Florida Department of Transportation
Aviation and Spaceports Office

Program Summary of the FAA Pond Post-Construction Monitoring at the Naples Municipal Airport

FAA Pond Post-Construction Monitoring

Contract C9889

Task Work Order #7

January 2016

PROGRAM SUMMARY

Executive Summary

- The modified, steep sided, crenellated Pond 212 with reduced littoral area attracts 60% fewer birds that pose a strike hazard to aircraft than the originally configured pond. Pond 214 that was modified to reduce its size and to change one side to a vertical sheet pile wall also attracts 60% fewer birds than it did before being altered. Reducing littoral zones and vegetation and incorporating steep or vertical pond side slopes reduces the attraction of birds that pose a strike hazard to aircraft.
- The crenellated pond water quality performance for reducing nitrogen, phosphorus and total suspended solids equals the performance of a typical pond with littoral shelves that is 5 to 10 times larger. The pond footprint is about 2% of the contributing area, compared to the typical 10% to 20% footprint of standard ponds of equal performance.
- Excluding savings that may occur from fewer aircraft bird strikes, the crenellated retrofit has significant economic benefits. Considering the annual rental value of the airport land, the crenellated pond design represents about $10 million benefit to Naples Municipal Airport. The benefit/cost ratio for the design is 4:1 or greater.
- Incorporating the study into practice may be done either by rulemaking or by a design aid approach. The method has not been decided by the regulatory stakeholders as of the conclusion of this monitoring project.
- The design can be adapted to other project types and may be a benefit to those projects. Highways, ports or rail may benefit from adaptive studies of the concept.
- Other permutations of the study pond may provide even better water quality performance and economic benefit. For example, a new pond with a built-in baffle structure costs half as much as a gabion basket retrofit. The effectiveness of that concept and others must be evaluated with full scale testing, but offers environmental and economic benefits to justify investment in the research and data collection.
- The benefits of the extra engineering and analysis needed to use the Statewide Airport Stormwater results far outweigh the professional services costs. However, the already available methods have not been as widely used as possible. An education program for airport and transportation managers, and an extended education and training program for regulators, consultants, and airport and transportation technical staff are both apparently needed to achieve wider use.

Program History

The “FAA Pond” Water Quality and Wildlife Monitoring Project done at Naples Municipal Airport builds on over two decades of continued effort to provide “Clean Water – Safe Airports” in Florida. The work began in 1993 with a stakeholder group that included the Florida Department of Transportation (FDOT), the Federal Aviation Administration (FAA), the Southwest Florida Water Management District (SWFWMD), airports and consultants. The initial focus was reducing long permitting times. However,

this evolved into addressing the differences between airport water management and other land uses. Outcomes of those first group meetings were formation of an airport specific permitting team in SWFWMD, a new emphasis on Master Drainage Planning and Conceptual Permits by airports, and a demonstration project at Punta Gorda Airport (PGD). This latter project added 40+ acres of new airside pavement to the airport with no ponds for quality or quantity management. Monitoring indicated this was a viable option at PGD, but was not a sufficient basis for statewide use of the concepts. With the 1997 issuance of FAA Advisory Circular 150/5200-33 *Hazardous Wildlife Attractants On or Near Airports*, the stakeholder group was expanded to make the project a statewide initiative. The Florida Department of Environmental Protection (FDEP), the South Florida Water Management District (SFWMD), and the St. John's River Water Management District (SJRWMD) became regular participants, with periodic inclusion of Suwannee River Water Management District (SRWMD) and Northwest Florida Water Management District (NWFWMD). FDOT with grant assistance from FAA became the Sponsor and lead agency for this program.

