DESIGNING FOR WATER QUALITY AND WILDLIFE HAZARDS AT AIRPORTS

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Abstract. Stormwater Best Management Practices (BMPs) that hold water at airports for more than 48 hours attract waterfowl and other wildlife, which adversely affects flight safety. The Federal Aviation Administration (FAA) maintains a wildlife strike database which shows that since 1990 over 117,000 wildlife strikes on airplanes have been recorded (90% commercial; 10% military). This database also shows that there were more than four times as many strikes reported in 2005 than in 1990. Wildlife strikes are the second leading cause of aviation related accidents, which have been estimated to result in nearly 600,000 hours of aircraft downtime and cost the industry between up to $600 million annually. With stormwater regulations becoming more and more stringent, the North Carolina Department of Aviation (NCDOA) and the North Carolina Airports Association (NCAA) saw a need to develop a safer approach to treating water quality and quantity at public airports. Efforts to develop this more airport friendly approach to treating stormwater has resulted in the following:

- A master plan approach was developed that proactively plans out future development on a property-wide basis with upfront consideration of stormwater impacts.
- The document titled, *Stormwater BMP Toolbox for Public Airports in North Carolina*, dated July 2010, prepared by the NC State University Biological and Agricultural Extension Service in conjunction with WK Dickson, was developed to assist airports in selecting appropriate BMPs that provide water quality benefits while minimizing the detention or temporary ponding of water onsite. This toolbox will also help provide state-wide consistency in airport BMP planning and design, which will reduce permitting expense and expedite turnaround time.
- A partnership was formed between North Carolina Department of Water Quality (NCDWQ), North Carolina State University Biological and Agricultural Engineering Department (NCSU), USDA, Federal Aviation Administration, North Carolina Division of Aviation and North Carolina Airports Association with a focus to balance stormwater goals of the State with airport safety.

To further understand current practices used to convey and treat runoff at airports, site visits were made to ten airports throughout North Carolina. Airports were selected in each of the three hydrologic provinces of State including the Coastal Plain, Piedmont, and Mountains. All ten public airports visited had runways and taxiways that currently drain through filter strips and into swales. These swales may outlet to extended dry detention, which aids in peak flow mitigation. Runoff from the hangars, apron or ramp, and landside generally drain via surface flow to drainage swales, or directly to a piped storm drain network.

The BMP Toolbox includes the following two recommendations to assist airports in bringing future development into regulatory compliance with NCDWQ:

- The hardened edge of the runways and taxiways can be used in lieu of an engineered concrete level spreader for the NCDWQ-approved filter strip BMP.
- The pollutant removal efficiency rate for an extended detention dry pond will be prorated for detention times less than two days. Currently the dry pond must detain stormwater runoff for two to five days to receive a 50% efficiency rate on the removal of total suspended solids (TSS). The current NCDWQ design manual provides no credit for removing pollutants if detention times are less than two days.

The detailed inspections of ten airports showed that the flat nature of the runways and taxiways with flanking grassed buffer areas promotes infiltration of stormwater runoff into the soils. Given the safety issues with standing water onsite and the inherent layout of the airports that promotes infiltration, NCDWQ is recognizing that airports are different, and a more airport friendly approach is needed.

NEED FOR PROJECT AND WILDLIFE MANAGEMENT

The initial task for developing a more airport friendly approach to addressing stormwater treatment was to convince NCDWQ that airports are different than typical

site development projects. They are different because of adverse flight safety risks from standing water, and the water quality treatment potential inherent in an airport's layout.

An approach that addresses stormwater compliance would be more achievable with NCDWQ in agreement that airports must not unnecessarily detain stormwater runoff onsite. For this reason it became necessary to document the impacts that wildlife have on flight safety, beyond the highly-publicized 15 January "Miracle on the Hudson."

