

Florida Department of Transportation
Aviation Office

**Statewide Airport
Stormwater
Best Management Practices
Manual**



Clean Water – Safe Airports

**March 2023
Revision**

**STATEWIDE AIRPORT STORMWATER
BEST MANAGEMENT PRACTICES MANUAL**

CONTENTS

	Page
SECTION 1 – INTRODUCTION	
101. Purpose and Intent	1
102. Introduction to the Airport Environment	2
103. Limitations	5
104. Additional Permit Information	6
 SECTION 2 – AIRPORT STORMWATER QUALITY CHARACTERISTICS	
201. Pollutants	8
202. Event Mean Concentration.....	8
 SECTION 3 – SITE CHARACTERISTICS AND PROPERTIES	
301. General.....	11
302. Soil Properties.....	11
303. Infiltration Rates	11
304. Permeability/Hydraulic Conductivity	12
305. Porosity	13
306. Soil Suction.....	14
307. Ground Water	14
308. Topography	16
309. Slopes and Grading.....	16
 SECTION 4 - RAINFALL AND RUNOFF RELATIONS	
401. Event vs. Continuous Simulation.....	18
402. Hyetographs	20
403. Evaporation and Evapotranspiration	21
404. C vs. CN vs. Green-Ampt	22
 SECTION 5 - STORMWATER QUALITY CALCULATIONS	
501. Runoff Load and Concentration.....	24
502. Groundwater Contributions	24
503. BMP Efficiencies.....	26
504. Pre and Post Development Load Calculations	27

**STATEWIDE AIRPORT STORMWATER
BEST MANAGEMENT PRACTICES MANUAL**

SECTION 6 – BEST MANAGEMENT PRACTICES

601.	Overview.....	30
602.	Minimum Level of Stormwater Treatment	30
603.	Flood Control Requirements.....	30
604.	Required Site Information	31
605.	Structural Best Management Practices	31
	a. Overland Flow	31
	b. Dry Retention Basin	34
	c. Swales, Drainage Ditches, Channels, and Canals.....	38
	d. Wet Detention Systems (FAA Ponds).....	42
	e. Other Retention Treatment Methods	44
	f. Compensating Stormwater Treatment	44
606.	Procedural Best Management Practices	47
	a. Aircraft Fuel Sumping Control.....	47
	b. Turf Management	48
	c. Sweeping.....	48

SECTION 7 – MAINTENANCE

701.	System Maintenance	51
------	--------------------------	----

APPENDICES:

APPENDIX A	References
APPENDIX B	Glossary
APPENDIX C	Site Evaluation Checklist
APPENDIX D	Typical Green Ampt Parameters Based on Grain Size Analysis
APPENDIX E	Airline Safety and Wildlife Protection Act of Florida
APPENDIX F	General Permit for Construction, Operation, Maintenance, Alteration, Abandonment or Removal of Airport Airside Stormwater Management Systems
APPENDIX G	Jurisdictional Agencies
APPENDIX H	Federal Agencies Memorandum of Agreement on Aircraft-Wildlife Strikes
APPENDIX I	Wildlife Hazards and Airport Safety
APPENDIX J	Airport Compatible Specific Pond Design

**STATEWIDE AIRPORT STORMWATER
BEST MANAGEMENT PRACTICES MANUAL**

LIST OF TABLES

Table 202-1	Airside and Natural Nutrient Event Mean Concentration (antilog mean log) mg/L..	8
Table 304-1	Typical Range of Permeability of Natural Soil.....	12
Table 305-1	Typical Values of Porosity and Effective Porosity expressed as a Decimal Ratio	13
Table 306-1	Typical Values of Soil Suction	14
Table 401-1	Daily Rainfall Characteristics at Select Florida Airports with Published Design Storm Events.....	19
Table 402-1	Comparison of Time Step Effect on Calculated Runoff	20
Table 502-1	Median Nutrient Concentrations in Ground Water by County	24
Table 605-1	Accepted Methodologies for Recovery Analyses.....	36
Table 605-2	Erosion Velocity Limits	39
Table 605-3	Particle Size Distribution for Settling Computations	41
Table 606-1	Expected Nutrient Reduction from Sweeping with Collecting Vacuum and Broom Sweepers	50

**STATEWIDE AIRPORT STORMWATER
BEST MANAGEMENT PRACTICES MANUAL**

LIST OF FIGURES

Figure 102-1	Typical Airport Airside and Transitional Facilities.....	3
Figure 102-2	Illustration of Airside and Landside Areas.....	4
Figure 305-1	Soil Components Block Diagram	13
Figure 309-1	Peak Runoff Sensitivity Results for Impervious Areas.....	17
Figure 402-1	Recorded 5-minute Rainfall Record for Orlando International Airport.....	21
Figure 403-1	Plot of Daily Evapotranspiration Measured in Central Florida.....	22
Figure 404-1	Comparison of Actual and Green-Ampt Predicted Runoff.....	23
Figure 605-1	Recommended Placement of Underdrains	33
Figure 605-2	Recommended Underdrain Placement of to Avoid	33
Figure 605-3	Interevent Time at Selected Florida Weather Stations	36
Figure 605-4a and 4b	Retention Underdrains.....	37
Figure 605-5	Typical Well-Maintained and Functioning Dry Swale	38
Figure 605-6	Vegetated Wet Swale.....	40
Figure 605-7	Steep-Sided Wet Swale.....	40
Figure 605-8	Hazard Zones for Wildlife Attractants Around Airports.....	46
Figure 606-1	Mowing Buffer Around Inlets	49
Figure 701-1	Well Maintained and Functioning Wet FAA Pond	52
Figure 701-2	Algal Build Up and Bloom Requiring Maintenance	52
Figure 701-3	Well Maintained and Functioning Dry Swale	53
Figure 701-4	Erosion Damage in Wet Swale	53
Figure 701-5	Clogged Inlet Pipes	54
Figure 701-6	Well Maintained Dry Retention Area.....	54
Figure 701-7	Inlet Structure Requiring Maintenance.....	55

STATEWIDE AIRPORT STORMWATER BEST MANAGEMENT PRACTICES MANUAL

Section 1 INTRODUCTION

101. PURPOSE AND INTENT

The *Statewide Airport Stormwater Best Management Practices Manual (BMP Manual)* is intended for use by consultants, regulators, and airport sponsors charged with design, permitting, and operation of airport stormwater management facilities. Information included in the manual is intended for design of individual airside facilities or for master planning and designing airport-wide stormwater management systems. It is not a hydrology, hydraulics, or water chemistry text, and it presumes users have education, experience, and reference materials on those subjects. Some references found useful in preparing and/or using this manual are listed in **Appendix A**. **Appendix A** is not an exclusive or comprehensive list, and other references must also be used in applying these procedures and criteria.

This document (April 2013 version) is directly referenced in the General Permit for Construction, Operation, Maintenance, Alteration, Abandonment, or Removal of Airport Airside Stormwater Management Systems, Chapter 62-330.449, F.A.C. It sets forth the procedures and criteria for those facilities eligible for the General Permit. The General Permit is applicable to most, but not all, airside facilities, and its use must consider the site-specific conditions. This March 2023 revision is directly referenced in the 2023 Environmental Resource Permit (ERP) *Applicant's Handbook Volume 1*. The information in this BMP Manual, including data and procedures, may be used for projects that are not covered in the Airside General Permit but that are eligible for either an Individual Environmental Resource Permit (ERP) or a Conceptual ERP. This can include projects that encompass landside areas, projects that have combined airside and landside flows, or other non-airside land uses. It can also be used for airport master drainage planning for the airport as a whole and the recommended Conceptual ERP associated with that effort.

This BMP Manual has companion documents that may be consulted for more detailed information on the basis and limitation of the data. These include the *Technical Report for the Florida Statewide Airport Stormwater Study*; the *Application Assessment for the Florida Airports Stormwater Study*; the *Technical Report on the Wildlife/Bird Monitoring of the FAA Pond at Naples Municipal Airport*, and the *Technical Report on the Water Management Performance of the FAA Pond at Naples Municipal Airport*. These documents may be accessed at <https://www.fdot.gov/aviation/stormwater.shtm>.

The goals of airside stormwater management are two-fold. From a regulatory perspective, the stormwater management system must meet statutory and rule requirements intended to protect water quality, limit or prevent flooding, and preserve or maintain healthy ecosystems. From a public transportation perspective, the stormwater management system must be consistent with safe and efficient air transportation. Ultimately, from all perspectives, the public is the intended beneficiary of both stormwater management and transportation system efforts.

This manual was assembled because aircraft and airport operations differ significantly from other regulated development. Airport safety may be directly affected by the choice of stormwater management system. Surface water or wetlands in proximity to the airside can, and sometimes do, become safety hazards, particularly if they are wildlife attractants. Also, the airside operating environment and procedures result in lower pollutant loadings than most other urban land uses. Temporary flooding in extreme events is allowable on the airside. These issues dictate targeted

STATEWIDE AIRPORT STORMWATER BEST MANAGEMENT PRACTICES MANUAL

stormwater management practices. Information on the airport environment is included in the following subsection for familiarization purposes.

102. INTRODUCTION TO THE AIRPORT ENVIRONMENT

In its basic configuration, an airport consists of airside and landside areas. Airside includes all areas commonly allocated for aircraft operations or servicing. They are often separated by a fence or other barrier from landside areas to limit access. Ground vehicle traffic does occur on the airside. It is normally associated with servicing aircraft and performing routine inspections, and it is generally confined to aprons/ramps and internal airside access roads.

Typically, the airside includes significant open space/grass areas serving to separate runways and taxiways from each other. Elements of the airport airside are:

- One or more runways for aircraft landing and takeoff operations. These are usually paved but may be turf for facilities serving light airplanes.
- One or more taxiways allowing aircraft to move between the runway(s) and parking areas.
- One or more aprons (also called “ramps”) for aircraft to park.

Figure 102-1, excerpted from the Airport Facilities Directory, illustrates a Florida airport serving both light general aviation and commercial jet operations.

Landside areas are those where aircraft do not operate. In the most basic form, the landside area is a roadway for access and an automobile parking lot adjacent to the airside and outside the security fence. However, the landside may include a number of alternate uses. Airports often own large tracts of land that are not used for aviation purposes. A goal and requirement for airports is that they be as self-supporting as possible. Consequently, commercial and industrial parks are often constructed on non-aeronautical, airport-owned land. Some airports also have shopping centers, recreation areas, and professional sports facilities located on their property. These have characteristics typical of other, similar development in Florida. However, they are subject to the same hazard controls that apply to aviation use areas owned by the airport. The rents they pay help support airport operation, maintenance, and capital improvement programs. Figure 102-2 shows an Airport Layout Plan (ALP) illustrating various airside and landside land use and their relations to each other at a Florida commercial service airport.