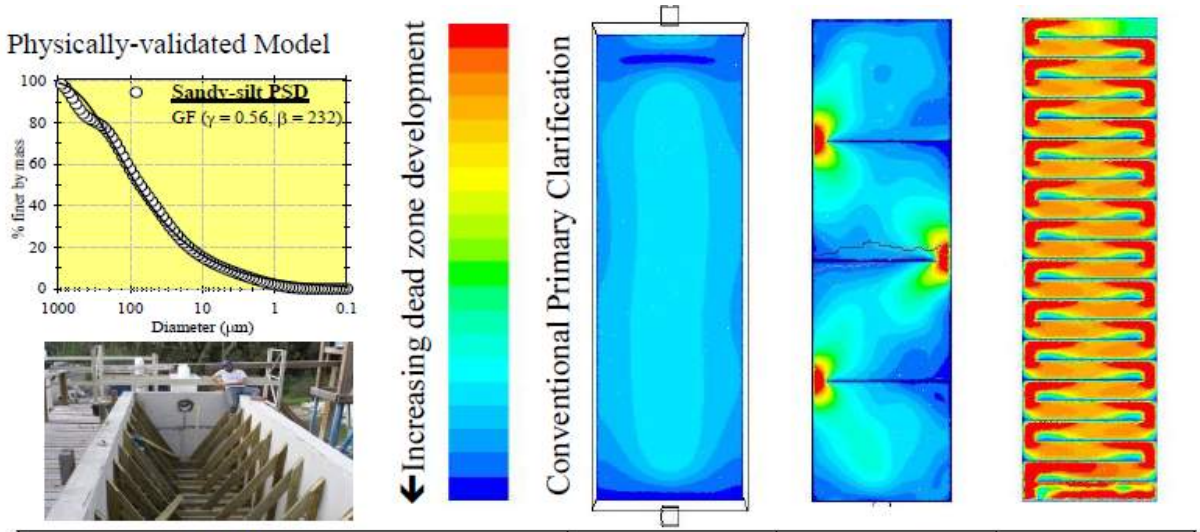
The initial results of the Statewide Airport Stormwater Study found airport airsides generated significantly less load and were generally much cleaner (and well-maintained) than other land uses. This was determined by monitoring stormwater runoff from runways, taxiways and aprons at 10% of the state's public use airports. These results ultimately led to the adoption of a new rule, Chapter 62-330.449 Florida Administrative Code (FAC) General Permit for Construction, Operation, Maintenance, Alteration, Abandonment or Removal of Airport Airside Surface Water Management Systems (*Airside General Permit*). When the overland flow design criteria of this approach apply, construction cost savings and improved safety from fewer wildlife hazards have been demonstrated. On six of the early projects at three airports, net cost savings of $4 million was achieved over conventional designs using either dry retention ponds with underdrainage or wet detention ponds. The criteria and data needed are in the Florida Department of Transportation, Aviation and Spaceports Office's Statewide Airport Stormwater Study Best Management Practices Manual (Airport BMP Manual). However, wet detention systems meeting criteria of the United States Department of Agriculture (USDA – the federal agency responsible for wildlife hazards) described as an "FAA Pond" or "FAA/USDA Pond" had not been shown as suitable for water quality management to meet state and federal requirements. As a consequence, wet detention systems were excluded from the Airport BMP Manual. This project in part addresses that limitation and qualifies one form of an FAA Pond for use on and around airports.

FAA Pond Qualification Study - Background Summary and Scope

The need to add a pond designed with USDA/FAA criteria to the options for water management on and near airports was recognized before the first Statewide Airport Stormwater Study results for overland flow became rule. The differences between an FAA Pond and the ponds used for presumptive permitting in Florida are driven by a need to be less attractive to wildlife and birds that are strike hazards to aircraft. FAA/USDA criteria exclude littoral shelves with vegetation that are wildlife attractants, but that presumptively provide a water quality improvement function in the typical Florida Water Management Pond design. FAA/USDA pond criteria are steep slopes beneath the pond water

surface, typically 2H:1V with concrete facing or rip-rap, or vertical walls. This contrasts with typical Water Management District criteria for slopes of 4H:1V or flatter. Finally, FAA/USDA criteria are for long, linear ponds whose length to width ratio is larger than typical water management design, but not precluded by normal presumptive criteria.

