-feet to 57.2 acre-feet and median of 7.4 acre-feet. Inflow and outflow volume differences are largely due to re-circulating flow from pond 208, continuous inflows, groundwater interactions, evaporation and less than robust velocimeter behavior. Event-based detained volume had nominal to negligible values. Rainfall, inflow volume, outflow volume and nominal to negligible detained volume did not generate a consistent pattern or order.

Event-based load-response of pond 212 to each of the 10 monitored events was examined for water chemistry analytes. Over the entire monitoring campaign the mass separation was: 60% for PM (as TSS), 46% for TP and 23% for TN. If the load-based response is examined on a more continual representative basis (presented in Tables 3-5 and 44) the mass separation is 88% for PM (as TSS), 78% for TP and 44% for TN despite the biologically-young retrofit. If pond 212 had been retrofitted for load reduction based on presumptive criteria for residence time and sizing (21 day or ERP design) the pond surface area would require 10 to 15 acres, three to five times larger than the current area; significantly increasing the wildlife hazard risk; but with a similar load reduction. Standard pond designs have a total cost, including land but excluding hazard costs associated with increased wildlife hazard, of five or more times of the pond 212 design with no net load benefit.

Results demonstrate significant load reduction can be produced by a pond with a surface to watershed area of 2% and retrofitted with permeable underwater gabions of recycled crushed carbonated concrete to create a primary flow path tortuosity of greater than 6. Recommendations for future extensibility are: (1) create CFD-based design tool for a representative FL-based geometry from pond 212/208 concepts which requires (2) robust in-situ monitoring devices for hydraulics, sampling, volume balances of pond 212/208 system, (3) monitoring to approximate the time series of intra- and inter-event pond load-response and nutrient-algae transport/fate, (4) a 212 curtain system to ameliorate short-circuiting, and (5) monitoring pond 212/208 groundwater, and design/monitoring a polishing sorptive/filter for pond 208 outflows from the 8-inch orifice.

1 INTRODUCTION AND SCOPE

Based on previous physical and computational modeling the treatment effectiveness (as PM separation) of stormwater treatment systems primarily depends on the hydrodynamic conditions established within the system. PM separation and nutrient treatment functionality is strongly affected by residence time distribution (RTD), not presumptive indices of residence time. One method to enhance treatment is the placement of baffles in a treatment system so that the system is volumetrically improved (no dead zones or short-circuiting). In such a system, flow is more evenly distributed, reducing short-circuiting, improving volumetric utilization and residence time distributions (RTD); maximizing the hydrodynamic distance from inlet to outlet, and approximating a plug flow reactor (PFR) system. For these reason, a unit operation and process (UOP, commonly best management practice, BMP) system such as pond 212 was retrofitted by placing baffles within the volumetric system, to improve the performance of the otherwise small on-line conveyance wet pond. Such an internal retrofit can potentially provide improved functionality without requiring additional area and volume.

The hydraulic response and treatment provided by stormwater systems have been traditionally studied using "lumped" parameters, such as surface overflow rate (SOR) defined as outflow (or a weighted combination of inflow and outflow) divided by the surface area of the pond or clarifier. In the last decades, in contrast to these traditional methods, advanced tools such as CFD have become a defensible approach to model the hydraulic and constituent behavior of stormwater treatment systems; with conventional methods incapable of representing the coupled hydrodynamic and water chemistry complexity of such systems. The CFD method is based on numerically solving the fundamental equations of multi-phase fluid flow, the Navier-Stokes (N-S) equations. CFD is especially powerful when the system is subject to non-ideal conditions, such as complex flows typical of runoff, heterogeneous multi-phase loadings and complex geometries which often are not possible to model accurately using the traditional methods. While a hydrodynamic model solves and simulates the flow field in CFD, a discrete phase model (DPM) is used for particle matter (PM) transport and fate. The latter approach is coupled with granulometric data, such as particle size distribution (PSD), chemical distribution with PM [for example mg/g] and specific gravity of PM to obtain the PM-based and solute transport and fate characteristics of the system.

Previous studies indicate that a CFD model is a feasible and efficient tool to evaluate and predict the UOP behavior under disparate, multiple and highly unsteady flow conditions based either on unsteady and step-wise steady CFD simulations. Once calibrated/validated, the CFD model can be utilized as a design tool comparing different geometrical configurations and layouts, avoiding the time and costs associated with physical testing of each configuration. Additionally, three-dimensional description of PM and solute transport and fate which may not be feasibly and clearly discerned from physical models, but can be simulated by CFD at each point within the system.

Beyond this general introduction, a summary of the directly related projects and phases that led to the Phase III is required as a background for the Phase III study. Previous Florida-based airport studies have demonstrated the efficacy of overland flow as a BMP for airport stormwater management. For example, the BMP Manual demonstrates the conditions where overland flow can be the primary practice for airside stormwater management. However, overland flow is not an adequate stormwater BMP for an estimated 20 to 30 % of airport airside projects. In these cases, continuously wet, stormwater management ponds are a potential BMP. Such ponds must be designed to minimize wildlife attractant features while providing hydrologic modification and load control. The Federal Aviation Administration (FAA) and United States Department of Agriculture (USDA) have set forth generic guidelines for stormwater management ponds in the FAA Advisory Circular (AC). These general guidelines recommend the construction of deep, steep-sided ponds without emergent vegetation. However, these guidelines do not conform to standard "presumptive" pond design criteria of the Florida WMDs or FDEP. Furthermore, detailed design experience and monitoring from FAA and USDA does not exist for these ponds; only general features that are intended to minimize ponds as avian and wildlife hazards.

The current Phase III of the Naples Municipal Airport (APF) Water Management System Improvement and Taxiway Extension Planning and Design was founded on two previous phases. These first two phases guided the purpose, scope and have implications for the results of Phase III. As such, the framework of Phase I and II as a required background to Phase III is presented.

Phase I

A Phase I deliverable was pond 212 characterization of the ambient water chemistry of pond 212 in a pre-retrofit condition as well as the benthic sediment of pond 212 utilizing grab samples. Synthesizing water chemistry and pre-retrofit bathymetry, the second primary deliverable was a computational fluid dynamics (CFD) model to develop the retrofit design alternatives of pond 212. All designs were constrained to the existing pond 212 surface area, depth and existing conveyance structures since pond 212 functions as an on-line conveyance pond as shown in Figure 1, connecting air- and landside (commercial) drainage systems and watersheds shown in Figure 2.

Within Phase I, as part of examining the loading inputs to pond 212, water chemistry sampling was conducted for pond 208 which is immediately south of pond 212 and directly hydraulically-connected to pond 212 through a series of box culverts; and pond 214 which discharges into the north end of pond 212 through a large grassed conveyance (the North ditch) along the west side of Airport-Pulling Road. An additional two ponds, isolated from pond 212, were sampled. A total of eight sets of grab samples were collected at 20 locations in ponds and open channels. Samples were be collected twice monthly during July through October 2012. Water column sample analysis included the water chemistry parameters of pH, specific conductance, dissolved oxygen, water temperature, total suspended solids (TSS), total nitrogen (TN), total Phosphorus (TP), total copper (Cu), total lead (Pb) and total zinc (Zn). Benthic sediments were collected from two locations in each of five ponds and analyzed for particle size distributions (PSDs), Pb, Cu, Zn, polycyclic aromatic hydrocarbons (PAHs), and organo-chlorinated pesticides. These aqueous and particulate-phase results along with the program criteria were coordinated with SFWMD and the stakeholder group composed of FDEP, the four other WMDs, the FDOT and the FAA. As part of the coordination, regular meetings were held with the stakeholders (including the Naples Airport's Management) to update and discuss the project data and models, design alternatives, features and modification of program attributes based on the results as necessary.

As part of Phase I, the CFD models for pond 212 were developed as the required tool for the proposed retrofit design alternatives presented to the stakeholders. The CFD models for a series of separate retrofit design were used to predict water chemistry load discharges from pond 212. The water chemistry, PSDs and bathymetry data were used to develop and calibrate the CFD models. CFD models examined the hydrodynamic and load transport/fate for a series of alternative retrofits for pond 212 within the constraints of existing pond 212 geometrics (alternative retrofit designs fit to existing surface area, depth and conveyances). In order for the alternative retrofit designs to meet these constraints, subsurface permeable baffles were designed for the bathymetry and existing conveyance structures of pond 212. The long linear nature of pond 212 in 2012 favored a design that converted the short-circuiting behavior of existing pond 212 as a conveyance pond, into a permeable serpentine baffled plug-flow type hydrodynamic system. In Phase I there were three alternative internal designs proposed to stakeholders with 7, 13, 17 baffles, designed as three-foot wide permeable gabion baffles constructed from carbonated recycled concrete (CRC) crushed to a nominal two to four inch equivalent diameter. The hydrologic loading metric used to test each design was a mean annual 24-hour design storm (2.33-year return storm for Naples, FL). The PSD and constituent partitioning metrics were based on ambient water chemistry and PSD data from existing pond 212. At the end of Phase I stakeholders recommended a 10 baffle design.

Phase II

Phase II began in the summer of 2013 with a new retrofit design for pond 212 that provided 12 three-foot wide L-shaped permeable gabion baffles based on the Phase I CFD model developed for the new design and subject to the mean annual design storm. This new design was required based on the volumetric reduction and elimination of baffles for pond 214 from Phase I. The 12 baffle design illustrated in Figure 3 and in Figure 4 with respect to pond 212 bathymetry, was shown by CFD to provide load reductions equal to or greater than the 10 baffle design from Phase I; recommended by stakeholders in October 2012. Ambient water chemistry from pond 212 and 208 as well as from the receiving water, Rock Creek indicated that based on salinity profiles that pond 212 could be subject to tidal influences through direct hydraulic interactions with pond 208. The CFD model assumed that pond 212 discharged into pond 208 although surface water stages and hydrodynamic interactions between pond 212 and 208 were unknown at the time, other than salinity profiles indicated that pond 208 could generate inflows into pond 212. Leaching tests using pond 212 ambient water were conducted on the CRC gabion media. The results indicated that there was no statistically significant leaching of TN and a statistically significant TP reduction (from 0.21 mg/L to 0.04 mg/L) in the water column by precipitation/sorption. Before the pond 212 retrofit, ambient water chemistry grab sampling continued to examine if there was any influence from pond 214 construction, on pond 212. Results indicated there was no statistically significant impact for any water chemistry parameters of particulate matter, PM (as SSC, TSS and PSDs), TN, TP and water chemistry (pH, redox, temperature, conductivity) with the exception of turbidity which did approach, but remained less than a mean of 30 NTU in pond 212.

Phase II primary tasks included: (1) as shown in Figure 3 and 4 a new 12 baffle retrofit based on CFD modeling, (2) ambient water chemistry monitoring, (3) evaluation of initial functionality and behavior of the monitoring systems shown in Figure 5, and also (4) pond 212 RTDs and short-circuiting. The monitoring systems were configured and installed by a specialty contractor. There were seven monitoring systems, one for each conveyance, and a monitored rain gage at pond 212. From Figure 3 there are N, NE, E and W conveyances, all assumed to be inflow conveyances. There are SE (south east), SM (south middle) and SW (south west) "outflow" conveyances, as parallel 5 x 8 foot concrete box culverts, that are the direct hydraulic connection with pond 208; conveying flows from back and forth between pond 208 and 212. An illustrative summary of the functionality and behavior of the monitoring system components, identified in Figure 5, is synthesized herein. These results are needed to examine monitoring results and recommendations from Phase III. The three critical components for an understanding of the Phase III results are (1) the behavior of the velocimeters, (2) RTDs and short-circuiting of pond 212, and (3) the direct hydrodynamic interaction between pond 212 and 208 which are functionally one hydraulic system.

A ***brief*** chronology of the monitoring system convolutions, in particular the velocimeters is given:

June 2014:

1. The monitoring system installations were largely complete,
2. Review identified flow velocity profiles were transmitting constant values that changed to zero for specific velocimeters for many conveyances,
3. Review identified acoustic signals and velocities that were "negative" for periods of time and these findings could not be physically explained, in particular for the inlet conveyances but also at the south conveyances which can be subject to recirculating flows from pond 208 where such negative values could be physically explained,
4. Review indicated that for intermittent periods of time for specific velocimeters that velocity values of zero were transmitted,
5. Review identified the water depths were transmitted as constant depth or error values,
6. Review identified velocimeter signal-to-noise ratio (SNR) errors for selected velocimeters during selected periods of data collection,

July 2014:

7. Final monitoring software was still required physical installation by specialty contractor on-site to address changes and corrections such as units, cross-sectional conveyance information and datum,
8. Review identified sample triggering errors (such as failure to sample) remained based on testing of each sampler and data logging system,

9. In July conference call the specialty contractor and manufacturer determined that the recommended sampling scheme of replicate samples could not be achieved,
10. Review identified the rain gage stopped transmitting data and required an on-site reset,
11. Request that the specialty contractor produce in-situ validation data to demonstrate that the velocimeter data from the monitoring systems are valid data given the continued velocimeter errors and negative velocities in July,

August 2014:

12. The N velocimeter failed during much of the loading of an approximate 100-year return storm at APF on 4 August 2014,
13. Separate discussions with the velocimeter manufacturer and specialty contractor indicated that SNR should remain above 25 for the velocimeter beams; and the specialty contractor indicated that the velocimeter problems were a maintenance problem,
14. A maintenance protocol was established and tested for each conveyance for pond 212 on 14 August 2014. Results provided to the manufacturer and specialty contractor indicated that while the cleaning protocol could raise the SNR back above 20 for selected velocimeter beams the SNR decayed to the original low values within several hours.
15. As of the end of August the specialty contractor agreed to update datums, inverts, software, re-install software and ensure all software versions are in agreement,
16. Despite the uncertainty of the velocimeter data validity the manufacturer and specialty contractor recommend turning off the velocimeter error filters,

September 2014:

17. Components of software and sampler data are not remotely available without manual on-site resets, and one monitoring station still has old software version,
18. Review indicates that a specific field-calibration of rain gage is still required,
19. Review indicates that software requires correction so that sampling and velocity data cannot be logged simultaneously,
20. Review indicates that the highly variable and negative velocity data continue to be reported by velocimeters; selected velocimeter beams provide highly negative data; these problems continue for the entirety of Phase III,
21. Review indicates that S velocimeters have stopped reporting occasionally, this is an occasional problem for most velocimeter for the entirety of Phase III,
22. Monitoring systems batteries all have to be replaced despite solar cell recharge,
23. Review indicates that SNR for many velocimeters remains too low,
24. The E sampler must be replaced,
25. Analysis of the 12 September 2014 event (Event #1) indicates that according to the velocimeter data approximately 15 to 20% of the influent flow volume actually exited pond 212 through inflow conveyances; this is physically challenging. Also, 30% of the “outflow” flow volume entered pond 212 as “inflow” through the SE, SM, SW barrels; this can be physically explained. Therefore, getting the velocity magnitude and directions correct is very critical for any load balances of pond 212.

October 2014:

26. The mathematical algorithm for the velocimeters that was requested in January 2014, was again requested on multiple occasions in writing. The intent of obtaining the algorithm used by the velocimeter, was to integrate each beam value across the fluid flow cross-section to generate the resulting velocity for during an increment in time, or to be able to drop beams that were producing errors. The algorithm was never provided and the velocimeter system functioned as a black-box where the output velocity was taken on faith. Apparently, the algorithms used in these velocimeters are (have to be) different than for previous velocimeter designs,
27. Manufacturer indicates that lower limit of pipe diameter for the IQ_{pipe} velocimeter is 0.46 m (1.4 ft) noting that the E conveyance has an equivalent diameter < 1.4 feet,

Synthesis of velocimeter recommendations and implications for Phase III:

1. Accurate pressure-velocity data is basis of Phase III monitoring/modeling of mass, M,
2. Accuracy of in-situ velocity ($\vec{v}$ is master variable) data from velocimeters is uncertain,
3. Velocimeter algorithm/documentation was requested but not provided,
4. Errors in velocity translate to flow volume (V) errors …translate to errors in mass (M),
5. Manufacturer recommends that IQ_{pipe} should be used in submerged pipe conditions,
6. Manufacturer recommends that IQ_{pipe} to be used in variable water depth box culverts,
7. Manufacturer recommends IQ_{pipe} installation on pipe crown for constantly submerged pipes,
8. Manufacturer recommends installation of IQ_{pipe} on invert for variably-submerged conditions,
9. Manufacturer recommends IQ_{pipe} installation for beams to experience fully-developed flow,
10. Manufacturer recommends SNR > 40, (re-install IQs w/strip of Cu for growth inhibition),
11. In-situ calibration/valibration of velocimeters is needed otherwise resulting magnitude and direction is taken on faith; this is a very basic and fundamental need. This need is standard given that lab or controlled conditions in the lab is different than the much more complex and variable in-situ conditions. Furthermore, replication of PM (particle size distributions, PSD and concentration) and to a lesser degree water chemistry in the hydraulics lab for in-situ conditions is very difficult; efficacy of Doppler (and λ) is PM-dependent in lab and in-situ,
12. Note: $\{\vec{v}\times A\times t\times[C] = M\}$ $(L^1T^{-1})(L^2)(T^1)(M^1L^3) = M^1$ ($\vec{v}$ has magnitude and direction),
13. As a first iteration of error ranges for measured parameters in Phase III:
    a. Flow cross-sectional areas, A ~ ± 5%, controlled by WSEL at outflow barrels
    b. Time, t ~ ±2%, dt set at a Δt of 1 minute assuming 1 hour of flow as minimum
    c. Concentration, [C] ~ ± 20%, some replicate variability but mainly auto sampling
    d. Velocity, $\vec{v}$ can be > 100%; in-situ accuracy is largely uncertain as are volumes
14. While velocity data are sampled at 1 minute intervals, integration over 5 to 15 minute intervals was required to smooth velocity variability, including negative fluctuations. This can treat symptoms but does not address the representativeness of velocity data.
15. Pressure and water surface elevation (WSEL) (master variables) do not correlate well; manufacturer indicated that pressure resolution can be "tricky" for an IQ+ in a pipe,
16. Accurate WSEL (or pressure) AND velocity required for pond 212 flow volume check:

$$\frac{d}{dt}\iiint_{storage}^{C.V.} dV + \iint_{outflows}^{(+)} \vec{v}\cdot A + \iint_{inflows}^{(-)} \vec{v}\cdot A = 0$$

17. Manufacturer recommends that all beam data should be dropped (the "mean" beam data) except for the "center-x" beam of all pond 212 velocimeters. As a result, all Phase III results are based only on the "center-x" velocity data from each velocimeter.

Phase III:
The pond 212 watershed was split into a series of catchments as shown in Figure 2 with a total drainage area of 166 acres of which 98 acres are impervious as 2014. Within the drainage system conveyances at pond 212 the monitoring station system were installed, configured and re-configured multiple times along with the remote communication controls for these systems by the specialty contractor. While this was part of the APF Construction Phase (Phase II) within the scope of the pond retrofits these activities continued until July 2015, at which time the specialty contractor no longer had an association with the project. During Phase III troubleshooting, testing of, and monitoring with each monitoring station system around pond 212 continued through storm event 10 in July 2015. A qualifying rainfall-runoff event was established to be at least 0.25 inches of rainfall (based on historical long-term time series of rainfall data collected during Phase II) with an inter-event dry period of at least 12 previous dry hours (pdh). The monitoring campaign encompassed the setup, monitoring and analysis of 10 qualifying events from September 2014 through July 2015. Water chemistry and flow (velocity) data were obtained through the combination of physical measurements, numerical CFD modeling and residence time distribution (RTD) guidance for pond 212. Given the hydrodynamic modifications to pond 212 and short-circuiting the sampling was guided by measured RTDs for pond 212 and results re-examined based on modeled RTDs. Results are presented as rainfall hyetographs, inflow and "outflow" hydrographs and event-based inflow and "outflow" water chemistry loads. Based on measurements and investigations made during Phase III, in large part to try and explain the behavior of the velocimeters, "outflow" indicates that the south outfalls also apparently function to bring re-circulating flow into the pond 212 volume of the combined pond 212/208 volumetric and treatment system. Event mean concentration (EMC) data for pond 212 were integrated with volume data to developed analyte loads. Analytes include particulate matter (PM) measurements as suspended sediment concentration (SSC), total suspended solids (TSS) and particle size distributions (PSDs) as well as total and dissolved phosphorus (P), total and dissolved nitrogen (N), and chemical oxygen demand (COD) for inflow and "outflow" conveyances.

2 MATERIAL AND METHODS

The monitoring, physical and CFD modeling for Phase III were carried out by the Department of Environmental Engineering Sciences at the University of Florida (UF-ESSIE). Hydrologic data and rainfall-runoff (stormwater) samples from the inflows and outflows of the pond 212 (retrofitted based on CFD modeling) were collected by UF-ESSIE personnel and delivered to UF-ESSIE laboratories for analyses. UF-ESSIE analyzed the hydrologic, hydraulic, PM and water chemistry data for 10 qualifying storm events. Water chemistry was integrated through hydraulic (velocity) data and resulting flow volumes to assess the sequestration behavior (treatment performance) of pond 212 based on EMCs. The sampling was guided by RTD data and flow data.

Responsibilities of significant personnel involved in this project are as follows. John J. Sansalone was responsible for the overall design and analysis project management. Gaoxiang Ying, Ph.D.

was the data analysis manager. Dr. Ying was also the UF-ESSIE Laboratory Director and responsible for supervising all laboratory analyses, data management and QA review. Xuan Li was responsible for laboratory analysis, data collection, result preparation, and statistical analysis. Steven Wilson was responsible for sampling, laboratory analysis, data collection, data sheet preparation and statistical analysis. David Spelman developed the CFD models and also with Alvin Beyerlein wrote the MatLab computer codes to transform the raw field data into results and integrate hydrologic and lab chemistry data into inflow and “outflow” loading tables. Research assistants and student workers assisted in the lab with analysis, templates and result preparation.

During Phase II of the project, monitoring and sampling stations were installed at seven (7) locations, which encompass all inlets (4) and outlets (3) of pond 212. Each inlet and outlet pipe/culvert were equipped with a velocimeter to provide measurements of velocity, pressure/depth measurements, and the use of an auto-sampler for flow sampling. This monitoring equipment was combined with data loggers, modems, batteries, and solar panels inside fiberglass stations located on the shore of pond 212, allowing for remote data acquisition and remote device communication during the monitoring campaign. In addition, a rain gauge was installed on site. This monitoring equipment was used to collect data for a total of 10 qualifying events from event 1 in September 2014 through event 10 in July 2015. The specific tasks are summarized.

1. **Completion of a Quality Assurance Project Plan (QAPP):** UF-ESSIE prepared and provided FDEP with a Quality Assurance Project Plan (QAPP) for the proposed research effort for CFD simulation of RTD and actual behavior of the retrofitted physical model (pond 212). The QAPP was guided based on knowledge gained from the CFD modeling of pond 212 behavior and followed up with 10 monitored storm events for hydrodynamic and load behavior of pond 212.
2. **Monitoring of at Pond 212 (physical model):** Aqueous sampling was conducted at each inlet/outlet location (total 7 locations around pond 212) during each of 10 events by auto-samplers installed at pond 212. The auto-sampler were controlled and triggered remotely at each sampling location for each storm event (rainfall ≥ 0.35 inches) at APF. Samples were transferred to UF-ESSIE laboratory after the storm event for subsequent laboratory analysis. Hydraulic and hydrologic data were also collected real-time for each event.
3. **Laboratory and Data Analysis for storm event behavior of pond 212:** Analysis of EMCs were conducted for each inlet/outlet for each storm event. The analytes included, as a minimum the required analytes of total nitrogen (TN), total phosphorus (TP), PM as total suspended solids (TSS), particle size distribution (PSD) and water chemistry parameters (pH, conductivity, temperature, alkalinity and turbidity); summarized in Table 1 and 2.
4. **Final Result Compilation, Statistical Analyses and Final Reporting/Presentation:** All the laboratory analyses for analytes were reported as EMCs or EMVs (event mean values that were not concentrations) and organized in a tabular manner. Since results varied for each location, inflows and outflows were also summarized individually for loads and hydrologic results. These results are including herein; written and presented by UF-ESSIE to stakeholders.

Sampling Locations

To monitor and evaluate the performance of pond 212, one rain gauge and five monitoring stations encompassing a total of seven inflow and outflow conveyances were installed around pond 212, as shown in Figure 5. The rain gauge is located within several hundred feet of pond 212 within the west catchment drainage area. One monitoring station (S1) is located at the north and northeast inlets, one (S2) at the east inlet, one (S3) at the west inlet, and the remaining two (S4 and S5) at the south "outlets". These "outlets" can (and do) function as inflow conveyances depending on the hydrodynamic gradients between pond 212 and pond 208. All the stations are located close to the inlet or outlet (within 50 feet). The stations are made of fiberglass with locking door and lid, the door in the front, and lid on the top. Solar panels are installed on the top of each station for charging the batteries that power all the equipment inside the station. Stations 1-4 each contain 1 data logger, 1 modem, 1-3 batteries, and 1-2 auto-samplers depending on the location. Station 5 contains 2 auto-samplers and 2 batteries. Individual batteries are required for each data logger and auto-sampler. One velocimeter is installed at each individual inlet or outlet culvert and connected to the data logger by a data transfer cable. S1 station contains the North (N In) inlet auto-sampler and the Northeast (NE In) inlet auto-sampler. S2 station contains the East (E In) inlet auto-sampler. S3 station contains the West (W In) inlet auto-sampler. S4 station contains the Southwest (SW) outlet auto-sampler. S5 station contains the South Middle (SM) outlet auto-sampler and the Southeast (SE) outlet auto-sampler. The vacuum intake hoses (3/8-inch I.D.) of each auto-samplers were installed in each inflow and outflow conveyance; mounted at the invert of each conveyance and five to ten feet within each of the seven conveyances. Sampling is made based on rainfall depth and flow rate. The rain gage is a tipping bucket rain gauge collecting 0.01 inches of rainfall per tip. The rainfall depth data is recorded automatically by a CR200x data logger. Specifications of rain gauge and monitoring systems at each inlet/outlet of pond 212 are listed in Figure 5 as is the schematic view of monitoring and sampling systems at pond 212. A list of parameters analyzed is provided in Table 2 with corresponding standards and methods.

When an auto-sampler is triggered, four, 500-mL liquid aliquots are collected consecutively with a vacuum sampler purge between each aliquot. The first two aliquots are injected into the first 1-L bottle then the distributor arm is programmed to move to the next 1-L bottle and inject the next two 500 mL aliquots for the given time increment. The distributor arm is then programmed to move to the next bottle and repeats the collection process when another set of samples is manually triggered for the next time increment of the specific conveyance. This continues until all samples are taken for that conveyance. The first sample set that is taken before runoff is triggered before the runoff represents the starting equilibrium condition of the water chemistry in pond 212. Samples are taken during the rising and falling limbs of each unique hydrograph for each conveyance. The sampling time increments are based on conveyance flows, catchment RTD and response time, and the RTD of pond 212. The last sample is triggered after runoff ends for a conveyance or after the RTD of the pond 212 for the "outflow" conveyances. This last sample represents the ending equilibrium condition of water chemistry in pond 212.

Decision criteria for monitoring and sampling a rainfall-runoff event
As a potentially qualifying storm event approaches APF, a decision was based on rainfall intensity, duration and storm cell vectors from high definition Miami, FL radar. Auto-samplers at each conveyance were triggered based on rainfall and initiation of flow; noting that each conveyance has a differing response time. Specifically, the planning of monitoring is summarized as follows.

<u>The day before:</u>

1. Monitoring equipment collecting real time data
2. Samplers deployed with lab-prepared bottles
3. ≥ 12 previous hours of no rainfall
4. Rainfall probability ≥ 50% within next 24 hour period
5. Set 6-hour on-call duties for UF personnel to monitor radar and equipment

<u>Within 90 minutes of rainfall at APF:</u>

1. Assess storm vectors, intensity, duration, and depth from radar
2. Reasonable likelihood of ≥ 0.25 inches of rainfall required
3. Check rainfall totals from other gages along storm path

<u>Real-time during runoff event at each sampling location:</u>

1. Initiate sampling at demonstrable (~ 10%) flow (velocity) increase at each location
2. Use radar, monitoring to assess rising limb, peak, and falling limb sampling
3. Inflow sampled to the end of flow or 96 hours since the NE flow is largely continuous
4. "Outflow" samples taken to 120 hours based on pond RTD from tracer data

Pond 212 Residence Time Distributions (RTDs) based on Rhodamine WT Tracer Study
A tracer study to determine an RTD is crucial to the understanding of hydrodynamics in any flow-through conveyance system. The tracer study performed on pond 212 allowed the creation of a RTD which quantitatively characterizes the response of the pond to hydrodynamic fluxes. The RTD gives insight into the advection and dispersion of PM and chemicals in a hydrodynamic system such as the pond 212/208 system. This information, in part, was used to make sampling decisions for pond 212 based on the hydrodynamic as illustrated by the RTDs.

The tracer study can be broken into three basic steps for pond 212: 1) After calibrating the fluorimeter, inject a Rhodamine WT (RWT) tracer into inflow stream of the pond at the beginning of a storm event, 2) monitor the concentration of RWT in the outflow of pond 212 at regular intervals, and 3) process the measured concentration data, coupled with flow data from the system, to determine the travel time and eventual elution of the tracer at the south end of pond 212 (the "outlet"). A series of separate injections and resulting tracer transport and fate were used to elucidate the response of the pond under storm various flow conditions, yielding an indication of the behavior of the system (pond 212/208) to unsteady fluxes.

The tracer used in this study is the fluorescent dye Rhodamine WT (RWT) which is commonly used in natural water systems, and is a standard tracer for field studies. Deep red in color, RWT concentration is measured using a fluorimeter at wavelengths of 530-555 nanometers (nm). The fluorimeter used in this study is a HYDROLAB MS5 with a sensor having a detection limit of 1 ppb, and a +/- 3% accuracy range specified for concentrations from 1-100 ppb. The sensor was calibrated in the UF-ESSIE laboratories to using serial dilutions of known RWT concentrations in deionized (DI) water. While RWT can have adverse properties at concentrations on the order of 10 ppm with a low to moderate ecological toxicity concern mainly due to shading effects on algae, however the concentration required for such effects are at least 100 ppm. The concentrations of RWT in this tracer study were on the order of 10 ppb, which is orders of magnitude lower than those at which any adverse effects were observed. Due to the low concentrations of RWT at the outlet of pond 212 (nearly imperceptible coloring of the outflow) and the further dilution of the tracer in pond 208 there was no visual observation of the tracer leaving the pond 212/208 into Rock Creek.

Injections of RWT were made just before the start of a rainfall-runoff event when there was no storm driven inflows. The tracer was injected into the north inlet conveyance (N_In) as an instantaneous pulse of 21% concentration by volume of RWT at the invert of N_In on the north side of Radio Road. The other main conveyor of flow and volume, the NE was not used for several reasons. There is no direct access to the NE conveyance about the discharge face of the NE headwall so that there was no ability to mix the tracer with the flow stream and the NE velocimeter data produced a nearly continual but highly unstable flow. The amount of tracer required was calculated based on the detection limit of the fluorimeter and the assumptions that the tracer will disperse into the entire volume of the pond and will also be diluted by the runoff volume of the storm event for which the injection was made. Given that the minimum concentration that is detectable by the fluorimeter with specified accuracy by the manufacturer is 1 ppb (in reality this was approximately 2 ppb), the target of 10 ppb concentration of RWT in the effluent was set to ensure a detectable measurement. To obtain a dye concentration of 10 ppb diluted into volume of pond 212 (~33 acre-ft) and storm volume (the volume, unsteadiness and inter-arrival frequency not known a-priori), a volume of approximately 2 L of 21% RWT solution was required for the pulse injection. The fluorimeter calibration curve is provided in Figure 6.

The RWT in the outflow was measured in-situ with the fluorimeter installed at the approximate east-west centroid of the outflow conveyance from pond 212 and approximately six feet in front of the north face of the outflow conveyance; the triple box culvert. Physically, the fluorimeter was tethered in place in front of the entrance to the middle box culvert (SM_Out). This location just outside the effluent box culverts provided a reasonably representative concentration of the effluent transported toward the three culverts; which centroidal location is of importance as the distribution of flow between the three culverts is known to vary. The fluorimeter had a built-in data logger which records measured concentration data at regular time intervals of 15 minutes to extend battery life. The time increment is significantly smaller than the residence time in pond 212 and the gradual variations in concentration that were observed. Data was manually downloaded on-site from the fluorimeter.

Utilizing Computational Fluid Dynamic Model (CFD)

Geometry and Mesh Generation

CFD modeling was performed using the ANSYS-FLUENT code with geometry and mesh generation being done using ANSYS-WORKBENCH Design Modeler and Meshing software, respectfully. A three dimensional unstructured tetrahedral mesh was generated for the pond 212 retrofit geometry/bathymetry. Based on the grid convergence study performed in Phase I, a mesh cell count on the order of 2 million cells was used; although the exact value varied between meshes generated for different baffle design geometries. Mesh quality was checked for all meshes generated to ensure that orthogonal quality and aspect ratio were within ideal ranges (orthogonal quality being above 0.1 and aspect ratio being below 100).