STATEWIDE AIRPORT STORMWATER BEST MANAGEMENT PRACTICES MANUAL

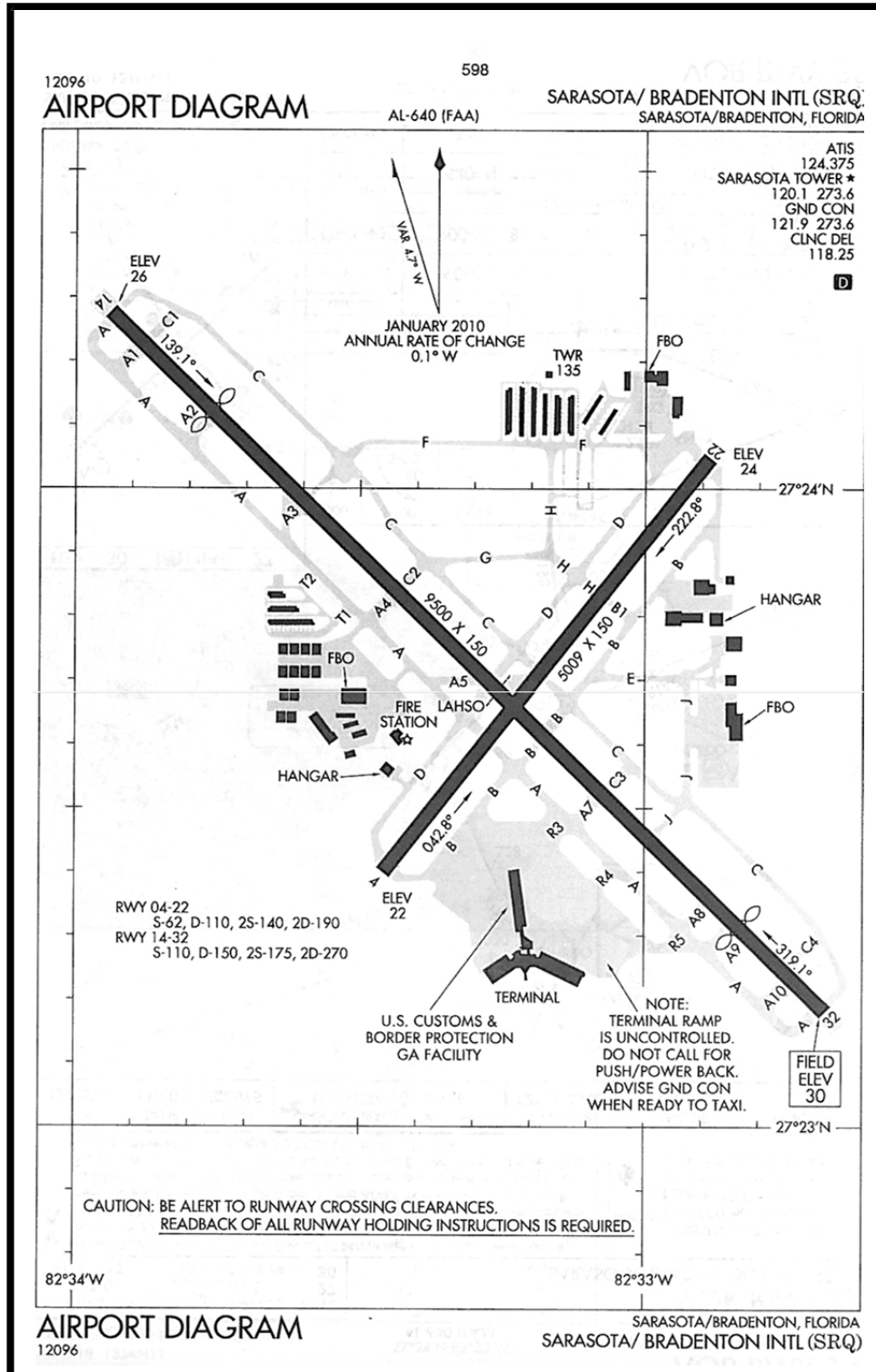
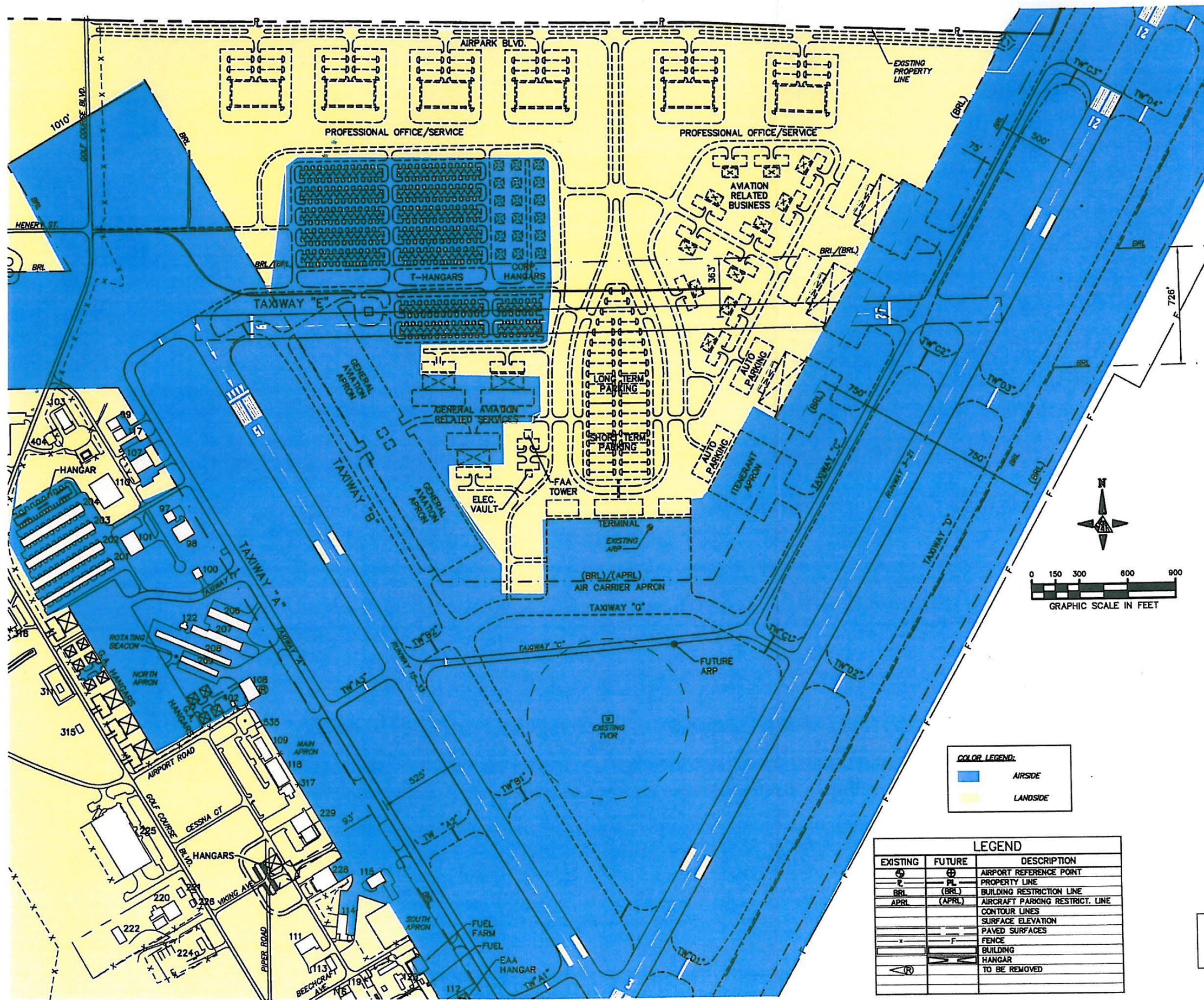


Figure 102-1 Typical Airport Airside and Transitional Facilities

STATEWIDE AIRPORT STORMWATER
BEST MANAGEMENT PRACTICES MANUAL



COLOR LEGEND:

- AIRSIDE
- LANDSIDE

LEGEND		
EXISTING	FUTURE	DESCRIPTION
		AIRPORT REFERENCE POINT
		PROPERTY LINE
		BUILDING RESTRICTION LINE
		AIRCRAFT PARKING RESTRICT. LINE
		CONTOUR LINES
		SURFACE ELEVATION
		PAVED SURFACES
		FENCE
		BUILDING
		HANGAR
		TO BE REMOVED

FIGURE 102-2: ILLUSTRATION OF AIRSIDE AND LANDSIDE AREAS

\\07Jobs\07A00070\figure 102-2.dwg Mar 07, 2011 - 1:38pm fehrs01355

STATEWIDE AIRPORT STORMWATER BEST MANAGEMENT PRACTICES MANUAL

Expansion and improvement projects undertaken by airports that typically require stormwater management permits include the following:

- Runways, including new runways and runway extensions
- Taxiways, including new taxiways, taxiway extensions, and taxiway widening
- Aprons/Ramps
- New Hangar Buildings
- Terminals, including new terminals and terminal expansions
- Perimeter Access/Safety Roads
- Automobile parking lots
- Access Roads
- Non-airport commercial and industrial uses

The above list is not all-inclusive but is meant to outline primary categories of projects completed by or on airports. While the airport is the property owner and is usually the permittee for stormwater management, private developers and corporations often do the projects on land leased from the airport, sometimes including taxiways and aprons.

A final item of importance in the general airport discussion is access control. Airport security is continually tightening in the wake of the events on September 11, 2001. The Transportation Security Administration (TSA) regulates airside security and access. TSA briefings indicate aviation remains a weapon and target of choice for terror attacks. Consequently, airside access is being made “harder” by design. This directly impacts permit conditions regarding observation and inspection of facilities, particularly at commercial service airports. It may also impact design of some stormwater management facilities to preclude these becoming a “soft” entry to the airside.

103. LIMITATIONS

The BMPs in this manual must be evaluated and applied with sound engineering judgment. Knowledge of the Conditions of Issuance for an Environmental Resource Permit is a prerequisite. The manual presumes use by registered professionals and technical professionals with a background that includes hydrology, hydraulics, water quality, geotechnical, transportation, and environmental subjects. Of course, applicability of any procedure is specific to the particular airport and its site and operating characteristics. Use of this BMP Manual is at the sole discretion and responsibility of the users.

Wildlife management and control are not elements of this document, although reducing standing water attractants is a goal of the stormwater management strategies presented. Users should refer to the Advisory Circulars 150/5200-18, 150/5200-33, 150/4200-36, FAA Rule 49 CFR 139, and the USDA/FAA Wildlife Hazard Management at Airports Manual for that guidance. **Appendices H and I** present additional information on wildlife hazards. The importance of considering wildlife hazards and attractants when selecting airport stormwater management strategies for the safety of the travelling public is emphasized.

The airport airside stormwater data presented is from the Florida Statewide Airport Stormwater Study, jointly funded by the Federal Aviation Administration (FAA) and the Florida Department

STATEWIDE AIRPORT STORMWATER BEST MANAGEMENT PRACTICES MANUAL

of Transportation (FDOT). This project included stormwater monitoring at 13 airports in Florida to characterize their runoff from airside activities. The technical details of the study are included in the *Technical Report for the Florida Statewide Airport Stormwater Study*. These data and publication were subject to review by the Florida Department of Environmental Protection (FDEP), South Florida Water Management District (SFWMD), Southwest Florida Water Management District (SWFWMD), Suwannee River Water Management District (SRWMD), and the St. John's River Water Management District (SJRWMD) during collection and reduction. These same agencies, along with the Northwest Florida Water Management District (NFWMD), the FAA, the FDOT, and the public have been afforded the opportunity to comment on this BMP Manual and its supporting data.

Information on the performance of an "FAA Pond" presented in **Appendix J** was also developed and collected as part of the Florida Statewide Airport Stormwater Study at a 14th airport. The technical details of that study are included in the *Technical Report on the Wildlife/Bird Monitoring of the FAA Pond at Naples Municipal Airport* and the *Technical Report on the Water Management Performance of the FAA Pond at Naples Municipal Airport*. Other information for wet pond design presented in Section 6 is based on studies in progress at the University of Florida, Engineering School of Sustainable Infrastructure and Environment (ESSIE).

104. ADDITIONAL PERMIT INFORMATION

This document is directed towards the water management design needed for an Environmental Resource Permit. However, other permits will be required for most new construction projects. In most cases, new projects will require a **Generic Permit for Stormwater Discharge from Large and Small Construction Activities (CGP)** from the Florida Department of Environmental Protection. This is required under Rule 62-621.300(4) FAC as part of the National Pollution Discharge Elimination System. It is needed for projects that:

1. Contribute stormwater discharges to surface waters of the State or into a municipal separate storm sewer system, and
2. Disturb one or more acres of land including clearing, excavating, and grading. If the specific project is less than one acre but part of a larger plan of common work that will in aggregate disturb more than one acre, a CGP is also required.

Refer to the Florida Department of Environmental Protection NPDES Stormwater Section at <https://floridadep.gov/Water/Stormwater>.

As noted in previous sections, this manual does not address activities in wetlands. However, additional to the Environmental Resource Permit requirements for wetlands, these are regulated by the Florida Department of Environmental Protection as delegated by the U.S. Army Corps of Engineers, and also by the Water Management Districts. Wetland impacts will also be an issue in the National Environmental Policy Act evaluations for airside projects where federal funds are involved.

Permits may also be required by counties, cities, and special districts, and these may impose other water quantity management criteria based on specific issues within those jurisdictions.

STATEWIDE AIRPORT STORMWATER BEST MANAGEMENT PRACTICES MANUAL

Section 2 AIRPORT STORMWATER QUALITY CHARACTERISTICS

201. POLLUTANTS

Airside stormwater quality was screened for a series of constituents that might exceed Florida water quality standards as established in Chapter 62-302, F.A.C. By definition, these constituents constitute potential pollutants. The detailed results are summarized and discussed in the *Technical Report for the Florida Statewide Airport Stormwater Study*. Briefly, only two metals traceable to airport operations are likely to present at concentrations that may cause water quality issues without treatment. These are lead and copper. Two others, cadmium and zinc, will occasionally be found at concentrations that will violate state water quality standards prior to treatment. Total Recoverable Petroleum Hydrocarbons are below state levels for oil and greases in all but the air carrier terminal apron environment and are not likely to cause or contribute to violations of water quality standards in receiving waters.

Stormwater problems are primarily caused by the stormwater loading that is discharged from a site. Additionally, water quality problems in receiving waters typically result from the cumulative pollutant loading from all land uses and discharges within a watershed, not from a single discharge. Consistent with State and Federal emphasis on managing nutrients as both the surrogate for and the primary water constituent causing water quality degradation, this manual focuses on reducing nitrogen and phosphorus loads in stormwater discharges from airports. This is consistent with both the *Technical Report for the Florida Statewide Airport Stormwater Study* and on the blue-green algae issues in Florida waters. The specific regulatory parameters for stormwater quality management analysis and design on airports are the nutrients Total Nitrogen (TN) and Total Phosphorus (TP).