Studies of wet detention pond behavior were done by the University of Florida using Computational Fluid Dynamics (CFD) and physical scale models to estimate the water quality changes between presumptive and FAA criteria designs. These studies indicated that a relatively linear and crenellated pond (Figure 1) where the flow snakes back and forth due to baffles with FAA/USDA design features would be better water quality management systems than presumptive ponds. The crenellation option was tested as a pond retrofit at Naples Municipal Airport in a water management feature identified as Pond 212. Also, partial vertical walls were tested as a wildlife reduction option in Pond 214 at Naples Municipal Airport. The construction of these retrofits was done by the airport in conjunction with a taxiway extension project with FAA, FDOT and local funds. The monitoring of the pond performance for both water quality and wildlife reduction was done by FDOT with FAA grant assistance.



Number of Baffles	0	3	17
Δ PM (%) (β = 0.56 , γ = 232.6)	45 to 60	60 to 70	> 80%
Volumetric Efficiency (%)	5 to 10	20 to 30	60 to 85

FIGURE 1- Linear and Crenellated Ponds Showing Flow Paths and Volumetric Efficiency (from UF Computational Fluid Dynamics Study and Scale Models (shown) for Statewide Airport Stormwater Study)

Pond 214 was modified by reducing its size, removing some, but not all littoral area, and creating a vertical sheet pile wall along one side of the pond. Figures 2, 3 and 4 show this. The modification was principally to accommodate a taxiway extension at standard distance from the primary runway, and to do so in a way to reduce wildlife attraction.

Figure 2 - Pond 214 Before It Was Modified

Figure 3 - Pond 214 After It Was Modified. The Red Line is the same limit in both Figure 2 and Figure 3.

Figure 4 - Sheet Pile Wall Pile Cap Used to Modify Pond 214

Pond 212 was modified by constructing a series of gabions and baffles with fixed and moveable elements, respectively. The fixed elements are gabion baskets filled with recycled, crushed Portland Cement Concrete. These are shown in Figures 5 and 6. The moveable elements are made of geo-fabric that is suspended by cables and adjusted by a chain and sprocket system to keep the water surface about 6 inches above the fabric tops. This was done for aesthetic reasons at the Naples Airport in lieu of extending the gabion baskets 3 or more feet above the water surface. The system is shown in Figure 7 with the fabric baffle raised to its highest position to show the operation.

Figure 5 - Gabion Baffles Under Construction

Figure 6 - Aerial View of Pond 212 Showing the Gabion Baffles

Figure 7 – Moveable Fabric Baffle and Fixed Gabion Baffle. Fabric is Up-Gradient.

Monitoring systems were incorporated into Pond 212, the primary water quality management feature of the system. Figure 8 shows a monitor station. The inflow to the Pond includes runoff from 120± acres of off-airport industrial/commercial land uses. These represent the predominant pollutant load inflowing to the treatment system.

Figure 8 – Typical Monitoring Station Equipment

FAA Pond Qualification Study – Summary Results

Wildlife monitoring was done before and after the ponds were modified and across the airport as a whole. Hazardous bird use of Pond 214 and of Pond 212 is down by about 60% in the retrofitted configuration compared to the original ponds. The bird population in the area of the airport is unchanged, confirming that the reduction at the ponds is a result of the pond changes and not a change in area bird population. The conclusion is that the retrofit features significantly reduce potential of a damaging or catastrophic bird strike originating from birds using the ponds.

The water quality performance of retrofitted Pond 212 equals or exceeds that of presumptive ponds with littoral shelves 5 to 10 times larger. That is, the water quality performance of Pond 212 occupying about 2% of the contributing area equals that of a standard pond occupying between 10% and 20% of the contributing area. This conclusion is based on the study monitoring results compared to an analysis of reported performance data for standard ponds compiled by FDEP and done by the University of Florida. The contributing area includes significant commercial/ industrial use and these contribute the majority of the pollutant load to the pond. This confirms the pond works for non-airside loads that are much greater than those from airside areas.