CFD Governing Equations

To resolve the flow field through the numerical mesh of pond 212, the Reynolds averaged Navier-Stokes (RANS) equations for incompressible flow were utilized and solved using the finite volume method. The RANS conservation equations are obtained from the N-S equations, by decomposing the fluid flow properties into their time-mean value and fluctuating component (the Reynold's decomposition). The mean velocity is defined as a time average for a period T which is larger than the time scale of the fluctuations. The time average of the fluctuations over time, t tended to zero, meaning the turbulence variability components did not tend to contribute to the bulk mass transport. The time-dependent RANS equations for continuity and momentum conservation are given as follows.

$$\frac{\partial}{\partial x_i}\left(\rho \overline{u_i}\right) = 0,$$

$$\rho \frac{\partial \overline{u_i}}{\partial t} + \rho \frac{\partial}{\partial x_j}\left(\overline{u_i u_j}\right) + \rho \frac{\partial}{\partial x_j}\left(\overline{u'_j u'_i}\right) = -\frac{\partial \overline{p}}{\partial x_i} + \mu \frac{\partial^2 \overline{u_i}}{\partial x_j{}^2} + \rho g_i$$

In these expressions r is fluid density, x_i is the i^th^ direction vector, u_j is the Reynolds averaged velocity in the i^{th} direction; p_j is the Reynolds averaged pressure; and g_i is the sum of body forces in the i^{th} direction. The decomposition of the momentum equation with Reynolds decomposition generates the Reynolds stresses term, $-\rho \overline{u'_i u'_j}$ from the nonlinear convection component.

Since the Reynolds stresses are unknown variables, the κ–ε (k-espilon) model is used to resolve the closure problem. Moreover, out of the three variations of the k-epsilon model, the Standard model was chosen. This model is an industry standard when it comes to simulating wall-bounded, free-shear layer flows under small pressure gradients which is a good representation of the variable interacting hydrodynamics between the pond 212/208 system that depend on the relative gradients of each pond. The standard model uses an analytically derived equation to model kinetic energy *k*, and an empirically derived equation for the kinetic energy dissipation rate ϵ. This model assumes that the flow is fully turbulent, and molecular viscosity does not contribute to energy dissipation. As such, the standard model is valid only for fully turbulent flows. During the incremental steps of a stepwise-steady procedure, the lowest flow rate corresponded to a Reynolds number of 4000; thus the assumption of fully turbulent flow is reasonable. The standard *k-e* model consists of a turbulent kinetic energy equation and a turbulence energy dissipation rate equation are given in the following equations.

For turbulent kinetic energy k:

$$\frac{\partial}{\partial t}(\rho k) + \frac{\partial}{\partial x_i}(\rho k u_i) = \frac{\partial}{\partial x_j}\left[\left(\mu + \frac{\mu_t}{\sigma_k}\right)\frac{\partial k}{\partial x_j}\right] + P_k + P_b - \rho\varepsilon - Y_M + S_k$$

For energy dissipation ϵ:

$$\frac{\partial}{\partial t}(\rho k) + \frac{\partial}{\partial x_i}(\rho \varepsilon u_i) = \frac{\partial}{\partial x_j}\left[\left(\mu + \frac{\mu_t}{\sigma_\varepsilon}\right)\frac{\partial \varepsilon}{\partial x_j}\right] + C_{1\varepsilon}\frac{\varepsilon}{k}(P_k + C_{3\varepsilon}P_b) - C_{2\varepsilon}\rho\frac{\varepsilon^2}{k} + S_\varepsilon$$

In these expressions, the constants are: $C_{1\varepsilon} = 1.44$, $C_{2\varepsilon} = 1.92$, $C_{3\varepsilon} = -0.33$, $C_\mu = 0.09$, $\sigma_\varepsilon = 1.0$, $\sigma_k = 1.3$; k is the turbulent kinetic energy; ε is the turbulent energy dissipation rate; S is the modulus of the mean strain rate tensor; μ_T is the eddy viscosity; μ is the fluid viscosity. The turbulent flow field is determined by solving a system of four equations including the previously given governing continuity and momentum equations and these *k-e* turbulence model equations. Values of k and ε were calculated according to FLUENT coding guidance.

A pressure-based solver with absolute velocity formulation was used to simulate incompressible flow (stormwater) in which motion is often driven by pressure gradients, whether from pond 212 into 208 or pond 208 into 212. Spatial discretization was performed using a second order upwind schemes for momentum, turbulent kinetic energy, and turbulent dissipation rate while a second order scheme was used for pressure. The Semi-Implicit Method for Pressure-Linked Equations (SIMPLE) algorithm was used for pressure-velocity coupling. The solutions were considered to be iteratively convergent when the scaled residuals from all governing equations stabilized and passed below 10^{-3} AND when stabilization was reached in a set of three surface integrals which measured flow rate through surfaces placed within the flow field.

CFD Boundary and Cell Zone Conditions

All geometry boundaries were modeled as no slip walls, while the three box culvert outlets between pond 212 and 208 were set as ‘outflow’. The four inlets to pond 212 were modeled as velocity-inlet boundary conditions. In all stepwise steady simulations, influent turbulence was specified using turbulence intensity and turbulent viscosity ratio which were set to values of 5% and 10, respectively. The gabion baffles were modeled as porous zones. The pervious conditions within the baffles were approximated by the Ergun equation. This equation allows for the calculation of pressure loss per length of baffle given an input of two parameters, α and C_2 which represent the viscous resistance coefficient and inertial resistance coefficient, respectively. These coefficients were determined based on assumed values of effective opening size (EOS) and porosity of 3 inches and 0.25, respectively.

Discrete Phase Model

The transport and fate of particulate matter (PM) was represented by a heterodisperse particle size distribution (PSD) discretized into 20 individual particle sizes. The influent design PSD was assumed as the standard PSD metric used for stormwater BMP treatment evaluations for many areas of the USA. The PSD metric used is modeled as a gamma distribution with a shape factor, γ equal to 0.56 and scaling factor, ß equal to 232.0. The PSD has a d_{50} of 67 µm and a range from 1 to 1000 µm. The PSD metric was compared to measured PSDs taken from the pond and the measured influent PSDs of pond 212 reasonably well based on Phase I results. PM density was assumed to be 2.65 g/cm^3, essentially siliceous soil and sediment representative of Naples, FL.

Each of the 20 representative particles sizes, ranging from 1-1000 µm, was injected into the flow field obtained in CFD at each of the four inlets and tracked through the system. Each injection consisted of 276 representative particles and removal efficiencies were determined by observing the fraction of these 276 that reached the outlet. The discrete phase model (DPM) is used in CFD to simulate the three-dimensional trajectories of discrete particles through the computational domain. The DPM is based on a combined Euler-Lagrangian approach in which the fluid flow field is first determined, and subsequently particles are injected and tracked in the Lagrangian reference frame. The following assumptions were made for Lagrangian particle tracking:

- The particles are spherical
- The particle motion is influenced by the continuous fluid phase, but the continuous fluid phase is not affected by the particle motion (one-way coupled model)
    - Valid for sparse solid fractions of less than 10% (Elghobashi, 1991).
- Particle-particle flocculation is neglected; therefore, dispersed phase is assumed to be sufficiently dilute by checking the volume fraction is less than 10% (Brennen, 2005)
- Particle-wall interaction is neglected except for reflection

Particle trajectories through the domain are determined via the integration of a governing equation which is based on a force balance on discrete particles. The forces considered are gravitational body force, drag force, inertial force, and buoyancy. The governing equation in the ith-direction is written as follows:

$$\frac{dv_{pi}}{dt} = F_{Di} \cdot \left(v_i - v_{pi}\right) + \frac{g_i \cdot \left(\rho_p - \rho\right)}{\rho_p}$$

The first term on the right-hand side is the drag force per unit particle mass, in which F_{Di} is defined as follows. The second term is buoyancy/gravitational force per unit particle mass.

$$F_{Di} = \frac{18\mu}{\rho_p d_p^2} \cdot \frac{C_{Di} \cdot \mathrm{Re}_i}{24}$$

The term Re_i represents the Reynolds number for a spherical particle, and C_{Di} is the drag coefficient;

$$\mathrm{Re}_i = \frac{\rho d_p \cdot \left| v_{pi} - v_i \right|}{\mu}$$

$$C_{Di} = \frac{K_1}{\mathrm{Re}_i} + \frac{K_2}{\mathrm{Re}_i^2} + K_3$$

In these equations, ρ is the fluid density, ρ_p is the particle density, v_i is particle velocity, d_p is particle diameter, μ is the dynamic viscosity, K_1, K_2, K_3 are empirical constants for spherical particles as a function of Re_i.

The governing DPM equations dictate particle movement through the system and are solved over thousands of discrete steps as the particles are routed through the flow field. The particle position and velocity is updated in steps, the length of which are dependent on local mesh size by the Fluent software. A crucial parameter for this process is the maximum number of DPM steps specified. This value specifies at what point the DPM solver will end calculations on any particle. This is needed as some portion of particles fall into eddies and circulate continuously, thus never reaching the outlet. A value of 40000 steps was chosen for the maximum number of DPM steps based on the determination of the number of steps necessary for neutrally buoyant tracer particles to reach the outlet.

Model implementation

Noting that the methodology in the use of CFD is comprised of three steps: geometry and mesh generation (pre-processing), setting-up and solving a physical model (processing) and finally, post-processing the modeled data. In this study, ANSYS Fluent version 14.5, ANSYS Workbench and AutoCAD 2013 algorithms are used to perform CFD analysis. The creation of the solid geometry is done using 3D AutoCAD modeling, while the mesh generation was is done within the ANSYS Workbench. ANSYS Fluent version 14.5 is used for solving the system of time averaged governing equations (RANS-based model) through the numerical method of finite volume difference elements.

The 3D AutoCAD environment is used to create the geometry of the pond. Using bathymetry contours created from survey data, with an enclosed 3D solid is created for the pond. Inflow and outflow conveyances are connected to this solid via a union function at their known locations and depths. This solid geometry represents the volume occupied by the flow in the computational domain. For pond 212, elevation data at surveyed locations in the pond are used in conjunction with as-built cross sections of the pond's perimeter slopes to create the solid geometry. An averaged depth across the pond is used from the surveyed points to reduce skewness and poor aspect ratios in meshing. The solid is exported from AutoCAD into ANSYS Fluent version 14.5 where its volume is spatially subdivided into a set of discrete simple-shaped cells referred to as mesh elements. These mesh elements are adjacently connected in a tetrahedral fashion. Cells are created in a non-uniform meshing scheme where the nodes do not reside on a grid. The quality of this mesh is crucial in the accuracy and convergence of the finite element computation and any aberration within the mesh will negatively impact the final result. Because of this, equiangular skewness and local variation in cell size are minimized to produce a high quality mesh. A grid convergence analysis is performed in order to determine the mesh density that balances solution accuracy and computation effort. Mesh refinement is performed based on this analysis.

The time step used for fluid flow calculations was varied according to the temporal resolution required to efficiently resolve the flow field under the highly unsteady input flow. The time step varied from 2 second intervals during the very steep sections of the hydrograph, to 600 second intervals during steady flow conditions near the end of the storm. Time step was optimized to minimize the run time of the simulations using 64 computational nodes.

Numerical tracer particles as neutrally-buoyant particles (not to be confused with RWT) were injected at intervals of 10 minutes for the first 30 hours of flow time, which represents the time that influent flow approached zero. Each discrete particle injection consisted of 1080 particles split amongst the four inlets. In addition to the tracer, 15 discrete particles sizes ranging from 4-75 μm were injected in the same manner. Consistent with the steady-state CFD methodology, these 15 discrete particle sizes accurately depict the behavior of PM over the entire PSD used for design. With all 16 injections, the total number of particles tracked through the pond throughout the simulation was 2.92 million. User defined code was written to record the time at which each particle reached the outlet, as well as its diameter, injection time, and an identifier of which inlet it was injected. This data was printed to a text file to be used in post-processing.

In post-processing, the DPM data was used to determine the cumulative PM and tracer elution from pond 212 for the design storm. Each particle that was eluted was weighted by the volume that its injection represented (based on a central differencing of the hydrograph around each 10 minute interval), the volume fraction that its inlet of origin represented, and the portion of the PSD that its particle diameter represented. From this procedure, each of the 2.92 million particles was properly weighted such that the weights could then be summed over all eluted particles to obtain the cumulative PM and tracer elution. Tracer elution was only summed for the 1 μm particles.

Integration of Hydrologic, Hydraulic and Water Chemistry Data

Raw data from the various pond 212 monitoring devices were copied from the raw output text files into an organized excel data sheet which was segregated monthly. Raw data were organized for each inlet/outlet (7 in total) with an additional data sheet for the rain gauge. The raw data were collected at one minute intervals. The following raw data were considered in data processing:

For Inlets:

1. Time stamp of each measurement
2. Water surface elevation (WSEL)
3. Center X axial velocity
4. Water temperature
5. System status flag
6. Center X axial velocity
7. Signal to noise ratio of the center velocimeter beam (SNR)

For Outlets (south box culverts that also act as inlets from pond 208):

1. Time stamp of each measurement
2. Water surface elevation (WSEL)
3. Flow rate internally calculated from mean velocity (and WSEL)
4. Mean velocity (as internally calculated by the Sonteq as a black-box calculation)
5. Water temperature
6. System status flag
7. Center X axial Velocity
8. Signal to noise ratio of the center velocimeter beam (SNR1)
9. Signal to noise ratio of the left velocimeter beam (SNR2)
10. Signal to noise ratio of the right velocimeter beam (SNR3)
11. Signal to noise ratio of the z velocimeter beam (SNR4)

For Rain Gauge:

- Time stamp of each measurement
- Depth of precipitation over the 1 minute interval

These raw data contain missing time stamps due to mechanical/programmatic/equipment failure and lack of measurement during auto-sampler measurements. The raw data also includes zero or

NaN (not a number) values in some time stamps due to other errors. In addition, inlet velocity values include negatives in the raw data which are not physically realistic. These errors were corrected via a data processing Matlab code which reads in the raw input monthly data excel sheet, performs corrections, organizes the data into the desired format, and writes the corrected data to two different output excel sheets. The two output excel sheets contain the same monthly data but are organized in different manners for convenience of future work and presentation. The internal process of the Matlab code which corrects for the aforementioned errors is described below. A data processing Matlab code over several hundred lines was written which handles all of the data management for the monthly pond 212 monitoring campaign.

Missing time stamps were accounted for via the following process:

1. A normalized array of time stamps at 1 minute intervals was created between the first time stamp (midnight on the 1st of the desired month) and the last time stamp (midnight on the 1st of the following month). This array was used for all inlet, outlets, and the rain gauge
2. A logic test was performed which checked whether each of the normalized time stamps was a member of the set of time stamps from the raw data for each inlet/outlet/rain-gauge
   a. If a time stamp was missing in the raw data, this logic statement was false
3. For all normalized time stamps in which the logic test was true, the raw data was simply inserted into the corrected data array (this applies for all variables, velocity, WSEL, SNR, etc.)
4. For all normalized time stamps in which the logic test was false:
   a. All variables other than velocity and flowrate were given a value of NaN
   b. Velocity and flowrate were linearly interpolated from the closest existing data points

At this stage no missing time stamps remained in the data. A further correction was done on the velocities for the inlets which removed negative values and replaced them with interpolated velocities from the closest positive values. This process was also carried out on any NaN or zero velocity values.

The above describes the only way in which the 1-minute raw data is altered other than organization. Flowrate was calculated from the 1-minute center X velocity (based on the manufacturer recommendation after the identification of significant velocimeter errors and results that were not physically defensible) by multiplying by the cross sectional area of each of the 7 inlet/outlet culverts. All inlets remained submerged and thus their entire cross sectional area was used; however the outlets were often partially submerged, and thus the area used varied. The outlet area was calculated at each time step using the water surface elevation. All inlet flowrate calculations utilized the center x velocity. Outlet flowrate was calculated using the mean velocity as internally calculated by the Sontek velocimeter from the beginning of the monitoring campaign until 3 February 2015 at which time flowrate calculations switched to using the center X velocities for the remaining monitoring duration. This change was based on manufacturer recommendation. For consistency, the previously reported 2014 data was re-integrated based on center-X velocities per manufacturer recommendations based on velocimeter errors and for consistency across the entire monitoring campaign. Averaging calculations were performed by the Matlab code because of the very high variability and noise of velocity data for flowrate. This was done for graphing purposes to smooth the flow data which contains a significant amount of noise at the one minute level.

Mass loading calculations

Sampling and laboratory procedures yield concentration values of various analytes (eg. SSC, TN, TP) at discrete sampling times for each inlet and outlet of pond 212. In order to obtain mass loads of these analytes and thus sequestration efficiencies of each, these discrete concentrations must be combined with flowrate through the conduits. A separate Matlab code was developed to perform this task. Input excel sheets were prepared specifying flow data, sample times, and sample concentrations for each analyte, as well as a desired time interval for output for each storm and each inlet/outlet. The Matlab code read in these input files, performed internal operations, and wrote output data to output excel sheets which provided incremental and cumulative influent/effluent masses of each analyte at the desired time interval as well as summary results. The internal Matlab operations are as follows:

1) Data was imported and assigned to variables
2) A time series was created of regular interval (as specified) at which output variables were calculated
3) Flowrate was averaged from 1 minute flow data to x minute, where x is the desired output time interval.
4) Analyte concentration was interpolated at each output time via linear interpolation of the sampled concentrations closest to each time step.
    a. Concentrations before the first sample and after the last sample were assumed to be equal to the concentration of the nearest sample
5) For outlets, positive and negative flows were separated into inflows and outflows
    a. For time stamps in which inflow occurs, the outflow is equal to zero, and likewise, time steps in which outflow occurs, inflow is equal to zero
6) Incremental volume was calculated for inflow and outflow by multiplying each flowrate by the time interval at each time step
7) Incremental analyte mass was calculated by multiplying incremental volume by interpolated analyte concentration at each time step
    a. Performed for inflow outflow mass in the case of the outlet culverts
8) Incremental volume and analyte masses were cumulatively summed to obtain cumulative volume and mass
9) Data were organized and written to the output excel workbooks

Mass Equations

Step 1. Calculate the cumulative mass for any water chemistry analyte, A.

$$M_{A,i} = EMC_{A,i} \cdot V_{A,i}$$

$M_{A,I}$: cumulative mass of analyte A at inlet i, Kg
$EMC_{A,I}$: event mean concentration of analyte A at inlet i, mg/L
$V_{A,I}$: cumulative volume at inlet i, m^3

$$M_{A,j} = PEMC_{A,j,in} \cdot V_{A,j,in} - PEMC_{A,j,out} \cdot V_{A,j,out}$$

$M_{A,j}$: cumulative mass of analyte A at outlet j, Kg
$PEMC_{A,j,in}$: event mean concentration of analyte A in inflow at outlet j, mg/L (Sansalone and Buchberger, 1997; Sansalone et al. 1998)
$PEMC_{A,j,out}$: event mean concentration of analyte A in outflow at outlet j, mg/L
$V_{A,j,in}$: cumulative inflow volume at inlet j, m^3
$V_{A,j,out}$: cumulative outflow volume at inlet j, m^3

Step 2. Calculate the sequestration (%) of analyte A for pond 212 for a collected event

$$S_A = \frac{\sum_{i=1}^{4} M_{A,i} - \sum_{j=1}^{3} M_{A,j}}{\sum_{i=1}^{4} M_{A,i}} \times 100\%$$

S_A : sequestration for analyte A, %
i : inlet number, including N, NE, E, and W inlets,
j : outlet number, including SW, SM, SE outlets.

4 RESULTS AND DISCUSSION

The tabular and graphical results are designed to be self-supporting and self-explanatory. As such, the written description of the results is presented succinctly.

Pond 212 Tracer Study Residence Time Distributions (RTDs)

During August and September 2014, RTDs were physically collected continuously over a period of 40 day at the south box culvert "outlets" during which individual RWT injections at the north end of pond 212 were made for individual storm events. Individual responses, each subject to multiple stochastic intra-RTD perturbations are shown in Figure 7 through 12. Figure 7 is an example of the RTD for pond 212, considered a discernable discrete response as part of the continuous pond 212 RTD response. This RWT injection was for the 20 August 2014 event shown in Figure 7 that began at 17:05 (beginning of storm event) and was a pulse injection into the north upper end of pond 212; and was the only response whose rising limb and initial decay response was not subject to previous RTD injections. This example, as well as each of the discernable discrete RTD responses of pond 212, were subject to a random time series of episodic rainfall-runoff loadings. Reviewing the continuous time series response shown in Figure 13; all subsequent RTD responses beyond the initial 20 August 2014 response represented a convolution of individual RTD responses. From this continuous time series there were intra-RTD perturbations due to subsequent and unknown hydrologic loadings a-priori, discrete RTD decay curve can be identified in Figure 13. Figure 14 illustrates that a mathematical deconvolution model that reproduced the measured RTD continuous time series of RWT.

Pond 212 Hydrology

Hydrologic results are tabulated for each individual storm event in Table 3 and 4. There were 10 random events captured and each event was examined on a single event basis per project requirements noting that the system was subject to re-circulating flows between pond 208 and 212 on a continual basis. The non-parametric distributions of flows from each inlet are summarized in Figure 16 and illustrate that the continuously-flow NE conveyance dominated flows followed by the N conveyance from pond 214 and Airport-Pulling Road inflows. The E and W conveyances each represented less than 10% of the total volume fraction from the four inlets. This analysis does not account for the inflows through the SE, SM and SW outflow box culverts between pond 212 and 208 or try and separate the continual and variable baseflow from dry and wet weather.

Given that pond 212 is a small continuously loaded on-line conveyance pond, volumes and loads should be examined on a longer term and more continual basis. Event-based results represent an instantaneous load-response behavior from what is a dynamic continuum of load-response that is driven by the hydrodynamic and hydraulic gradient relationships between pond 208/212. The temporal scaling and magnitude of this dis-equilibrium is a function of driving mechanisms such as hydraulic gradient direction between the ponds, wind-mobilized currents or the approach and trajectory of a storm event that may preferentially load the watershed of one pond as compared to the other pond. Such phenomena were only observed once monitoring was conducted. Therefore to try and discern a more representative load-response for pond 212, but outside the project scope, code was written and analysis was conducted on a more continual time series basis for storms 1 to 3, storms 5 to 8, and storms 4 to 9, each as a longer time series period of pond behavior. Furthermore to try and validate the variability of the water surface elevation (WSEL), the WSEL was monitored at the pond 208 weir/orifice. The temporal variability of the WSEL for August 2014, the month in which RWT injections commenced, and also each individually monitored event is superimposed in time as shown in Figure 17 to 20. The WSEL response to major hydrologic events can be discerned in each figure and represents the only robust WSEL monitoring data from the monitoring campaign. Results illustrate that the weir rarely conveys outflows; the single clear exception is the 100-year storm event of 4 August 2014. Nearly all outflow to Rock Creek on a continual basis is conveyed by the 8-inch orifice at the pond 208 weir. This is a critical result for the next monitoring/modeling phase of the project and this location is the most representative for monitoring the pond 212/208 system where 212 and 208 are hydraulically connected and inter-dependent cells or partitions of the same pond system.

Pursuant to the event-based project scope the monitoring campaign generated hydrology and hydraulic results for each of the 10 monitored storm events. Given the complexity with multiple inlets and outlets (that also functioned as inlets) results are summarized as a combined inflow hydrograph and separately as a combined outflow hydrograph. The event-based cumulative volumes of inflow, net outflow and storage are examined as a function of elapsed time through the period from the start of rainfall (time 0 for each event) to the cessation of “outflow” at 120 hours. Hyetographs are examined as rainfall intensity as a function of elapsed time. Individual event-based results are summarized in Figure 21 to 30. Given the problems associated with the velocimeters and the lack of a physical basis for the four inlets (N, NE, W and E) to transmit outflows from pond 212, negative inflows were truncated to zero. However, for the SE, SM and SW hydraulic connections as box culverts, the direction of flow between pond 212 and 208 could not be negated. The negative “outflows” (actually inflows from pond 208 into pond 212) were observed qualitatively in the field as flows into pond 212. Therefore, in Figure 21 to 30, plot B shows these outflows, noting that any negative flows are inflows into pond 212. While the inflows have significant variability there are events where the coupled hyetograph-hydrograph response can be discerned, such as in Figure 21; many of the inflow plots show significant and continuous inflows that do not appear to be driven by a measurable hyetograph. Any in-situ device or monitoring system failures were approximated as straight-line functions between the measured endpoints. The outflow plot (plot B) of each figure illustrates even more significant variability as compared to the inflows shown in plot A. Of particular note is the lack of storage for each event as shown in plot C of each figure. Applying a more continuous longer term analysis as opposed to a single event-based analysis, Figure 31 to 33 illustrate the continuous time series results from storms 1 to 3, separately storm 5 to 8, and also storm 4 to 9. Noting the differences in the flow scale of each inflow plot (plot A of each figure), results indicate the inflows are continuous while clearly responding to the significant transient hyetographs. As noted in Figure 21 to 30 any negative flows were truncated to zero given the lack of a physical basis for outflows from the four inlets. Similarly, noting the differences in the flow scale of each outflow plot (plot B of each figure), results indicate that both outflows and inflows of the SE, SM and SW box culverts between pond 212 and 208 are continuous; yet in contrast to inflows, do not clearly respond to the major or significant hyetographs. While the lack of significant storage can be discerned from the event-based results of Figure 21 to 30, the longer term time series of storage portrayed in plot C of Figure 31 to 33 more clearly demonstrates negligible storage in pond 212 as would be expected for a continuously loaded on-line pond.

The longer-term time series examination clearly demonstrate the hypothesis that pond 212 is a continuously loaded on-line pond with negligible storage that is a directly hydraulically connected to pond 208 and the pond 208 ouflow is the primary system control. However, while this proof-of-concept has been established from Phase III monitoring, a rigorous quantitative volume and flow balance awaits the next phase of this project. Given the lack of robust velocimeter behavior especially during continuous lower flows, unknown infiltration/exfiltration interactions and unknown accuracy of WSEL, excepting the WSEL measured outside the project scope, a volume balance was not possible. Future monitoring must address such monitoring needs so a volume/flow balance can be facilitated. In addition, treating pond 212/208 as a contiguous on-line hydraulic system that is continually loaded with the monitoring of flow, WSEL and water chemistry at the pond 208 weir/orifice will facilitate this volume, flow and storage analysis.

Pond 212 Load Response

Hydrology and hydrodynamics control the transport and fate of water chemistry species and PM load whether for smaller source area catchments such as the E catchment or larger watershed such as the NE watershed. Furthermore, treatment is driven by hydrology and hydrodynamics. In this study the project scope required that 10 discrete rainfall-runoff events with rainfall greater than 0.25 inch be monitored and analyzed for load reduction. The focus of the load reduction was TP, TN and PM. Specific fractions (such as the dissolved fraction), PM indices and basic water chemistry parameters were also analyzed on a discrete event basis. Data were analyzed as event mean concentrations (EMCs).

Load-response is a function of pond 212 as a continuously loaded on-line pond and the flow direction and hydrodynamics of the pond 212/208 contiguous system is dictated by relative hydraulic gradients, wind direction and magnitude which varies depending on time of day and individual storm trajectory, as well as the hydrodynamic re-circulation between the 212 and 208 cells that represent parts of the same system. Therefore the 10 discrete event-based mass separation (%) illustrated in Table 5 represent an instantaneous behavior of the system which has been shown in Figure 31 to 33 to be a continuously loaded on-line system. Therefore the event-basis variability illustrated in Figure 21 to 30 is also reflected in the mass separation results for each of the 10 discrete events in Table 5. A total mass-based analysis from the entire monitoring campaign in which each analyte mass was summed for inflows and outflows across the 10 discrete events yielded the row identified as “Overall” in Table 5.

However, even this “Overall” row of results in Table 5 only represented 10 event-based points sampled from a continuous time series of loadings from September 2014 through July 2015. This “Overall” result is considered as state of the practice for ponds but such a method is less accurate for a continuously loaded on-line pond such as pond 212. Therefore, code was written and analyses conducted for the time series of loadings representing the continuous loading period from event 1 through 3, separately for event 5 through 8, and also for event 4 through 9. These mass separation results over these longer term time series are considered to be more representative for this continuously loaded on-line pond. The longer the time series, the more representative the mass separation. Table 4 and 5 represents the succinct project summary of pond 212 hydrologic and mass separation behavior whether on an event basis per the project scope or on a longer term time series basis outside the project scope but considered more representative than the event basis results. For completeness, Table 6 through 44 summarize the entire water chemistry and load database on an event basis for the entire monitoring campaign to satisfy project requirements. These tables are designed so that each table is fully self-supporting. In these tables for each event, the event mean chemistry and PM indices are provided for inlets and outlets in separate tables and also in a single event basis table for volume and mass of analytes for each of the 10 events.

5 CONCLUSIONS

The focus of this Phase III study is retrofitted pond 212 at APF(with 12 subsurface permeable carbonated reclaimed concrete baffles to train the pond hydrodynamics); as small on-line conveyance pond that is continuously loaded by dry weather flows from the off-site commercial NE catchment (the largest drainage catchment) and by wet weather flows from the NE, N, E and W catchments. The dry weather flows are from surficial groundwater, irrigation water flows from the NE conveyance system and drainage to the NE dendritic storm sewer network. Beyond providing load reduction for nutrients and PM the pond 212 retrofit was constrained based on the following requirements: the retrofit of pond 212 had to be commensurate with the existing context-sensitive aesthetic appeal of the pond as a local amenity, could not be increased in surface area, could not be a wildlife attractant, and given that the pre-retrofit pond 212 was an on-line conveyance pond the north inflow and south “outflow” conveyances could not be modified. While the focus of the study is pond 212, a critical complexity of the retrofitted system was that pond 212 and 208 are hydraulically the same pond that are directly connected by a series of box culverts; pond 208 a primary controlling feature of pond 212. The hydraulic gradient between these two ponds is negligible except during storm flows where depending on the storm direction and wind gradients, pond 208 can flow north into pond 212. The surface to watershed area of pond 212 is approximately 2%, not the more typical ratio of greater than 10 to 15% or greater for retention ponds that are designed to provide storage for flow, volume and constituent load control.

Within Phase III, 10 event-based storms (wet weather flows) from 12 September 2014 (event 1) to 24 July 2015 (event 10) were captured with rainfall depths that ranged from 0.74 (19.0 mm) to 3.18 inches (80.8 mm) with a median of 1.26 inches (32.0 mm). The event-based combined inflows varied based on each catchment conveyance and (irrespective of pond 208 inflows into pond 212) ranged from 14.7 acre-feet to 51.3 acre-feet with a median of 27.2 acre-feet. Event-based net outflows to pond 208 (from SE, SM and SW box culverts connecting pond 212 and 208) ranged from 4.5 acre-feet (5,533 m^3) to 57.2 acre-feet with a median of 7.4 acre-feet. Event-based pond 212 detained volume ranged from 0.006 acre-feet (8 m^3) to 2.2 acre-feet with a median of 1.2 acre-feet (1,511 m^3). Rainfall, inflow volume, outflow volume and nominal to negligible detained volume did not generate a consistent pattern or order.

Event-based load-response of pond 212 to each of the 10 monitored events was examined for water chemistry analytes, focused on PM, TN and TP. Over the entire monitoring campaign the mass separation was: 60% for PM (as TSS), 46% for TP and 23% for TN. The mass separation for other monitored analytes were: 60% for PM (as SSC, suspended sediment concentration), 34% for TDP (total dissolved phosphorus), 31% for TDN (total dissolved nitrogen), and 56% for COD (chemical oxygen demand). If the load-based response is examined on a more continual representative basis (presented in Tables 3-5 and 44) the mass separation is 88% for PM (as TSS), 78% for TP and 44% for TN despite the biologically-young retrofit; approximately one year in June 2015.

In contrast to the 12 internal underwater permeable gabions retrofit that did not require an increase in pond area or volume, if pond 212 had been retrofitted for load reduction based on presumptive criteria for residence time and sizing, the two common retrofit methods are the 21 day residence time design and the ERP design. These design methods would have required a pond 212 surface area would require from 10 to 15 acres, three to five times larger than the current area as compared to the retrofitted pond 212 design for the same level of load reduction. Beyond altering the context-sensitive nature and certainly surface area of pond 212 to at least approach an equal level of treatment performance, these designs increase the pond cost by a factor of three and also increase the wildlife hazard risk. Beyond the wildlife hazard risk and the context-sensitive constraints, the potential to reduce pond surface area and pond costs utilizing CFD designs such as internal permeable baffling with engineered gabion media that provides peer-reviewed documentation of surface complexation (such as sorption) and filtration phenomena can greatly enhance the cost/benefit ratio for ponds. Such extensibility/implementation of CFD-based designs to Florida ponds, in particular when coupled with a continuous monitoring/modeling approach represents the first revolutionary design/protocol change for load control using stormwater ponds in the last 30 to 40 years. We regularly modify/retrofit wastewater and drinking water clarification and contact systems with CFD-based design and continuous testing; we should the same for stormwater ponds.