202. EVENT MEAN CONCENTRATION

The following table presents the Event Mean Concentrations (EMC) of Total Nitrogen and Total Phosphorus for use in calculating stormwater loadings from airside pavement. Note that the airside EMC values apply at the edge of pavement. If concerns arise over other constituents during the design and permitting of a stormwater management system the *Technical Report for the Statewide Airport Stormwater Study* may be consulted for other constituent EMC values.

**Table 202-1 Airside and Natural Nutrient Event Mean
Concentration (antilog mean log) mg/L**

Airside Type or Feature	Total Nitrogen (TN) mg/l	Total Phosphorus (TP) mg/l
General Aviation Apron	0.335	0.051
Airline Terminal Apron	0.398	0.057
T-Hangar Apron (Paved)	0.551	1.836*
Air Cargo Apron	0.259	0.053
General Aviation Runway	0.365	0.081
Air Carrier Runway	0.401	0.049
Taxiways	0.569	0.110
T-Hangar (Open)*	0.617	0.178
AOA Internal Access Roads**	0.94	0.100
Undeveloped Airside***	1.15	0.074
Natural Vegetative Community	0.930	0.100
<p>* For T-Hangars with grassed areas provided between hangars, see Reference 34 in Appendix A. ** For internal airside access roads with minimal vehicle traffic the FDEP 2012 data includes a two-lane road, Flamingo Drive in Collier County that is analogous to AOA internal access roads. ***Based on unadjusted mean data from FDEP</p>		

STATEWIDE AIRPORT STORMWATER BEST MANAGEMENT PRACTICES MANUAL

Landside Event Mean Concentration data should be obtained from Section 9, Table 9.2 in the ERP *Applicant's Handbook Volume 1*.

Section 3 SITE CHARACTERISTICS AND PROPERTIES

301. GENERAL

Site characteristics needed to analyze stormwater management strategies are associated with establishing rainfall-runoff relations. **Appendix C** provides a checklist that may prove useful while collecting site-specific data. References listed in **Appendix A** will also be valuable sources of data and of the proper application of the data.

Typical values provided in this section are not intended as recommended values. They do not and should not supersede those measured by a well-designed and executed field and laboratory test program interpreted by an experienced registered professional. They are guidance values that can be used if the field and laboratory testing are too limited or inconclusive to establish site-specific characteristics or when the difficulty of testing some parameters requires a relation with index properties be used.

302. SOIL PROPERTIES

Establishing infiltration and ground water conditions is a prerequisite to stormwater quantity determinations, which are needed for stormwater loading evaluations as well as drainage design. This section briefly reviews the soil properties that may be needed to estimate infiltration and ground water conditions. When evaluating soil properties for stormwater quantity and quality calculations, care must be taken to differentiate between conditions that exist on the site and those that will be built on the site. The obvious example is when a site will be filled. The fill soil may have very different properties than the soils at the site surface. However, less obvious changes will also affect the soil properties relative to infiltration and ground water movement. Chief among these on most airport airside is the compaction process. Soils are typically compacted beneath and adjacent to pavement and in safety overrun areas to increase their support capacity. This can reduce porosity, reduce permeability, and increase suction among other effects. These possible changes require judgment when establishing a field and laboratory test program to characterize site conditions for surface and ground water calculations.

303. INFILTRATION RATES

Infiltration rates for site soils will vary depending on soil type/mineralogy, moisture content, capillarity/suction, and porosity among other factors. It will also vary with rainfall rate. Infiltration rate is not the same as soil permeability or hydraulic conductivity, which is more directly a property of the soil matrix.

The Green-Ampt equation discussed in Section 404 estimates infiltration considering soil properties, rainfall rates, and accumulated rainfall volume. It requires estimates or determinations of soil porosity, effective porosity, saturation, moisture deficit, saturated vertical permeability, and soil suction.

**STATEWIDE AIRPORT STORMWATER
BEST MANAGEMENT PRACTICES MANUAL**

304. PERMEABILITY/HYDRAULIC CONDUCTIVITY

Permeability, used interchangeably with hydraulic conductivity in this manual, expresses the relative ease of movement of a given fluid, in this case water, through a soil matrix. It is reported in units of velocity and is expressed by the coefficient k in the experimentally derived Darcy equation.

The following equation is Darcy's law and is the basic relation used to estimate groundwater flow.

$$Q = kiA$$

Where: Q = flow rate
 k = permeability
 i = hydraulic gradient $\Delta h/L$ (change in hydraulic head/length of flow through soil)
 A = cross sectional area

Permeability may be established in-situ by means of field tests. The basic time lag method established by the U.S. Army Corps of Engineers (USACOE) (Reference 79) presents options for isolating vertical and horizontal components. Cautions with field testing include the effect of compaction during construction. Other methods to measure field permeability may also be used at the discretion of the geotechnical, geohydrologic, and/or design professional.

A supplement or alternate to field tests is the laboratory permeability test. If compaction changes are not likely, undisturbed samples taken with Shelby tube (ASTM D1587-08) or Hvorslev sampler (in very sandy soils) can be used for laboratory testing. When future compaction is an issue or when fill soils are being imported to the project site, bulk samples of the soil can be laboratory compacted and tested for permeability in the laboratory. Determinations of compacted porosity and even soil suction can be completed at the same time.

Soil permeability can also be estimated based on grain size characteristics (determined per ASTM 6913-04), soil classification determined from either laboratory (ASTM D2487-10), or visual (ASTM D 2488-09a) classification. Typical values of permeability based on soil classification are presented below in Table 304-1. **Appendix D** presents charts of typical values of permeability based on soil gradation, along with estimates of soil suction and porosity. Figure 304-1 in Reference 56 is particularly useful in sands of varying density and can be used to estimate the effects of compaction on permeability for a specific soil.

Table 304-1 Typical Range of Permeability of Natural Soil (Reference 56)

Soil Classification	Range of Permeability, k (ft/day)
Clean, uniform graded gravel (GP)	500 - 2500+
Well graded gravel (GW)	140 - 850
Uniformly graded Sand (SP)	15 - 500
Well Graded sand (SW)	2 - 250
Silty Sand (SM)	2 - 15
Clayey Sand (SC)	0.2 - 2.5
Silt (ML)	0.1 - 0.2
Low Plasticity Clay (CL)	.000001 - 0.2

**STATEWIDE AIRPORT STORMWATER
BEST MANAGEMENT PRACTICES MANUAL**

305. POROSITY

Soil is a three-phase system, composed of soil, water, and air. The block diagram that follows as Figure 305-1 illustrates the relation between the components. Porosity is the ratio of the volume of the voids containing air or water to the total volume of the soil. It is generally expressed as a percentage or a decimal ratio. Effective porosity is a different concept and recognizes that some water will be bound to soil particles. Only those voids that when filled with water will free drain under gravity form effective porosity.

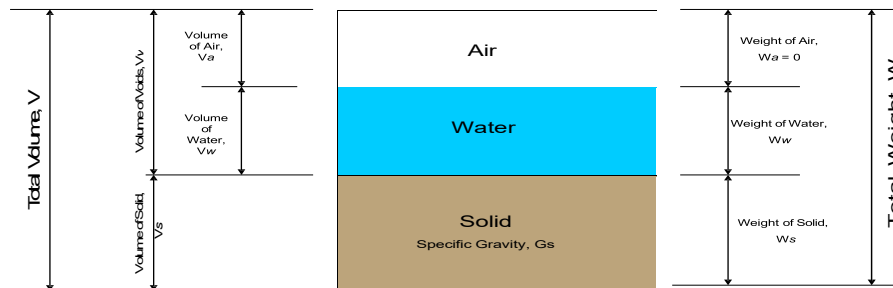


Figure 305-1 Soil Components Block Diagram

The saturation is the volume of the voids filled with water compared to the volume of the voids, expressed as a percentage. The maximum volume of water that can be infiltrated during any event is the difference between the moisture content at the start of a rain event and the moisture content that represents 100% saturation. The difference is the Moisture Deficit, M_d of the soil.

The soil properties can be evaluated based on field and laboratory testing but are more commonly estimated based on the soil type or gradation. Table 305-1 provides typical values of porosity.

Table 305-1 Typical Values of Porosity and Effective Porosity expressed as a Decimal Ratio

Soil Textural Classification	Porosity	Effective Porosity
Sand	0.437	0.417
Loamy Sand	0.437	0.401
Sandy Loam	0.453	0.412
Loam	0.463	0.434
Silt Loam	0.501	0.486
Sandy Clay Loam	0.398	0.330
Clay Loam	0.464	0.309
Silty Clay Loam	0.471	0.432
Sandy Clay	0.430	0.321
Silty Clay	0.479	0.423
Clay	0.475	0.385

**STATEWIDE AIRPORT STORMWATER
BEST MANAGEMENT PRACTICES MANUAL**

Moisture content based on weight (W_w/W_s) is easily determined by simple laboratory tests and should be part of each investigation. However, Green-Ampt formulations use moisture content based on volume, expressed as V_w/V in the block diagram nomenclature. When using soil information from a geotechnical exploration, this difference must be understood, and the appropriate moisture content used in the analyses.

Appendix D presents charts of typical values of permeability based on soil gradation, along with estimates of soil suction and permeability.

306. SOIL SUCTION

Soil suction, expressed in units of length, is generally denoted by the symbol ψ . The parameter is essentially the capillarity of the soils and increases as the grain size of the soil decreases. Typical values are provided in Table 306-1.

Table 306-1 Typical Values of Soil Suction (Reference 4)

Soil Textural Classification	Typical Wetting Front Suction ψ (inches)
Sand	2.0
Loamy Sand	2.4
Sandy Loam	4.3
Loam	3.5
Silt Loam	6.6
Sandy Clay	8.6
Clay Loam	8.2
Silty Clay	10.
Sandy Clay	9.4
Silty Clay	11.5
Clay	12.5

Appendix D presents charts of typical values of permeability based on soil gradation, along with estimates of soil suction and porosity.

Field and laboratory tests of soil suction for the surficial soils, most associated with infiltration rates, can also be made. Tensiometers can be used to measure the soil suction at a specific point in time. However, they are best installed, and measurements of soil suction made over a period of time to establish a typical or seasonal condition. Laboratory tests can establish soil suction relations at various compaction levels and moisture contents. In both cases though, soil suction tests are relatively uncommon and likely to be prohibitively expensive and time consuming. Using typical values is therefore recommended.

307. GROUND WATER

Ground water levels on the site are clearly important in evaluating the infiltration capacity. If underdrains are used to modify ground water levels, the drawdown flows must be estimated to establish the nutrient contribution from the drawdown.

STATEWIDE AIRPORT STORMWATER BEST MANAGEMENT PRACTICES MANUAL

Seasonal High Ground Water Table (SHGWT) estimates are crucial in designing stormwater treatment systems, and they are nearly always estimated as part of a site geotechnical study. The estimates should consider the effect of past filling and drainage on a site and should generally not be based on the unaltered site seasonal high water levels reported in NRCS Soil Surveys, unless the site is, in fact, unmodified. This is rarely the case for airfield projects, most of which are completed on sites that have served as airports since the 1940s. The NRCS estimates may, however, be useful in determining the site's predevelopment stormwater loadings before it was an airport. Along with the seasonal high estimates, seasonal low and annual median ground water estimates should be established for the site. Unlike the SHGWT, it should be noted that soil indicators (i.e., color, redoximorphic features, depth of root zone, etc.) do not typically provide a basis for accurate Seasonal Low Groundwater Table (SLGWT) estimates.

The estimated SHGWT shall be used for single event modeling for flood management and event quantity management purposes in the absence of a compelling, documentable reason to use an alternative. The groundwater elevation used to compute average annual infiltration and runoff will be dependent on the modeling approach selected in harmony with the physical site conditions. Nutrient loading calculations made using continuous simulations with Seasonal High Ground Water elevations will tend to overestimate the runoff volumes and nutrient loads on an average annual basis. Use of SLGWT elevations will do the opposite and tend to underestimate runoff volumes and nutrient loads on an average annual basis. A median annual elevation will provide a better approximation of physical reality.

Obtaining the ground water elevation to use is a critical component of the process. Most airport sites are disturbed land, often fill, and often artificially drained. In these cases, the SHGWT from NRCS sources will not apply. It may or may not be possible to establish the typical high and low ground water elevations based on the indications typically noted within the soil profile on undisturbed sites. Options available include but are not limited to:

- Using ground water ranges reported by NRCS for undisturbed soil series in the airport vicinity and correcting these for changes at the airport including ditching, filling, and similar man-made site alterations. NRCS groundwater ranges can be obtained from the Official Soil Series Descriptions (OSD) web sites as follows:
https://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/soils/home/?cid=nrcs142p2_053587
<https://soilseries.sc.egov.usda.gov/osdname.asp>
In addition, the OSD web site can be accessed through the NRCS Web Soil Survey as follows: <http://websoilsurvey.nrcs.usda.gov/app/>
It should be noted that these NRCS groundwater range estimates are typically limited to roughly the first 80 inches (2 meters) below the undisturbed/historic ground elevations.