Wildlife, including rodents, larger mammals, and birds, pose a threat to the safety of flight; while wildlife strikes are not common when compared to the number of daily flights in the U.S. (around 40,000 flights/day), it only takes one major incident to cause loss of human life. Data from the FAA Wildlife Strike Database shows that 29,607 incidents between wildlife and aircraft were reported between 1990 and 1999; 69,881 wildlife strikes were reported between 2000 and 2009; and 6,061 wildlife strikes were reported between 1 January and 31 August 2010 (117,083 total). In 1990, nearly 1,800 wildlife strikes were reported, while in 2005 over 7,000 strikes were reported. The majority of wildlife strikes between 1990 and 2000 involved birds, with 2,395 bird strikes and 443 mammalian strikes causing damage to aircraft. Of non-rodent mammals that were struck, 94 percent were deer and 5 percent were carnivores. This is most likely due to the burgeoning U.S. deer population, which has increased from 350,000 in 1900 to approximately 20 million in 2010. Of birds that were struck, 32 percent were waterfowl, 30 percent were gulls, and 17 percent were raptors. Other species comprised the remaining 21 percent. The most hazardous bird species are those with the greatest body mass, including vultures, geese, pelicans, cranes, and eagles. The Canada goose is nearly ubiquitous in North Carolina, as many populations have become permanent residents. This species prefers close-cropped grasses and open bodies of water, which are commonly found on or near airports.

Natural landscape portions of the airport environment provide food, shelter, and travel corridors for wildlife. Indirect hazards, such as mice, rabbits, and groundhogs, forage in the grassy areas around the airport. These species attract direct hazards, such as raptors and coyotes, to the airport, which can cause significant damage to aircraft. When stormwater practices that impound water for extended periods (more than 48 hours) are installed, they provide a refuge for birdlife. The presence of multiple wetlands or wet detention ponds at an airport provides travel corridors for birds that often cross runways, as they do at Piedmont-Triad International Airport. Since a majority (73 percent) of wildlife strikes occur at altitudes below 500 feet above ground level, reducing or eliminating wet detention ponds and wetlands on an airport would substantially reduce the odds of a bird strike. Another important factor in bird strikes is the decreased engine redundancy on commercial aircraft in the U.S. fleet; 75 percent of aircraft had 3-4 engines in 1969, while only 10 percent of commercial airplanes have more than two engines today (Wenning et al., 2004). This means that losing one engine has a larger impact on the ability of the airplane to stay airborne. Thus, stormwater features selected for use at airports must not be attractants to wildlife, or a reduction in flight safety will result. All engineering and maintenance decisions at airports, including those related to stormwater management, must consider wildlife hazards in order to provide an environment conducive to safe flight.

To this end, the FAA requires commercial aviation (Part 139) airports that have developed Wildlife Hazard Mitigation Plans (WHMPs) to immediately correct wildlife hazards associated with existing stormwater facilities. "Where possible, airport operators should modify stormwater detention ponds to allow a maximum 48-hour detention period for the design storm. The FAA recommends that airport operators avoid or remove retention ponds and detention ponds featuring dead storage to eliminate standing water. Detention basins should remain totally dry between rainfalls. Where constant flow of water is anticipated through the basin, or where any portion of the basin bottom may remain wet, the detention facility should include a concrete or paved pad and/or ditch/swale in the bottom to prevent vegetation that may provide nesting habitat. When it is not possible to drain a large detention pond completely, airport operators may use physical barriers, such as bird balls, wire grids, pillows, or netting, to deter birds and other hazardous wildlife. When physical barriers are used, airport operators must evaluate their use and ensure they will not adversely affect water rescue" (FAA Advisory Circular 150/5200-33B).

The NCAA and NCDOA also wanted the regulators to understand that the inherent design of an airport results in an effective drainage system for the treatment of stormwater runoff. Much of the runoff from the taxiways and runways are collected through a series of wide, flat filter strips and grassed swales that convey water offsite. The layout of an airport is different than most site developments that hold land value at a premium and the design of stormwater drainage systems are often times an after thought. On the other hand, airports have extensive wide open infield areas that

are designed for safety of flight. This safety of flight design results in a large area of grassy open space that diffuses flow off the runways and taxiways until it reaches a relatively wide and flat grass swale. This encourages infiltration which is ideal for treating water quality.

BMP TOOLBOX

Traditional site development BMPs detain stormwater runoff onsite to bring a project into regulatory compliance for water quantity and quality. Detention times of two to five days are required to meet NCDWQ design requirements for such BMPs as wet ponds or extended detention wetlands. Because these detention times attract waterfowl and create other wildlife habitat, they result in adverse flight safety impacts. For this reason, it became apparent to the NCAA and NCDOA that a document was needed to supplement the NCDWQ Stormwater BMP Manual. This document would assist airports in selecting appropriate BMPs that provide water quality benefits while minimizing the detention or temporary ponding of water onsite. The second objective of the document is to help bring some consistency in the planning and design of the BMPs at airports in an effort to make the permitting process less expensive and faster. The document that was developed is titled *Stormwater BMP Toolbox for Public Airports in North Carolina*.