6 RECOMMENDATIONS FOR FUTURE EXTENSIBILITY

The foundation from the monitoring/modeling results of APF Phase III was built upon the supporting APF Phase I and II results. Furthermore all of these APF project phases from 2012 through the present were directly founded on the prototype CFD numerical and controlled physical model testing of an internal baffle system for steep-sided FAA pond in 2008/2009 at the University of Florida. Based in this linage of developments there are a series of pertinent recommendations with respect to the APF pond 212/208 system for future extensibility across Florida. These are:

1. APF Phase III demonstrated proof-of-concept for a full-scale prototype pond system with a surface to watershed area of 2% retrofitted with permeable underwater gabions of recycled crushed carbonated concrete to create a primary flow path tortuosity of greater than 6, despite constraining and complex upstream and downstream conditions. The extensibility of the pond 212 system as a full-scale testbed requires modifications to monitoring that address the continuous dry- and episodic wet weather interactions of the hydrologic and constituent loadings as well as the variably constraining downstream control of pond 208,

2. Pursuant to recommendation 1, a more continuous monitoring campaign should be carried out for a complete dry season for continuous flow impacts on load and a complete wet season for episodic impacts on load transport and fate through the pond 212/208 system,

3. The current monitoring system requires several critical improvements to address system weaknesses that compromised the Phase III monitoring. One of the critical improvements required is that the velocimeters must be rehabilitated/replaced to provide accurate storm flow velocities and augmented with separate velocimeters at each monitoring location for monitoring the much lower dry weather flows. The current velocimeters are simply not robust for lower flows and in some cases, for high flows and the significant problems of the velocimeters/installations compromised pond 212 volume balances,

4. Ground water flows, losses/gains and gradients at pond 212 and 208 must be measured; this was a significant unknown during Phase III,

5. There was and is only one outfall location for the pond 212/208 system; the weir/orifice of pond 208, which requires continuous monitoring for flow, WSEL and sampling, pursuant to recommendation 1. This recommendation is critical to implementation of recommendation 1,

6. Fine particulate matter (likely algal PM) with complexed nutrients is sloughed/transported from the baffle curtains, and PM detritus and vegetation materials with nutrients are short-circuited along the littoral zones of pond 212 and transported through the outlets. This algal/vegetation/detritus PM and nutrient association, first requires characterization, and second requires a simple adsorptive filter designed as a horizontal or vertical radial/axial small diameter “plug-and-play” appurtenance on the pond 208 orifice which controls all flows except episodic peak flows such as 04 August 2014. This is a simple but critical recommendation which has extensibility to Florida ponds and systems where media that is currently promoted does not have a demonstrable foundation or defensible monitoring basis.

7. Modify the existing baffle curtains to examine their contribution to pond 212 behavior.

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8 LIST OF FIGURES

Figure 15. APF pond 212 CFD model simulations of residence time distributions (RTD) for at -2.62 ft NAVD88 at mean flow rate of 34 L/s from the monitored period of time starting on 20 August 2014. The illustration plots are (A) for the pre-development condition, (B) permeable baffles without fabric curtains, (C) permeable baffles with fabric curtains to eliminate over the top of baffles short-circuiting but allow littoral zone short-circuiting, (D) and extended baffle and fabric curtains into the slope above the water surface to eliminate short-circuiting over the top of the baffles and along the vegetation/nutrient rich littoral zone. All concentration values reported in ppb (parts per billion). The simulations indicated that the Rhodamine WT was transported to the box culvert outlets of pond 212 at (A) 84.5 hr, (B) 212 hr, (C) 160 hr, and (D) 366 hr for each of the four models of pond 212 component conditions.

Figure 16. Volume weighting of each inlet to APF pond 212 over the 10 captured events.

Figure 17. Water surface elevation (WSEL) at the south middle outlet of APF pond 212 for the month of August, 2014.

Figure 18. Water surface elevation (WSEL) at the south middle outlet of APF pond 212 for the month of September, 2014. Captured storm event start of rainfall plotted with event number.

Figure 19. Water surface elevation (WSEL) at the south middle outlet of APF pond 212 for the months of April and May, 2015. Captured storm event start of rainfall plotted with event number.

Figure 20. Water surface elevation (WSEL) at the south middle outlet of APF pond 212 for the month of July, 2015. Captured storm event start of rainfall plotted with event number.

Figure 21. Storm hydrology and hydraulics for event 1 on 12-Sep-14 at APF pond 212.

Figure 22. Storm hydrology and hydraulics for event 2 on 17-Sep-14 at APF pond 212.

Figure 23. Storm hydrology and hydraulics for event 3 on 25-Sep-14 at APF pond 212.

Figure 24. Storm hydrology and hydraulics for event 4 on 28-Apr-15 at APF pond 212.

Figure 25. Storm hydrology and hydraulics for event 5 on 11-May-15 at APF pond 212.

Figure 26. Storm hydrology and hydraulics for event 6 on 12-May-15 at APF pond 212.

Figure 27. Storm hydrology and hydraulics for event 7 on 13-May-15 at APF pond 212.

Figure 28. Storm hydrology and hydraulics for event 8 on 17-May-15 at APF pond 212.

Figure 29. Storm hydrology and hydraulics for event 9 on 23-May-15 at APF pond 212.

Figure 30. Storm hydrology and hydraulics for event 10 on 24-Jul-15 at APF pond 212.

Figure 31. Storm hydrology and hydraulics for events 1-3 from 12-Sep-14 to 30-Sep-14 at APF pond 212.

Figure 32. Storm hydrology and hydraulics for events 5-8 from 11-May-15 to 22-May-15 at APF pond 212.

Figure 33. Storm hydrology and hydraulics for events 4-9 from 28-Apr-15 to 28-May-15 at APF pond 212.

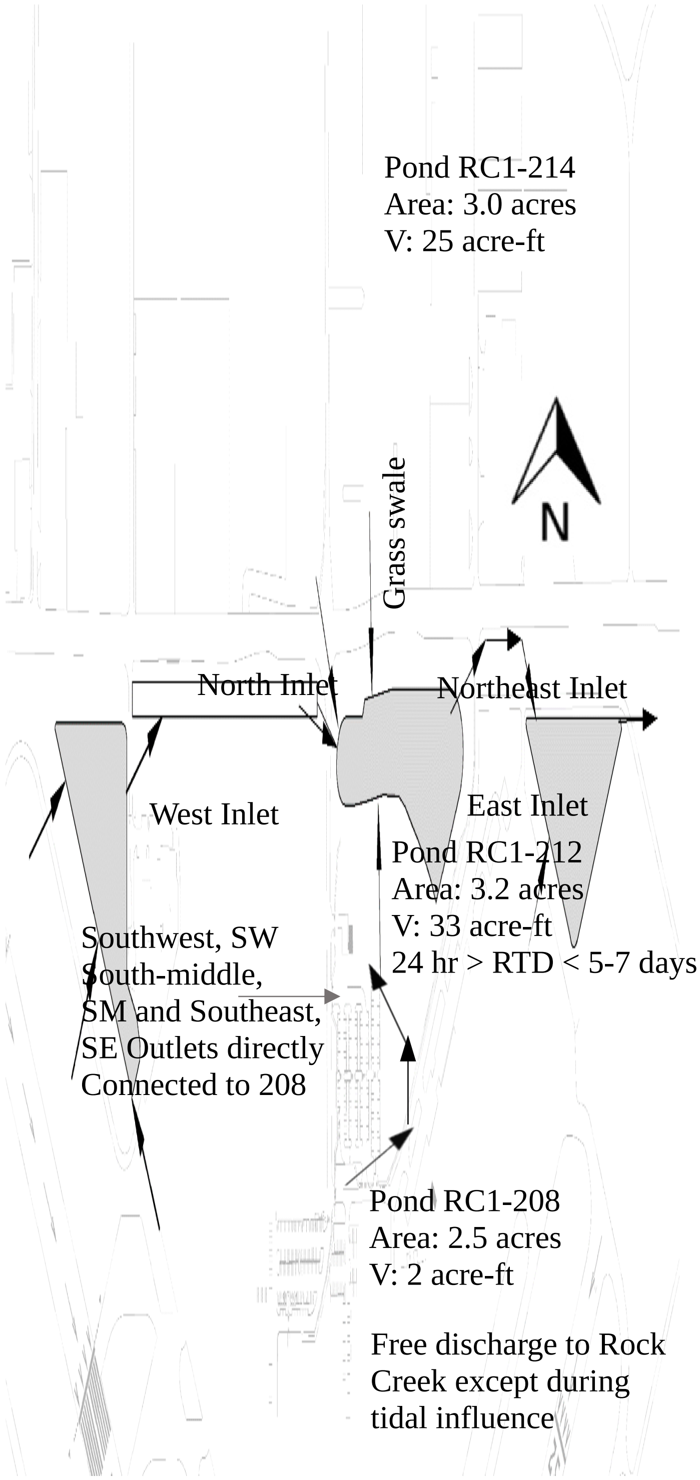


Figure 1. Process flow diagram of APF ponds 214, 212, and 208. Residence time distribution (RTD) initial and ending elution based on 20-Aug-14 rhodamine WT (RWT) tracer injection.

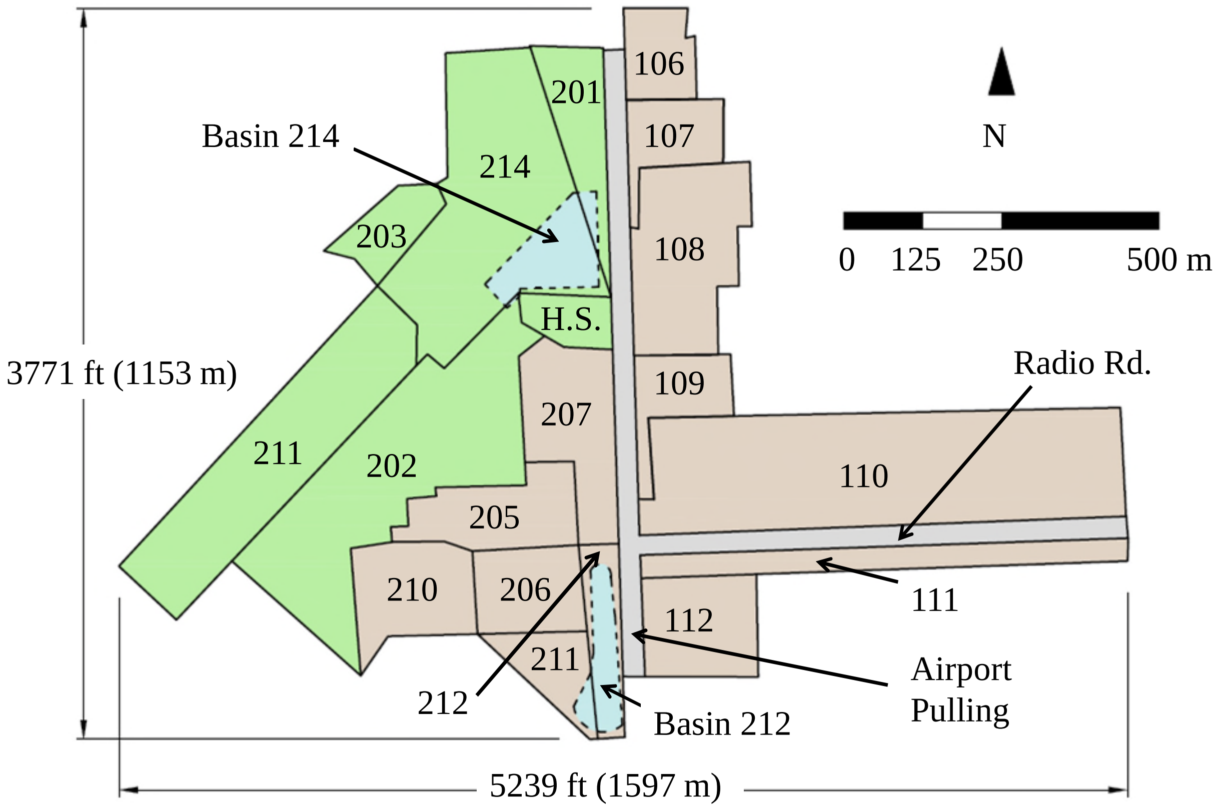
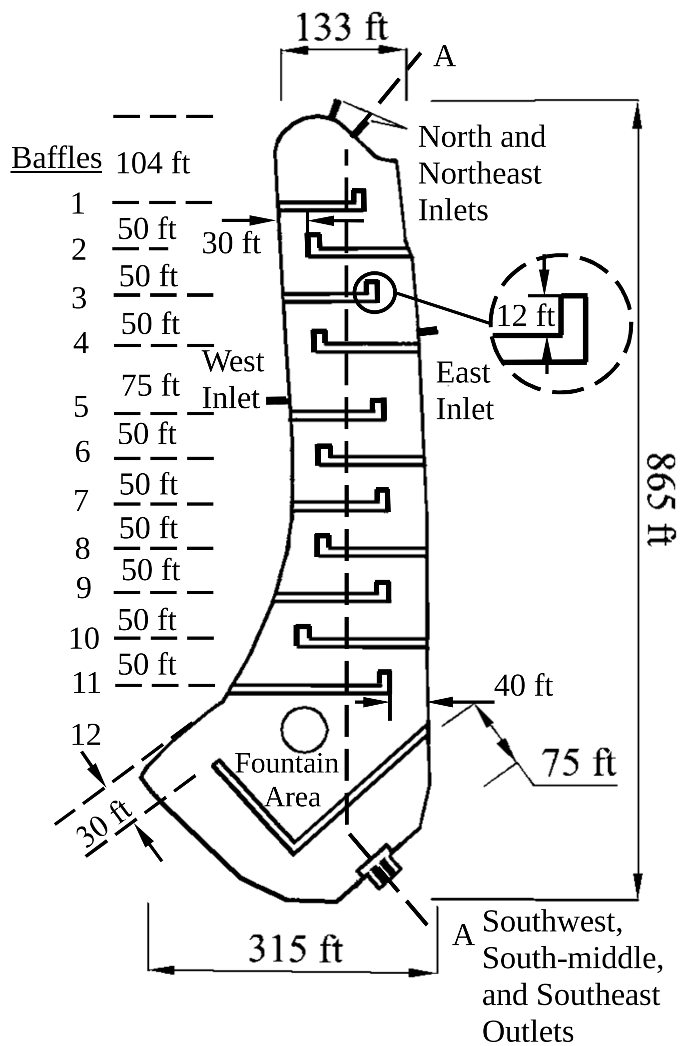


Figure 2. Watershed and catchments draining through APF pond 212 watershed.



Location	Size (vertical x horizontal)	Type
East Inlet	15” x 36”	Elliptical
West Inlet	18” x 36”	Elliptical
Northeast Inlet	43” x 68”	Elliptical
North Inlet	43” x 68”	Elliptical
Southwest Outlet	5' x 8'	Box Culvert
South-Middle Outlet	5' x 8'	Box Culvert
Southeast Outlet	5' x 8'	Box Culvert

Figure 3. Plan view of pond 212 with retrofit design.

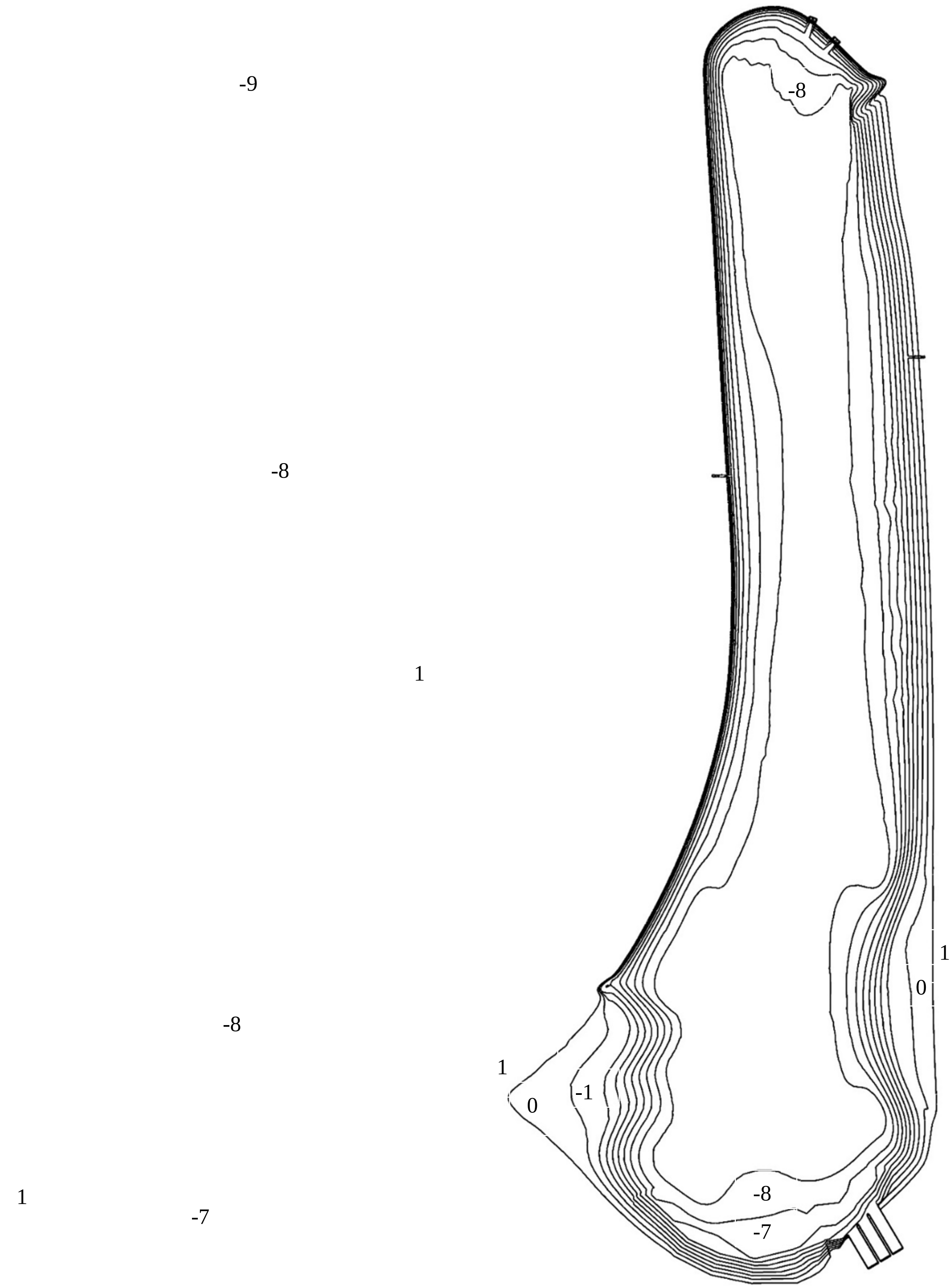
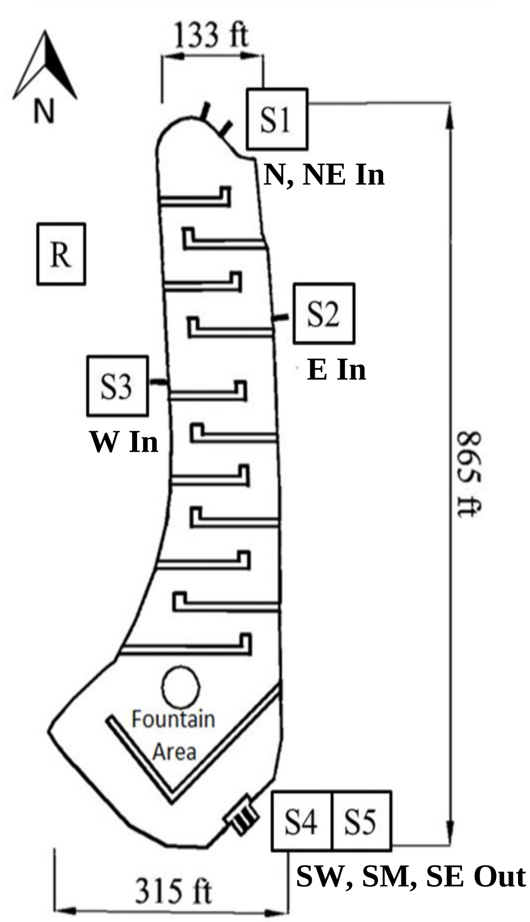


Figure 4. APF pond 212 as-built bathymetric 1ft interval contours (left) and pre-development bathymetric 1ft interval contours (right). The vertical datum is NAVD 88.



Location	Data Logger	Rain Gauge		
R	CR200x	CS700		
		Pressure Transducer	Sampler	Velocimeter
E In	CR1000	CS451-7.25psig	PVS5120D	SonTek-IQ Series Pipe Intelligent Flow
W In	CR1000	CS451-7.25psig	PVS5120D	SonTek-IQ Series Pipe Intelligent Flow
NE In	CR1000	CS451-7.25psig	PVS5120D	SonTek-IQ Series Plus Intelligent Flow
N In	CR1000	CS451-7.25psig	PVS5120D	SonTek-IQ Series Plus Intelligent Flow
SW Out	CR1000	CS451-7.25psig	PVS5120D	SonTek-IQ Series Plus Intelligent Flow
SM Out	CR1000	CS451-7.25psig	PVS5120D	SonTek-IQ Series Plus Intelligent Flow
SE Out	CR1000	CS451-7.25psig	PVS5120D	SonTek-IQ Series Plus Intelligent Flow

All monitoring equipment excluding velocimeters are Campbell Scientific products

R	Rain Gauge	N In	North Inlet
E In	East Inlet	SW Out	Southwest Outlet
W In	West Inlet	SM Out	South Middle Outlet
NE In	Northeast Inlet	SE Out	Southeast Outlet

Figure 5. Monitoring stations with data collection, logging and sampling equipment summary for monitoring campaign at APF pond 212. Conveyances are nominally classified as “In” or “Out”.

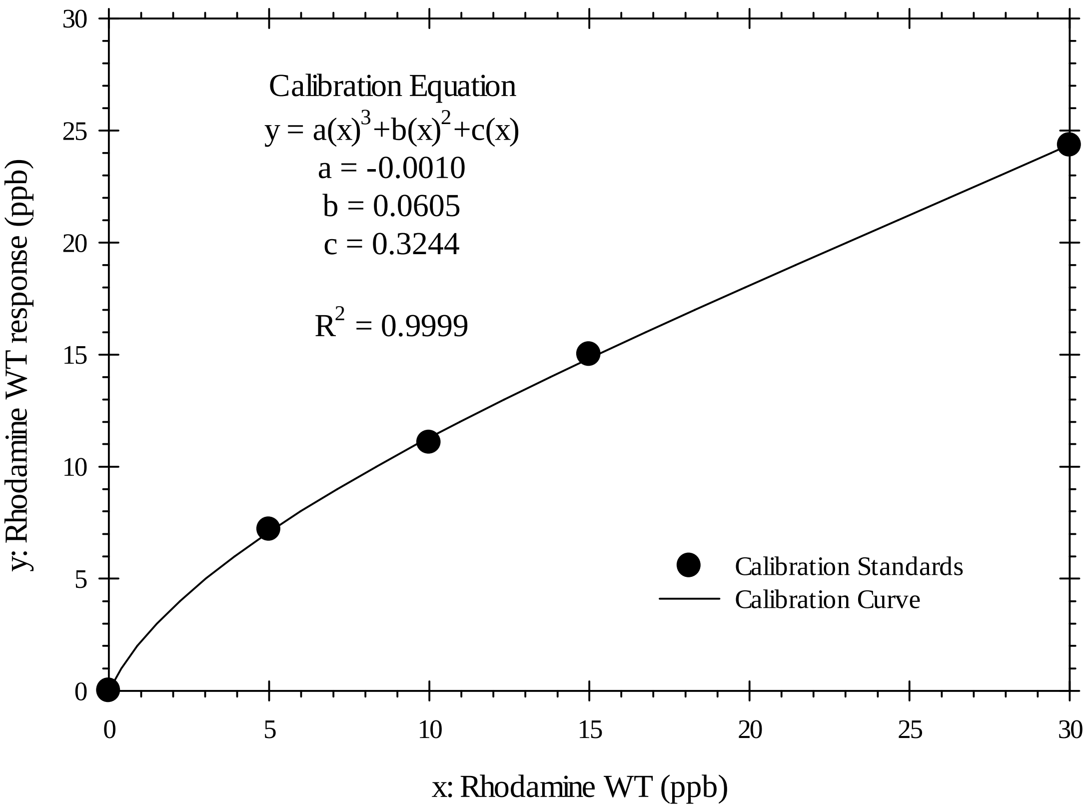


Figure 6. Fluorimeter calibration curve.

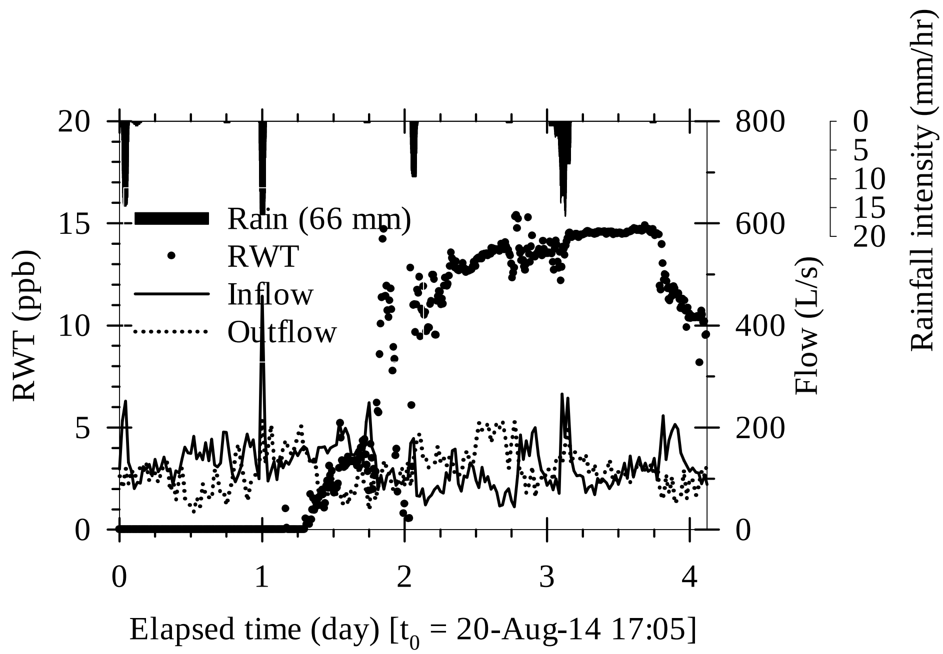


Figure 7. APF pond 212 tracer study measured Rhodamine WT (RWT) concentration for injection 1 (20-Aug) plotted against summed influent and effluent flowrate as well as rainfall intensity. 20-August rainfall event was 0.62 inches in depth.

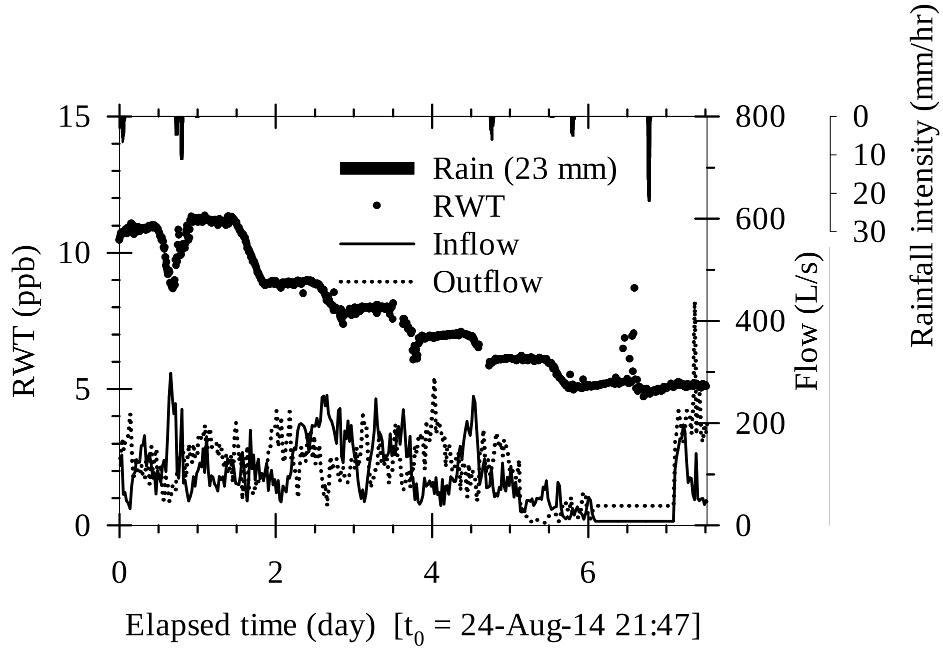


Figure 8. APF pond 212 tracer study measured Rhodamine WT (RWT) concentration for injection 2 (24-Aug) plotted against summed influent and effluent flowrate as well as rainfall intensity.

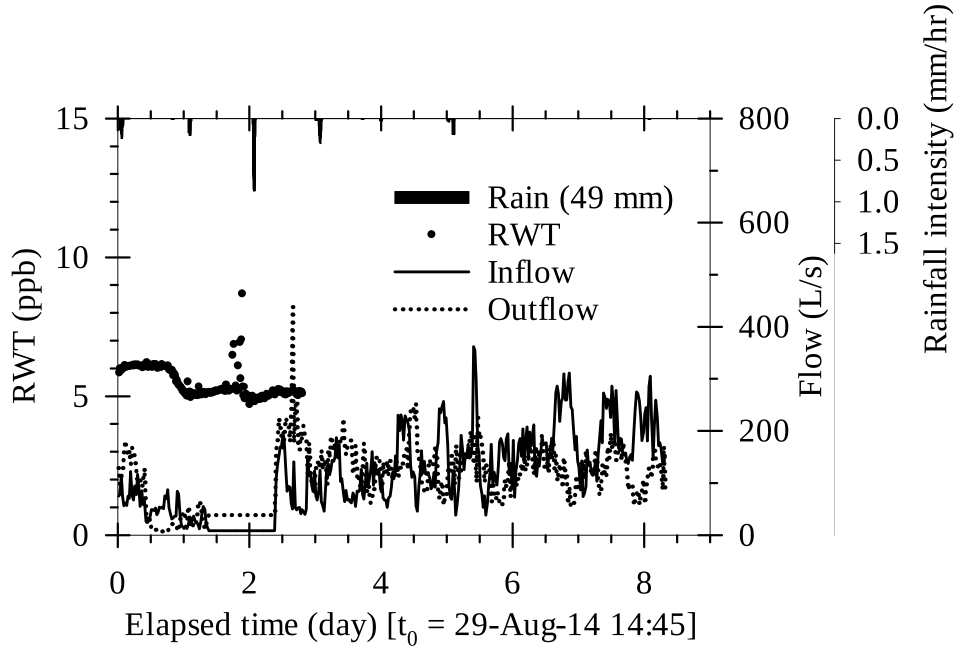


Figure 9. APF pond 212 tracer study measured Rhodamine WT (RWT) concentration for injection 3 (29-Aug) plotted against summed influent and effluent flowrate as well as rainfall intensity. RWT concentration data missing from 1-Sep 10:55 to 7-Sep 8:40 due to equipment failure.

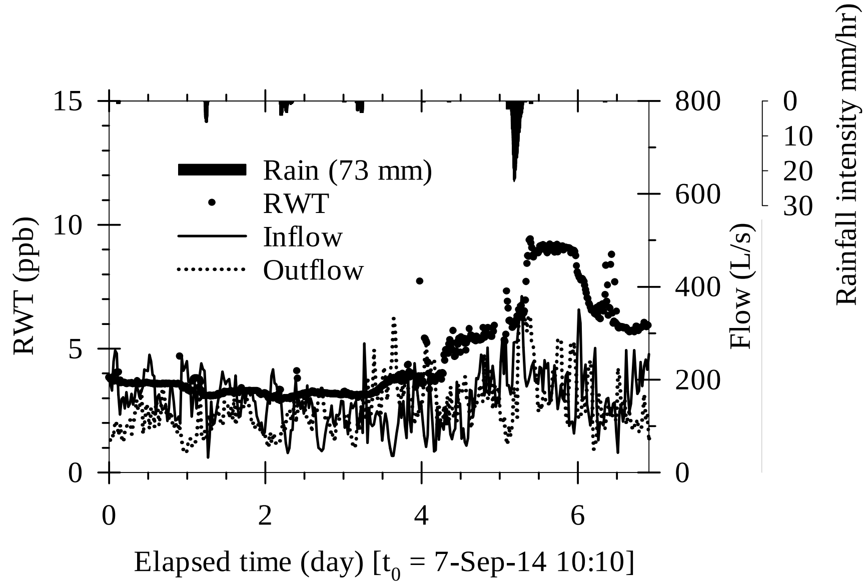


Figure 10. APF pond 212 tracer study measured Rhodamine WT (RWT) concentration for injection 4 (7-Sep) plotted against summed influent and effluent flowrate as well as rainfall intensity.