A cautionary note is that the soil types must be similar with respect to geohydrologic properties. That is, the airport cannot be constructed of clay fill on underlying sands and the comparative sites consist solely of sands.

- Using information obtained from wells that are located within the surficial aquifer and that have been monitored for a period of 10 years or more and located in the general

STATEWIDE AIRPORT STORMWATER BEST MANAGEMENT PRACTICES MANUAL

vicinity of the airport. If the wells are water supply, the drawdown curve must be considered relative to the well and site locations. The data can supply guidance on the range changes between high, low, and median ground water levels also, which can be site adapted.

- Ground water and surface water interaction modeling using the site geometries, surficial soil infiltration and lateral ground water movement parameters, and the annual rainfall hyetograph. In this approach, the surface water model is used with a trial ground water elevation and the infiltration volumes on a monthly basis are extracted. The monthly infiltrations are applied to a finite difference ground water model and the ground water elevations – high, median, and low estimated. The median is then used again in the surface water model for new infiltration volumes. The process is done iteratively until the water balance closes to within 10%.

- Using a model that directly couples the surface and ground water models similar to the above.

When using model data with site geometric, rainfall, and soil parameters, a reality check can be made against point observations for reasonableness. For example, if a reported ground water elevation near the end of the wet season in a wet year is lower than the model results for the ground water elevation in a normal year – the model does not adequately approximate reality and must be adjusted. Comparisons with surface water observations on a point basis can also be made and can provide valuable guidance for model calibration.

Whichever method and ground water elevation is chosen for annual loading calculation, the value of the relative answer will depend on consistent use. That is, if SHGWT is used in existing site evaluations it should also be used in proposed site evaluation, modified, of course, for the site changes the project will induce.

308. TOPOGRAPHY

Topographic information is a given for airport design projects. Airports, as a matter of policy, use the 1988 NAVD for all mapping and design. However, flood studies, water levels reported for gaged water bodies, and similar information that may be collected may be referenced to 1929 NGVD depending on the age and source of the information. The effect on design can be substantial since the difference can amount to more than 1 foot (0.3 meters) and is variable by location in the state.

309. SLOPES AND GRADING

Airports have defined grading criteria associated with safe and efficient operation of aircraft. These are provided in FAA AC 150/5300-13 (latest version). Within Florida, the minimum slopes for airfield grading are often used. These are beneficial to airport stormwater management as illustrated in Figure 309-1.

STATEWIDE AIRPORT STORMWATER BEST MANAGEMENT PRACTICES MANUAL

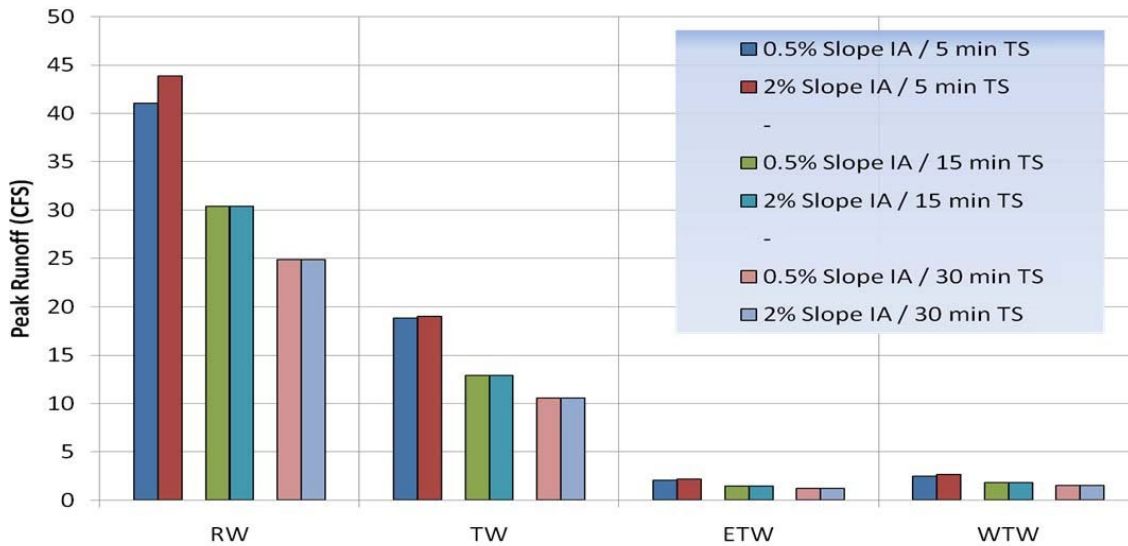


Figure 309-1 Peak Runoff Sensitivity Results for Impervious Areas

Figure 309-1 is derived from computer simulations using the public domain software EPA SWMM. It illustrates the runoff changes that result from nothing more than flattening side slopes along pavement edges. BMP recommendations within this manual consider this result and the benefits it confers in water quality management. It also illustrates the effect of the time step of the rainfall data in computations, discussed further and quantified in the discussion of hyetographs for continuous simulations.

A cautionary note when defining basins with nearly flat longitudinal and/or transverse slopes is needed for modeling existing systems. The data collection phase of the Statewide Airport Stormwater Study found that drainage basins with nearly flat slopes will change irrespective of the topographic elevations that apparently define them. Wind effects in thunderstorms were a commonly observed cause of the drainage pattern shifts. High grass and sediment buildup along a single edge of some pavements also caused observed changes to actual basin boundaries as opposed to limits based solely on pavement elevation data. In cases the effects measured were substantial, increasing contributing areas on the downwind side or on the side opposite built-up edges by over 10%. Visual observation of flow paths during several rain events may be needed to reasonably represent the actual basin limits on some existing pavement.

STATEWIDE AIRPORT STORMWATER BEST MANAGEMENT PRACTICES MANUAL

Section 4 RAINFALL AND RUNOFF RELATIONS

401. EVENT vs. CONTINUOUS SIMULATION

Most designers and regulators are familiar with the event-based analysis and design used to size conveyance systems, establish flood protection criteria, and size detention systems for flow rate attenuation. Event-based design establishes maximum rainfall amounts or intensities that may be expected in an area using statistical analyses of past rainfall events. The rainfall is usually expressed in terms of the expected recurrence interval of a storm, for example, a 5-year storm. The event durations may range from 10 minutes to 3 days or in some cases from 8 minutes to 10 days. The rainfall hyetograph distribution is predefined within rules of the various water management districts or by FDOT within its variously defined regions. The five water management districts and the FDOT establish design events for rate control and flood protection. FDOT procedures are appropriate when discharging into FDOT stormwater conveyance and right-of-way.

FAA guidance is to use event-based design to size drainage inlets and pipes to convey water away from airside pavement. FAA AC 150/5320-5D, paragraph 2-2.4.2 recommends a 5-year recurrence interval storm for airside pavement, with inlet surcharges less than 4 inches on aprons where personnel will operate or passengers and crew walk across.

Stormwater quality analysis and design is based on the annual behavior of the system, not the behavior in an extreme event, such as those used for design of conveyance and flood protection. Continuous simulation requires rainfall information that represents a typical year, derived from several years of historical data. Table 401-1 provides non-parametric statistics for daily rainfall events at a series of representative Florida airports. The ERP *Applicant's Handbook Volume 1* includes isopleths of annual rainfall in Appendix M. This presents annual rainfalls in greater detail graphically and with a longer historical database. The annual rainfall totals in Appendix M of the *Applicant's Handbook Volume 1* may be used to normalize data or as a check upon the 15-minute hyetographs described in Section 402 that are used for continuous simulation surface water models. The annual volume of rainfall in the models should closely approximate the average annual rainfall shown by the isopleths.

Table 401-1 also presents the typical seasonal distribution of rainfall at the listed airports. Contrasting the rainfall characteristics in the table with the 10-year and 25-year, 24-hour design event rainfalls established by FDOT, included in the final two rows of the table for convenience, clearly shows the difference between design event and typical rainfall. Additional discussion and recommendations for rainfall hyetographs for stormwater quality calculations is included in the next section of this document.

Continuous simulation computations and estimates require rainfall – runoff relations that reflect the highly variable intensities and volumes that Table 401-1 implies. They must also consider changes in soil moisture and recovery, evaporation effects, and similar that happen for the typical annual rain distributions. A following section on Rational Method Runoff Coefficient (C), Natural Resource Conservation Service (NRCS – formerly Soil Conservation Service {SCS}) Curve Number (CN), and the Green-Ampt equation describes the differences and provides the recommended approach for airside stormwater management.

**STATEWIDE AIRPORT STORMWATER
BEST MANAGEMENT PRACTICES MANUAL**

Table 401-1 Daily Rainfall Characteristics at Select Florida Airports and Comparison with Published Design Storm Events

	RSW	GNV	JAX	MIA	MCO	PNS	TLH	TPA
Modal Rainfall (inches)	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01
Median Rainfall (inches)	0.24	0.19	0.2	0.18	0.19	0.3	0.24	0.19
Percent Rain less than 0.5 inches	67%	73%	71%	72%	71%	62%	66%	71%
80th Percentile Rainfall (inches)	0.83	0.68	0.72	0.70	0.73	0.98	0.87	0.72
90th Percentile Rainfall (inches)	1.33	1.10	1.23	1.22	1.17	1.55	1.44	1.16
95th Percentile (inches)	1.83	1.52	1.81	1.74	1.55	2.41	2.04	1.56
Average Interval Between Rain Events during the Rainy Season June 1 - September 30 (Hours)	22	25	26	21	24	29	27	26
Percent of Rain during the Rainy Season June 1 -September 30	65%	48%	51%	54%	52%	41%	45%	58%
Average Annual Rainfall, 1985-1999 (inches)	55	49	54	62	52	67	61	46
Design Rainfall (inches) for 10-year, 24-hour Event (reference 30)	7.5	7.5	7.7	8.9	7.4	9.1	8.6	8.8
Design Rainfall (inches) for 25-year, 24-hour Event (reference 30)	8.4	8.5	8.9	10.1	8.4	10.8	10.3	10.1

Data source same as companion *Technical Report* (reference 34) and is based on 1984 – 1999 daily rainfall records

RSW is located in Fort Myers
GNV is located in Gainesville
JAX is located in Jacksonville
MIA is located in Miami
MCO is located in Orlando
PNS is located in Pensacola
TLH is located in Tallahassee
TPA is located in Tampa

**STATEWIDE AIRPORT STORMWATER
BEST MANAGEMENT PRACTICES MANUAL**

402. HYETOGRAPHS

Hyetographs used for continuous simulation must, as a minimum, include the entire defined rainy season, if one is established for the region. A better simulation can be completed using the historical rainfall records of nearby weather stations, and this is the recommended approach. Daily rainfall values, without further reduction into smaller time intervals, are generally not suitable for continuous simulation computer models but may be useful for hand calculation depending on the loss and infiltration method used.

Table 402-1 illustrates the difference in runoff rates and volumes estimated based on 5-minute, 15-minute, and 30-minute increment rainfall hyetographs. The table is derived from computer simulations using the public domain software EPA SWMM.

Table 402-1 Comparison of Time Step Effect on Calculated Runoff

	5-minute	15-minute	30-minute
Impervious Area Peak Runoff Rate	baseline	30% less	43% less
Impervious Area Runoff Volume	baseline	0.1% less	0.1% less
Overland Flow Peak Runoff Rate	baseline	13% less	33% less
Overland Flow Runoff Volume	baseline	10% less	24% less

Two methods are available to establish hyetographs – synthetic generation and historical record. Combinations of the two are also possible, and often needed, to provide a sufficiently detailed record if computer analysis is used. The recommended time increment for the rainfall record is 15-minutes depending on the available data set. The computed error between the 5-minute and the 15-minute data are well within other modeling uncertainties. Increments of 30-minutes and larger, while usable, begin to diverge from the 5-minute information at levels that require more care when interpreting results.

Figure 402-1 illustrates a 5-minute rainfall record for Orlando International Airport for a 20-month period.