Cost and Safety Implications

The total construction cost of the pond retrofit was approximately $620,000. This excludes several one-time research costs such as physical scale modeling, computational fluid dynamics (CFD), monitor system construction and water quality and wildlife pre-and post-construction monitoring. Looking at the total cost of the pond including the value of land that the pond occupies, the total cost for the pond in 2015 dollars is approximately $3½ million. By contrast, a presumptive pond with littoral shelf, 4H: 1V or flatter side slopes, and a standard treatment volume would have a total cost including the land value the pond occupies of about $14 million.

The total construction cost of a similar pond with earth baffles built-in (by not excavating earth and rock where the baffles are) is approximately $330,000. A pond like this was also constructed at the Naples Municipal Airport, but without state or federal funds and with no wildlife or water quality monitoring. It is designated as the West Quad Pond. The efficiency of this pond can only be estimated based on inferences from computational fluid dynamics studies. Ultimately inclusion of design features of this type will require full scale qualification testing.

As noted above, the retrofitted ponds attract fewer birds that pose a wildlife strike hazard to aircraft. The actual risk reduction is more complex than a simple, direct correlation between the 60% reduction of bird use of the ponds. However, reducing the number of birds attracted to airport ponds clearly reduces the number of possible bird/aircraft interactions, and thus the potential of a damaging or catastrophic birdstrike.

Unanswered Questions

The monitoring project enabled by the pond retrofits at Naples Municipal Airport has provided information on very specific construction materials and pond geometries. These can be immediately used for safety, economic and environmental benefits at airports. However they do not represent a full suite of available options that may offer the potential for greater benefits in all three of the aforementioned categories.

Using the data obtained from the project study in refined Computational Fluid Dynamic models, University of Florida researchers have found some surprising and intriguing water quality possibilities. Referring to Figure 9 following, Cases (A) and (C) represent Pond 212 in the original and retrofitted configurations respectively. The CFD models imply that the retrofitted system creates almost twice the

transport time of the original system, which is a large contributor to the improved performance achieved. However, Case (B) implies that a removal of the fabric baffles would increase the transport time another 30%, further improving the water quality performance. Case (D) where the baffles extend 3 feet or more above the water surface and socket into the bank, increases transport time to over double that of the pond as retrofitted, and more than four times the original pond configuration. Pollutant removal efficiency from such an improvement would likely not be a linear improvement, but improved discharge water quality will occur.