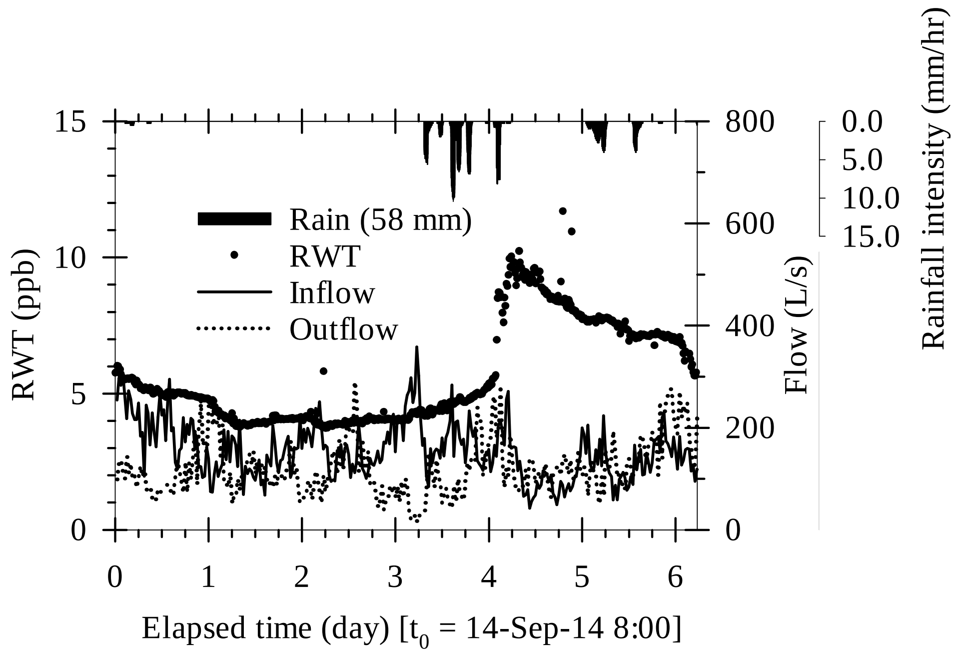


Figure 11. APF pond 212 tracer study measured Rhodamine WT (RWT) concentration for injection 5 (14-Sep) plotted against summed influent and effluent flowrate as well as rainfall intensity.

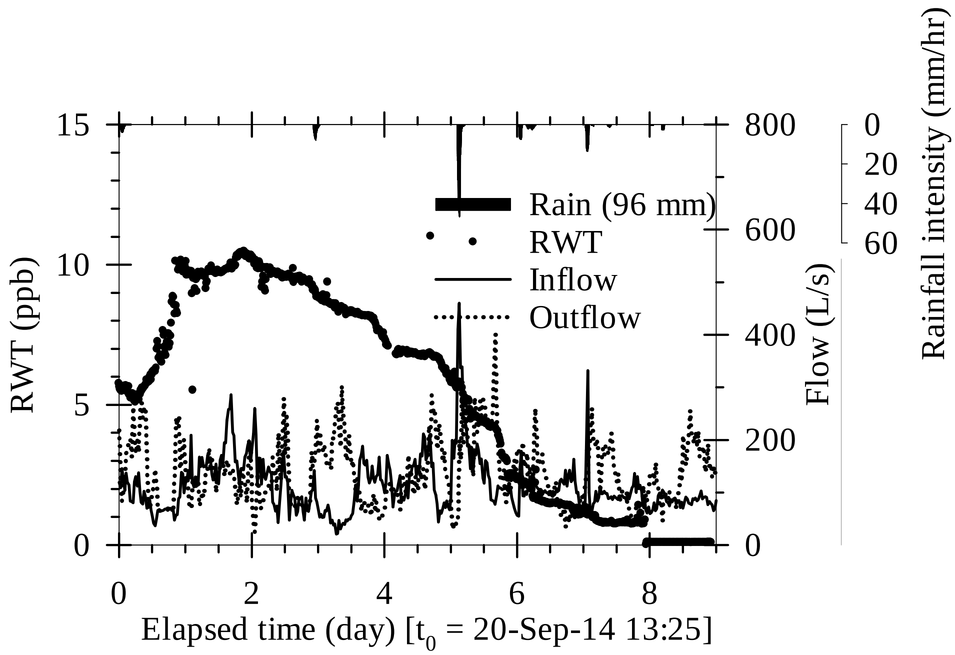


Figure 12. APF pond 212 tracer study measured Rhodamine WT (RWT) concentration for injection 4 (20-Sep) plotted against summed influent and effluent flowrate as well as rainfall intensity.

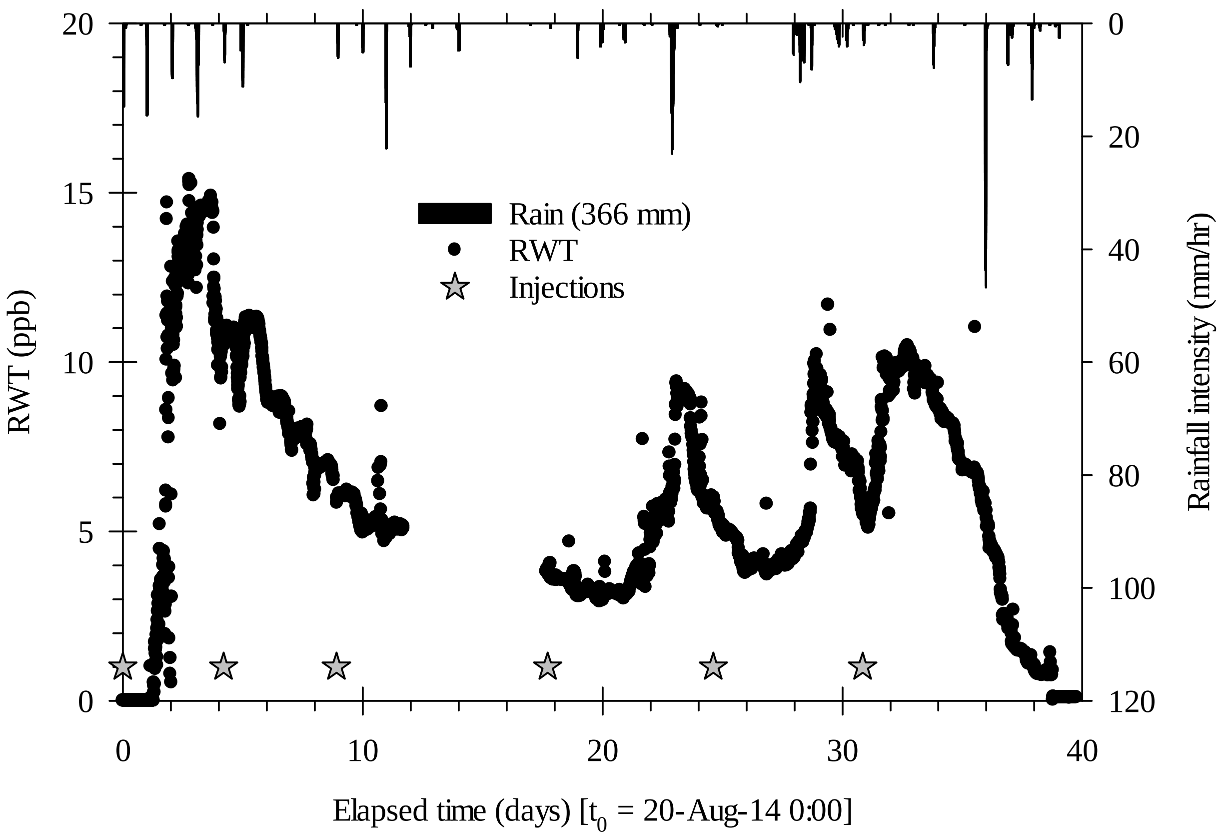


Figure 13. APF pond 212 tracer study measured Rhodamine WT (RWT) concentration for all injections plotted against rainfall intensity.

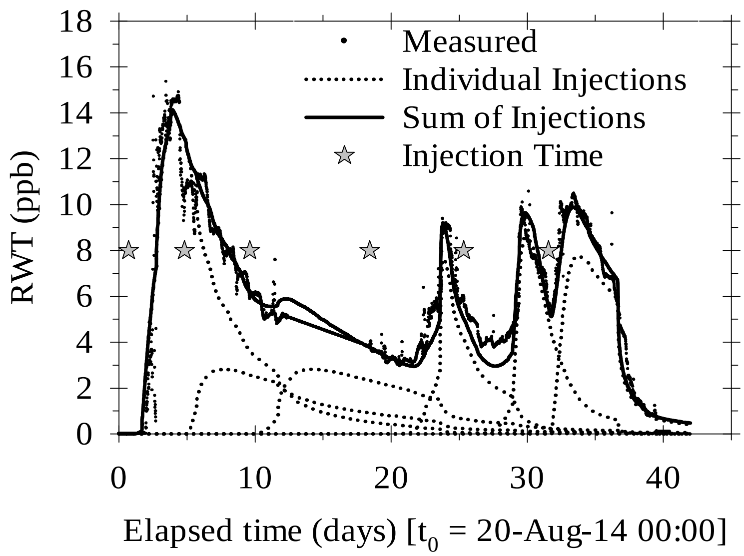


Figure 14. APF pond 212 tracer study measured Rhodamine WT (RWT) concentration for all injections plotted against deconvoluted concentration signals from each injection.

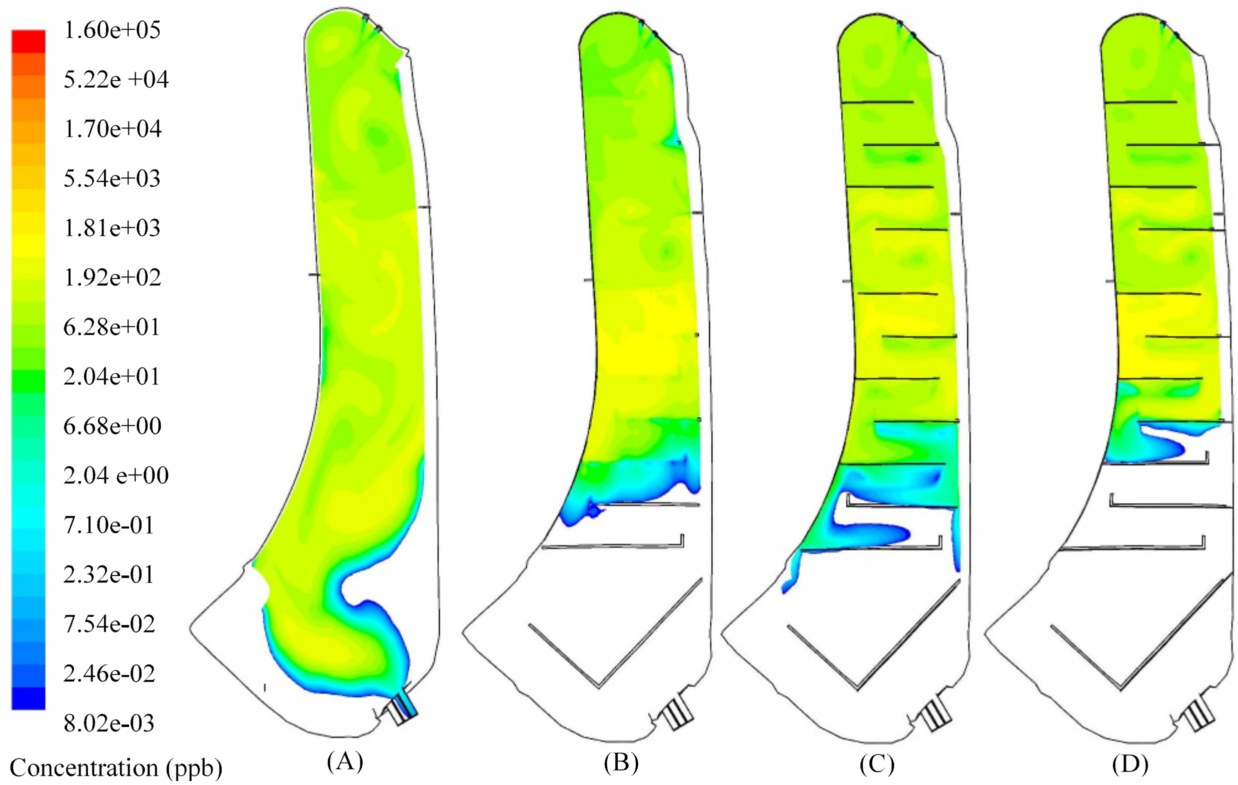


Figure 15. APF pond 212 CFD model simulations of residence time distributions (RTD) for at -2.62 ft NAVD88 at mean flow rate of 34 L/s from the monitored period of time starting on 20 August 2014. The illustration plots are (A) for the pre-development condition, (B) permeable baffles without fabric curtains, (C) permeable baffles with fabric curtains to eliminate over the top of baffles short-circuiting but allow littoral zone short-circuiting, (D) and extended baffle and fabric curtains into the slope above the water surface to eliminate short-circuiting over the top of the baffles and along the vegetation/nutrient rich littoral zone. All concentration values reported in ppb (parts per billion). The simulations indicated that the Rhodamine WT was transported to the box culvert outlets of pond 212 at (A) 84.5 hr, (B) 212 hr, (C) 160 hr, and (D) 366 hr for each of the four models of pond 212 component conditions.

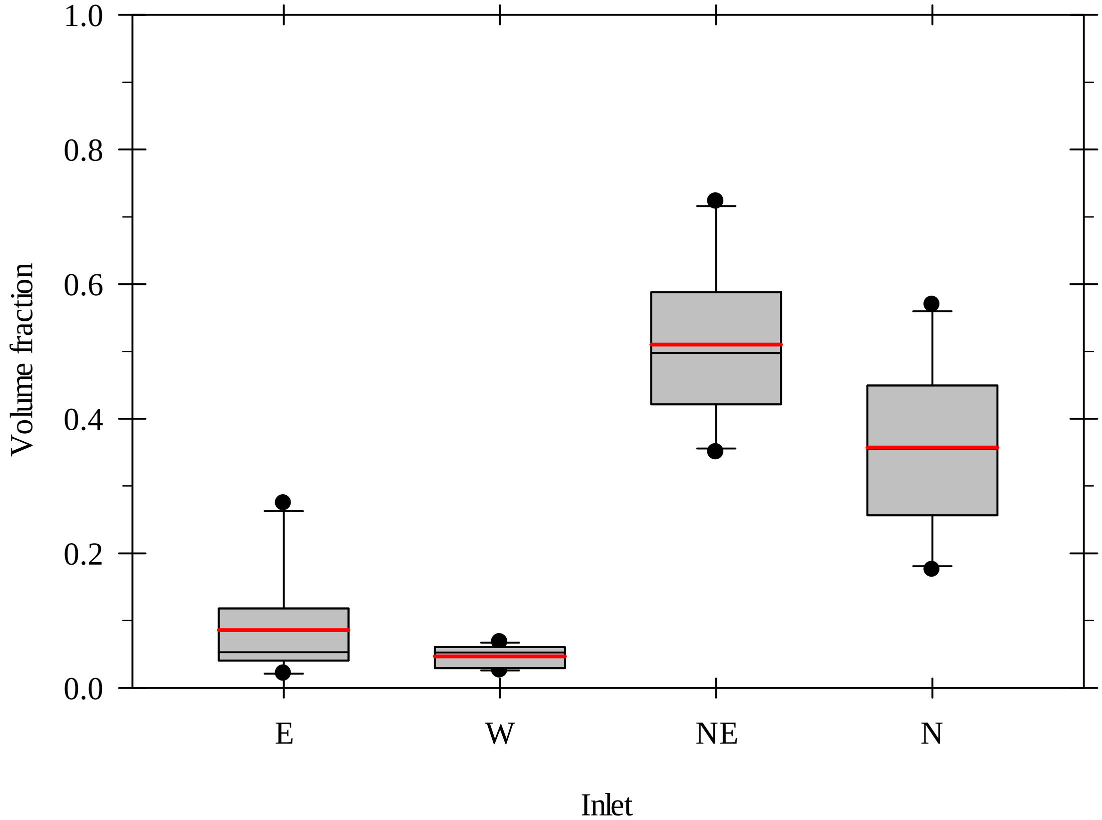


Figure 16. Volume weighting of each inlet to APF pond 212 over the 10 captured events

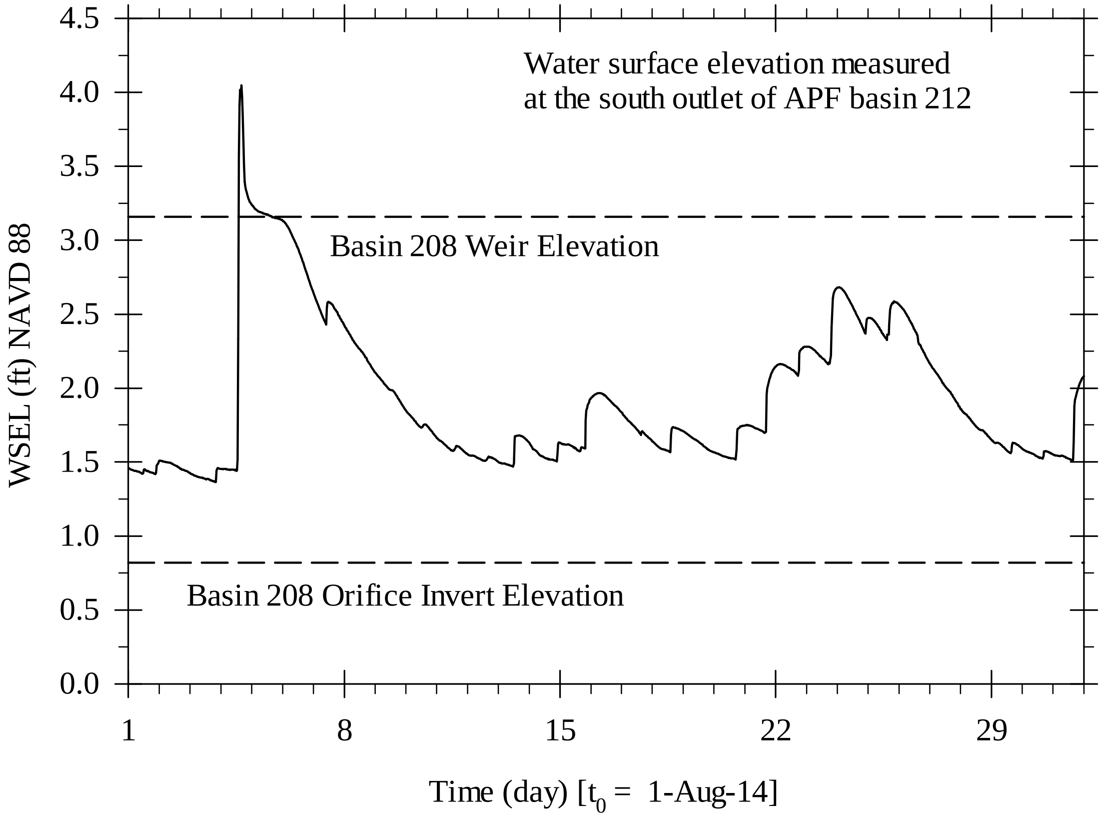


Figure 17. Water surface elevation (WSEL) at the south middle outlet of APF pond 212 for the month of August, 2014.

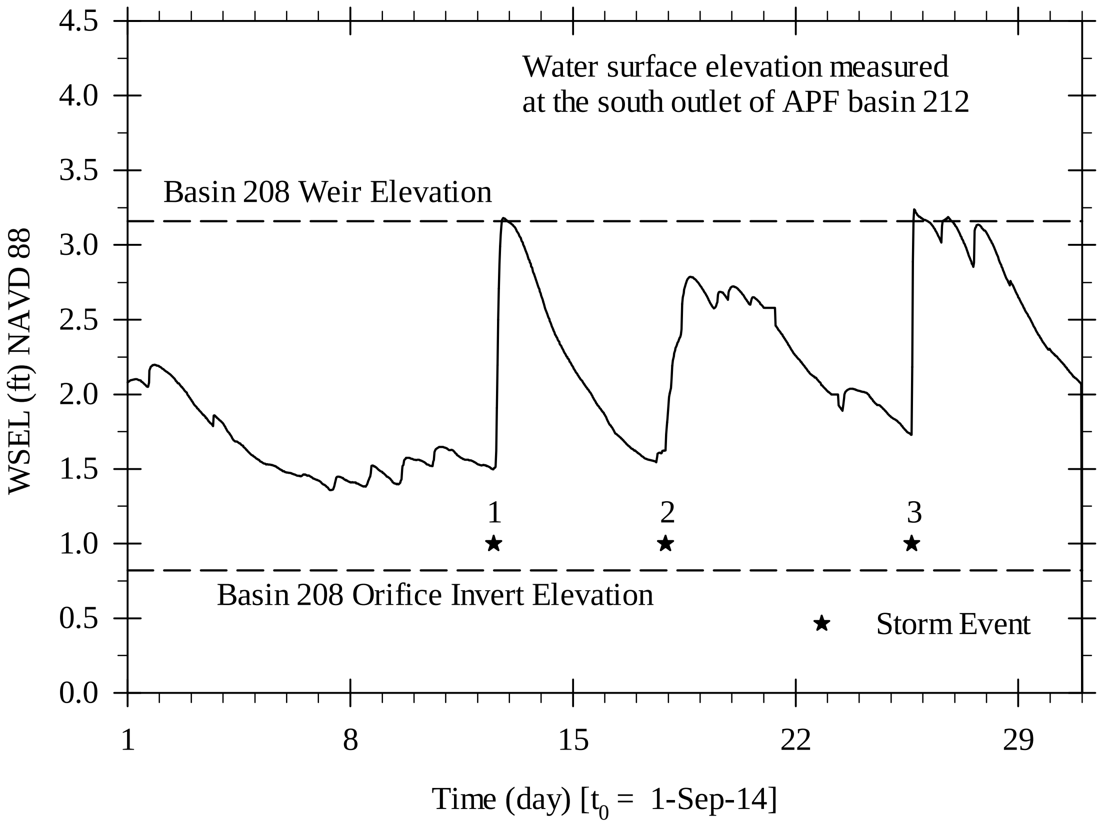


Figure 18. Water surface elevation (WSEL) at the south middle outlet of APF pond 212 for the month of September, 2014. Captured storm event start of rainfall plotted with event number.

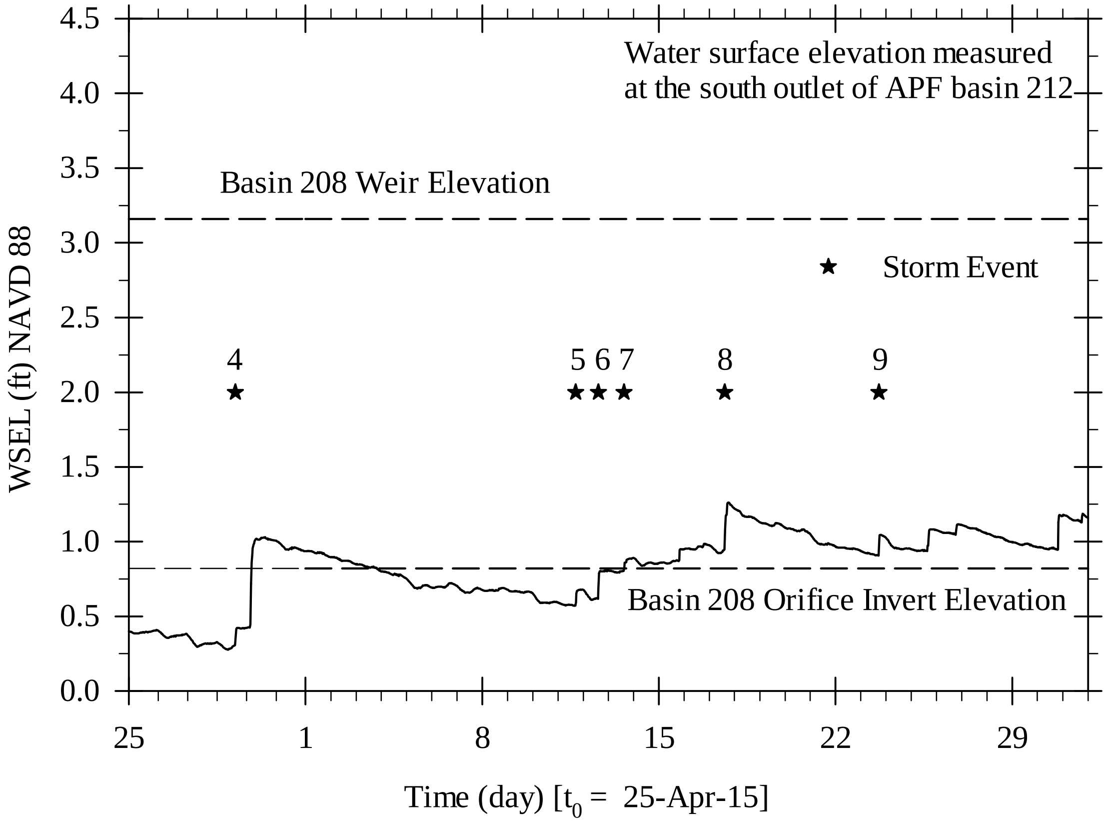


Figure 19. Water surface elevation (WSEL) at the south middle outlet of APF pond 212 for the months of April and May, 2015. Captured storm event start of rainfall plotted with event number.

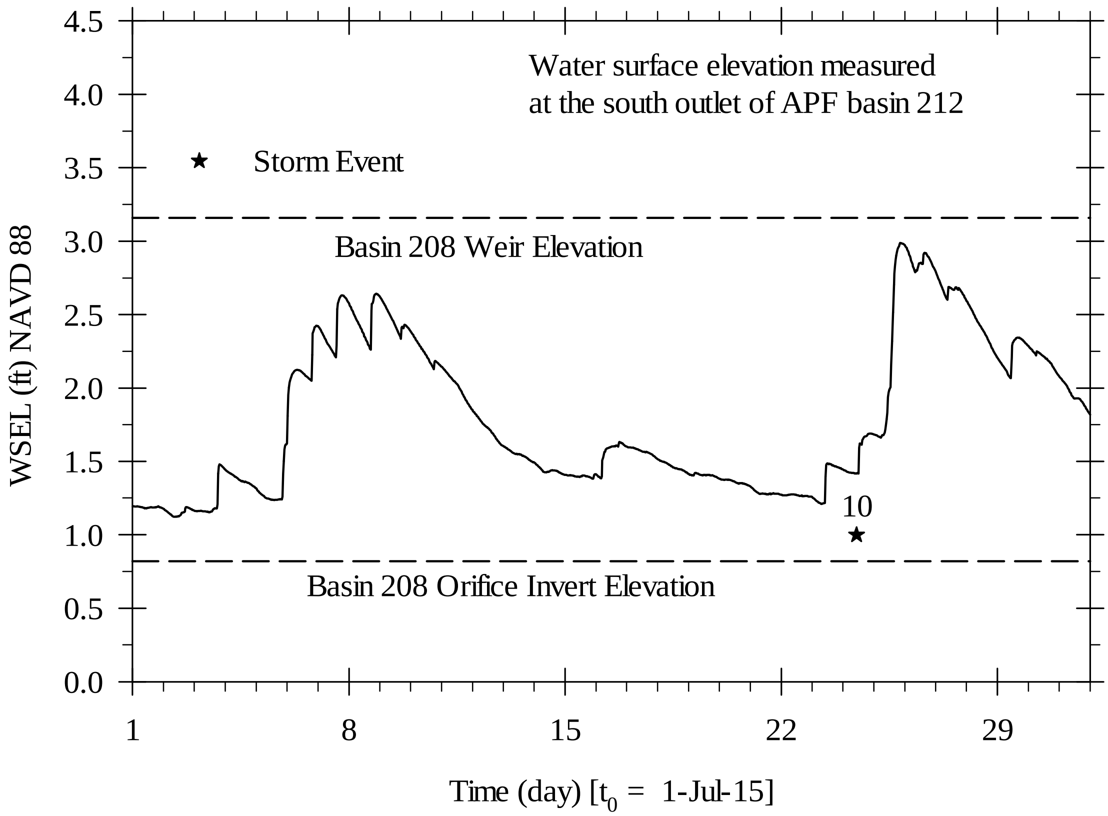


Figure 20. Water surface elevation (WSEL) at the south middle outlet of APF pond 212 for the month of July, 2015. Captured storm event start of rainfall plotted with event number.

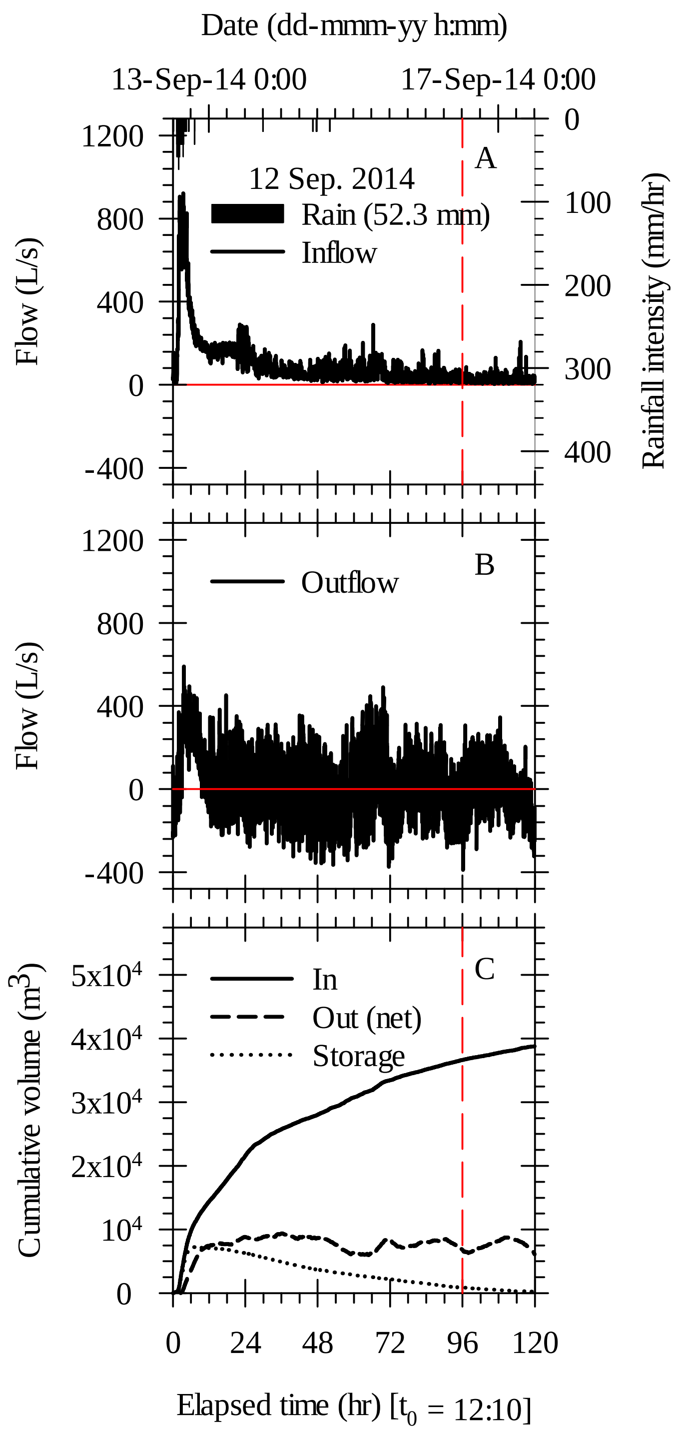


Figure 21. Storm hydrology and hydraulics for event 1 on 12-Sep-14 at APF pond 212.