STATEWIDE AIRPORT STORMWATER BEST MANAGEMENT PRACTICES MANUAL

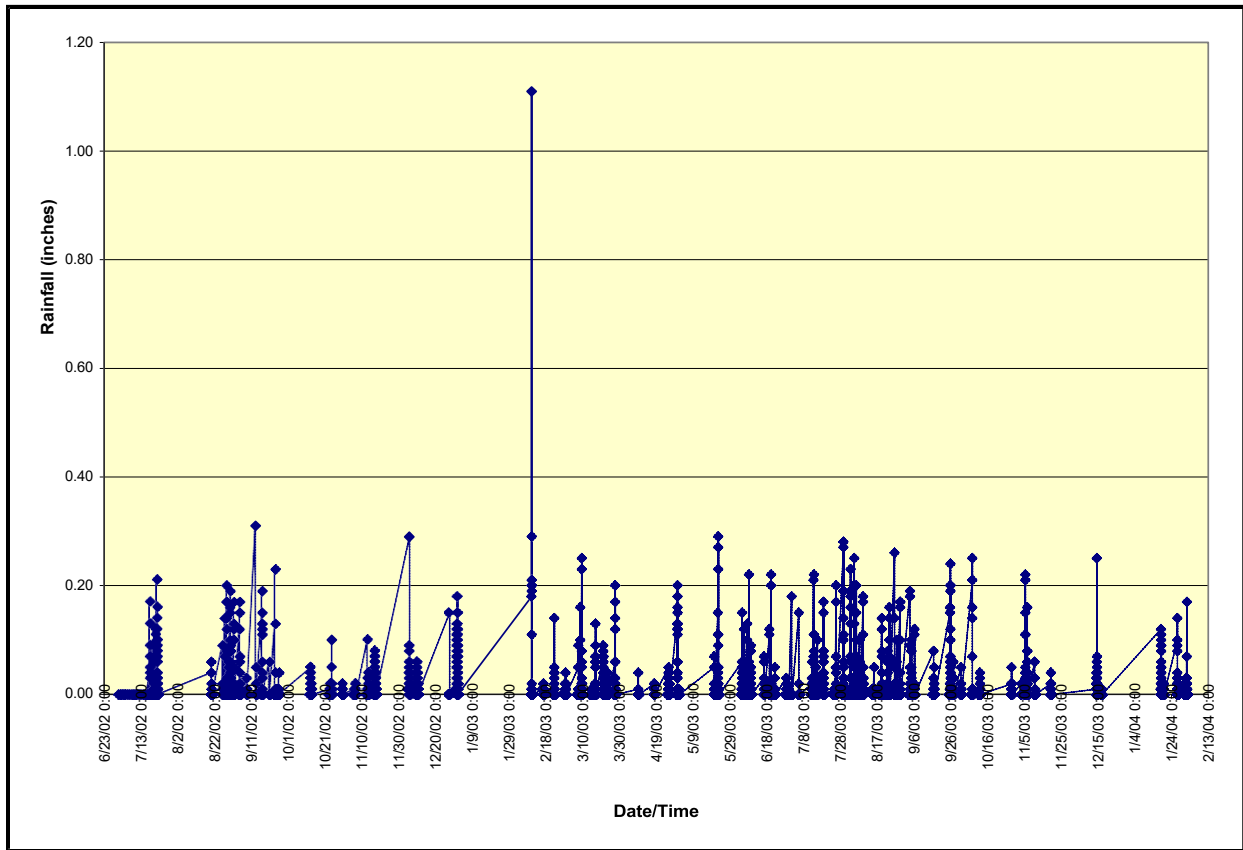


Figure 402-1 Recorded 5-minute Rainfall Record for Orlando International Airport

403. EVAPORATION AND EVAPOTRANSPIRATION

Evaporation and evapotranspiration are needed in most continuous simulations since these are often major components in the recovery of soil storage. The simulations do not need these parameters defined to the same intervals as the rainfall hyetographs since they predominantly influence the soil storage recovery not the immediate runoff established by rainfall – runoff relations. An evapotranspiration data set is shown in Figure 403-1. Evaporation and evapotranspiration records can be obtained from: Florida Automated Weather Network, (FAWN), <http://fawn.ifas.ufl.edu/>.

STATEWIDE AIRPORT STORMWATER BEST MANAGEMENT PRACTICES MANUAL

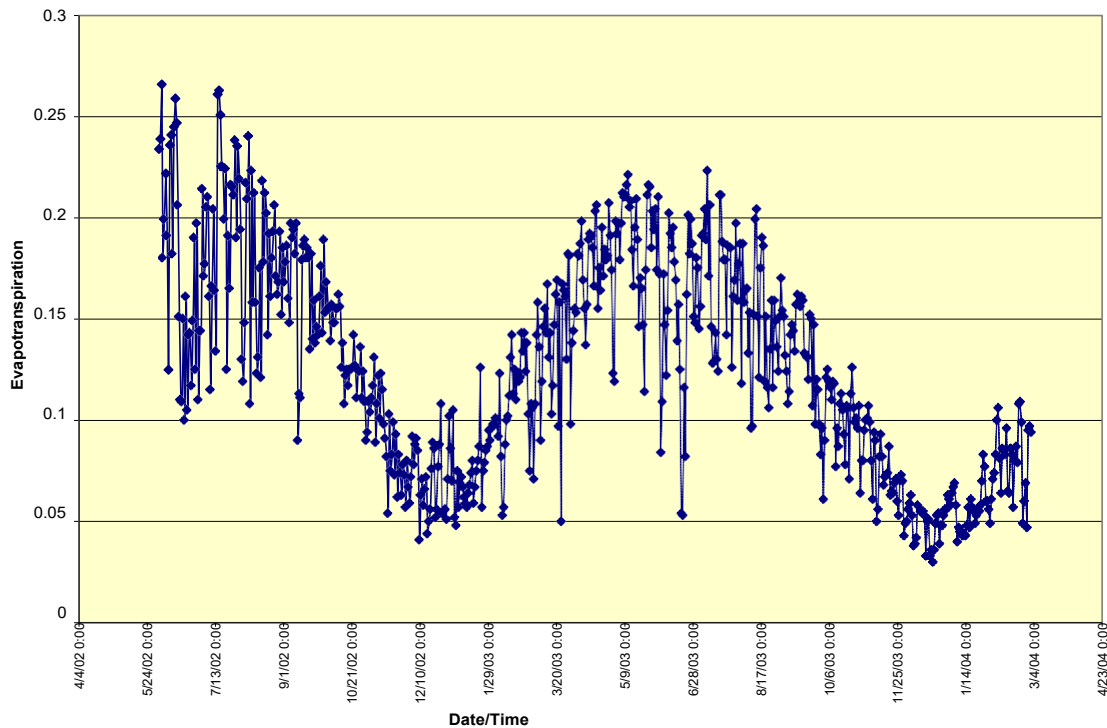


Figure 403-1 Plot of Daily Evapotranspiration Measured in Central

404. C vs. CN vs. GREEN-AMPT

Event-based water conveyance, rate control, or flood protection design is generally done using the NRCS Curve Number to relate the runoff to rainfall. On specific airside areas and for short duration, high intensity convective storms, the Rational Method is often used to size inlets and pipes. These methods, within the site limits they derive from, can provide good estimates of the peak runoff rates and volumes during more intense storms and when applied with experienced judgment. However, they can dramatically misestimate the runoff on an annualized basis. The data from the Florida Statewide Airport Stormwater Study found Rational Method C varied from 0.01 to 1.00 for direct pavement runoff depending on storm volume and intensity, with a median that averages 0.7. Generally, the lower the storm intensity and the lower the total rain volume, the lower the measured value of C. Comparing these ranges with the typically accepted ranges of C for pavement, 0.95 to 1.00, it is evident that C for continuous simulation modeling is likely to substantially overestimate runoff and loads.

Curve Number, CN, was also back figured from measured rainfall-runoff relations found in the Florida Statewide Airport Stormwater Study. Using a pavement example as before, calculated CN ranged from 72 to 95. The typically accepted CN for pavement in Florida is 95. Lower intensity and volume rains yield lower CN. Using CN for continuous simulation modeling is likely to substantially overestimate runoff and loads.

STATEWIDE AIRPORT STORMWATER BEST MANAGEMENT PRACTICES MANUAL

Figure 404-1 illustrates the measured runoff for pavement and overland flow compared with the runoff estimated using the Green Ampt equation for one year of recorded information. Actual measured runoff was 3.61 inches; the Green Ampt equation predicted runoff was 3.65 inches. Note that on any given event the estimated and measured values will differ but overall agreement is excellent.

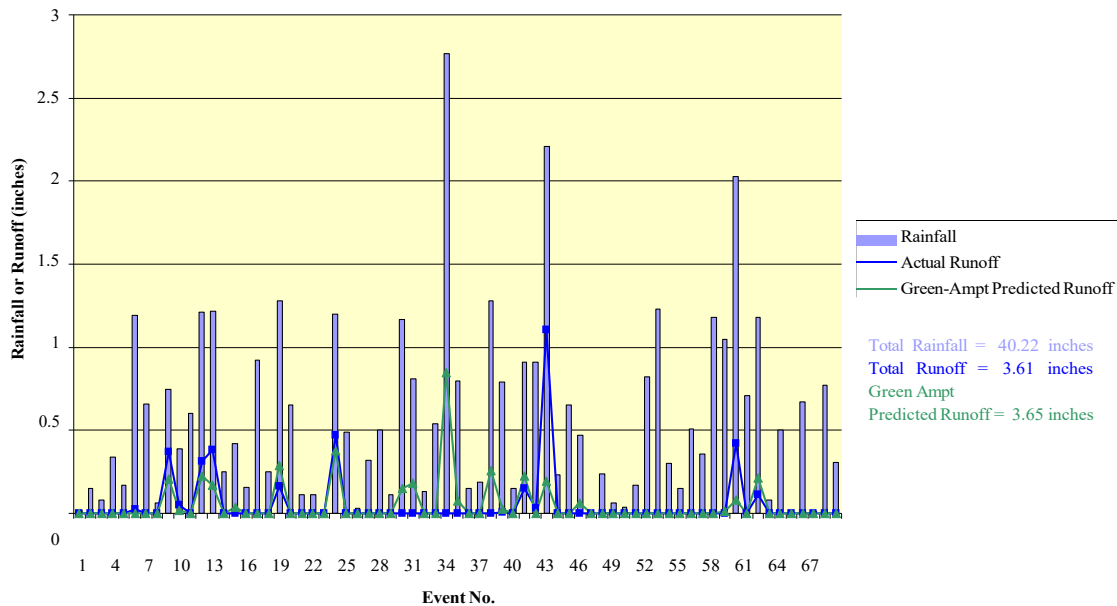


Figure 404-1 Comparison of Actual and Green-Ampt Predicted Runoff

The Green Ampt equation is discussed in references 4 and 13. Its basic form is:

$$f = K_s (1 - M_d \psi / LM_d)$$

Where:

- f = infiltration rate
- K_s = saturated vertical hydraulic conductivity
- M_d = initial moisture deficit further defined as the saturated moisture content minus the initial moisture content
- Ψ = soil suction
- L = depth to the infiltrating wetting front which varies with infiltration volume

It is iteratively solved and is available in several software packages, including EPA SWMM used in the *Application Assessment for the Statewide Airport Stormwater Study*. The equation also lends itself to spreadsheet solution, where iterative calculations can be rapidly performed. The parameters that go into the equation can be directly measured or surrogate measures, such as gradation and soil classification, can be used to estimate the parameters with guidance provided in this manual and references listed in **Appendix A**.

**STATEWIDE AIRPORT STORMWATER
BEST MANAGEMENT PRACTICES MANUAL**

Section 5 STORMWATER QUALITY CALCULATIONS

501. RUNOFF LOAD AND CONCENTRATION

Basic stormwater quality calculations using Event Mean Concentrations are straightforward. The load (units of weight) is the EMC (units of weight per volume) multiplied by the volume of runoff, with appropriate unit conversions. Conversely, concentration can be calculated as the load divided by the volume of runoff, again, with appropriate unit weight conversions.

Airside pavement EMC values for nutrients, at the pavement edge with no overland flow considered, are given in Table 202-1. The distinction that these are direct pavement EMC is important in modeling or hand computations. As discussed in the section on BMP efficiencies, overland flow alters the EMC, generally within a distance of 25 feet based on the data collected in the Florida Statewide Airport Stormwater Study. If the basin definition includes, as is typical, both pavement and a section of overland flow, the EMC changes due to the overland flow must be reflected in the computation.

502. GROUNDWATER CONTRIBUTIONS

If dewatering is needed for either pavement structure protection or site improvement for stormwater management, the ground water discharged from the site will have nutrients that must be accounted for in stormwater loading calculations. Underdrains placed immediately at the outside edge of pavement will likely have lower nutrient concentrations but may have higher metal concentrations and possibly PAH in particulate phase. Consequently, underdrains for airside pavement should be moved either 25 feet away from outside the pavement edge or beneath the pavement. Note that artificially lowering the ground water table may be precluded in some areas of the state and by some jurisdictional agencies for management and resource conservation reasons. Also, if underdrains are used, General Permit 62-330.449 does not apply.

Nutrient load in ground water was not measured during the Florida Statewide Airport Stormwater Study. Table 502-1 contains the values that may be used when calculating ground water nutrient loadings and were supplied by FDEP. FDEP or the jurisdictional Water Management District should be consulted for updated values.