The BMP Toolbox is a joint effort by the North Carolina Airports Association (NCAA), the North Carolina Department of Transportation Division of Aviation (NCDOA), North Carolina State University (NCSU), and the North Carolina Division of Water Quality (NCDWQ). The BMP Toolbox is meant to supplement the current North Carolina Department of Environment and Natural Resources (NC DENR) Stormwater BMP Design Manual. The toolbox includes a matrix to assist with selecting suitable BMPs based on such factors as:

- Impervious cover type.
- BMP location relative to airport infrastructure.
- BMP location relative to the property's environmental features.
- Installation and maintenance costs.
- Potential drawbacks.

The matrix breaks down the airport into airside and landside for the purposes of recommending BMP types. Airside refers to all areas where aircraft are operated or serviced such as runways, taxiways, hangars, ramps, and aprons. Landside refers to all other non-flight commercial developments areas such as parking lots and terminal buildings.

To further understand current practices used to drain and treat runoff at airports, site visits were made to ten airports throughout North Carolina. All ten public airports visited had runways and taxiways that currently drain through filter strips and into swales. These swales may outlet to extended dry detention, which aids in peak flow mitigation. Runoff from the hangars, apron or ramp, and landside generally drained via surface flow to drainage swales, or directly to the piped storm drain network.

Impervious cover on airport properties typically ranges between eight and twenty-five percent, which is consistent with low density residential development. Many impervious areas on public airports, namely runways and taxiways, are disconnected (not directly connected hydrologically). After less than 100 feet of flow on a paved surface, runoff enters a grassed buffer with widths often measuring greater than 60 feet. In this airport-specific land use, it is rare that runways and taxiways act as a pocket of high density development. One of the conclusions drawn in the development of the BMP Toolbox is that the layout of the airside development of an airport is inherently ideal for treating water quality. The relatively wide and flat grassed buffers with flanking grassed swales act to maximize infiltration while stormwater runoff is being conveyed through the system.

In some cases, the water table is near the ground surface, precluding the use of infiltration BMPs. This typically occurs at airports located at or near the coast. At these locations, peak flow rate mitigation may require the use of wet detention ponds. While wet detention ponds are not ideal for public airports (and are not recommended in the BMP toolbox, diligent, routine maintenance, and proactive management may prevent mammals and birds from occupying these areas. These management practices may include using grid wires to prevent birds from landing, pyrotechnics to scare animals away, a larger length to width ratio during the design phase, steeper side slopes, and trapping and removal of rodents and mammals. Stormwater wetlands should be avoided in all cases at airports, as they are excellent habitat for, and proven attractants of, both birds and terrestrial mammals.

The BMP Toolbox includes the following two recommendations in an effort to develop a more airport friendly approach to treating water quality:

- Provide airports a reduced removal efficiency rate for providing a BMP that detains stormwater less than the current mandated detention time of two

to five days. For example, to receive credit for pollutant removal the current BMP design manual requires that a dry extended detention basin hold the design storm for a minimum of two to five days. The approved removal efficiency rate for total suspended solids is 50%. The BMP Toolbox recommends that NCDWQ consider giving airports a removal efficiency less than 50% for detaining water in this BMP for less than 48 hours.

- Waive the NCDWQ requirement for an engineered concrete level spreader for the runways and taxiways found on airports. The inherent design of runways and taxiways requires that the impervious surface be relatively flat without a large contributing drainage area. For this reason, the runways and taxiways serve the same purpose as an engineered concrete level spreader required for a BMP filter strip. An inspection of all ten airports in the study showed the runways and taxiways acting to diffuse flow with no areas of concentrated flow. Waiving the requirement of an engineered concrete level spreader will allow the airports to take credit for the BMP filter strips flanking the runways and taxiways.