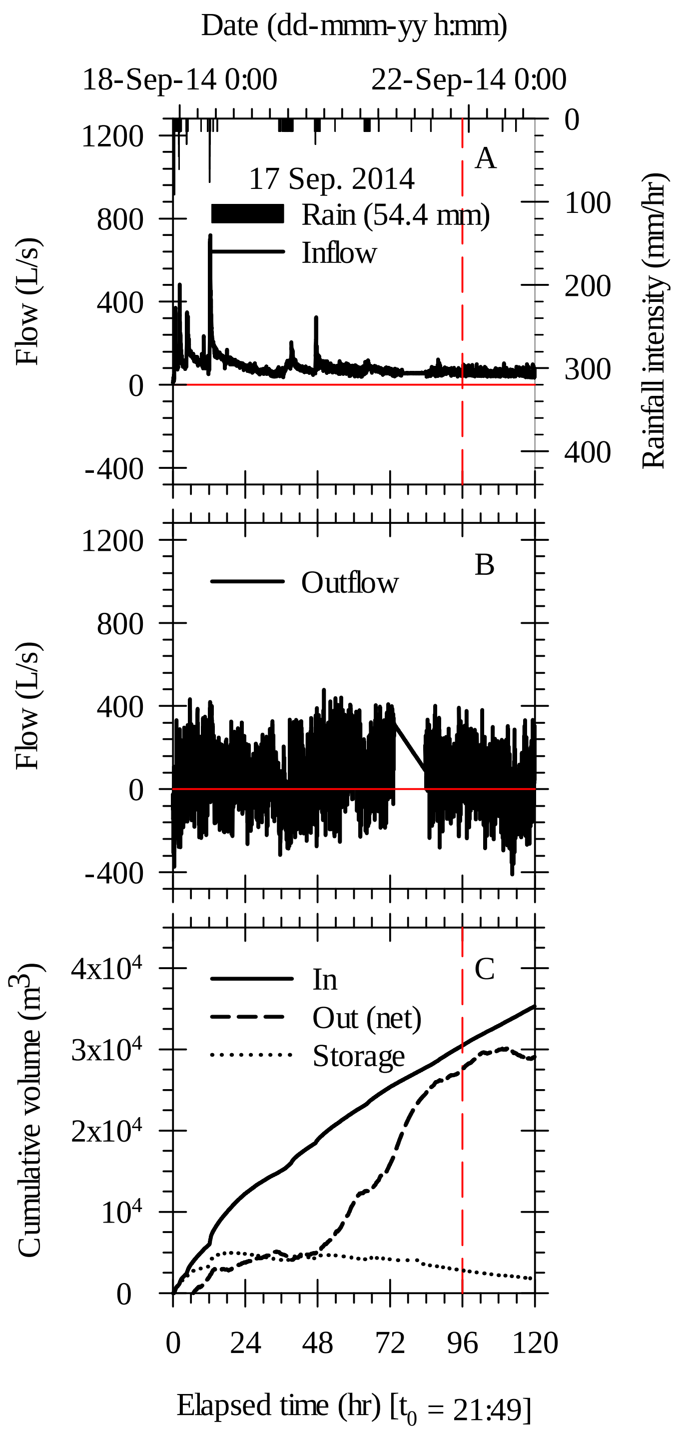


Figure 22. Storm hydrology and hydraulics for event 2 on 17-Sep-14 at APF pond 212.

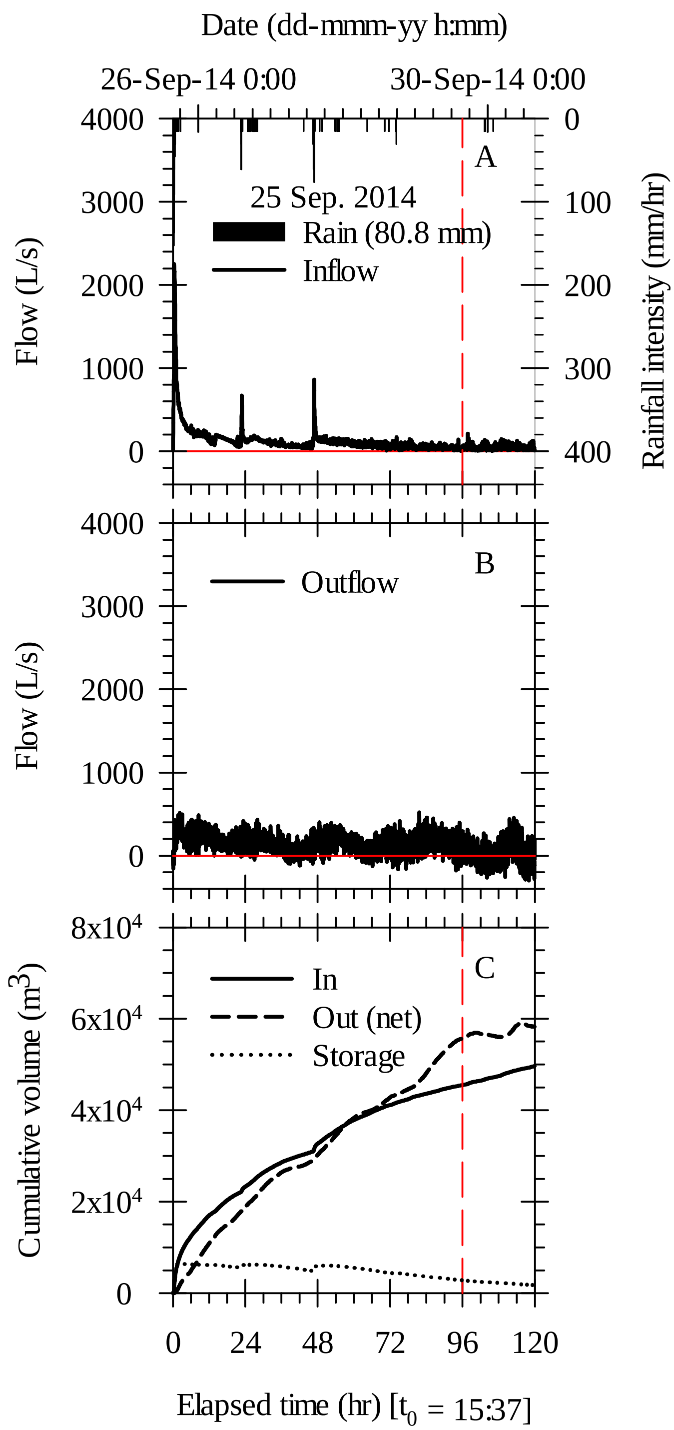


Figure 23. Storm hydrology and hydraulics for event 3 on 25-Sep-14 at APF pond 212.

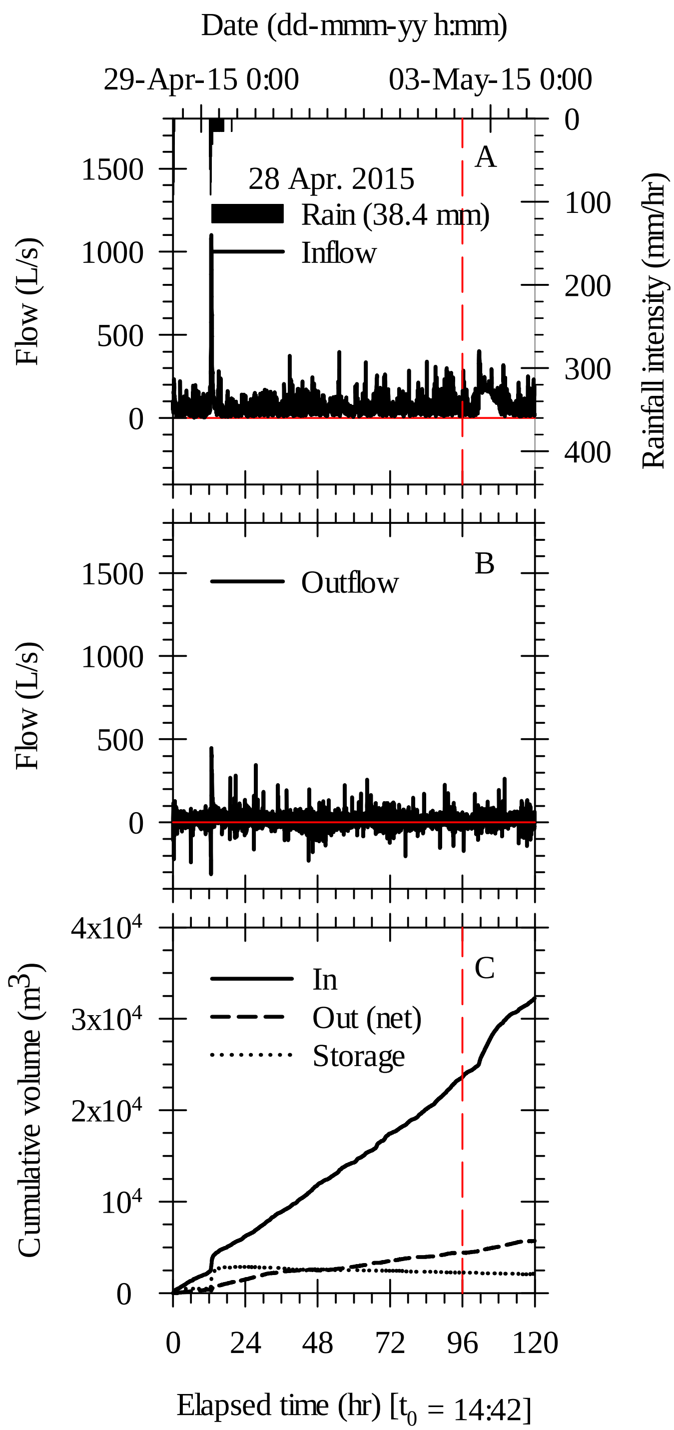


Figure 24. Storm hydrology and hydraulics for event 4 on 28-Apr-15 at APF pond 212.

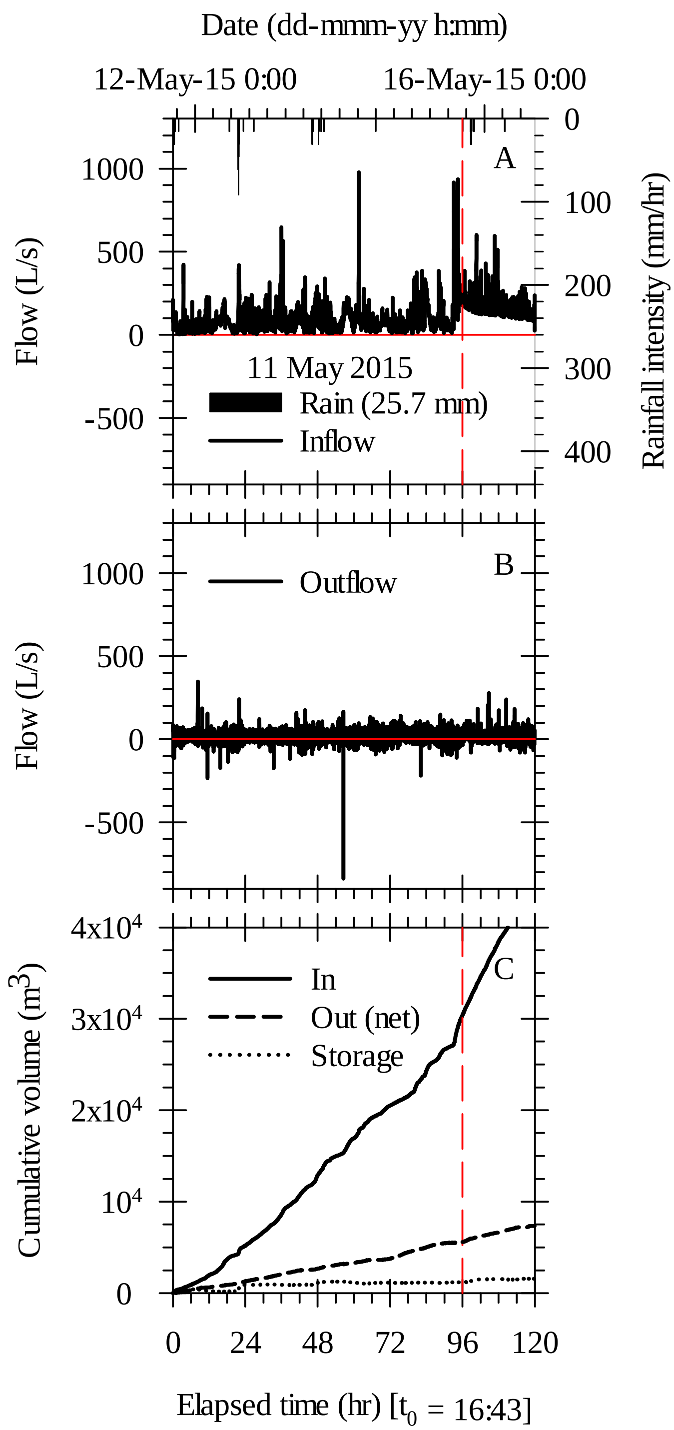


Figure 25. Storm hydrology and hydraulics for event 5 on 11-May-15 at APF pond 212.

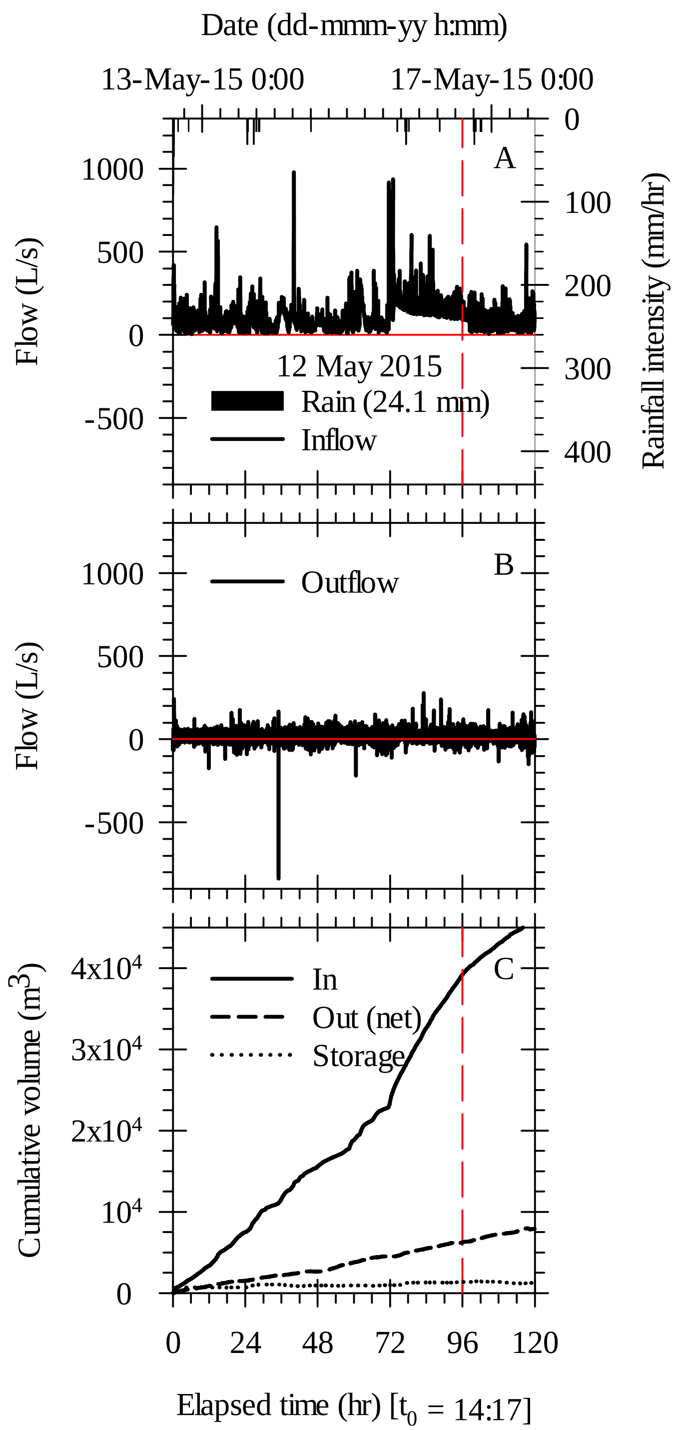


Figure 26. Storm hydrology and hydraulics for event 6 on 12-May-15 at APF pond 212.

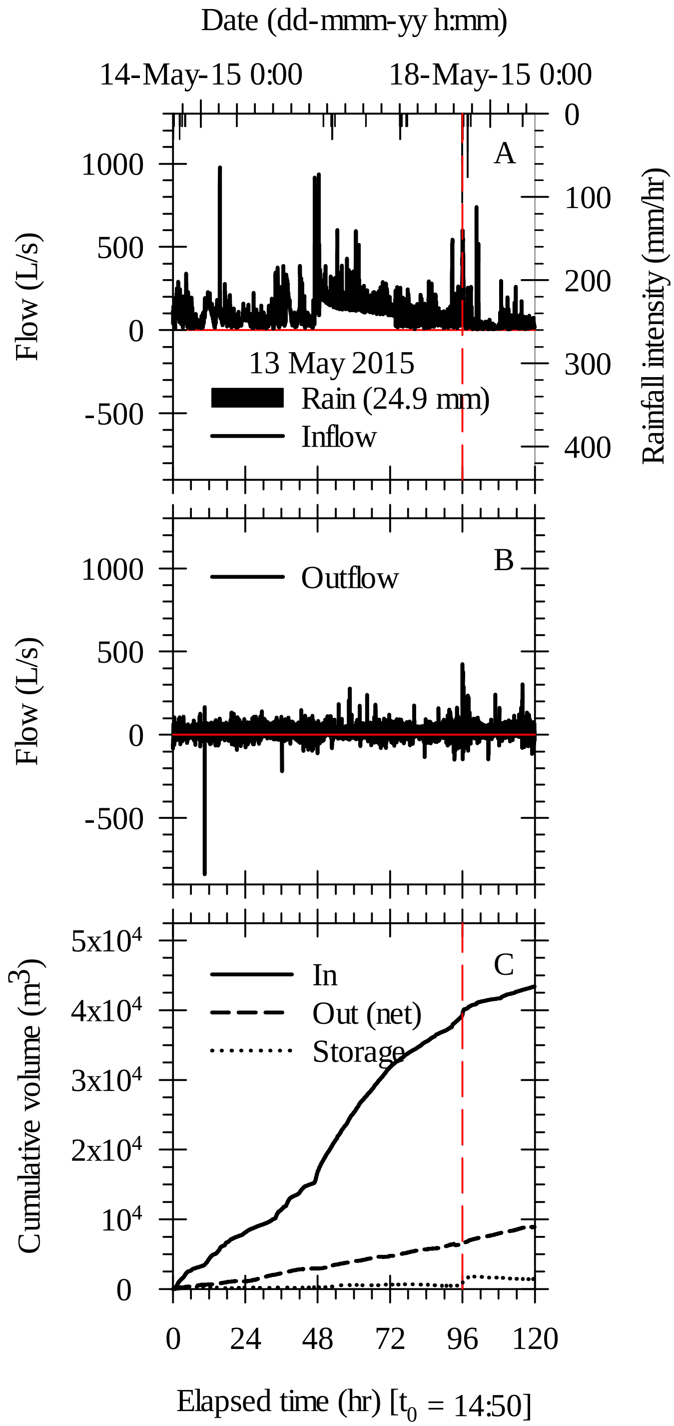


Figure 27. Storm hydrology and hydraulics for event 7 on 13-May-15 at APF pond 212.

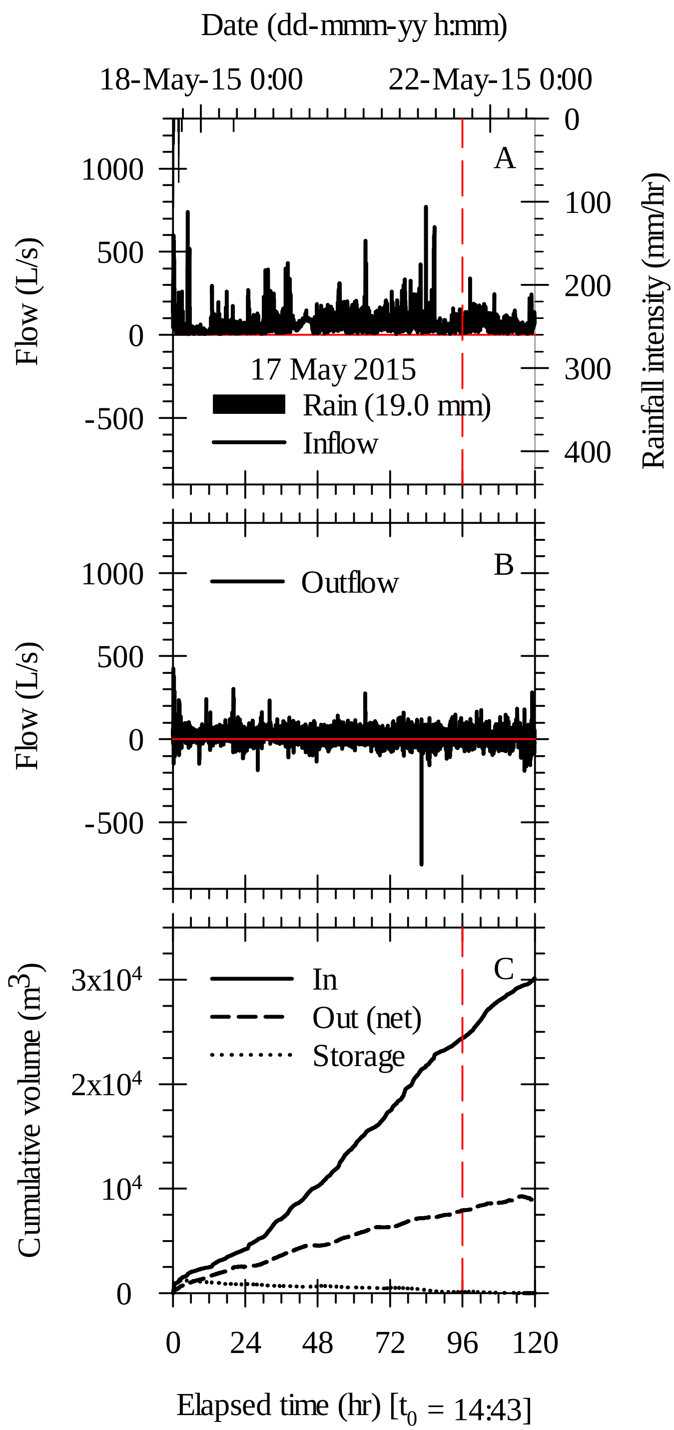


Figure 28. Storm hydrology and hydraulics for event 8 on 17-May-15 at APF pond 212.

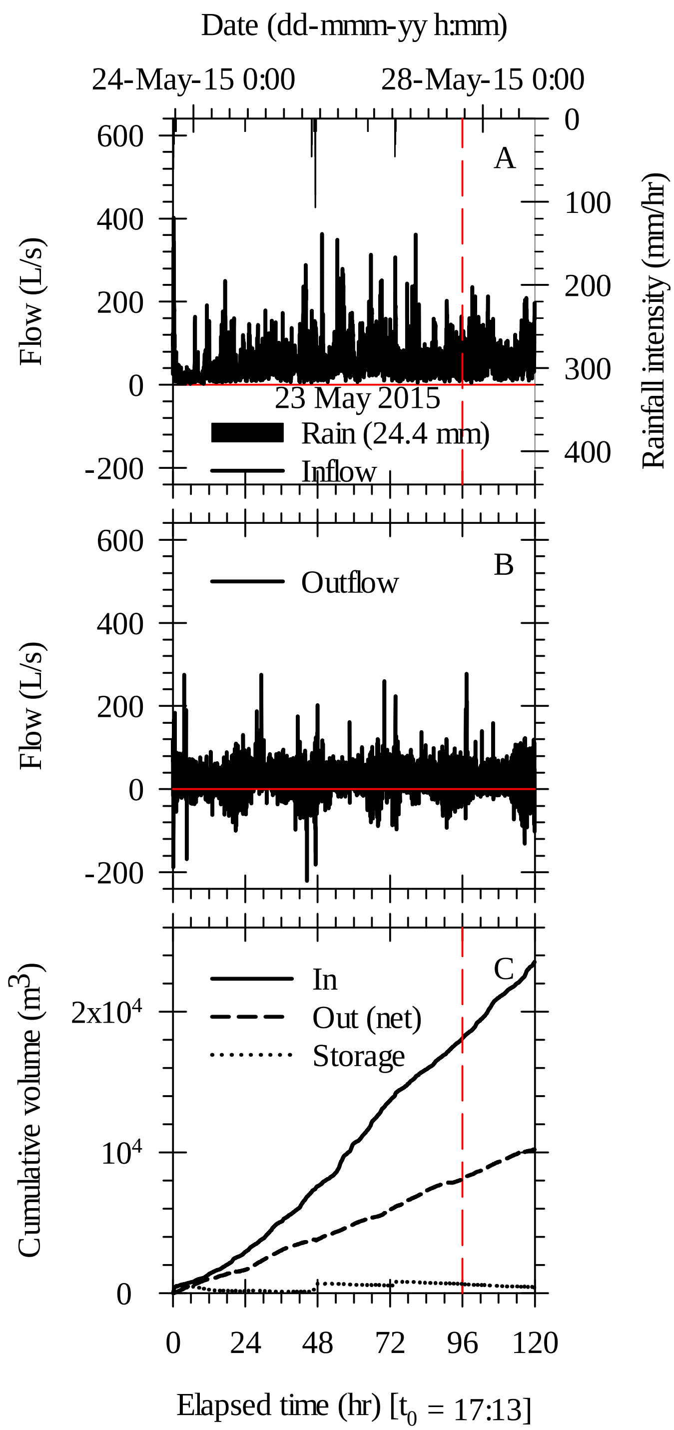


Figure 29. Storm hydrology and hydraulics for event 9 on 23-May-15 at APF pond 212.

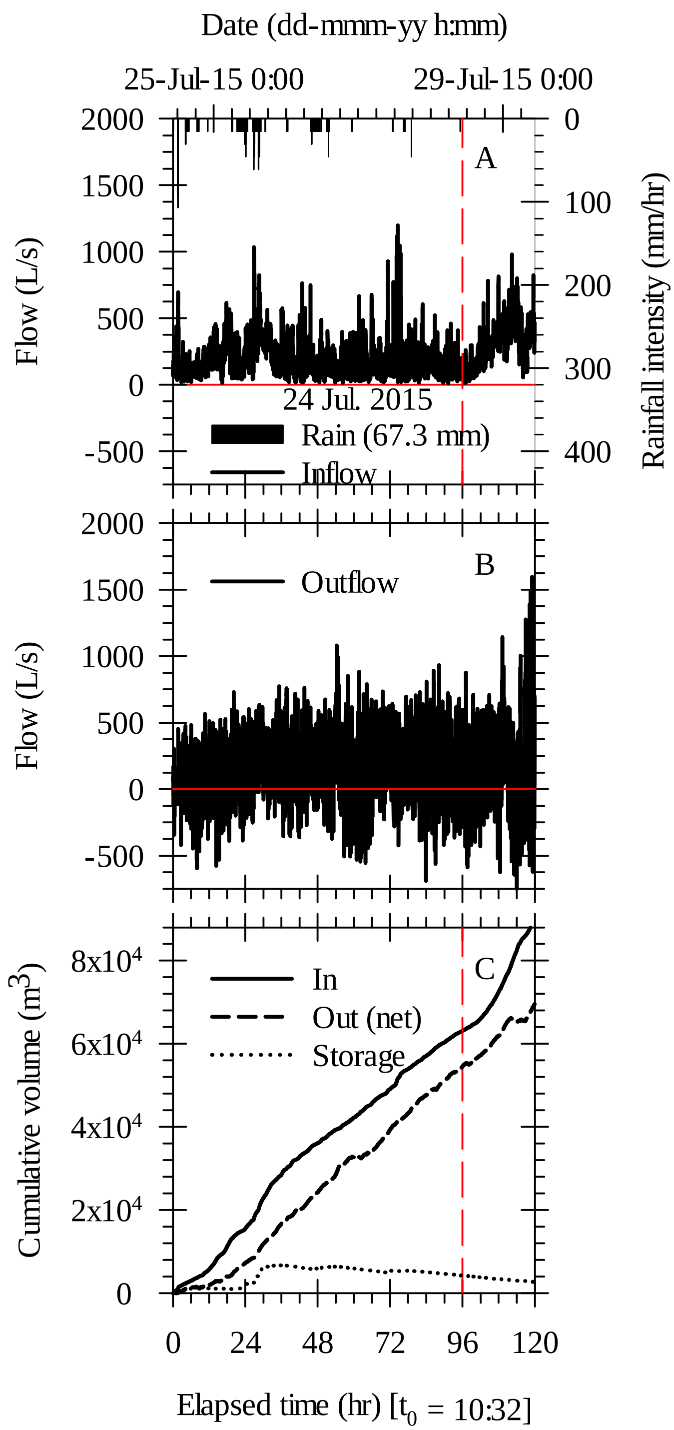


Figure 30. Storm hydrology and hydraulics for event 10 on 24-Jul-15 at APF pond 212.

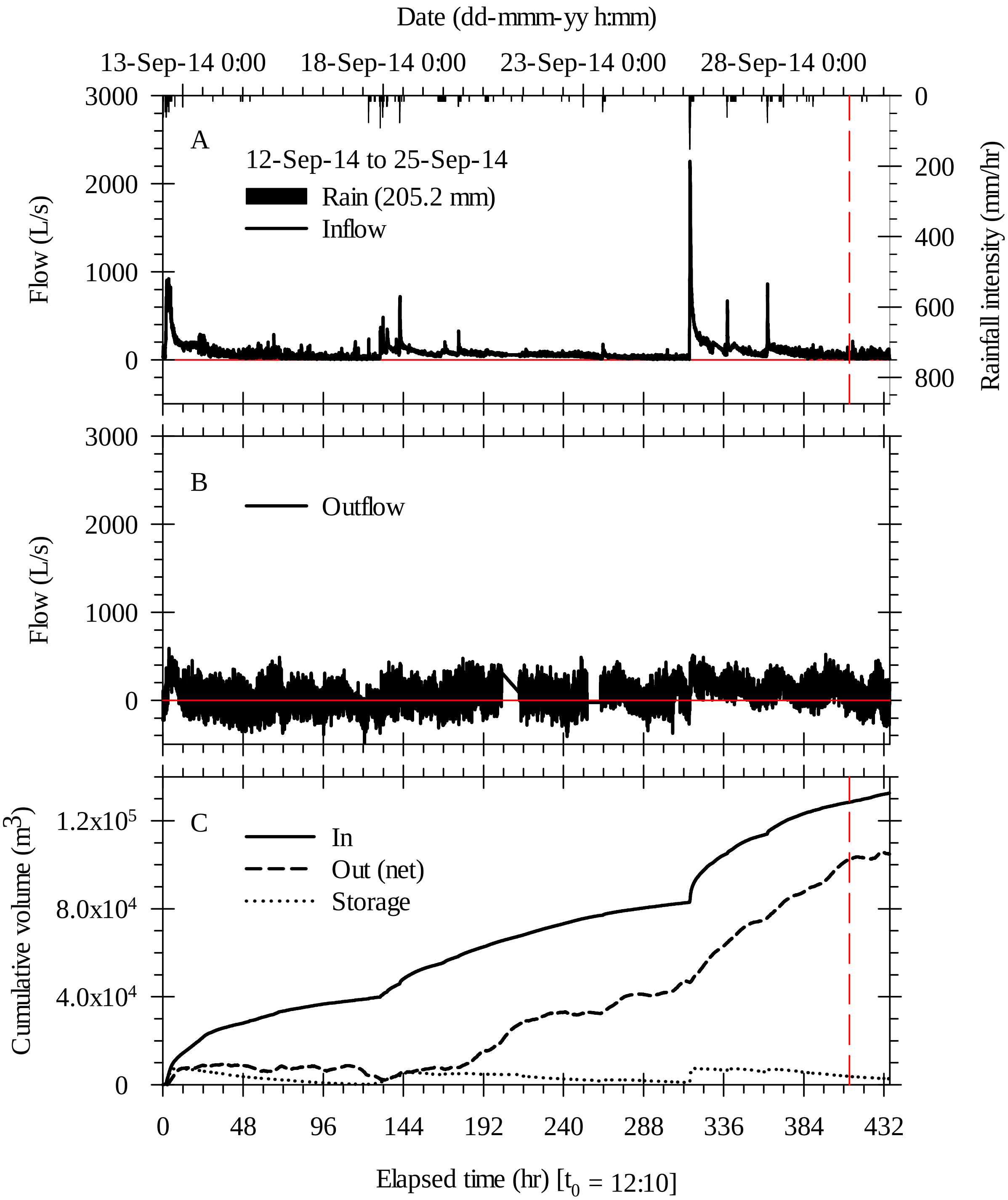


Figure 31. Storm hydrology and hydraulics for events 1-3 from 12-Sep-14 to 30-Sep-14 at APF pond 212.