Table 502-1. Median Nutrient Concentrations in Ground Water by County

COUNTY	NITRATE and NITRATE+NITRITE as N mg/L	TOTAL PHOSPHORUS as P mg/L
ALACHUA	0.16	0.0625
BAKER	0.02	0.03
BAY	0.025	0.004
BRADFORD	0.05	0.105
BREVARD	0.02	0.05
BROWARD	0.02	0.07
CALHOUN	0.42	0.004
CHARLOTTE	0.02	0.04
CITRUS	0.27	0.07

**STATEWIDE AIRPORT STORMWATER
BEST MANAGEMENT PRACTICES MANUAL**

COUNTY	NITRATE and NITRATE+NITRITE as N mg/L	TOTAL PHOSPHORUS as P mg/L
CLAY	0.02	0.021
COLLIER	0.02	0.022
COLUMBIA	0.02	0.05
DADE	0.022	0.02
DESOTO	0.02	0.26
DIXIE	*0.02	*0.10
DUVAL	0.06	0.019
ESCAMBIA	0.17	0.01
FLAGLER	0.02	0.18
FRANKLIN	0.02	*0.10
GADSDEN	0.082	0.012
GILCHRIST	0.02	0.091
GLADES	0.012	0.035
GULF	0.02	*0.10
HAMILTON	2.6	1.1
HARDEE	0.02	0.46
HENDRY	0.02	0.07
HERNANDO	0.056	0.033
HIGHLANDS	0.02	0.043
HILLSBOROUGH	0.02	0.02
HOLMES	0.06	*0.10
INDIAN RIVER	0.02	0.35
JACKSON	4	0.018
JEFFERSON	1.6	0.01
LAFAYETTE	5.8	0.337
LAKE	0.05	0.031
LEE	0.015	0.034
LEON	0.0395	0.03
LEVY	0.06	0.086
LIBERTY	0.017	0.014
MADISON	0.042	0.097
MANATEE	0.02	0.03
MARION	0.98	0.05
MARTIN	0.02	0.11
MONROE	0.012	0.01
NASSAU	0.008	0.12
OKALOOSA	0.113	0.004
OKEECHOBEE	0.007	0.18

STATEWIDE AIRPORT STORMWATER BEST MANAGEMENT PRACTICES MANUAL

COUNTY	NITRATE and NITRATE+NITRITE as N mg/L	TOTAL PHOSPHORUS as P mg/L
ORANGE	0.02	0.063
OSCEOLA	0.012	0.3
PALM BEACH	0.02	0.08
PASCO	0.004	0.0185
PINELLAS	0.02	0.15
POLK	0.79	0.0365
PUTNAM	0.011	0.049
SANTA ROSA	0.11	0.004
SARASOTA	0.02	0.195
SEMINOLE	0.02	0.19
ST. JOHNS	0.02	0.035
ST. LUCIE	0.006	0.04
SUMTER	0.04	0.05
SUWANNEE	3	0.1
TAYLOR	0.04	0.1
UNION	0.3	0.07
VOLUSIA	0.042	0.15
WAKULLA	0.015	0.19
WALTON	0.845	0.004
WASHINGTON	0.04	0.004
*DATA NOT REPORTED – OVERALL MEDIAN OF REPORTED DATA FOR ALL COUNTIES USED.		

503. BMP EFFICIENCIES

BMP effectiveness can be measured as either reductions in load and/or concentration. However, for the purposes of Florida's stormwater regulatory program, the focus is on average annual load reduction. During the Florida Statewide Airport Stormwater Study, load reductions were observed for all parameters, including nutrients. Concentration reductions were observed for all parameters except nutrients during overland flow.

Load reductions can occur via five primary mechanisms. First, the stormwater volume that is discharged from a site can be reduced. This typically occurs through infiltration in which the stormwater soaks into the ground and becomes groundwater, where nutrients are transported in whole or in part into the groundwater system. This can be done with overland flow, dry swales, dry retention, and similar and can also occur in wet systems through pond and swale sides and bottoms depending on hydraulic conditions. It is generally assumed that 100% of the nutrient loading is removed when the stormwater is infiltrated onsite, but the proximity of the infiltration area to potential surface waters where groundwater can transport the nutrients can invalidate this. The infiltrated water may re-emerge as surface water transporting some portion of the initial nutrient load or possibly an increased nutrient load depending on site conditions. This must be considered in load calculations. Evaporation and evapotranspiration also reduce the stormwater

STATEWIDE AIRPORT STORMWATER BEST MANAGEMENT PRACTICES MANUAL

volumes but are typically accompanied by an increase in constituent concentration such that the net effect will depend on the efficiency of other constituent reduction mechanisms.

Second, structural controls, such as stormwater ponds, can sequester the constituents primarily by particulate settling. Most of the removal in wet ponds occurs through this process.

Third, nutrients can be transformed, sequestered, or removed by biologic or physical chemistry processes. For example, microorganisms growing on plant roots or other substrate in wet systems, such as ponds or swales, can assimilate some nutrients. Also, some materials such as weathered, recycled crushed concrete, can also serve to uptake some nutrients.

Fourth and very effective to the extent used and practical, source control BMPs can be used to reduce the concentration of pollutants that get into the stormwater. An example is using Florida-friendly fertilizers or reusing or properly disposing of aircraft fuel during fuel sumping.

The last major load reduction mechanism is removal of accumulated sediments and pollutants from the stormwater management system. This is discussed further in Section 7 Maintenance.

504. Pre and Post Development Load Calculations

The pre and post development load calculations that are the basis of this manual are predicated on using continuous simulation, numerical modeling methods. The US EPA SWMM software package that was used exclusively in completing the *Application Assessment* is well suited to this analysis. Other public domain or commercial software products with continuous simulation capability may also be used.

The parameters establishing the rainfall-runoff and water quality relations in the existing and developed conditions are particularly important to the analyses, and the need to establish and agree upon them early in the process requires a pre-application meeting with the jurisdictional Water Management District.

The recommended modeling technique to estimate the loads from the project area under natural site conditions follows. The discussion is generic since the specific model software or approach may vary from project to project.

1. Using current or historic aerial photography, USGS quadrangle sheets, NRCS/SCS Soil Surveys, or other available and reliable information, establish in consultation with the regulatory agencies the natural site condition for the project area. In some cases, the current conditions will be natural site conditions. However, for the majority of airports and the majority of their property, the site will have been altered from natural conditions. In these cases, best available historic information must be used with the concurrence of the jurisdictional regulatory agency.
2. Define basins for the project site initially by topography and outfall locations. Further define basins by areas of different projected ground water elevation and soil types, if necessary.
3. The natural vegetative community EMC data from Table 202-1 and soil properties (Tables 304-1, 305-1, and 306-1 or **Appendix D**) representing soil types/conditions prior to alteration from the natural site will be used for the baseline natural site runoff load calculation.

STATEWIDE AIRPORT STORMWATER BEST MANAGEMENT PRACTICES MANUAL

4. Run the continuous simulation surface water model with rainfall and evapotranspiration data and groundwater interaction for a one-year period. The total rainfall should represent average annual rainfall for the site as given by the Average Annual Isopleth Map for Florida provided in *Applicant's Handbook Volume 1*, Appendix M.
5. Review the results for reasonableness. Revise the models as necessary.
6. Establish the natural site condition baseline loads based on the model and calculations.

The recommended modeling technique to estimate the pre-development load is as follows. The discussion is generic since the specific model software or approach may vary from project to project.

1. Establish the pre-development condition consistent with the definition contained in Section 2 of the *Applicant's Handbook Volume 1*.
2. Define basins for the project site initially by topography and outfall locations. Further define basins by areas of different projected ground water elevation and soil types, if necessary. It will also be necessary to further define basins by land use if the project area is not currently a natural vegetative community.
3. The EMC data from Table 202-1 and the *Applicant's Handbook Volume 1* will be used for runoff and BMP efficiencies associated with existing stormwater management will be included.
4. Run the continuous simulation surface water model with rainfall and evapotranspiration data and groundwater interaction for a one-year period. The total rainfall should represent average annual rainfall for the site as given by the Average Annual Isopleth Map for Florida provided in *Applicant's Handbook Volume 1*, Appendix M. The rainfall records should be defined on 15-minute or smaller intervals for the one-year period.
5. If necessary, using an equation or a ground water model validate the groundwater fluctuations indicated by the continuous simulation model. These generally use a daily or monthly rate based on the volume the surface water model indicates was infiltrated. They do not use 15-minute data. The necessity is determined by the reasonableness of ground water levels in the continuous simulation model compared to known or observed existing site conditions. If the results are substantially different than used in the surface water model, another iteration of surface and ground water modeling is needed.
6. Review the results for reasonableness. Revise the models as necessary.
7. Establish the pre-development target loads based on the model and calculations.

Post-development Green-Ampt and groundwater parameters are established as described in Section 3. The recommended continuous simulation surface water models will define rainfall runoff relations using the information discussed in Sections 3 and 4 preceding. The model will also use the EMC data from Section 2. The recommended generic modeling technique for the post-development condition, when designed following the criteria of Section 6, is as follows:

1. Define basins for the developed project site by topography and outfall locations, projected ground water elevations, soil types, and land use. The airside pavement areas should include up to the first 25 feet of overland flow when runoff is sheet flow from the impervious onto the pervious surfaces.
2. Define the EMCs for each different land use type associated with the project (e.g., air carrier runway, taxiway, airside road, high intensity commercial use, and similar) using Tables 202-1 and the *Applicant's Handbook Volume 1*.

STATEWIDE AIRPORT STORMWATER BEST MANAGEMENT PRACTICES MANUAL

3. Define the BMP efficiencies for new stormwater management systems. The definition may be load or concentration based, depending on the selected model. In all cases the ultimate requirement is discharge load calculation.
4. Run the continuous simulation, surface water model with rainfall records defined on 15-minute or smaller intervals for a one-year period. If necessary, run a ground water model or equation to help validate the infiltration volumes as discussed for the pre-development modelling recommendations above. If the results are substantially different than used in the surface water model, another iteration beginning with step 1 should be completed.
5. Review the results for reasonableness.
6. Compare the post-development loads to the target loads required by regulation which may be either a natural site or a load reduction from the pre-development condition as required by rule. If the post-development loads exceed the target loads, add design features to reduce the post development load, and re-evaluate.

References in **Appendix A** may be consulted for additional information, along with specific user manuals for software products used for modeling.

STATEWIDE AIRPORT STORMWATER BEST MANAGEMENT PRACTICES MANUAL

Section 6 BEST MANAGEMENT PRACTICES

601. OVERVIEW

Best Management Practices for airside stormwater management must satisfy both aviation safety and water quality and quantity management criteria. Aviation safety requires that the Best Management Practices avoid or minimize attracting hazardous wildlife. Water quality management will generally require a reduction of pollutants leaving the airport in the post-development condition when compared to the existing site conditions or verifying that post-development nutrient loads are not greater than those from a natural vegetative community. Water quantity management is generally rate based, with no increase of calculated discharges above those from the pre-project site during a specified design storm. In specific locations, local regulations may require reducing the flows to less than the existing values. This is usually needed where the off-airport areas are experiencing flooding problems. Structural and Procedural Best Management Practices presented in this section are available tools for airside Best Management Practice stormwater design and permitting for Florida airports.

602. MINIMUM LEVEL OF STORMWATER TREATMENT

Florida has implemented a technology-based stormwater rule based on three principles:

- A “performance standard” that sets the minimum level of treatment,
- BMP design criteria that can achieve the performance standard, either alone or through a BMP treatment train, and
- A rebuttable presumption that a stormwater treatment system designed using demonstrated and FDEP approved efficiencies for the selected BMP elements will not cause or contribute to violations of water quality standards.

The performance standards for Florida’s stormwater rules are set forth in Section 62-40.432, F.A.C. They include:

- For construction activities, no violation of the turbidity water quality criterion, which is 29 NTUs above background for most waters, but zero (0) NTUs above background in an Outstanding Florida Waterbody (OFW).
- For the General Permit as set forth in Chapter 62-330.449, F.A.C., the performance standard for airside airport activities is currently: “The nutrient load after development shall not exceed the nutrient loading from natural vegetative communities.”
- For Conceptual and Individual Permits, the performance standards shall be those provided in Section 8 of the *Applicant’s Handbook Volume 1* but shall not be required to reduce nutrient loading below that which would result from a natural vegetative community.

603. FLOOD CONTROL REQUIREMENTS

All projects must be designed to prevent adverse flood impacts. The five Water Management Districts prescribe specific design events that must be evaluated and the design criteria that apply to meet the flood control requirements. **Appendix G** provides a listing of public airports by jurisdictional Water Management District. Consult District websites and publications for current flood protection criteria. Discharges from the airport property will be limited by these criteria. Floodplain impacts and compensating/mitigating design criteria are also established.

The Florida Department of Transportation establishes flood protection criteria for its various roadways and the criteria apply to discharge to the right of way and drainage systems. These

STATEWIDE AIRPORT STORMWATER BEST MANAGEMENT PRACTICES MANUAL

may require checks of multiple design events up to a specified level to determine a controlling discharge. FDOT criteria and methodologies are available in manuals and handbooks at <http://www.dot.state.fl.us/rddesign/dr/Manualsandhandbooks.shtm>.