STORMWATER MASTER PLAN APPROACH

Airports are typically considered low density developments because the total percent of impervious cover is below 25. However, NCDWQ has traditionally looked at individual projects at airports as "pockets of high density". These individual projects are required to meet NCDWQ requirements for stormwater quantity and quality. Historically this has resulted in a series of BMPs scattered throughout the airport that may or may not work together to meet water quality and quantity goals. Each of these projects must go through the regulatory approval process to secure the necessary permits which can be inefficient and result in delays to construction. In an effort to achieve a more airport friendly approach to meeting stormwater regulations a master plan approach is being proposed for airports that includes upfront buy-in from local and State regulators.

Traditionally NCDWQ has allowed airports to receive "credits" for treating impervious surfaces that are not required to be treated in lieu of providing a BMP to treat the pockets of high density development. The existing impervious surface must drain to a BMP that meets all the NCDWQ design requirements found in the current NCDWQ Stormwater BMP Manual. In addition, the airport must donate a conservation easement for the land that encompasses the BMP. Allowing this "horse trading" to occur provides the airport a more cost-effective means to bring their future development into regulatory compliance. It also allows the airport to reduce the total area of land dedicated to the treatment of stormwater.

A master plan approach to addressing stormwater compliance at airports makes sense for the following reasons:

- Many of the onsite existing grassed swales and filter strips meet all NCDWQ design requirements for a BMP. A master plan approach allows you to quantify and take advantage of pollutant removal loads from runways and taxiways that drain through the filter strips and grassed swales.
- A master plan approach allows the airport to organize its current and future development and stormwater needs with a well thought out approach. Future BMP needs can be mapped out to offset pollutant loadings and peak flow increases generated from projects identified in the Airport Layout Plans (ALPs).
- Upfront buy-in from the reviewing agencies can be secured for stormwater compliance which can prevent unnecessary permitting surprises closer to construction. This can prevent delays and reduce project costs.

Airports in North Carolina use ALPs to help identify and plan out future development. The ALP provides the stormwater engineer much of the information needed to develop a master plan that brings the airport into compliance with local and State environmental regulations. An understanding of the site's environmental features such as perennial streams, wetlands, seasonal high water tables, soil types and drainage patterns in relation to existing and proposed infrastructure will also be need to develop a sound, well thought out master plan. To minimize standing water, airport BMPs should rely heavily on infiltration and not on long detention times that allow pollutants to settle out. For this reason, BMPs need to be located outside of wetlands and in areas that achieve the necessary separation from seasonal high water table. The following table provides an example of how pollutant loadings can be quantified for proposed projects identified in the ALP:

Table 1: Summary of TSS Loadings from ALP Projects

Project ID #	Project Description	New Impervious Area (acres)	TSS Loading (lbs)
1	Extend Blast Pad Area	0.04	22
2	General Aviation Parking Lot	0.21	101
3	Proposed T-hangar	0.51	250
4	15,000 Hangar	0.34	168
5	Centurion Hangar	0.39	193
6	Widen and Extend Taxiway N	0.83	408
7	1200-Foot Runway Extension	5.44	2686
8	Perimeter Road Extension	2.41	1785
9	Remove Existing Gravel Road	- 3.36	-1657

A total loading of 3,956 lbs of TSS will be generated from the nine projects identified in the ALP. With a regulatory requirement to remove 85% of this total, the net loading required to be removed is 3363 lbs. Table 2 shows the TSS loading that are being removed by the filter strip and grass swale BMPs identified in this example:

Table 2: TSS Loadings Removed at Existing BMPs

BMP ID	Cumulative Drainage Area (ac)	TSS Load Supplied (lb)	TSS Load Removed (lb)
Filter Strip - FS#1	13.7	6747	1687
Filter Strip - FS#2	0.26	127	32
Filter Strip - FS#3	0.72	357	89
Filter Strip - FS#4	0.72	354	88
Filter Strip - FS#5	2.01	991	248
Swale - SW#1	16.79	1039	273
Swale - SW#2	5.37	751	197
Swale - SW#3	12.53	1752	460
Swale - SW#4	16.12	2253	591
Swale - SW#5	10.12	1414	371

As shown in Table 2, the existing BMPs will remove 4036 lbs of TSS annually. This amount exceeds the required TSS loading required to meet regulatory compliance.

The master plan approach provides the airport a well thought out and mapped out plan to meet stormwater regulations for the future. It also gets the airport buy-in with the local and State regulatory agencies that minimizes construction costs, maintenance costs and potential for bird strikes.