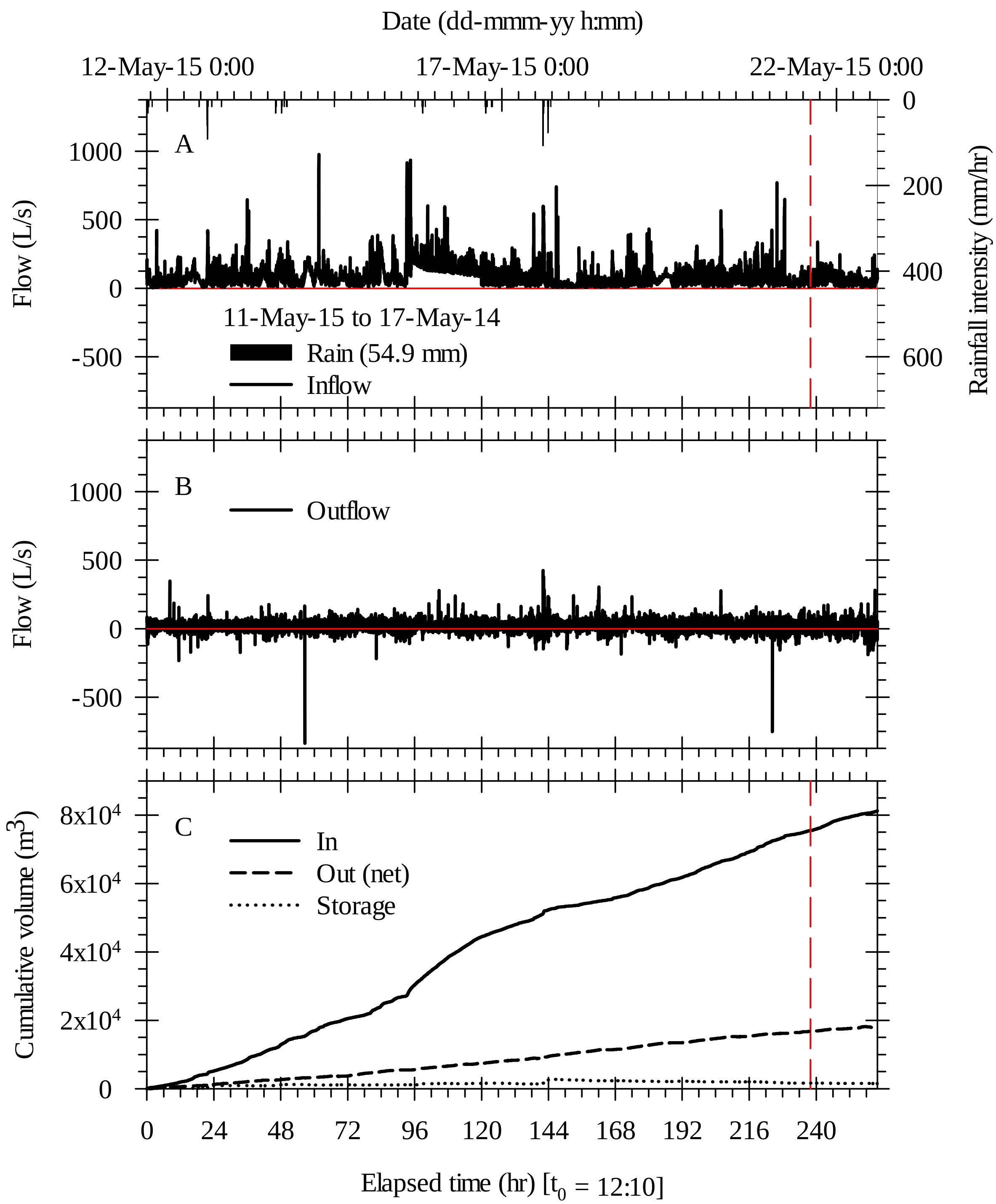


Figure 32. Storm hydrology and hydraulics for events 5-8 from 11-May-15 to 22-May-15 at APF pond 212.

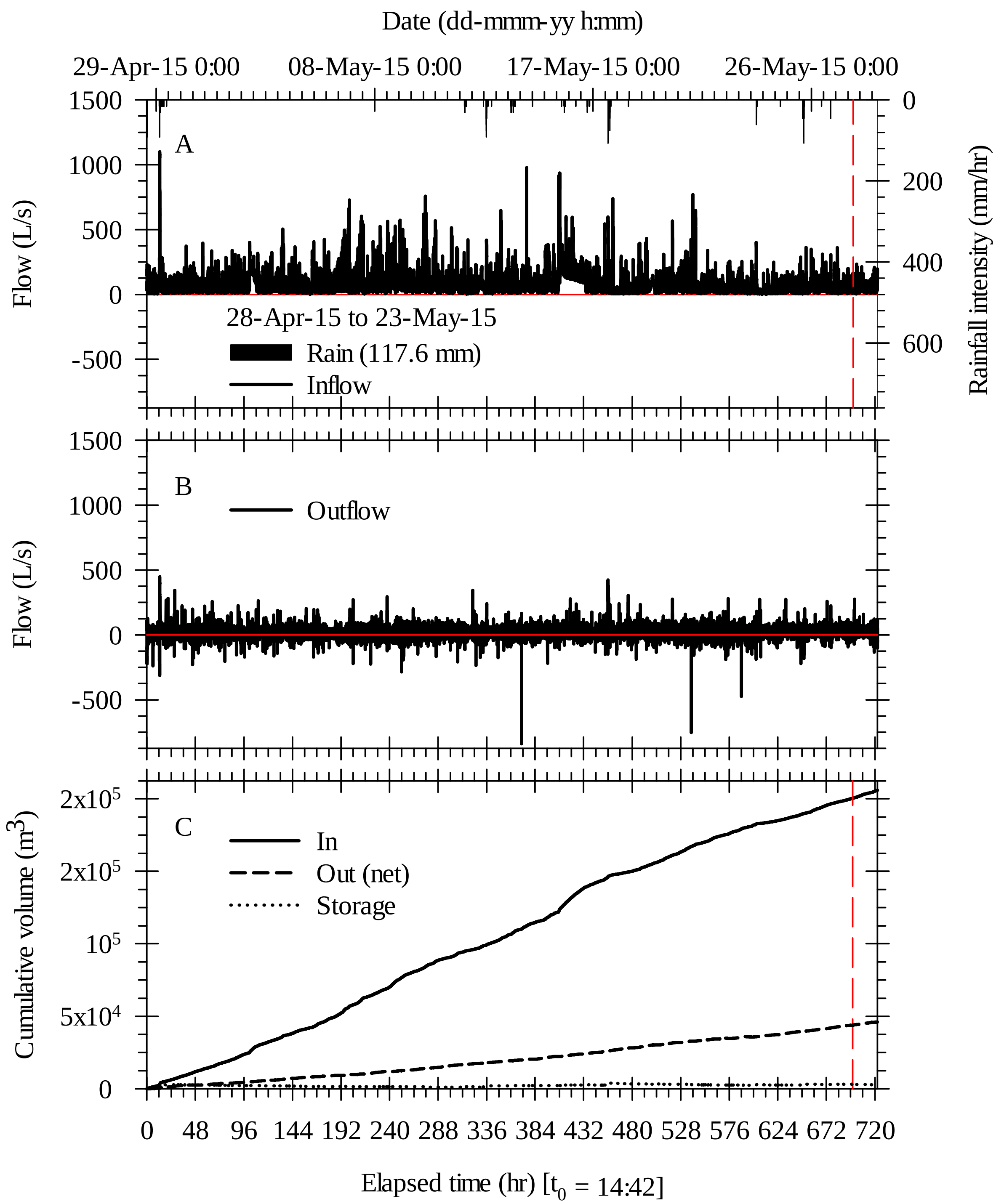


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Table 43. Outlet event mean values for events 4-9 from 28-Apr-15 to 28-May-15 at APF pond 212.

Table 44. Summary of mass separation for events 4-9 from 28-Apr-15 to 28-May-15 at APF pond 212.

Table 1. Event-Based, Protocol-Specific Parameters, as event mean values for APF pond 212.

Category	**Parameter**	**Inflows**	**"Outflows"**
Water Chemistry Analysis	pH	●	●
	Conductivity/TDS	●	●
	Temperature	●	●
	Total COD	●	●
	Alkalinity	●	●
Particulate Matter (PM) Analysis	Total PM (as SSC)	●	●
	Volatile PM (VSS)	●	●
	Total Suspended Solid (TSS)	●	●
	Particle Size Distribution (PSD) Indices	●	●
	Turbidity	●	●
Phosphorus Analysis	Total Phosphorus (TP)	●	●
	Total Dissolved Phosphorus (TDP)	●	●
Nitrogen Analysis	Total Nitrogen (TN)	●	●
	Total Dissolved Nitrogen (TDN)	●	●

Table 2. Summary of methods for each parameter analysis at APF pond 212.

Analysis performed	**Sampled from**	**Volume used**	**Standard Method**	**Preservation during transit and for lab holding to analysis**
pH	1.0L bottle	N/A	S.M. 4500-H^+ B	On ice, refrigerated
Conductivity	1.0L bottle	N/A	S.M.2510	On ice, refrigerated
Salinity	1.0L bottle	N/A	S.M.2510	On ice, refrigerated
TDS	1.0L bottle	N/A	S.M.2510	On ice, refrigerated
Temperature	1.0L bottle	N/A	S.M.2550	On ice, refrigerated
Total COD	1.0L bottle	2mL	Reactor Digestion Method (USEPA approved)	On ice, refrigerated
Turbidity	1.0L bottle	N/A	S.M.2130	On ice, refrigerated
Total PM (SSC)	1.0 L bottle	1000mL	ASTM D-3977-97	On ice, refrigerated
TSS	1.0L bottle	1000mL*	S.M.2540-D	On ice, refrigerated
Volatile TSS	1.0 L bottle	1000mL*	S.M.2540-E	On ice, refrigerated
PSD Indices	1.0 L bottle	800mL	S.M.2560-D	On ice, refrigerated
Phosphorous	1.0 L bottle	50mL	S.M. 4500-P-B Acid Hydrolysis S.M. 4500-P-E Ascorbic Acid Method	On ice, refrigerated
Nitrogen	1.0 L bottle	2mL	Persulfate Digestion Method	On ice, refrigerated
Alkalinity	1.0 L bottle	50 mL	S. M. 2320	On ice, refrigerated

*Share volume with total PM

Table 3. Summary of hydrology for all events at APF pond 212. Rainfall, peak flows, and inflow volumes are based on 96 hours. Outflow volumes and volume detained are based on 120 hours. Turnover fractions are calculated from the storage at t_0 (start of rainfall) for each event. The turnover fraction is the ratio of event flow volume to initial storage volume.

		Rainfall	Peak Flow, Q_P				Total Inflow Volume	Inflow Turnover Fraction	Net Outflow Volume	Outflow Turnover Fraction	Volume Detained
			E	W	NE	N					
		mm	L/s	L/s	L/s	L/s	m^3		m^3		m^3
Event Number	1	52.3	211	249	520	341	36,657	1.20	5,533	0.18	244
	2	54.4	138	112	528	182	30,459	0.98	28,698	0.92	1,751
	3	80.8	325	344	1,401	451	45,507	1.44	58,212	1.84	1,730
	4	38.4	163	335	536	199	23,644	0.92	5,726	0.22	2,094
	5	25.7	88	61	639	911	30,432	1.13	7,374	0.27	1,575
	6	24.1	204	61	639	911	39,245	1.45	7,918	0.29	1,306
	7	24.9	204	88	509	911	39,445	1.42	8,852	0.32	1,448
	8	19.0	187	75	751	222	24,497	0.86	9,290	0.33	8
	9	24.4	227	84	348	128	18,175	0.64	10,232	0.36	426
	10	67.3	464	158	1,105	602	63,244	2.09	70,490	2.33	2,703
25th		24.3	157	72	517	194	24,284	0.90	6,962	0.26	380
50th		32.0	204	100	587	396	33,558	1.17	9,071	0.32	1,511
75th		57.6	252	270	839	911	40,960	1.44	36,077	1.15	1,837
	1-3	205.2	325	344	1,401	451	128,342	4.20	104,699	3.42	2,695
	5-8	54.9	204	88	751	911	75,505	2.81	17,941	0.67	1,531
	4-9	117.6	227	335	751	911	200,488	7.77	46,094	1.79	2,840

Event	Date	Rain start time
1	12-Sep-14	12:10
2	17-Sep-14	21:49
3	25-Sep-14	15:37
4	28-Apr-15	14:42
5	11-May-15	16:43
6	12-May-15	14:17
7	13-May-15	14:50
8	17-May-15	14:43
9	23-May-15	17:13
10	24-Jul-15	10:32

Table 4. Summary of volumes for all events at APF pond 212. Inlet volumes are based on 96 hours. Outlet volumes are net based on 120 hours.

		Volume (m^3)								
		E	W	NE	N	In	SW	SM	SE	Out
Event Number	1	3,862	2,044	15,622	15,129	36,657	-3,414	-3,940	12,887	5,533
	2	640	1,808	10,667	17,345	30,459	18,985	-6,743	16,456	28,698
	3	958	2,946	20,000	21,603	45,507	22,487	17,153	18,573	58,212
	4	1,867	1,195	13,398	7,184	23,644	2,450	490	2,786	5,726
	5	1,566	928	19,891	8,048	30,432	1,676	1,133	4,565	7,374
	6	1,848	1,011	20,468	15,918	39,245	1,677	1,267	4,974	7,918
	7	2,143	1,178	18,717	17,407	39,445	1,877	1,571	5,404	8,852
	8	1,158	1,332	17,710	4,297	24,497	2,341	1,190	5,760	9,290
	9	2,830	1,231	9,900	4,214	18,175	2,371	2,087	5,774	10,232
	10	17,342	1,746	25,615	18,541	63,244	45,757	-18,507	43,240	70,490
25th		1,108	1,137	12,715	6,462	24,284	1,677	-4,641	4,872	6,962
50th		1,858	1,281	18,213	15,523	33,558	2,356	1,161	5,767	9,071
75th		3,088	1,867	20,117	17,691	40,960	19,861	1,700	16,985	36,077
	1-3	6,053	8,245	51,997	62,048	128,342	48,042	2,709	53,949	104,699
	5-8	3,991	2,870	45,208	23,435	75,505	4,164	2,488	11,290	17,941
	4-9	12,880	8,979	126,006	52,622	200,488	12,547	6,775	26,773	46,094

Table 5. Summary of mass separation for all events at APF pond 212. Mass separation is the difference of the total inlet mass and net outlet mass compared to the total inlet mass.

		Mass Separation (%)						
		SSC	TN	TP	TSS	TDN	TDP	COD_t
Event Number	1	83.7	43.7	70.1	89.1	52.1	90.6	74.4
	2	-24.0	-53.6	29.1	-52.6	-30.0	-43.1	-18.3
	3	70.1	-109.8	13.6	48.4	-78.2	18.5	-107.7
	4	86.9	24.3	75.1	86.5	24.1	74.5	73.5
	5	68.8	53.0	45.8	80.3	57.3	19.5	80.7
	6	67.6	64.6	44.6	80.6	68.2	35.9	78.7
	7	57.0	58.6	54.1	70.6	63.6	41.3	85.9
	8	66.8	-25.3	76.8	76.2	-5.0	75.5	84.7
	9	77.2	-10.2	49.6	82.7	-3.3	45.5	50.5
	10	22.1	-139.7	44.4	23.2	-187.6	-13.1	1.9
Overall*		59.7	22.9	46.4	59.9	31.4	34.0	56.4
	1-3	61.8	-19.4	31.0	21.8	0.8	37.9	18.5
	5-8	72.4	44.4	65.6	81.8	50.5	56.4	87.9
	4-9	84.6	43.8	77.7	88.0	46.3	71.0	88.0

* Mass separation based on total influent and effluent mass for entire monitoring campaign
SSC Suspended Sediment Concentration
TN Total Nitrogen (40)
TP Total Phosphorus (70)
TSS Total Suspended Solids (80)
TDN Total Dissolved Nitrogen
TDP Total Dissolved Phosphorus
COD_t Total Chemical Oxygen Demand

Table 6. Inlet event mean values for event 1 on 12-Sep-14 at APF pond 212.

All runoff represents pond 212 inflow			Inlets			
			E	W	NE	N
Flow duration (hr)			96	96	96	96
Runoff volume, m^3			3862	2044	15622	15129
Analytes (volume-weighted values); EMC or EMV	PM	d_{10m} (μm)	12.8	13.1	17.2	17.8
		d_{50m} (μm)	51.0	54.1	64.1	86.6
		d_{90m} (μm)	406.8	168.0	245.8	600.2
		VSSC [mg/L]	6.3	5.0	8.3	6.3
		Suspended (TSS) [mg/L]	3.0	2.7	2.4	2.5
		Settleable [mg/L]	5.1	5.4	5.6	5.0
		Sediment [mg/L]	4.9	4.3	6.5	8.8
		SSC [mg/L]	13.0	12.4	14.5	16.3
		TDS (calculated) [mg/L]	122	36	51	61
	N	Dissolved TDN [mg/L]	1.38	1.17	0.68	1.21
		Total TN [mg/L]	4.02	1.93	1.87	2.00
	P	Dissolved TDP [mg/L]	0.13	0.09	0.14	0.16
		Total TP [mg/L]	0.15	0.13	0.38	0.28
	COD	Dissolved COD_d [mg/L]	7.8	4.4	11.5	10.4
		Total COD_t [mg/L]	12.3	7.3	44.7	47.3
	Water Chemistry	Conductivity (μS/cm)	182	53	76	90
		Redox (+mV)	437	522	482	514
		pH	7.17	6.99	6.66	6.91
		Dissolved Oxygen [mg/L]	5.5	4.8	7.8	4.9
		Turbidity (NTU)	5.2	1.8	4.9	4.3
		Alkalinity [mg/L as $CaCO_3$]	63.2	26.2	33.6	40.9

TDS Total Dissolved Solids
TN Total Nitrogen
TDN Total Dissolved Nitrogen
COD_t Total Chemical Oxygen Demand
COD_d Dissolved Chemical Oxygen Demand
SSC Suspended Sediment Concentration
VSSC Suspended Sediment Concentration
PM Particulate Matter
TP Total Phosphorous
TDP Total Dissolved Phosphorous
TSS Total Suspended Solids
NTU Nephelometric Turbidity Unit

Table 7. Outlet event mean values for event 1 on 12-Sep-14 at APF pond 212.

"Out" indicates flow leaving pond 212 "In" indicates flow entering pond 212 from pond 208			Outlets					
			SW		SM		SE	
			Out	In	Out	In	Out	In
Flow duration (hr)			120	120	120	120	120	120
Flow volume, m^3			12792	16205	7321	11261	13588	701
Analytes (volume-weighted values); EMC or EMV	**PM**	d_{10m} (µm)	19.4	17.2	18.9	15.1	16.9	18.3
		d_{50m} (µm)	68.9	52.4	58.3	47.0	53.4	64.2
		d_{90m} (µm)	233.5	147.2	244.3	198.3	166.9	211.6
		VSSC [mg/L]	7.0	7.1	6.0	5.9	5.5	4.8
		Suspended (TSS) [mg/L]	1.9	2.1	2.6	2.8	2.5	2.1
		Settleable [mg/L]	4.4	5.1	6.0	5.0	5.9	4.4
		Sediment [mg/L]	4.1	3.4	4.3	3.7	3.8	3.8
		SSC [mg/L]	10.4	10.6	12.8	11.1	12.2	10.3
		TDS (calculated) [mg/L]	351	324	387	322	368	368
	N	Dissolved TDN [mg/L]	2.87	2.74	2.15	1.76	2.26	2.14
		Total TN [mg/L]	5.38	4.92	5.29	3.68	4.51	4.74
	P	Dissolved TDP [mg/L]	0.09	0.07	0.13	0.12	0.07	0.08
		Total TP [mg/L]	0.21	0.15	0.19	0.16	0.28	0.38
	COD	Dissolved COD_d [mg/L]	13.3	11.8	11.0	9.4	12.5	14.1
		Total COD_t [mg/L]	31.2	20.8	25.4	18.9	27.1	35.2
	Water Chemistry	Conductivity (µS/cm)	523	484	578	481	549	549
		Redox (+mV)	459	482	478	482	471	463
		pH	7.31	7.40	7.43	7.44	7.26	7.18
		Dissolved Oxygen [mg/L]	3.5	4.2	3.6	3.9	3.8	2.9
		Turbidity (NTU)	3.2	1.7	2.6	1.9	3.1	5.9
		Alkalinity [mg/L as $CaCO_3$]	140.6	132.3	148.8	129.2	144.6	144.1

TDS Total Dissolved Solids
PM Particulate Matter
TN Total Nitrogen
TP Total Phosphorous
TDN Total Dissolved Nitrogen
TDP Total Dissolved Phosphorous
COD_t Total Chemical Oxygen Demand
TSS Total Suspended Solids
COD_d Dissolved Chemical Oxygen Demand
NTU Nephelometric Turbidity Unit
SSC Suspended Sediment Concentration
VSSC Suspended Sediment Concentration

Table 8. Summary of mass separation for event 1 on 12-Sep-14 at APF pond 212.

Outlet mass as net pond 212 discharge		Event volume (m^3)	Cumulative mass (kg)						
			SSC	TN	TP	TSS	TDN	TDP	COD_t
Inlets	E	3862	50.1	15.5	0.6	11.5	5.3	0.5	47.6
	W	2044	25.4	4.0	0.3	5.5	2.4	0.2	14.9
	NE	15622	225.8	29.3	6.0	37.2	10.6	2.3	698.9
	N	15129	247.0	30.2	4.2	38.0	18.2	2.4	714.9
	Sum	36657	548.3	79.0	11.0	92.1	36.6	5.4	1476.4
Outlets	SW	-3414	-38.4	-10.8	0.3	-8.9	-7.7	0.0	62.0
	SM	-3940	-30.8	-2.7	-0.5	-13.0	-4.0	-0.4	-26.8
	SE	12887	158.7	58.0	3.5	32.0	29.2	0.9	343.5
	Sum	5533	89.6	44.4	3.3	10.1	17.5	0.5	378.6
Mass separation (%)			84	44	70	89	52	91	74

SSC Suspended Sediment Concentration
TN Total Nitrogen
TP Total Phosphorous
TSS Total Suspended Solids
TDN Total Dissolved Nitrogen
TDP Total Dissolved Phosphorous
COD_t Total Chemical Oxygen Demand

Table 9. Inlet event mean values for event 2 on 17-Sep-14 at APF pond 212.

All runoff represents pond 212 inflow			Inlets			
			E	W	NE	N
Flow duration (hr)			96	96	96	96
Runoff volume, m^3			640	1808	10667	17345
Analytes (volume-weighted values); EMC or EMV	**PM**	d_{10m} (μm)	14.3	9.4	9.5	13.4
		d_{50m} (μm)	45.2	38.8	30.7	40.8
		d_{90m} (μm)	382.7	94.9	87.5	166.9
		VSSC [mg/L]	2.1	0.7	2.6	1.8
		Suspended (TSS) [mg/L]	1.9	0.5	2.0	1.1
		Settleable [mg/L]	1.0	0.6	2.3	1.8
		Sediment [mg/L]	1.1	0.2	0.7	0.9
		SSC [mg/L]	3.9	1.2	5.0	3.8
		TDS (calculated) [mg/L]	80	37	70	95
	N	Dissolved TDN [mg/L]	0.85	0.62	0.87	1.15
		Total TN [mg/L]	1.88	0.93	1.31	1.41
	P	Dissolved TDP [mg/L]	0.07	0.06	0.04	0.10
		Total TP [mg/L]	0.15	0.07	0.23	0.25
	COD	Dissolved COD_d [mg/L]	3.9	6.9	6.4	9.7
		Total COD_t [mg/L]	7.8	8.2	17.1	14.8
	Water Chemistry	Conductivity (μS/cm)	119	55	105	141
		Redox (+mV)	501	520	493	483
		pH	7.26	7.19	7.28	7.39
		Dissolved Oxygen [mg/L]	6.1	4.9	4.8	4.9
		Turbidity (NTU)	3.4	1.1	5.1	1.4
		Alkalinity [mg/L as $CaCO_3$]	50.2	27.3	47.9	57.9

TDS Total Dissolved Solids
TN Total Nitrogen
TDN Total Dissolved Nitrogen
COD_t Total Chemical Oxygen Demand
COD_d Dissolved Chemical Oxygen Demand
SSC Suspended Sediment Concentration
VSSC Suspended Sediment Concentration

PM Particulate Matter
TP Total Phosphorous
TDP Total Dissolved Phosphorous
TSS Total Suspended Solids
NTU Nephelometric Turbidity Unit

Table 10. Outlet event mean values for event 2 on 17-Sep-14 at APF pond 212.

"Out" indicates flow leaving pond 212 "In" indicates flow entering pond 212 from pond 208			**Outlets**					
			SW		SM		SE	
			Out	In	Out	In	Out	In
Flow duration (hr)			120	120	120	120	120	120
Flow volume, m^3			26251	7265	3415	10157	16662	206
Analytes (volume-weighted values); EMC or EMV	**PM**	d_{10m} (µm)	9.5	10.0	10.6	11.7	14.2	14.3
		d_{50m} (µm)	28.1	32.8	34.8	38.6	35.6	35.2
		d_{90m} (µm)	103.5	135.0	144.1	168.6	121.4	113.5
		VSSC [mg/L]	1.9	1.8	1.1	1.5	2.1	0.6
		Suspended (TSS) [mg/L]	2.4	2.2	1.5	1.5	1.6	1.2
		Settleable [mg/L]	1.8	1.9	1.7	2.0	3.1	2.4
		Sediment [mg/L]	0.7	0.9	0.9	1.2	0.9	0.6
		SSC [mg/L]	5.0	5.0	4.1	4.8	5.6	4.2
		TDS (calculated) [mg/L]	303	305	294	305	306	296
	N	Dissolved TDN [mg/L]	1.63	1.77	1.22	1.64	1.38	1.22
		Total TN [mg/L]	2.22	2.48	2.89	3.18	2.79	3.25
	P	Dissolved TDP [mg/L]	0.13	0.14	0.16	0.14	0.11	0.10
		Total TP [mg/L]	0.21	0.20	0.23	0.22	0.15	0.13
	COD	Dissolved COD_d [mg/L]	14.6	14.9	13.6	13.8	13.0	12.9
		Total COD_t [mg/L]	17.5	17.2	14.8	15.8	19.3	17.1
	Water Chemistry	Conductivity (µS/cm)	451	455	438	456	457	442
		Redox (+mV)	497	487	509	503	495	500
		pH	7.40	7.46	7.45	7.52	7.39	7.35
		Dissolved Oxygen [mg/L]	4.8	4.9	4.7	4.9	5.0	4.9
		Turbidity (NTU)	1.2	1.1	1.0	1.1	1.4	1.2
		Alkalinity [mg/L as $CaCO_3$]	129.1	129.3	127.6	129.7	129.0	127.4

TDS Total Dissolved Solids
TN Total Nitrogen
TDN Total Dissolved Nitrogen
COD_t Total Chemical Oxygen Demand
COD_d Dissolved Chemical Oxygen Demand
SSC Suspended Sediment Concentration
VSSC Suspended Sediment Concentration

PM Particulate Matter
TP Total Phosphorous
TDP Total Dissolved Phosphorous
TSS Total Suspended Solids
NTU Nephelometric Turbidity Unit

Table 11. Summary of mass separation for event 2 on 17-Sep-14 at APF pond 212.

Outlet mass as net pond 212 discharge		Event volume (m^3)	Cumulative mass (kg)						
			SSC	TN	TP	TSS	TDN	TDP	COD_t
Inlets	E	640	2.5	1.2	0.1	1.2	0.5	0.0	5.0
	W	1808	2.2	1.7	0.1	0.9	1.1	0.1	14.8
	NE	10667	53.4	13.9	2.5	21.5	9.3	0.4	182.1
	N	17345	65.9	24.5	4.3	18.7	19.9	1.7	257.2
	Sum	30459	124.0	41.3	7.0	42.3	30.9	2.3	459.2
Outlets	SW	18985	95.5	40.2	4.0	48.2	29.9	2.4	335.6
	SM	-6743	-35.0	-22.4	-1.4	-10.5	-12.5	-0.8	-110.3
	SE	16456	93.2	45.7	2.4	26.8	22.8	1.8	317.9
	Sum	28698	153.7	63.5	5.0	64.5	40.2	3.3	543.3
Mass separation (%)			-24	-54	29	-53	-30	-43	-18

SSC Suspended Sediment Concentration
TN Total Nitrogen
TP Total Phosphorous
TSS Total Suspended Solids
TDN Total Dissolved Nitrogen
TDP Total Dissolved Phosphorous
COD_t Total Chemical Oxygen Demand

Table 12. Inlet event mean values for event 3 on 25-Sep-14 at APF pond 212.

All runoff represents pond 212 inflow			Inlets			
			E	W	NE	N
Flow duration (hr)			96	96	96	96
Runoff volume, m^3			958	2946	20000	21603
Analytes (volume-weighted values); EMC or EMV	**PM**	d_{10m} (μm)	13.6	15.6	13.6	11.1
		d_{50m} (μm)	48.1	42.9	42.4	26.8
		d_{90m} (μm)	394.7	127.4	150.4	146.9
		VSSC [mg/L]	4.2	1.5	5.3	1.6
		Suspended (TSS) [mg/L]	2.4	0.7	4.1	1.0
		Settleable [mg/L]	3.0	1.7	7.6	0.8
		Sediment [mg/L]	3.0	0.7	7.7	0.5
		SSC [mg/L]	8.4	3.1	19.4	2.2
		TDS (calculated) [mg/L]	101	42	61	42
	N	Dissolved TDN [mg/L]	1.12	0.56	0.89	1.06
		Total TN [mg/L]	2.95	0.84	1.68	1.22
	P	Dissolved TDP [mg/L]	0.10	0.06	0.22	0.16
		Total TP [mg/L]	0.15	0.19	0.35	0.23
	COD	Dissolved COD_d [mg/L]	5.9	9.0	6.7	7.5
		Total COD_t [mg/L]	10.1	13.4	13.0	8.9
	Water Chemistry	Conductivity (μS/cm)	150	63	91	62
		Redox (+mV)	469	463	480	467
		pH	7.22	7.03	7.27	7.15
		Dissolved Oxygen [mg/L]	5.8	0.6	0.5	0.6
		Turbidity (NTU)	4.3	0.8	7.2	1.2
		Alkalinity [mg/L as $CaCO_3$]	56.7	34.9	41.6	28.5

TDS Total Dissolved Solids PM Particulate Matter
TN Total Nitrogen TP Total Phosphorous
TDN Total Dissolved Nitrogen TDP Total Dissolved Phosphorous
COD_t Total Chemical Oxygen Demand TSS Total Suspended Solids
COD_d Dissolved Chemical Oxygen Demand NTU Nephelometric Turbidity Unit
SSC Suspended Sediment Concentration
VSSC Suspended Sediment Concentration

Table 13. Outlet event mean values for event 3 on 25-Sep-14 at APF pond 212.

"Out" indicates flow leaving pond 212 "In" indicates flow entering pond 212 from pond 208			Outlets					
			SW		SM		SE	
			Out	In	Out	In	Out	In
Flow duration (hr)			120	120	120	120	120	120
Flow volume, m^3			28392	5906	17404	252	18831	258
Analytes (volume-weighted values); EMC or EMV	**PM**	d_{10m} (µm)	12.1	12.9	11.2	9.2	14.0	17.5
		d_{50m} (µm)	29.9	30.8	30.7	24.9	40.4	51.5
		d_{90m} (µm)	97.5	91.8	152.1	142.0	187.7	124.7
		VSSC [mg/L]	1.3	1.1	1.8	2.1	0.8	1.2
		Suspended (TSS) [mg/L]	0.9	0.7	1.2	1.3	0.7	1.2
		Settleable [mg/L]	0.9	0.9	1.1	0.9	1.0	3.6
		Sediment [mg/L]	0.3	0.2	0.5	0.4	0.5	2.0
		SSC [mg/L]	2.1	1.8	2.8	2.5	2.1	6.8
		TDS (calculated) [mg/L]	279	233	264	229	285	342
	N	Dissolved TDN [mg/L]	0.88	0.75	1.82	1.77	1.36	0.80
		Total TN [mg/L]	2.20	2.55	2.81	2.61	2.23	3.80
	P	Dissolved TDP [mg/L]	0.18	0.16	0.07	0.05	0.07	0.12
		Total TP [mg/L]	0.26	0.26	0.17	0.17	0.12	0.46
	COD	Dissolved COD_d [mg/L]	14.9	13.4	11.9	8.8	15.8	18.4
		Total COD_t [mg/L]	17.0	15.7	14.8	13.0	21.5	33.5
	Water Chemistry	Conductivity (µS/cm)	416	347	394	342	426	511
		Redox (+mV)	386	393	396	399	392	402
		pH	7.73	7.75	7.79	7.76	7.82	6.99
		Dissolved Oxygen [mg/L]	0.4	0.4	0.4	0.4	0.4	0.4
		Turbidity (NTU)	1.5	1.6	1.4	1.2	0.9	1.9
		Alkalinity [mg/L as $CaCO_3$]	121.1	107.8	116.4	105.0	121.7	141.0

TDS Total Dissolved Solids PM Particulate Matter
TN Total Nitrogen TP Total Phosphorous
TDN Total Dissolved Nitrogen TDP Total Dissolved Phosphorous
COD_t Total Chemical Oxygen Demand TSS Total Suspended Solids
COD_d Dissolved Chemical Oxygen Demand NTU Nephelometric Turbidity Unit
SSC Suspended Sediment Concentration
VSSC Suspended Sediment Concentration

Table 14. Summary of mass separation for event 3 on 25-Sep-14 at APF pond 212.