Additionally, Water Control Districts and local government may have criteria for flood protection that are more stringent than Water Management District criteria. These are often based on local experience of excess flooding with smaller and more frequent rainfall events than those prescribed by the jurisdictional Water Management District. The local agencies should be contacted for their specific requirements that will influence project design. The most stringent of the Water Management District or local criteria must be met with respect to protecting areas away from the airside from adverse flood impacts.

The Water Management District and local criteria are intended to protect offsite areas from specified flood events, but also typically address on-site flooding. However, the flood protection criteria are not appropriate to airside pavements. Specifically, FAA Advisory Circular 150/5320-5D, applies to airside pavement. The circular allows temporary flooding of airfield pavement to specific depths for storms with a 5-year recurrence interval. Joint use civil-military airfields may be designed for flooding under more frequent events, sometimes those with a 1-year recurrence interval. This is the basis for infield ponding or even pavement flooding as design features used to reduce peak flows leaving the site.

604. REQUIRED SITE INFORMATION

Successful design of retention BMPs depends greatly upon knowing conditions at the site, especially information about the drainage system, topography receiving waters, soil, geology, and water table conditions. A non-inclusive checklist to obtain specific data needed for analyses and design of a retention BMP is provided in **Appendix C**.

605. STRUCTURAL BEST MANAGEMENT PRACTICES

The following Structural Best Management Practices may be used alone or as part of a BMP treatment train that combines structural and/or Procedural BMPs to meet the minimum stormwater treatment requirements for airport improvements. In particular, this means meeting the performance standards discussed in Section 602. Other BMPs not listed in this manual may be appropriate, but they were not specifically evaluated as part of the Florida Statewide Airport Stormwater Study. FDEP and/or WMD approved BMP efficiencies for other BMPs shall be obtained from FDEP or the jurisdictional WMD.

A caveat to any of the structural BMPs is that if the existing site does not generate runoff from the average annual rainfall and the post-development site does, by definition loads leaving the site are increased. In these cases, it may be necessary to retain and infiltrate/evaporate the entire runoff volume in the post-development condition.

a. Overland Flow

An overland flow system is a BMP in which the runoff moves off the impervious area and sheet flows over the adjacent grassed area allowing the stormwater to infiltrate into the ground. Overland flow is the preferred BMP for runway and taxiway stormwater management. It may also be applicable to aprons, depending on specific site geometry and conditions, and for full or partial treatment of runoff from other development types.

STATEWIDE AIRPORT STORMWATER BEST MANAGEMENT PRACTICES MANUAL

During overland flow, metals concentration reduction varies from a low of about 35% to a high of just more than 65%. Nutrients, however, exhibited an increase in concentration of 5% for phosphorus and up to 50% for nitrogen. Understanding the reason for the results and their significance are critical to proper application of the data and good modeling practice. The decrease or increase measured represents low levels of constituents in the pavement runoff that rapidly approach the background or pristine site concentration. This must be used with care when establishing the BMP induced concentration changes and can affect the choice of basin limits for water quality computation. The effect is most pronounced in the first 25 feet of overland flow, beyond that the observed concentrations tend to stabilize. Consult the *Technical Report for the Statewide Airport Stormwater Study* (Reference 34, **Appendix A**) for detailed information.

1. **BMP Efficiency Information**

The concentrations of Tables 202-1 and from the ERP *Applicant's Handbook Volume 1* may be used for overland flow runoff over distances of up to 25 feet from pavement edges, after which EMC data for the appropriate pervious land use from Tables 202-1 and the ERP *Applicant's Handbook Volume 1* shall be incorporated in the models. The continuous simulation model including infiltration and evapotranspiration results will establish the load reduction from overland flow. The efficiency is dependent on the design features, including soil type and compaction in the overland flow area, and is not a fixed value.

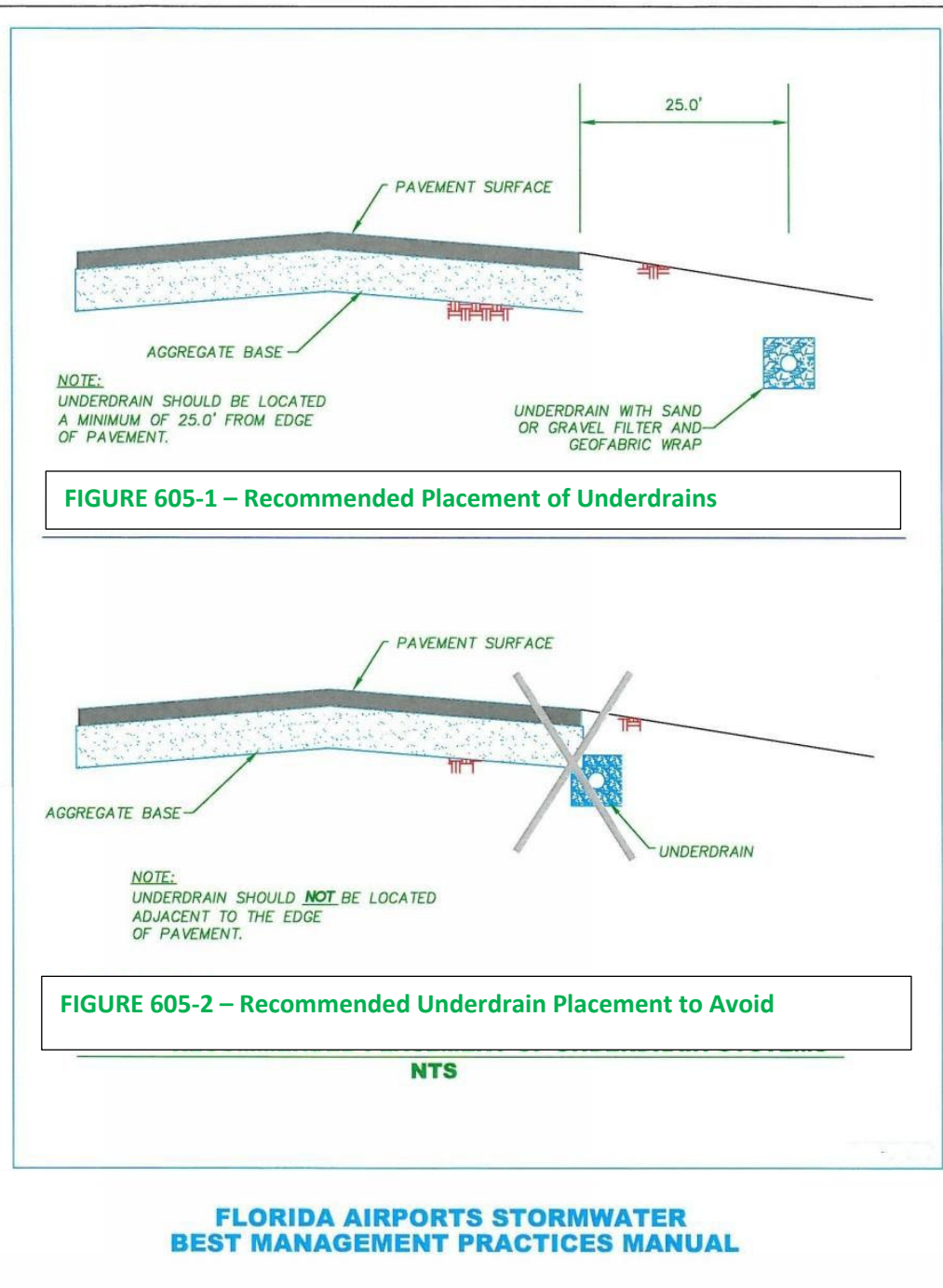
2. **Suggested Design Criteria to Improve Water Management Efficiencies**

- Slopes shall be as flat as possible with .1% - 3.0% recommended in the first 25 feet of overland flow.
- Design airside inlets and conveyance pipes for the 5-year post development storm using the Rational Method. Ponding should be less than 4 inches on aircraft parking aprons. These criteria are expressed in Advisory Circular 150/5320-5D, Paragraph 2-2.4.2.
- Evaluate the pre- and post-development peak flows from the project using the design storm event specified by the jurisdictional water management district and local agencies. This is typically a 10-, 25-, or 100-year recurrence interval storm of 1 to 3 days duration. Verify post project discharge from the airport is less than pre-project discharge for this event and method.
- On the airport airside, set inlets at grade in the infield, or, if needed and consistent with airfield safety, up to 3 inches above grade to achieve required load reductions.
- Based on the evaluation of annual nutrient loads for the natural, pre-development, and post-development conditions, establish the design features to achieve the required load reductions.
- If SHGWT levels must be lowered using underdrains, place underdrains at least 25 feet from the edge of pavement (see Figure 605-1). Underdrains placed directly adjacent to pavement (see Figure 605-2) should not be used for stormwater management or pavement base protection, since these may transport higher pollutant loads from the pavement edge directly to the stormwater conveyance. Underdrains placed under the pavement are an option for pavement structure or base protection, and loads may be calculated as described for those placed 25 feet away. Include underdrain nutrient loads in the post-development discharge loading calculations as appropriate. Note that artificially lowering the ground water table may be precluded

STATEWIDE AIRPORT STORMWATER BEST MANAGEMENT PRACTICES MANUAL

in some areas of the state and by some jurisdictional agencies for management and resource conservation reasons.

- The overland flow system shall be appropriately stabilized to minimize or prevent erosion.
- Follow the Turf Management Procedural BMPs described in Section 606.b.



b. Dry Retention Basin

A dry retention basin is the preferred BMP for airside aprons where overland flow is not a sufficient management practice and for landside development. A “retention system” is a recessed

STATEWIDE AIRPORT STORMWATER BEST MANAGEMENT PRACTICES MANUAL

area within the landscape that is designed to store and retain a defined quantity of runoff, allowing it to evaporate or percolate through permeable soils into the shallow ground water aquifer. This section discusses the requirements for retention systems, historically referred to as “dry retention basins,” which are constructed or natural depressional areas, often integrated into a site’s landscaping, where the bottom is typically flat, and turf, natural ground covers or other appropriate vegetation, or other methods are used to promote infiltration and stabilize the basin slopes and help maintain infiltration rates.

Soil permeability and water table conditions must be such that the retention basins can percolate the required treatment runoff volume within a specified time following a storm event. After drawdown has been completed, the basin does not hold any water, thus the system is normally “dry.” Unlike detention basins, the treatment volume for retention systems is not discharged to surface waters. Like all infiltration BMPs, dry retention systems are assumed to remove 100% of the nutrient load for all the runoff volume that is fully retained within the system. Lesser removals occur for those storms that exceed the treatment volume of the retention basin and bypass the system to be discharged offsite unless the retention basin is designed as an offline BMP.

Proximity to areas where ground water can re-emerge into surface waters or in spring protection areas must be considered in the design and use of these systems. This can be done in the continuous simulation surface water models that have a groundwater interaction feature or in a separate groundwater model using infiltration data from the surface water model.

Dry retention may not be appropriate if any of the following conditions exist:

- Soils are silts and clays with stabilized infiltration rates less than 1.0 inches/hour and horizontal hydraulic conductivities less than 10 feet/day.
- Aquitard or aquiclude is located within 10 feet of the proposed retention system bottom.
- SHGWT elevations are less than 3 feet beneath the proposed bottom of the dry retention system.
- The area beneath the proposed retention system contains gravels, shells, or similar highly permeable material that connects directly to an aquifer allowing pollutants to migrate rapidly into the ground water.
- Site is in a Karst Sensitive Area or an area of significant sinkhole activity.

The above conditions do not automatically preclude the use of this BMP but may require special design features and will require consultation with the jurisdictional regulatory agencies prior to use.

1. BMP Efficiency Information

As noted above, the treatment efficiency for the volume of water that infiltrates without discharging from the BMP is 100%. For systems that have a designed discharge for rainfall events above a certain level, the efficiency is proportional to the amount infiltrated.

Systems that have an indirect discharge via groundwater flow to a nearby stream or watercourse will also have a reduced efficiency proportional to both the volume of discharged a groundwater flow and treatment effects of flowing through the soil matrix. For systems where the flow distance through the soil exceeds 25 feet, a 100% treatment efficiency may be used. Note also that if underdrains are used to control groundwater

STATEWIDE AIRPORT STORMWATER BEST MANAGEMENT PRACTICES MANUAL

mounding and are located less than 25 feet from the outside edge of the retention pond bottom, nutrient removal, particularly nitrogen, will be reduced or potentially negated. The most current FDEP, WMD, or published and peer-reviewed data on nutrient removal through varying distances of groundwater flow should be consulted and used to adjust the efficiencies.