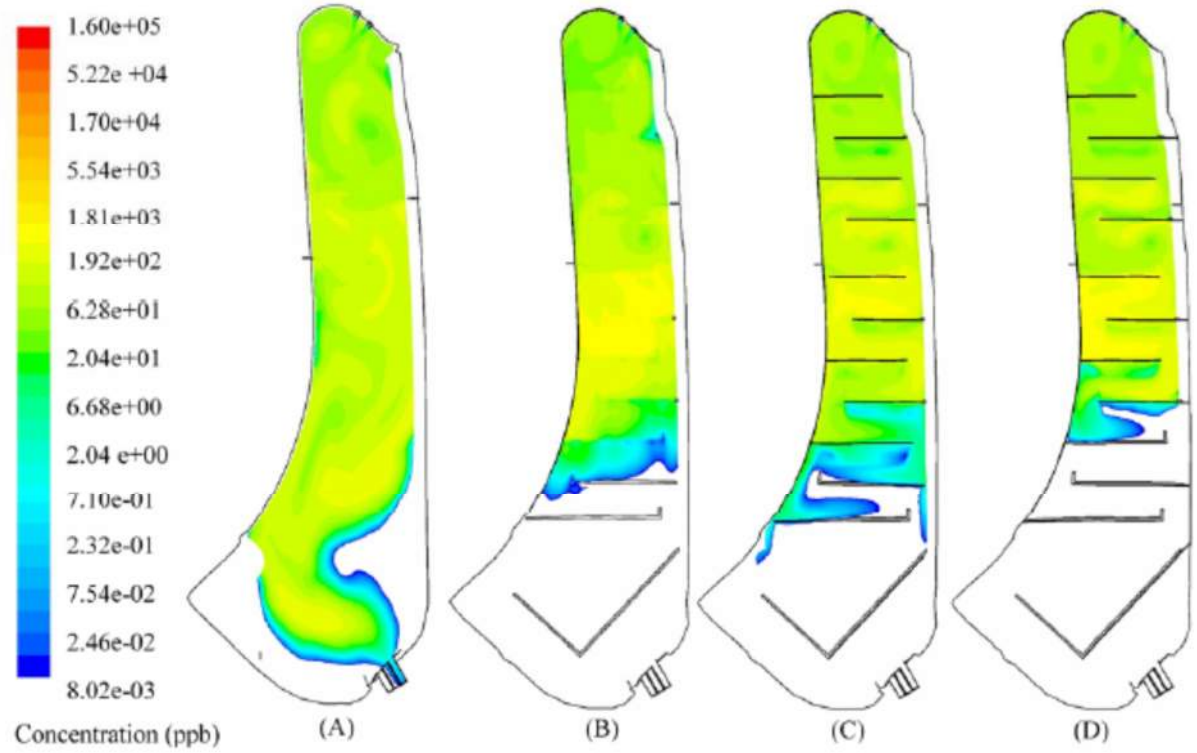


FIGURE 9 - Computational Fluid Dynamic Models Reflecting Data from APF Pond Monitoring. Case (A) is the original pond with an 85 hour transport time. Case (B) is the pond as retrofitted less the moveable fabric baffles with a transport time of 212 hours. Case (C) is the pond as retrofitted with a transport time of 160 hours. Case (D) is the initial design concept with gabion baskets three feet above the water surface and socketed into the pond banks with a transport time of 366 hours. The initial concept could not be used at Naples for aesthetic reasons.

Considering all the above, some of the questions that are unanswered by this study, but whose answers may offer major benefits include:

- How effective are built in crenellations creating sinuous or tortuous flow for water quality treatment? How do they compare with baffles built of gabions filled with recycled, crushed concrete?
- How effective will gabions constructed with fill materials other than recycled, crushed concrete be for water quality treatment?
- How will birds react to gabions that are three or more feet above the water surface as opposed to those that are an average of three feet beneath the water surface? What bird exclusion methods are applicable to fixed baffles extending more than 3 feet above the water surface?
- How will birds react to removing the flexible baffles?
- What are the limits to water quality improvement for a crenellated pond? That is, if the pond footprint is increased to a greater proportion of the contributing area, will the water quality improvement increase significantly? What is the point where no further improvement to water quality occurs?
- Are there other scaling effects for the pond for either wildlife or water quality performance?

Some of the above questions can be answered with a modification and a continuation of the monitoring program at Naples Municipal Airport. Others will require different construction and different test sites to evaluate. Candidate sites were identified in some of the previous technical studies including the FAA Pond Design Criteria Water Quality treatment Report previously done by FDOT.

Implications to Other Transportation Projects

The smaller footprint of the crenellated pond design that provides equal or better water quality performance is likely applicable to other transportation projects. It may be particularly valuable where right-of-way for water management is limited or very expensive to acquire. Specific design features such as those intended to attract fewer birds may not be needed or desired in the other applications. Specifically, depending on the location that a pond will occupy, steep side slopes and vertical gabion components might be a safety hazard as opposed to the safety improvement they provide on and near airports. For example, if the pond location is located sufficiently close to travel lanes, a car that loses directional control might reasonably be expected to enter the pond. In this case, steep side slopes, vertical gabion walls and greater depths in the pond would pose an egress hazard to the crash victims. Consequently, adapting the pond to highway use will require additional study to be successful. Likewise, specific port and rail design and operating features will also require study if the FAA Pond results are to be adapted for those uses.

Another consideration for adapting the results of the study to other transportation projects is the water quality associated with those project types. Airport water quality from runways, taxiways and aprons was well-established by the FDOT Statewide Airport Stormwater Study with oversight from the regulatory stakeholders. Fully evaluating the benefit of adapting the results of this pond study may require a similar characterization effort for highways, roadways, rails and ports. The research investment decision should consider the tangible cost of land and construction as the primary drivers, since the safety driver of the current study is unique to airport and aircraft operations.