Outlet mass as net pond 212 discharge		Event volume (m^3)	Cumulative mass (kg)						
			SSC	TN	TP	TSS	TDN	TDP	COD_t
Inlets	E	958	8.1	2.8	0.1	2.3	1.1	0.1	9.6
	W	2946	9.0	2.5	0.6	2.0	1.6	0.2	39.6
	NE	20000	387.5	33.6	7.0	82.2	17.7	4.4	259.9
	N	21603	48.5	26.3	5.0	21.2	22.9	3.5	192.2
	Sum	45507	453.2	65.2	12.7	107.8	43.3	8.2	501.3
Outlets	SW	22487	48.6	47.5	5.8	22.8	20.5	4.1	391.4
	SM	17153	48.1	48.3	3.0	19.9	31.3	1.3	254.5
	SE	18573	38.6	41.1	2.1	12.9	25.4	1.3	395.5
	Sum	58212	135.4	136.8	10.9	55.6	77.1	6.7	1041.3
Mass separation (%)			70	-110	14	48	-78	18	-108

SSC Suspended Sediment Concentration
TN Total Nitrogen
TP Total Phosphorous
TSS Total Suspended Solids
TDN Total Dissolved Nitrogen
TDP Total Dissolved Phosphorous
COD_t Total Chemical Oxygen Demand

Table 15. Inlet event mean values for event 4 on 28-Apr-15 at APF pond 212.

All runoff represents pond 212 inflow			Inlets			
			E	W	NE	N
Flow duration (hr)			96	96	96	96
Runoff volume, m^3			1867	1195	13398	7184
Analytes (volume-weighted values); EMC or EMV	**PM**	d_{10m} (μm)	13.6	9.9	9.8	7.3
		d_{50m} (μm)	97.1	71.7	71.9	41.5
		d_{90m} (μm)	468.5	381.8	365.5	278.6
		VSSC [mg/L]	17.6	8.6	6.0	8.1
		Suspended (TSS) [mg/L]	13.6	4.4	2.9	4.3
		Settleable [mg/L]	5.5	3.8	2.6	3.2
		Sediment [mg/L]	8.3	5.6	4.7	4.9
		SSC [mg/L]	27.4	13.9	10.1	12.4
		TDS (calculated) [mg/L]	356	125	397	385
	N	Dissolved TDN [mg/L]	6.92	1.10	3.41	4.03
		Total TN [mg/L]	8.86	3.14	6.62	5.78
	P	Dissolved TDP [mg/L]	0.09	0.13	0.13	0.12
		Total TP [mg/L]	0.25	0.24	0.15	0.15
	COD	Dissolved COD_d [mg/L]	31.9	14.2	21.2	32.7
		Total COD_t [mg/L]	35.9	21.3	31.2	41.0
	Water Chemistry	Conductivity (μS/cm)	531	186	593	575
		Redox (+mV)	196	202	210	207
		pH	7.72	7.38	7.50	7.55
		Dissolved Oxygen [mg/L]	4.0	4.4	3.9	4.0
		Turbidity (NTU)	17.7	6.6	3.5	3.6
		Alkalinity [mg/L as $CaCO_3$]	134.5	54.9	163.4	164.7

TDS Total Dissolved Solids
TN Total Nitrogen
TDN Total Dissolved Nitrogen
COD_t Total Chemical Oxygen Demand
COD_d Dissolved Chemical Oxygen Demand
SSC Suspended Sediment Concentration
PM Particulate Matter
TP Total Phosphorous
TDP Total Dissolved Phosphorous
TSS Total Suspended Solids
NTU Nephelometric Turbidity Unit

VSSC Suspended Sediment Concentration

Table 16. Outlet event mean values for event 4 on 28-Apr-15 at APF pond 212.

"Out" indicates flow leaving pond 212 "In" indicates flow entering pond 212 from pond 208			Outlets					
			SW		SM		SE	
			Out	In	Out	In	Out	In
Flow duration (hr)			120	120	120	120	120	120
Flow volume, m^3			2480	30	905	415	2943	157
Analytes (volume-weighted values); EMC or EMV	**PM**	d_{10m} (μm)	9.2	12.7	7.9	7.7	7.6	10.2
		d_{50m} (μm)	51.1	76.5	43.1	38.3	38.6	54.3
		d_{90m} (μm)	305.2	462.9	279.5	214.6	188.4	320.1
		VSSC [mg/L]	3.8	4.0	4.1	4.7	3.8	3.0
		Suspended (TSS) [mg/L]	2.2	1.6	2.4	2.4	2.5	1.9
		Settleable [mg/L]	2.2	2.2	2.2	2.3	2.5	2.3
		Sediment [mg/L]	2.3	3.0	1.9	1.7	1.8	2.3
		SSC [mg/L]	6.7	6.8	6.5	6.5	6.8	6.6
		TDS (calculated) [mg/L]	626	665	641	642	642	648
	N	Dissolved TDN [mg/L]	10.26	12.88	8.94	8.77	13.79	16.80
		Total TN [mg/L]	19.87	22.69	18.13	18.78	20.56	23.46
	P	Dissolved TDP [mg/L]	0.11	0.16	0.13	0.17	0.15	0.18
		Total TP [mg/L]	0.16	0.25	0.20	0.24	0.19	0.27
	COD	Dissolved COD_d [mg/L]	15.7	16.0	10.8	10.5	22.5	23.4
		Total COD_t [mg/L]	30.5	34.3	32.6	32.7	44.1	44.4
	Water Chemistry	Conductivity (μS/cm)	935	992	957	958	959	967
		Redox (+mV)	271	274	255	256	206	194
		pH	8.31	8.19	8.36	8.33	8.21	8.07
		Dissolved Oxygen [mg/L]	4.7	4.5	4.7	4.7	4.2	3.9
		Turbidity (NTU)	1.5	2.0	1.5	1.5	1.8	1.9
		Alkalinity [mg/L as $CaCO_3$]	178.6	180.6	178.3	169.1	175.6	180.2

TDS Total Dissolved Solids
TN Total Nitrogen
TDN Total Dissolved Nitrogen
COD_t Total Chemical Oxygen Demand
COD_d Dissolved Chemical Oxygen Demand
SSC Suspended Sediment Concentration
PM Particulate Matter
TP Total Phosphorous
TDP Total Dissolved Phosphorous
TSS Total Suspended Solids
NTU Nephelometric Turbidity Unit

VSSC Suspended Sediment Concentration

Table 17. Summary of mass separation for event 4 on 28-Apr-15 at APF pond 212.

Outlet mass as net pond 212 discharge		Event volume (m^3)	Cumulative mass (kg)						
			SSC	TN	TP	TSS	TDN	TDP	COD_t
Inlets	E	1867	51.1	16.5	0.5	25.4	12.9	0.2	67.1
	W	1195	16.6	3.7	0.3	5.3	1.3	0.2	25.4
	NE	13398	135.7	88.7	2.1	38.4	45.7	1.7	417.9
	N	7184	89.0	41.6	1.1	30.5	28.9	0.8	294.9
	Sum	23644	292.4	150.5	3.9	99.6	88.9	2.8	805.3
Outlets	SW	2450	16.3	48.6	0.4	5.3	25.0	0.3	74.6
	SM	490	3.2	8.6	0.1	1.2	4.5	0.0	16.0
	SE	2786	18.8	56.8	0.5	7.0	37.9	0.4	122.8
	Sum	5726	38.3	114.0	1.0	13.5	67.4	0.7	213.3
Mass separation (%)			87	24	75	86	24	75	74

SSC Suspended Sediment Concentration
TN Total Nitrogen
TP Total Phosphorous
TSS Total Suspended Solids
TDN Total Dissolved Nitrogen
TDP Total Dissolved Phosphorous
COD_t Total Chemical Oxygen Demand

Table 18. Inlet event mean values for event 5 on 11-May-15 at APF pond 212.

All runoff represents pond 212 inflow			Inlets			
			E	W	NE	N
Flow duration (hr)			96	96	96	96
Runoff volume, m^3			1566	928	19891	8048
Analytes (volume-weighted values); EMC or EMV	**PM**	d_{10m} (µm)	12.4	4.6	6.3	3.5
		d_{50m} (µm)	80.4	22.9	26.9	14.7
		d_{90m} (µm)	203.2	66.5	74.5	46.4
		VSSC [mg/L]	6.1	2.3	3.7	3.0
		Suspended (TSS) [mg/L]	3.2	2.5	4.1	2.6
		Settleable [mg/L]	2.9	1.6	1.8	0.9
		Sediment [mg/L]	4.3	0.3	0.6	0.2
		SSC [mg/L]	10.4	4.5	6.6	3.7
		TDS (calculated) [mg/L]	488	542	488	448
	N	Dissolved TDN [mg/L]	8.42	11.73	6.19	5.46
		Total TN [mg/L]	10.85	15.20	7.50	9.23
	P	Dissolved TDP [mg/L]	0.08	0.05	0.07	0.06
		Total TP [mg/L]	0.14	0.07	0.14	0.11
	COD	Dissolved COD_d [mg/L]	33.0	28.1	24.0	31.1
		Total COD_t [mg/L]	50.9	37.1	44.8	37.2
	Water Chemistry	Conductivity (µS/cm)	728	809	728	669
		Redox (+mV)	256	225	267	245
		pH	7.69	7.74	7.63	7.47
		Dissolved Oxygen [mg/L]	9.4	7.0	9.1	10.0
		Turbidity (NTU)	18.3	6.2	9.0	6.6
		Alkalinity [mg/L as $CaCO_3$]	161.9	179.8	191.1	191.5

TDS Total Dissolved Solids
PM Particulate Matter
TN Total Nitrogen
TP Total Phosphorous
TDN Total Dissolved Nitrogen
TDP Total Dissolved Phosphorous
COD_t Total Chemical Oxygen Demand
TSS Total Suspended Solids
COD_d Dissolved Chemical Oxygen Demand
NTU Nephelometric Turbidity Unit

SSC Suspended Sediment Concentration
VSSC Suspended Sediment Concentration

Table 19. Outlet event mean values for event 5 on 11-May-15 at APF pond 212.

"Out" indicates flow leaving pond 212 "In" indicates flow entering pond 212 from pond 208			**Outlets**					
			SW		SM		SE	
			Out	In	Out	In	Out	In
Flow duration (hr)			120	120	120	120	120	120
Flow volume, m^3			1793	116	1562	429	4607	42
Analytes (volume-weighted values); EMC or EMV	**PM**	d_{10m} (µm)	39.9	38.8	29.6	19.9	4.9	8.3
		d_{50m} (µm)	188.2	162.2	128.8	88.7	28.9	32.4
		d_{90m} (µm)	441.1	363.6	279.9	199.6	79.6	83.5
		VSSC [mg/L]	1.5	1.6	2.1	2.2	3.3	3.5
		Suspended (TSS) [mg/L]	1.0	1.6	1.6	1.9	4.0	3.2
		Settleable [mg/L]	1.1	1.3	2.0	2.3	3.9	3.8
		Sediment [mg/L]	3.3	2.9	2.7	1.8	0.9	1.2
		SSC [mg/L]	5.4	5.8	6.3	6.0	8.8	8.2
		TDS (calculated) [mg/L]	648	645	647	645	650	666
	N	Dissolved TDN [mg/L]	7.06	6.86	8.70	9.83	13.17	6.68
		Total TN [mg/L]	11.43	13.10	10.64	11.82	19.52	17.24
	P	Dissolved TDP [mg/L]	0.22	0.21	0.06	0.06	0.26	0.35
		Total TP [mg/L]	0.30	0.35	0.12	0.11	0.33	0.49
	COD	Dissolved COD_d [mg/L]	25.9	26.5	30.9	31.7	32.5	31.8
		Total COD_t [mg/L]	28.4	29.8	34.9	35.9	36.2	38.6
	Water Chemistry	Conductivity (µS/cm)	968	963	965	962	970	994
		Redox (+mV)	202	204	190	192	135	98
		pH	8.37	8.32	8.40	8.37	8.22	8.08
		Dissolved Oxygen [mg/L]	3.6	3.5	3.5	3.5	3.5	3.4
		Turbidity (NTU)	3.1	2.7	4.1	4.4	5.1	4.6
		Alkalinity [mg/L as $CaCO_3$]	164.8	164.6	164.2	164.7	164.0	166.6

TDS Total Dissolved Solids
PM Particulate Matter
TN Total Nitrogen
TP Total Phosphorous
TDN Total Dissolved Nitrogen
TDP Total Dissolved Phosphorous
COD_t Total Chemical Oxygen Demand
TSS Total Suspended Solids
COD_d Dissolved Chemical Oxygen Demand
NTU Nephelometric Turbidity Unit

SSC Suspended Sediment Concentration
VSSC Suspended Sediment Concentration

Table 20. Summary of mass separation for event 5 on 11-May-15 at APF pond 212.

Outlet mass as net pond 212 discharge		Event volume (m^3)	Cumulative mass (kg)						
			SSC	TN	TP	TSS	TDN	TDP	COD_t
Inlets	E	1566	16.2	17.0	0.2	5.0	13.2	0.1	79.7
	W	928	4.1	14.1	0.1	2.3	10.9	0.0	34.5
	NE	19891	131.4	149.2	2.8	82.5	123.2	1.4	891.9
	N	8048	29.7	74.3	0.9	20.8	43.9	0.5	299.4
	Sum	30432	181.4	254.6	4.0	110.7	191.2	2.0	1305.4
Outlets	SW	1676	9.0	19.0	0.5	1.7	11.8	0.4	47.5
	SM	1133	7.3	11.6	0.1	1.8	9.4	0.1	39.1
	SE	4565	40.4	89.2	1.5	18.4	60.4	1.2	165.4
	Sum	7374	56.7	119.7	2.1	21.9	81.6	1.6	252.0
Mass separation (%)			69	53	46	80	57	20	81

SSC Suspended Sediment Concentration
TN Total Nitrogen
TP Total Phosphorous
TSS Total Suspended Solids
TDN Total Dissolved Nitrogen
TDP Total Dissolved Phosphorous
COD_t Total Chemical Oxygen Demand

Table 21. Inlet event mean values for event 6 on 12-May-15 at APF pond 212.

All runoff represents pond 212 inflow			Inlets			
			E	W	NE	N
Flow duration (hr)			96	96	96	96
Runoff volume, m^3			1848	1011	20468	15918
Analytes (volume-weighted values); EMC or EMV	**PM**	d_{10m} (μm)	8.1	4.5	5.8	3.1
		d_{50m} (μm)	32.7	20.5	24.2	11.5
		d_{90m} (μm)	101.7	59.6	67.6	37.1
		VSSC [mg/L]	4.4	2.0	3.4	2.8
		Suspended (TSS) [mg/L]	2.8	2.4	4.0	2.4
		Settleable [mg/L]	2.5	1.2	1.5	0.6
		Sediment [mg/L]	1.5	0.2	0.5	0.1
		SSC [mg/L]	6.9	3.8	6.0	3.1
		TDS (calculated) [mg/L]	513	546	484	442
	N	Dissolved TDN [mg/L]	11.66	13.74	7.86	5.84
		Total TN [mg/L]	13.79	16.96	8.26	9.84
	P	Dissolved TDP [mg/L]	0.06	0.04	0.07	0.06
		Total TP [mg/L]	0.09	0.05	0.11	0.11
	COD	Dissolved COD_d [mg/L]	31.1	25.3	25.3	27.2
		Total COD_t [mg/L]	41.4	30.5	33.4	31.3
	Water Chemistry	Conductivity (μS/cm)	765	816	722	660
		Redox (+mV)	266	221	270	242
		pH	7.64	7.67	7.59	7.41
		Dissolved Oxygen [mg/L]	11.6	7.5	10.4	11.2
		Turbidity (NTU)	12.7	6.8	9.7	7.0
		Alkalinity [mg/L as $CaCO_3$]	173.1	179.1	188.5	189.1

TDS Total Dissolved Solids
TN Total Nitrogen
TDN Total Dissolved Nitrogen
COD_t Total Chemical Oxygen Demand
PM Particulate Matter
TP Total Phosphorous
TDP Total Dissolved Phosphorous
TSS Total Suspended Solids

COD_d Dissolved Chemical Oxygen Demand NTU Nephelometric Turbidity Unit
SSC Suspended Sediment Concentration
VSSC Suspended Sediment Concentration

Table 22. Outlet event mean values for event 6 on 12-May-15 at APF pond 212.

"Out" indicates flow leaving pond 212 "In" indicates flow entering pond 212 from pond 208			Outlets					
			SW		SM		SE	
			Out	In	Out	In	Out	In
Flow duration (hr)			120	120	120	120	120	120
Flow volume, m^3			1831	154	1737	469	5100	126
Analytes (volume-weighted values); EMC or EMV	**PM**	d_{10m} (µm)	37.9	37.3	21.4	12.7	4.4	6.4
		d_{50m} (µm)	172.7	154.4	93.7	57.3	27.6	27.9
		d_{90m} (µm)	425.3	345.4	208.0	132.1	76.5	75.8
		VSSC [mg/L]	1.4	1.6	2.0	2.1	3.3	2.6
		Suspended (TSS) [mg/L]	1.1	1.2	1.9	1.9	4.1	2.3
		Settleable [mg/L]	1.0	1.3	2.2	2.4	3.8	2.1
		Sediment [mg/L]	3.0	2.7	2.0	1.1	0.9	0.5
		SSC [mg/L]	5.0	5.2	6.1	5.4	8.8	4.9
		TDS (calculated) [mg/L]	644	646	643	641	646	644
	N	Dissolved TDN [mg/L]	7.03	7.54	9.96	10.32	13.60	11.61
		Total TN [mg/L]	11.66	13.73	11.64	13.02	19.41	15.19
	P	Dissolved TDP [mg/L]	0.20	0.15	0.06	0.06	0.23	0.15
		Total TP [mg/L]	0.32	0.27	0.13	0.11	0.31	0.19
	COD	Dissolved COD_d [mg/L]	25.9	25.7	31.6	32.0	32.9	29.1
		Total COD_t [mg/L]	28.4	29.3	35.9	39.3	36.7	33.8
	Water Chemistry	Conductivity (µS/cm)	961	964	960	957	964	961
		Redox (+mV)	204	229	193	201	144	137
		pH	8.35	8.30	8.36	8.34	8.22	8.15
		Dissolved Oxygen [mg/L]	3.6	3.8	3.5	3.6	3.5	4.0
		Turbidity (NTU)	2.9	4.6	4.1	4.4	5.1	4.3
		Alkalinity [mg/L as $CaCO_3$]	164.4	163.5	164.0	164.9	163.6	164.4

TDS Total Dissolved Solids PM Particulate Matter
TN Total Nitrogen TP Total Phosphorous
TDN Total Dissolved Nitrogen TDP Total Dissolved Phosphorous
COD_t Total Chemical Oxygen Demand TSS Total Suspended Solids

COD_d Dissolved Chemical Oxygen Demand NTU Nephelometric Turbidity Unit
SSC Suspended Sediment Concentration
VSSC Suspended Sediment Concentration

Table 23. Summary of mass separation for event 6 on 12-May-15 at APF pond 212.

Outlet mass as net pond 212 discharge		Event volume (m^3)	Cumulative mass (kg)						
			SSC	TN	TP	TSS	TDN	TDP	COD_t
Inlets	E	1848	12.7	25.5	0.2	5.3	21.5	0.1	76.5
	W	1011	3.8	17.1	0.1	2.4	13.9	0.0	30.8
	NE	20468	122.2	169.1	2.2	81.6	161.0	1.4	684.0
	N	15918	49.7	156.6	1.7	39.0	93.0	0.9	499.0
	Sum	39245	188.4	368.3	4.1	128.3	289.4	2.5	1290.3
Outlets	SW	1677	8.4	19.2	0.5	1.7	11.7	0.3	47.5
	SM	1267	8.1	14.1	0.2	2.4	12.5	0.1	43.8
	SE	4974	44.5	97.1	1.6	20.8	67.9	1.2	182.9
	Sum	7918	61.0	130.4	2.3	24.9	92.1	1.6	274.2
Mass separation (%)			68	65	45	81	68	36	79

SSC Suspended Sediment Concentration
TN Total Nitrogen
TP Total Phosphorous
TSS Total Suspended Solids
TDN Total Dissolved Nitrogen
TDP Total Dissolved Phosphorous
COD_t Total Chemical Oxygen Demand

Table 24. Inlet event mean values for event 7 on 13-May-15 at APF pond 212.

All runoff represents pond 212 inflow			Inlets			
			E	W	NE	N
Flow duration (hr)			96	96	96	96
Runoff volume, m³			2143	1178	18717	17407
Analytes (volume-weighted values); EMC or EMV	**PM**	d_{10m} (μm)	6.3	5.1	5.8	4.1
		d_{50m} (μm)	24.2	25.6	25.6	16.2
		d_{90m} (μm)	93.2	67.2	78.1	59.4
		VSSC [mg/L]	8.1	1.7	2.0	2.9
		Suspended (TSS) [mg/L]	9.1	1.8	2.6	2.7
		Settleable [mg/L]	4.7	1.1	0.9	1.1
		Sediment [mg/L]	2.7	0.2	0.3	0.4
		SSC [mg/L]	16.5	3.1	3.8	4.2
		TDS (calculated) [mg/L]	514	580	464	453
	N	Dissolved TDN [mg/L]	13.15	13.48	7.91	5.16
		Total TN [mg/L]	15.16	16.07	9.13	8.28
	P	Dissolved TDP [mg/L]	0.05	0.04	0.07	0.05
		Total TP [mg/L]	0.23	0.05	0.12	0.10
	COD	Dissolved COD_d [mg/L]	29.2	23.4	23.5	29.9
		Total COD_t [mg/L]	38.0	29.3	56.2	61.6
	Water Chemistry	Conductivity (μS/cm)	768	866	693	677
		Redox (+mV)	201	181	266	245
		pH	7.57	7.85	7.63	7.49
		Dissolved Oxygen [mg/L]	8.8	7.0	10.3	8.7
		Turbidity (NTU)	22.3	4.5	9.2	5.8
		Alkalinity [mg/L as $CaCO_3$]	170.5	176.4	192.2	192.6

TDS Total Dissolved Solids
TN Total Nitrogen
TDN Total Dissolved Nitrogen
PM Particulate Matter
TP Total Phosphorous
TDP Total Dissolved Phosphorous

COD_t Total Chemical Oxygen Demand TSS Total Suspended Solids
COD_d Dissolved Chemical Oxygen Demand NTU Nephelometric Turbidity Unit
SSC Suspended Sediment Concentration
VSSC Suspended Sediment Concentration

Table 25. Outlet event mean values for event 7 on 13-May-15 at APF pond 212.

"Out" indicates flow leaving pond 212 "In" indicates flow entering pond 212 from pond 208			Outlets					
			SW		SM		SE	
			Out	In	Out	In	Out	In
Flow duration (hr)			120	120	120	120	120	120
Flow volume, m³			2067	189	2007	436	5443	39
Analytes (volume-weighted values); EMC or EMV	**PM**	d_{10m} (μm)	26.8	27.9	7.7	6.9	3.4	3.5
		d_{50m} (μm)	116.7	116.6	34.3	32.0	32.9	24.4
		d_{90m} (μm)	282.7	278.5	88.7	80.9	59.2	52.9
		VSSC [mg/L]	6.5	4.3	1.7	2.0	3.2	2.7
		Suspended (TSS) [mg/L]	5.8	3.0	1.8	1.9	3.7	2.7
		Settleable [mg/L]	5.4	4.7	2.0	2.3	3.4	2.4
		Sediment [mg/L]	3.4	3.3	0.6	0.6	0.9	0.8
		SSC [mg/L]	14.7	11.2	4.6	5.1	8.0	5.9
		TDS (calculated) [mg/L]	638	636	637	637	639	644
	N	Dissolved TDN [mg/L]	10.07	9.40	11.59	11.46	12.09	12.00
		Total TN [mg/L]	15.55	15.16	15.48	14.68	18.10	15.95
	P	Dissolved TDP [mg/L]	0.14	0.12	0.06	0.06	0.19	0.16
		Total TP [mg/L]	0.24	0.23	0.13	0.12	0.25	0.21
	COD	Dissolved COD_d [mg/L]	25.0	25.3	31.1	32.4	31.5	29.9
		Total COD_t [mg/L]	28.4	28.6	45.0	43.0	35.3	34.2
	Water Chemistry	Conductivity (μS/cm)	952	949	950	951	954	961
		Redox (+mV)	239	243	217	210	147	143
		pH	8.26	8.25	8.27	8.30	8.16	8.18
		Dissolved Oxygen [mg/L]	4.1	4.1	3.9	3.8	3.8	3.9
		Turbidity (NTU)	9.9	8.4	4.4	4.3	5.1	4.2
		Alkalinity [mg/L as $CaCO_3$]	162.0	162.8	162.6	163.5	163.1	161.6

TDS Total Dissolved Solids PM Particulate Matter
TN Total Nitrogen TP Total Phosphorous
TDN Total Dissolved Nitrogen TDP Total Dissolved Phosphorous

COD_t Total Chemical Oxygen Demand   TSS Total Suspended Solids
COD_d Dissolved Chemical Oxygen Demand   NTU Nephelometric Turbidity Unit
SSC Suspended Sediment Concentration
VSSC Suspended Sediment Concentration

Table 26. Summary of mass separation for event 7 on 13-May-15 at APF pond 212.

Outlet mass as net pond 212 discharge		Event volume (m^3)	Cumulative mass (kg)						
			SSC	TN	TP	TSS	TDN	TDP	COD_t
Inlets	E	2143	35.3	32.5	0.5	19.4	28.2	0.1	81.4
	W	1178	3.7	18.9	0.1	2.1	15.9	0.0	34.5
	NE	18717	70.6	170.9	2.2	47.8	148.1	1.4	1051.8
	N	17407	73.1	144.2	1.7	46.4	89.9	0.8	1071.9
	Sum	39445	182.7	366.5	4.4	115.8	282.0	2.4	2239.5
Outlets	SW	1877	28.3	29.3	0.5	11.4	19.0	0.3	53.3
	SM	1571	7.0	24.7	0.2	2.8	18.3	0.1	71.6
	SE	5404	43.3	97.9	1.3	19.8	65.3	1.0	190.6
	Sum	8852	78.7	151.8	2.0	34.1	102.6	1.4	315.5
Mass separation (%)			57	59	54	71	64	41	86

SSC Suspended Sediment Concentration
TN Total Nitrogen
TP Total Phosphorous
TSS Total Suspended Solids
TDN Total Dissolved Nitrogen
TDP Total Dissolved Phosphorous
COD_t Total Chemical Oxygen Demand

Table 27. Inlet event mean values for event 8 on 17-May-15 at APF pond 212.

All runoff represents pond 212 inflow			Inlets			
			E	W	NE	N
Flow duration (hr)			96	96	96	96
Runoff volume, m^3			1158	1332	17710	4297
Analytes (volume-weighted values); EMC or EMV	**PM**	d_{10m} (μm)	5.0	6.7	4.2	4.4
		d_{50m} (μm)	25.1	39.2	14.7	18.8
		d_{90m} (μm)	104.2	108.6	72.4	65.9
		VSSC [mg/L]	6.1	2.9	3.8	3.1
		Suspended (TSS) [mg/L]	5.6	1.9	3.3	3.7
		Settleable [mg/L]	4.1	2.3	1.7	1.8
		Sediment [mg/L]	3.5	1.0	1.1	0.5
		SSC [mg/L]	13.2	5.2	6.1	6.0
		TDS (calculated) [mg/L]	426	562	372	324
	N	Dissolved TDN [mg/L]	9.43	7.21	3.50	2.58
		Total TN [mg/L]	11.82	11.88	4.54	4.37
	P	Dissolved TDP [mg/L]	0.05	0.05	0.11	0.04
		Total TP [mg/L]	0.08	0.07	0.13	0.07
	COD	Dissolved COD_d [mg/L]	19.7	23.6	25.7	25.6
		Total COD_t [mg/L]	26.2	42.7	84.3	84.7
	Water Chemistry	Conductivity (μS/cm)	636	839	556	484
		Redox (+mV)	201	120	138	255
		pH	7.60	7.76	7.56	7.59
		Dissolved Oxygen [mg/L]	5.1	5.2	5.4	5.9
		Turbidity (NTU)	10.3	2.0	6.6	6.2
		Alkalinity [mg/L as $CaCO_3$]	146.4	163.2	147.7	143.2

TDS Total Dissolved Solids
TN Total Nitrogen
PM Particulate Matter
TP Total Phosphorous

TDN	Total Dissolved Nitrogen
TDP	Total Dissolved Phosphorous
COD_t	Total Chemical Oxygen Demand
TSS	Total Suspended Solids
COD_d	Dissolved Chemical Oxygen Demand
NTU	Nephelometric Turbidity Unit
SSC	Suspended Sediment Concentration
VSSC	Suspended Sediment Concentration

Table 28. Outlet event mean values for event 8 on 17-May-15 at APF pond 212.

"Out" indicates flow leaving pond 212 "In" indicates flow entering pond 212 from pond 208			Outlets					
			SW		SM		SE	
			Out	In	Out	In	Out	In
Flow duration (hr)			120	120	120	120	120	120
Flow volume, m^3			2519	178	1826	636	6112	353
Analytes (volume-weighted values); EMC or EMV	**PM**	d_{10m} (μm)	6.5	6.4	5.3	4.1	8.8	6.5
		d_{50m} (μm)	38.1	43.2	24.4	20.0	53.5	47.9
		d_{90m} (μm)	127.5	233.7	78.5	75.8	234.6	113.9
		VSSC [mg/L]	5.5	4.9	1.5	1.7	2.4	2.7
		Suspended (TSS) [mg/L]	4.8	3.5	1.1	1.6	1.3	0.9
		Settleable [mg/L]	4.8	5.6	0.7	0.9	1.4	1.4
		Sediment [mg/L]	1.7	2.3	0.3	0.4	1.3	0.9
		SSC [mg/L]	11.3	11.4	2.3	2.8	4.0	3.2
		TDS (calculated) [mg/L]	604	595	605	589	595	578
	N	Dissolved TDN [mg/L]	12.60	13.24	11.08	11.61	9.91	12.72
		Total TN [mg/L]	18.01	18.47	19.63	18.28	16.69	20.23
	P	Dissolved TDP [mg/L]	0.05	0.04	0.06	0.06	0.06	0.06
		Total TP [mg/L]	0.06	0.06	0.08	0.07	0.07	0.07
	COD	Dissolved COD_d [mg/L]	23.2	23.3	25.0	20.4	23.4	23.1
		Total COD_t [mg/L]	27.7	27.3	63.0	61.3	27.1	26.8
	Water Chemistry	Conductivity (μS/cm)	901	888	902	880	888	863
		Redox (+mV)	258	249	265	265	148	167
		pH	8.04	8.01	8.12	8.09	7.97	7.87
		Dissolved Oxygen [mg/L]	5.3	5.4	4.7	4.7	4.4	4.5
		Turbidity (NTU)	12.7	12.5	4.4	5.2	5.3	6.9
		Alkalinity [mg/L as $CaCO_3$]	157.9	159.1	161.7	163.8	159.2	160.7

TDS	Total Dissolved Solids
PM	Particulate Matter
TN	Total Nitrogen
TP	Total Phosphorous

TDN Total Dissolved Nitrogen TDP Total Dissolved Phosphorous
COD_t Total Chemical Oxygen Demand TSS Total Suspended Solids
COD_d Dissolved Chemical Oxygen Demand NTU Nephelometric Turbidity Unit
SSC Suspended Sediment Concentration
VSSC Suspended Sediment Concentration

Table 29. Summary of mass separation for event 8 on 17-May-15 at APF pond 212.

Outlet mass as net pond 212 discharge		Event volume (m^3)	Cumulative mass (kg)						
			SSC	TN	TP	TSS	TDN	TDP	COD_t
Inlets	E	1158	15.3	13.7	0.1	6.5	10.9	0.1	30.4
	W	1332	6.9	15.8	0.1	2.5	9.6	0.1	56.9
	NE	17710	108.6	80.4	2.4	59.2	62.0	1.9	1493.4
	N	4297	25.7	18.8	0.3	15.7	11.1	0.2	364.1
	Sum	24497	156.7	128.6	2.9	83.9	93.6	2.2	1944.8
Outlets	SW	2341	26.5	42.1	0.1	11.4	29.4	0.1	64.8
	SM	1190	2.4	24.2	0.1	1.0	12.8	0.1	76.0
	SE	5760	23.2	94.9	0.4	7.5	56.1	0.4	156.2
	Sum	9290	52.1	161.2	0.7	19.9	98.3	0.5	297.0
Mass separation (%)			67	-25	77	76	-5	76	85

SSC Suspended Sediment Concentration
TN Total Nitrogen
TP Total Phosphorous
TSS Total Suspended Solids
TDN Total Dissolved Nitrogen
TDP Total Dissolved Phosphorous
COD_t Total Chemical Oxygen Demand

Table 30. Inlet event mean values for event 9 on 23-May-15 at APF pond 212.

All runoff represents pond 212 inflow			Inlets			
			E	W	NE	N
Flow duration (hr)			96	96	96	96
Runoff volume, m^3			2830	1231	9900	4214
Analytes (volume-weighted values); EMC or EMV	**PM**	d_{10m} (μm)	9.1	5.8	3.7	4.5
		d_{50m} (μm)	51.9	28.6	17.6	26.6
		d_{90m} (μm)	194.2	86.8	68.6	80.4
		VSSC [mg/L]	8.4	1.9	2.8	2.9
		Suspended (TSS) [mg/L]	6.9	1.8	4.9	2.7
		Settleable [mg/L]	3.9	1.6	2.3	2.1
		Sediment [mg/L]	4.1	0.6	0.8	0.6
		SSC [mg/L]	14.9	4.0	7.9	5.4
		TDS (calculated) [mg/L]	459	352	389	466
	N	Dissolved TDN [mg/L]	9.92	4.70	4.58	8.54
		Total TN [mg/L]	12.10	8.58	6.24	10.39
	P	Dissolved TDP [mg/L]	0.07	0.11	0.07	0.07
		Total TP [mg/L]	0.16	0.19	0.11	0.13
	COD	Dissolved COD_d [mg/L]	29.0	24.5	28.1	29.1
		Total COD_t [mg/L]	38.5	72.9	33.5	32.9
	Water Chemistry	Conductivity (μS/cm)	686	525	580	695
		Redox (+mV)	224	242	233	233
		pH	7.65	7.66	7.72	7.75
		Dissolved Oxygen [mg/L]	7.8	5.4	5.5	6.1
		Turbidity (NTU)	16.3	8.0	16.7	8.8
		Alkalinity [mg/L as $CaCO_3$]	157.3	126.7	201.1	185.1

TDS Total Dissolved Solids PM Particulate Matter

TN Total Nitrogen   TP Total Phosphorous
TDN Total Dissolved Nitrogen   TDP Total Dissolved Phosphorous
COD_t Total Chemical Oxygen Demand   TSS Total Suspended Solids
COD_d Dissolved Chemical Oxygen Demand   NTU Nephelometric Turbidity Unit
SSC Suspended Sediment Concentration
VSSC Suspended Sediment Concentration

Table 31. Outlet event mean values for event 9 on 23-May-15 at APF pond 212.

"Out" indicates flow leaving pond 212 "In" indicates flow entering pond 212 from pond 208			Outlets					
			SW		SM		SE	
			Out	In	Out	In	Out	In
Flow duration (hr)			120	120	120	120	120	120
Flow volume, m^3			2394	24	2191	104	5806	32
Analytes (volume-weighted values); EMC or EMV	**PM**	d_{10m} (µm)	7.5	7.8	6.2	6.5	7.2	7.6
		d_{50m} (µm)	32.9	35.5	30.6	31.2	31.3	28.2
		d_{90m} (µm)	81.7	82.8	79.8	78.3	74.9	92.4
		VSSC [mg/L]	2.3	2.3	2.6	2.7	1.5	3.2
		Suspended (TSS) [mg/L]	1.2	1.2	1.9	2.3	1.3	2.2
		Settleable [mg/L]	1.4	1.6	2.0	2.3	1.5	1.8
		Sediment [mg/L]	0.4	0.5	0.5	0.6	0.3	0.8
		SSC [mg/L]	3.0	3.2	4.4	5.2	3.0	4.8
		TDS (calculated) [mg/L]	545	548	579	576	536	555
	N	Dissolved TDN [mg/L]	12.43	11.14	9.62	9.20	11.99	10.25
		Total TN [mg/L]	17.13	15.31	18.30	18.20	15.02	13.81
	P	Dissolved TDP [mg/L]	0.06	0.06	0.07	0.07	0.08	0.12
		Total TP [mg/L]	0.10	0.09	0.10	0.10	0.12	0.15
	COD	Dissolved COD_d [mg/L]	27.1	27.1	26.1	26.9	26.6	27.5
		Total COD_t [mg/L]	37.6	39.1	29.3	29.8	31.3	31.1
	Water Chemistry	Conductivity (µS/cm)	813	819	864	859	800	828
		Redox (+mV)	258	260	262	265	259	272
		pH	8.00	8.00	8.01	7.97	7.85	7.74
		Dissolved Oxygen [mg/L]	5.0	5.0	5.0	5.1	5.1	5.1
		Turbidity (NTU)	2.4	1.6	2.8	3.0	1.9	1.0
		Alkalinity [mg/L as $CaCO_3$]	162.7	163.3	163.5	165.5	161.8	167.3

TDS Total Dissolved Solids   PM Particulate Matter

TN Total Nitrogen
TP Total Phosphorous
TDN Total Dissolved Nitrogen
TDP Total Dissolved Phosphorous
COD_t Total Chemical Oxygen Demand
TSS Total Suspended Solids
COD_d Dissolved Chemical Oxygen Demand
NTU Nephelometric Turbidity Unit
SSC Suspended Sediment Concentration
VSSC Suspended Sediment Concentration

Table 32. Summary of mass separation for event 9 on 23-May-15 at APF pond 212.

Outlet mass as net pond 212 discharge		Event volume (m^3)	Cumulative mass (kg)						
			SSC	TN	TP	TSS	TDN	TDP	COD_t
Inlets	E	2830	42.1	34.2	0.4	19.4	28.1	0.2	108.9
	W	1231	4.9	10.6	0.2	2.2	5.8	0.1	89.7
	NE	9900	78.6	61.8	1.1	48.3	45.3	0.7	331.7
	N	4214	22.7	43.8	0.6	11.2	36.0	0.3	138.5
	Sum	18175	148.3	150.4	2.3	81.2	115.1	1.4	668.8
Outlets	SW	2371	7.2	40.6	0.2	2.9	29.5	0.1	89.0
	SM	2087	9.1	38.2	0.2	4.0	20.1	0.1	61.1
	SE	5774	17.5	86.8	0.7	7.2	69.3	0.5	180.6
	Sum	10232	33.8	165.6	1.2	14.1	118.9	0.7	330.7
Mass separation (%)			77	-10	50	83	-3	46	51

SSC Suspended Sediment Concentration
TN Total Nitrogen
TP Total Phosphorous
TSS Total Suspended Solids
TDN Total Dissolved Nitrogen
TDP Total Dissolved Phosphorous
COD_t Total Chemical Oxygen Demand

Table 33. Inlet event mean values for event 10 on 24-Jul-15 at APF pond 212.

All runoff represents pond 212 inflow			Inlets			
			E	W	NE	N
Flow duration (hr)			96	96	96	96
Runoff volume, m^3			17342	1746	25615	18541
Analytes (volume-weighted values); EMC or EMV	**PM**	d_{10m} (μm)	11.0	8.2	6.5	8.2
		d_{50m} (μm)	40.7	29.3	25.8	34.4
		d_{90m} (μm)	155.9	101.2	85.7	103.0
		VSSC [mg/L]	8.8	2.3	3.1	4.0
		Suspended (TSS) [mg/L]	5.8	1.7	2.9	3.3
		Settleable [mg/L]	7.4	1.7	2.0	2.9
		Sediment [mg/L]	3.6	0.5	0.7	1.4
		SSC [mg/L]	16.8	3.9	5.5	7.6
		TDS (calculated) [mg/L]	151	70	143	112
	N	Dissolved TDN [mg/L]	1.62	0.54	0.54	0.46
		Total TN [mg/L]	2.14	0.96	1.23	0.80
	P	Dissolved TDP [mg/L]	0.07	0.07	0.08	0.07
		Total TP [mg/L]	0.13	0.11	0.12	0.16
	COD	Dissolved COD_d [mg/L]	21.6	13.7	19.6	16.9
		Total COD_t [mg/L]	35.0	16.5	27.4	29.8
	Water Chemistry	Conductivity (μS/cm)	226	105	214	167
		Redox (+mV)	276	295	274	259
		pH	7.65	7.51	7.65	7.75
		Dissolved Oxygen [mg/L]	5.2	5.0	5.1	5.5
		Turbidity (NTU)	8.1	1.0	2.8	3.5
		Alkalinity [mg/L as $CaCO_3$]	92.1	50.7	104.9	79.3

TDS	Total Dissolved Solids	PM	Particulate Matter
TN	Total Nitrogen	TP	Total Phosphorous
TDN	Total Dissolved Nitrogen	TDP	Total Dissolved Phosphorous
COD_t	Total Chemical Oxygen Demand	TSS	Total Suspended Solids
COD_d	Dissolved Chemical Oxygen Demand	NTU	Nephelometric Turbidity Unit
SSC	Suspended Sediment Concentration		
VSSC	Suspended Sediment Concentration		

Table 34. Outlet event mean values for event 10 on 24-Jul-15 at APF pond 212.

"Out" indicates flow leaving pond 212 "In" indicates flow entering pond 212 from pond 208			**Outlets**					
			SW		SM		SE	
			Out	In	Out	In	Out	In
Flow duration (hr)			120	120	120	120	120	120
Flow volume, m^3			46377	620	224	18730	44403	1163
Analytes (volume-weighted values); EMC or EMV	**PM**	d_{10m} (µm)	7.7	7.7	9.1	8.8	12.8	12.4
		d_{50m} (µm)	25.7	27.3	29.2	30.7	55.0	54.6
		d_{90m} (µm)	68.2	69.4	102.9	123.2	228.6	240.2
		VSSC [mg/L]	2.0	2.5	1.8	1.9	1.8	1.7
		Suspended (TSS) [mg/L]	3.3	2.2	1.2	1.1	1.2	1.0
		Settleable [mg/L]	3.1	2.2	1.2	1.1	1.5	1.1
		Sediment [mg/L]	0.4	0.3	0.3	0.5	1.6	1.6
		SSC [mg/L]	6.8	4.7	2.7	2.6	4.3	3.8
		TDS (calculated) [mg/L]	271	255	297	262	268	262
	N	Dissolved TDN [mg/L]	2.49	2.36	3.40	2.53	1.87	1.99
		Total TN [mg/L]	3.22	3.12	4.44	3.65	2.88	2.85
	P	Dissolved TDP [mg/L]	0.07	0.08	0.08	0.07	0.09	0.08
		Total TP [mg/L]	0.09	0.11	0.19	0.33	0.15	0.15
	COD	Dissolved COD_d [mg/L]	21.5	19.9	24.7	20.4	22.0	21.9
		Total COD_t [mg/L]	25.0	23.9	27.8	23.1	26.2	24.6
	Water Chemistry	Conductivity (µS/cm)	405	380	443	391	399	391
		Redox (+mV)	262	264	267	266	269	270
		pH	8.00	7.99	7.91	8.01	7.92	7.92
		Dissolved Oxygen [mg/L]	5.2	5.3	5.0	4.9	4.9	4.8
		Turbidity (NTU)	1.0	1.3	0.7	0.8	1.2	0.9
		Alkalinity [mg/L as $CaCO_3$]	151.6	142.5	168.6	147.8	148.3	148.3

TDS Total Dissolved Solids PM Particulate Matter
TN Total Nitrogen TP Total Phosphorous
TDN Total Dissolved Nitrogen TDP Total Dissolved Phosphorous
COD_t Total Chemical Oxygen Demand TSS Total Suspended Solids
COD_d Dissolved Chemical Oxygen Demand NTU Nephelometric Turbidity Unit
SSC Suspended Sediment Concentration
VSSC Suspended Sediment Concentration

Table 35. Summary of mass separation for event 10 on 24-Jul-15 at APF pond 212.

Outlet mass as net pond 212 discharge		Event volume (m^3)	Cumulative mass (kg)						
			SSC	TN	TP	TSS	TDN	TDP	COD_t
Inlets	E	17342	290.9	37.2	2.3	100.0	28.2	1.3	606.6
	W	1746	6.8	1.7	0.2	3.0	0.9	0.1	28.8
	NE	25615	141.4	31.6	3.1	74.1	13.8	2.1	700.7
	N	18541	140.3	14.8	2.9	60.9	8.5	1.3	552.4
	Sum	63244	579.4	85.3	8.5	238.0	51.4	4.9	1888.5
Outlets	SW	45757	312.7	147.4	4.3	150.7	113.9	3.0	1144.0
	SM	-18507	-48.9	-67.4	-6.2	-21.0	-46.6	-1.4	-426.0
	SE	43240	187.7	124.4	6.6	53.1	80.6	3.9	1135.5
	Sum	70490	451.5	204.4	4.7	182.8	147.9	5.5	1853.5
Mass separation (%)			22	-140	44	23	-188	-13	2

SSC Suspended Sediment Concentration
TN Total Nitrogen
TP Total Phosphorous
TSS Total Suspended Solids
TDN Total Dissolved Nitrogen
TDP Total Dissolved Phosphorous
COD_t Total Chemical Oxygen Demand

Table 36. Inlet event mean values for events 1-3 from 12-Sep-14 to 30-Sep-14 at APF pond 212.

All runoff represents pond 212 inflow			Inlets			
			E	W	NE	N
Flow duration (hr)			411	411	411	411
Runoff volume, m^3			6053	8245	51997	62048
Analytes (volume-weighted values); EMC or EMV	**PM**	d_{10m} (μm)	22.8	13.7	15.3	14.8
		d_{50m} (μm)	74.0	46.6	51.4	50.0
		d_{90m} (μm)	463.8	128.0	165.3	254.8
		VSSC [mg/L]	5.0	2.0	5.5	2.7
		Suspended (TSS) [mg/L]	2.4	1.0	2.8	1.2
		Settleable [mg/L]	3.6	2.2	5.3	2.0
		Sediment [mg/L]	4.0	1.4	5.7	2.5
		SSC [mg/L]	9.9	4.6	13.7	5.8
		TDS (calculated) [mg/L]	103	79	119	108
	N	Dissolved TDN [mg/L]	1.29	0.75	1.04	1.26
		Total TN [mg/L]	3.31	1.25	1.96	1.74
	P	Dissolved TDP [mg/L]	0.11	0.08	0.17	0.16
		Total TP [mg/L]	0.16	0.17	0.40	0.26
	COD	Dissolved COD_d [mg/L]	6.0	9.0	10.6	11.1
		Total COD_t [mg/L]	13.1	12.7	25.8	22.1
	Water Chemistry	Conductivity (μS/cm)	153	119	177	161
		Redox (+mV)	459	492	482	484
		pH	7.15	7.09	7.05	7.23
		Dissolved Oxygen [mg/L]	5.4	2.8	3.3	2.7
		Turbidity (NTU)	4.5	1.2	6.4	2.1
		Alkalinity [mg/L as $CaCO_3$]	56.9	46.6	68.4	60.8

TDS	Total Dissolved Solids	PM	Particulate Matter
TN	Total Nitrogen	TP	Total Phosphorous
TDN	Total Dissolved Nitrogen	TDP	Total Dissolved Phosphorous
COD_t	Total Chemical Oxygen Demand	TSS	Total Suspended Solids
COD_d	Dissolved Chemical Oxygen Demand	NTU	Nephelometric Turbidity Unit
SSC	Suspended Sediment Concentration		
VSSC	Suspended Sediment Concentration		

Table 37. Outlet event mean values for events 1-3 from 12-Sep-14 to 30-Sep-14 at APF pond 212.

"Out" indicates flow leaving pond 212 "In" indicates flow entering pond 212 from pond 208			Outlets					
			SW		SM		SE	
			Out	In	Out	In	Out	In
Flow duration (hr)			435	435	435	435	435	435
Flow volume, m^3			82317	34275	32870	30161	54957	1008
Analytes (volume-weighted values); EMC or EMV	**PM**	d_{10m} (µm)	12.4	13.9	14.5	15.4	15.2	19.0
		d_{50m} (µm)	37.0	44.8	44.6	50.1	43.5	60.6
		d_{90m} (µm)	160.1	155.1	181.2	187.0	155.9	186.4
		VSSC [mg/L]	2.4	3.4	2.5	3.0	2.4	3.0
		Suspended (TSS) [mg/L]	2.2	1.9	1.4	1.7	1.4	1.3
		Settleable [mg/L]	1.4	2.7	2.2	2.8	3.1	3.4
		Sediment [mg/L]	0.9	1.8	1.6	2.2	1.6	2.9
		SSC [mg/L]	4.5	6.4	5.1	6.6	6.1	7.7
		TDS (calculated) [mg/L]	312	314	309	324	319	364
	N	Dissolved TDN [mg/L]	1.53	2.09	2.03	1.95	1.54	1.94
		Total TN [mg/L]	2.74	3.45	3.50	3.44	3.14	4.39
	P	Dissolved TDP [mg/L]	0.16	0.14	0.12	0.15	0.09	0.13
		Total TP [mg/L]	0.30	0.25	0.22	0.24	0.20	0.38
	COD	Dissolved COD_d [mg/L]	15.2	14.5	13.0	13.3	14.4	14.6
		Total COD_t [mg/L]	21.0	19.6	17.9	17.9	23.6	34.6
	Water	Conductivity (µS/cm)	465	468	461	483	476	544
		Redox (+mV)	431	450	429	473	444	454
		pH	7.44	7.43	7.63	7.45	7.46	7.11
		Dissolved Oxygen [mg/L]	2.4	3.5	1.8	3.6	2.7	3.7
		Turbidity (NTU)	1.8	1.5	1.6	1.5	1.7	4.4

		Alkalinity [mg/L as $CaCO_3$]	131.4	130.4	128.9	132.6	131.8	143.6

TDS Total Dissolved Solids
TN Total Nitrogen
TDN Total Dissolved Nitrogen
COD_t Total Chemical Oxygen Demand
COD_d Dissolved Chemical Oxygen Demand
SSC Suspended Sediment Concentration
VSSC Suspended Sediment Concentration
PM Particulate Matter
TP Total Phosphorous
TDP Total Dissolved Phosphorous
TSS Total Suspended Solids
NTU Nephelometric Turbidity Unit

Table 38. Summary of mass separation for events 1-3 from 12-Sep-14 to 30-Sep-14 at APF pond 212.

Outlet mass as net pond 212 discharge		Event volume (m^3)	Cumulative mass (kg)						
			SSC	TN	TP	TSS	TDN	TDP	COD_t
Inlets	E	6053	60.0	20.0	0.9	14.3	7.8	0.7	79.3
	W	8245	37.6	10.3	1.4	8.6	6.2	0.7	104.3
	NE	51997	711.7	101.8	20.8	143.6	54.2	8.6	1343.1
	N	62048	358.5	107.9	16.3	76.2	78.3	9.8	1373.9
	Sum	128342	1167.8	240.1	39.4	242.6	146.5	19.8	2900.6
Outlets	SW	48042	146.6	107.3	16.4	118.3	54.3	8.1	1054.0
	SM	2709	-29.4	11.5	-0.1	-6.4	8.1	-0.7	49.3
	SE	53949	328.5	168.0	10.8	77.9	82.9	4.8	1262.1
	Sum	104699	445.7	286.8	27.2	189.9	145.3	12.3	2365.4
Mass separation (%)			62	-19	31	22	1	38	18

SSC Suspended Sediment Concentration
TN Total Nitrogen
TP Total Phosphorous
TSS Total Suspended Solids
TDN Total Dissolved Nitrogen
TDP Total Dissolved Phosphorous
COD_t Total Chemical Oxygen Demand

Table 39. Inlet event mean values for events 5-8 from 11-May-15 to 22-May-15 at APF pond 212.

All runoff represents pond 212 inflow			Inlets: E	W	NE	N
Flow duration (hr)			238	238	238	238
Runoff volume, m^3			3991	2870	45208	23435
Analytes (volume-weighted values); EMC or EMV	**PM**	d_{10m} (μm)	7.9	5.9	4.8	4.2
		d_{50m} (μm)	44.8	32.8	19.8	17.4
		d_{90m} (μm)	130.6	89.2	73.3	62.1
		VSSC [mg/L]	6.7	2.4	3.3	3.1
		Suspended (TSS) [mg/L]	6.4	1.9	3.4	2.9
		Settleable [mg/L]	3.7	1.8	1.6	1.3
		Sediment [mg/L]	3.0	0.6	0.8	0.5
		SSC [mg/L]	13.0	4.4	5.7	4.7
		TDS (calculated) [mg/L]	488	559	435	431
	N	Dissolved TDN [mg/L]	10.35	9.56	5.01	4.59
		Total TN [mg/L]	12.65	13.23	6.19	7.48
	P	Dissolved TDP [mg/L]	0.06	0.05	0.09	0.05
		Total TP [mg/L]	0.18	0.06	0.14	0.09
	COD	Dissolved COD_d [mg/L]	27.8	24.7	24.2	30.2
		Total COD_t [mg/L]	38.5	37.8	68.0	65.5
	Water	Conductivity (μS/cm)	728	834	649	643
		Redox (+mV)	210	160	215	248
		pH	7.63	7.81	7.63	7.53
		Dissolved Oxygen [mg/L]	7.2	5.9	7.2	7.8
		Turbidity (NTU)	18.4	3.5	7.8	6.0

		Alkalinity [mg/L as $CaCO_3$]	163.1	170.3	174.9	183.8

TDS Total Dissolved Solids
TN Total Nitrogen
TDN Total Dissolved Nitrogen
COD_t Total Chemical Oxygen Demand
COD_d Dissolved Chemical Oxygen Demand
SSC Suspended Sediment Concentration
VSSC Suspended Sediment Concentration
PM Particulate Matter
TP Total Phosphorous
TDP Total Dissolved Phosphorous
TSS Total Suspended Solids
NTU Nephelometric Turbidity Unit

Table 40. Outlet event mean values for events 5-8 from 11-May-15 to 22-May-15 at APF pond 212.

"Out" indicates flow leaving pond 212 "In" indicates flow entering pond 212 from pond 208			**Outlets**					
			SW		SM		SE	
			Out	In	Out	In	Out	In
Flow duration (hr)			262	262	262	262	262	262
Flow volume, m^3			4500	336	3624	1137	11688	398
Analytes (volume-weighted values); EMC or EMV	**PM**	d_{10m} (μm)	20.0	18.1	64.4	104.2	6.9	6.5
		d_{50m} (μm)	97.7	84.3	125.5	155.1	41.7	47.5
		d_{90m} (μm)	263.4	268.9	229.4	245.9	161.3	111.6
		VSSC [mg/L]	3.8	3.4	1.8	1.9	2.8	2.8
		Suspended (TSS) [mg/L]	3.2	2.5	1.4	1.5	2.6	1.0
		Settleable [mg/L]	3.2	3.7	1.4	1.4	2.5	1.6
		Sediment [mg/L]	2.3	2.3	1.5	1.1	1.2	0.9
		SSC [mg/L]	8.9	8.7	4.4	4.1	6.2	3.7
		TDS (calculated) [mg/L]	623	620	626	613	621	588
	N	Dissolved TDN [mg/L]	10.14	10.75	10.26	10.68	11.72	12.07
		Total TN [mg/L]	15.05	16.13	15.17	15.67	18.01	19.87
	P	Dissolved TDP [mg/L]	0.12	0.11	0.06	0.06	0.15	0.09
		Total TP [mg/L]	0.18	0.18	0.10	0.09	0.19	0.12
	COD	Dissolved COD_d [mg/L]	24.3	24.6	28.2	25.4	27.9	24.1
		Total COD_t [mg/L]	27.8	28.5	48.6	51.3	31.6	28.1
	Water	Conductivity (μS/cm)	930	925	934	915	927	878
		Redox (+mV)	231	237	227	236	143	159
		pH	8.18	8.14	8.25	8.20	8.09	7.90
		Dissolved Oxygen [mg/L]	4.5	4.6	4.1	4.2	4.0	4.4
		Turbidity (NTU)	8.2	8.5	4.3	4.8	5.4	6.7

		Alkalinity [mg/L as $CaCO_3$]	164.0	163.5	163.7	164.3	163.4	162.5

TDS Total Dissolved Solids
TN Total Nitrogen
TDN Total Dissolved Nitrogen
COD_t Total Chemical Oxygen Demand
COD_d Dissolved Chemical Oxygen Demand
SSC Suspended Sediment Concentration
VSSC Suspended Sediment Concentration
PM Particulate Matter
TP Total Phosphorous
TDP Total Dissolved Phosphorous
TSS Total Suspended Solids
NTU Nephelometric Turbidity Unit

Table 41. Summary of mass separation for events 5-8 from 11-May-15 to 22-May-15 at APF pond 212.

Outlet mass as net pond 212 discharge		Event volume (m^3)	Cumulative mass (kg)						
			SSC	TN	TP	TSS	TDN	TDP	COD_t
Inlets	E	3991	51.8	50.5	0.7	25.4	41.3	0.2	153.5
	W	2870	12.6	38.0	0.2	5.5	27.4	0.1	108.6
	NE	45208	259.1	279.8	6.2	154.1	226.5	3.9	3072.0
	N	23435	110.9	175.4	2.2	68.8	107.7	1.2	1534.1
	Sum	75505	434.4	543.7	9.3	253.8	403.0	5.5	4868.2
Outlets	SW	4164	37.2	62.3	0.8	13.4	42.0	0.5	115.8
	SM	2488	11.2	37.2	0.3	3.3	25.0	0.2	117.7
	SE	11290	71.4	202.6	2.2	29.5	132.2	1.7	357.9
	Sum	17941	119.8	302.1	3.2	46.3	199.3	2.4	591.4
Mass separation (%)			72	44	66	82	51	56	88

SSC Suspended Sediment Concentration
TN Total Nitrogen
TP Total Phosphorous
TSS Total Suspended Solids
TDN Total Dissolved Nitrogen
TDP Total Dissolved Phosphorous
COD_t Total Chemical Oxygen Demand

Table 42. Inlet event mean values for events 4-9 from 28-Apr-15 to 28-May-15 at APF pond 212.

All runoff represents pond 212 inflow			Inlets			
			E	W	NE	N
Flow duration (hr)			699	699	699	699
Runoff volume, m^3			12880	8979	126006	52622
Analytes (volume-weighted values); EMC or EMV	**PM**	d_{10m} (µm)	8.3	8.0	5.5	5.7
		d_{50m} (µm)	48.2	41.0	34.3	27.2
		d_{90m} (µm)	205.3	164.0	165.7	117.2
		VSSC [mg/L]	10.0	5.3	5.2	5.2
		Suspended (TSS) [mg/L]	8.5	2.9	4.4	3.5
		Settleable [mg/L]	4.3	3.4	2.2	2.5
		Sediment [mg/L]	4.1	2.2	2.1	1.7
		SSC [mg/L]	16.9	8.5	8.6	7.7
		TDS (calculated) [mg/L]	471	439	443	445
	N	Dissolved TDN [mg/L]	8.01	5.26	4.26	4.83
		Total TN [mg/L]	11.41	10.98	6.23	6.89
	P	Dissolved TDP [mg/L]	0.08	0.13	0.13	0.10
		Total TP [mg/L]	0.23	0.20	0.21	0.21
	COD	Dissolved COD_d [mg/L]	32.5	31.5	23.0	40.9
		Total COD_t [mg/L]	51.5	65.6	69.4	65.1
	Water	Conductivity (µS/cm)	704	655	661	664
		Redox (+mV)	208	207	225	241
		pH	7.65	7.67	7.58	7.53
		Dissolved Oxygen [mg/L]	5.9	5.0	5.2	5.7
		Turbidity (NTU)	14.9	5.4	7.1	5.3

		Alkalinity [mg/L as $CaCO_3$]	160.8	144.5	194.3	187.7

TDS Total Dissolved Solids
TN Total Nitrogen
TDN Total Dissolved Nitrogen
COD_t Total Chemical Oxygen Demand
COD_d Dissolved Chemical Oxygen Demand
SSC Suspended Sediment Concentration
VSSC Suspended Sediment Concentration
PM Particulate Matter
TP Total Phosphorous
TDP Total Dissolved Phosphorous
TSS Total Suspended Solids
NTU Nephelometric Turbidity Unit

Table 43. Outlet event mean values for events 4-9 from 28-Apr-15 to 28-May-15 at APF pond 212.

"Out" indicates flow leaving pond 212 "In" indicates flow entering pond 212 from pond 208			Outlets					
			SW		SM		SE	
			Out	In	Out	In	Out	In
Flow duration (hr)			723	723	723	723	723	723
Flow volume, m^3			13094	547	8997	2223	27793	1020
Analytes (volume-weighted values); EMC or EMV	**PM**	d_{10m} (µm)	12.2	14.3	38.0	61.0	7.5	7.7
		d_{50m} (µm)	59.9	67.8	108.0	123.3	37.0	42.3
		d_{90m} (µm)	211.4	242.3	256.1	267.1	138.1	141.4
		VSSC [mg/L]	3.5	3.4	2.8	3.1	2.8	3.1
		Suspended (TSS) [mg/L]	2.4	2.4	1.6	1.8	2.3	1.6
		Settleable [mg/L]	2.4	3.1	1.6	1.6	2.4	1.8
		Sediment [mg/L]	1.7	2.0	1.9	1.8	1.1	1.2
		SSC [mg/L]	6.6	7.6	5.1	5.2	5.9	4.5
		TDS (calculated) [mg/L]	619	635	622	627	614	584
	N	Dissolved TDN [mg/L]	11.04	11.15	9.34	9.88	11.42	12.30
		Total TN [mg/L]	16.91	16.66	15.77	16.12	17.37	18.13
	P	Dissolved TDP [mg/L]	0.14	0.16	0.09	0.10	0.17	0.12
		Total TP [mg/L]	0.20	0.23	0.14	0.14	0.23	0.15
	COD	Dissolved COD_d [mg/L]	23.9	24.9	24.4	21.5	26.8	25.3
		Total COD_t [mg/L]	33.6	32.7	38.7	42.1	34.7	31.8
	Water	Conductivity (µS/cm)	924	947	929	935	917	872
		Redox (+mV)	246	239	239	241	179	204
		pH	8.16	8.15	8.22	8.24	8.04	7.85
		Dissolved Oxygen [mg/L]	4.5	4.4	4.4	4.4	4.2	4.6
		Turbidity (NTU)	4.2	5.9	3.5	3.8	3.7	3.9

		Alkalinity [mg/L as $CaCO_3$]	167.1	165.2	165.8	165.8	165.4	167.8

TDS Total Dissolved Solids
TN Total Nitrogen
TDN Total Dissolved Nitrogen
COD_t Total Chemical Oxygen Demand
COD_d Dissolved Chemical Oxygen Demand
SSC Suspended Sediment Concentration
VSSC Suspended Sediment Concentration
PM Particulate Matter
TP Total Phosphorous
TDP Total Dissolved Phosphorous
TSS Total Suspended Solids
NTU Nephelometric Turbidity Unit

Table 44. Summary of mass separation for events 4-9 from 28-Apr-15 to 28-May-15 at APF pond 212.

Outlet mass as net pond 212 discharge		Event volume (m^3)	Cumulative mass (kg)						
			SSC	TN	TP	TSS	TDN	TDP	COD_t
Inlets	E	12880	217.3	146.9	3.0	109.5	103.2	1.1	663.0
	W	8979	76.2	98.6	1.8	26.0	47.3	1.2	589.4
	NE	126006	1089.7	785.6	26.7	549.4	537.0	16.2	8742.5
	N	52622	404.1	362.6	10.8	184.5	253.9	5.4	3423.1
	Sum	200488	1787.4	1393.8	42.4	869.4	941.4	23.9	13417.9
Outlets	SW	12547	82.5	212.3	2.4	29.9	138.4	1.8	421.6
	SM	6775	34.7	106.0	0.9	10.6	62.1	0.6	254.3
	SE	26773	158.7	464.4	6.1	63.4	304.8	4.5	932.4
	Sum	46094	275.9	782.7	9.4	104.0	505.3	6.9	1608.3
Mass separation (%)			85	44	78	88	46	71	88

SSC Suspended Sediment Concentration
TN Total Nitrogen
TP Total Phosphorous
TSS Total Suspended Solids
TDN Total Dissolved Nitrogen
TDP Total Dissolved Phosphorous
COD_t Total Chemical Oxygen Demand