2. Suggested Design Criteria to Improve Water Management Efficiencies

- Site the dry retention basin such that the outside edge of the pond bottom is more than 25 feet from a surface water area or underdrain where flows could re-emerge without reducing to background levels.
- Design the retention system to completely recover the treatment volume within 24 to 36 hours depending upon the location and the area's wet season interevent dry season (Figure 605-4). Also, the design should avoid standing surface water for more than 48-hours, consistent with Advisory Circular 150/5200-33 *Hazardous Wildlife Attractants on or Near Airports*.
- Stabilize the retention basin sides and bottom with permanent vegetative cover, some other pervious material, or other methods acceptable to the jurisdictional regulatory agency to limit or prevent erosion and sedimentation.
- Required site information - Successful design of a retention system depends greatly upon knowing conditions at the site, especially information about the soil, geology, and water table conditions. Specific data and analyses required for the design of a retention system including details related to safety factors, mounding analyses, and required soil testing must be developed by professionals knowledgeable and experienced in geohydrology/hydrogeology.
- Evaluate ground water mounding on a continuous simulation instead of a single event basis using one of the methods in Table 605-1. The mounding recovery is evaluated using the Horizontal Saturated Flow methodologies and generally uses infiltration rates averaged over the rainy season. The maximum mound from this analysis should remain at least 18 inches beneath the pond bottom.
- If SHWGWT levels must be lowered using underdrains, the underdrains should be located no closer than 25 feet from the bottom edge of the retention system (see Figure 605-4A). Underdrains placed directly in the retention system bottom (see Figure 605- 4B) shall not be used for stormwater management, since these may transport more soluble pollutants directly to the stormwater conveyance. Include underdrain loads in the post-development discharge load calculations. Note that artificially lowering the ground water table may be precluded in some areas of the state and by some jurisdictional agencies for management and resource conservation reasons. Also, General Permit 62-330.449 is not applicable for designs incorporating underdrains.
- Design the retention system to retain or detain, as appropriate, the design storm so that post-development peak flows from the project site do not exceed pre-development peak flows for the design event. The design storm is typically a 10-, 25-, or 100-year recurrence interval event of 1 to 3 days duration. It is not necessary to retain the entire design storm except where the pre-development condition had no discharge, but the required treatment volume shall be retained and not discharged. Total volume controls may be applied by some local jurisdictions and may control the design.

**STATEWIDE AIRPORT STORMWATER
BEST MANAGEMENT PRACTICES MANUAL**

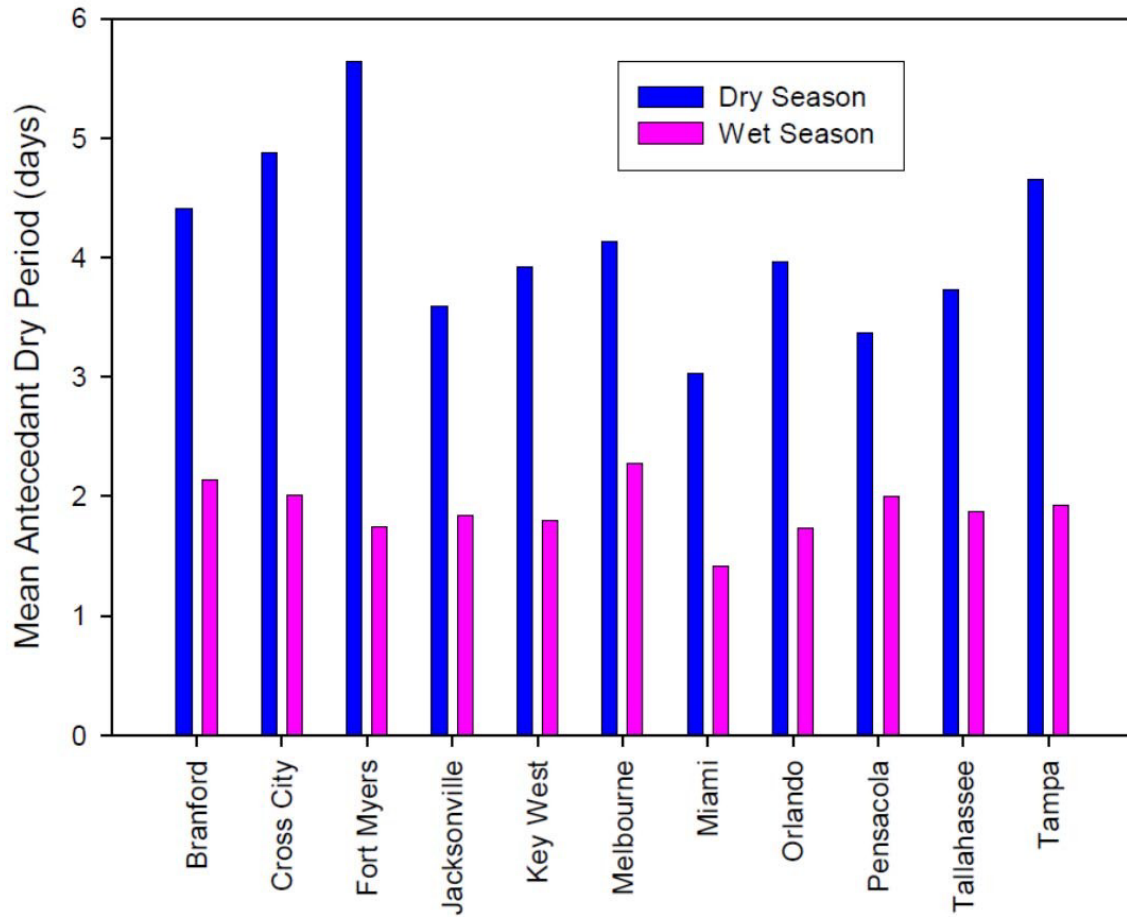
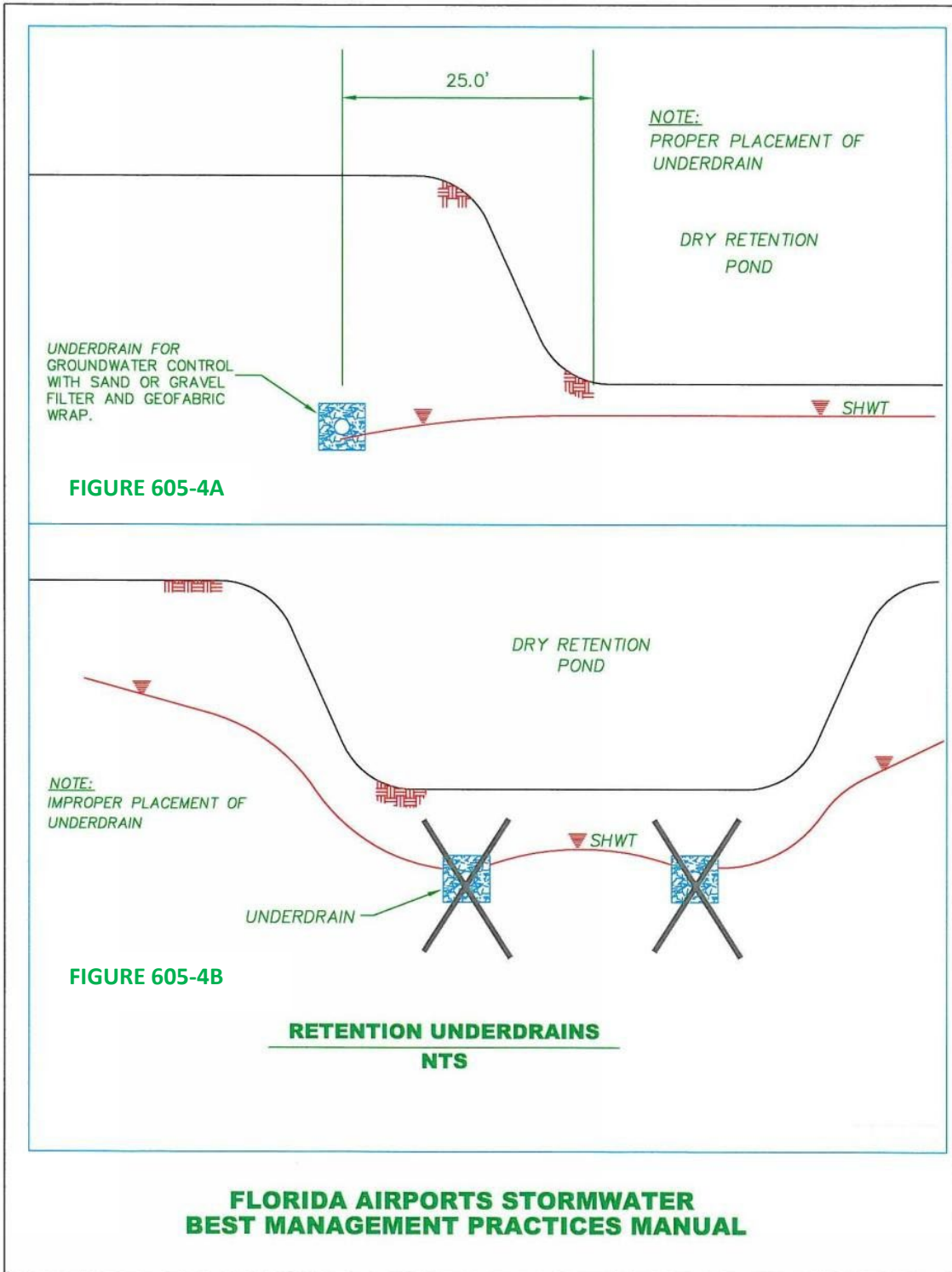


Figure 605-3 Interevent Time at Selected Florida Weather Stations

Table 605-1 Accepted Methodologies for Recovery Analyses

Infiltration	Horizontal Saturated Flow
Green Ampt Equation	Simplified Analytical Method with Darcy Equation
Richards Equation	Hantush Equation
Phillips Equation	MODFLOW
Horton Equation	Finite difference spreadsheet with Dupuit assumption
Commercial Software Products	Commercial Software Products

STATEWIDE AIRPORT STORMWATER
BEST MANAGEMENT PRACTICES MANUAL



STATEWIDE AIRPORT STORMWATER BEST MANAGEMENT PRACTICES MANUAL

c. Swales, Drainage Ditches, Channels, and Canals

Swales, drainage ditches, channels, and canals are an important part of the stormwater conveyance system that provides integral water treatment at most airports and can potentially function as BMPs for the project or as part of the water quality treatment train. They are defined in Volume 1, Section 2.1, 62-330 F.A.C.

c.1 Dry Swales and Drainage Ditches

Dry swales and drainage ditches (Figure 605-5) function like overland flow with respect to reducing stormwater pollutant concentrations and loads, that is, treatment occurs via infiltration of the stormwater. High flow events may re-suspend trapped pollutants previously removed in both systems.

1. BMP Efficiency Information

The volume of water infiltrated in this BMP has a 100% treatment efficiency to a point 25 feet upstream of continuously standing surface water either during the rainy season, the period of SHGWT, or on an annual basis. The efficiency closer than 25 feet should, in most cases, be neglected. This can be facilitated through surface water computer models by shortening the available infiltration distance either with groundwater levels or soil properties in that zone. A continuous simulation model including infiltration and evapotranspiration results will establish the load reduction from dry swales and drainage ditches. The efficiency is dependent on the design features, including geometry, soil type, and compaction in the dry swale or drainage ditch area and is not a fixed or singular value.



Figure 605-5 Typical Well-Maintained and Functioning Dry Swale

**STATEWIDE AIRPORT STORMWATER
BEST MANAGEMENT PRACTICES MANUAL**

2. Suggested Design Criteria to Improve Water Management Efficiencies

- Side slopes of 4H:1V or flatter landside and 3H:1V or flatter airside
- Longitudinal slopes should be as flat as possible with .1% - .5% recommended
- Limit swale/ditch flow velocity to 1.0 feet per second during a 0.5-inch storm and below the erodible velocity of site soils (Table 605-2) during the 2.33-year storm event

Table 605-2 Erosion Velocity Limits

Channel Bottom and Side Condition	Maximum Velocity (feet per second)
Grass/Plants on Sand	4
Grass/Plants on Clay	5

- Based on the evaluation of annual nutrient loads for the pre-development and post-development condition and the resulting required nutrient load reduction, determine the annual volume of runoff that must be infiltrated within the swale/ditch.
- Swale blocks may be used, if necessary, to reduce flow velocity and promote infiltration. However, check ground water mounding effects, and avoid designs that retain water in the swale/ditch for more than 24 hours after any rainfall.
- Design outfall control structure(s) to limit post-development peak flows to pre-development peak flows for the design storm if other water quantity management controls are not available prior to discharge from the airport. This is typically a 10-, 25-, or 100- year recurrence interval storm of 1 to 3 days duration event. Avoid designs that retain water in the swale for more than 24 hours following the event.
- **Dry swales and drainage ditches must not be designed or located where they will preclude crash or fire vehicle access on the airport airside in designated safety or object free areas.**

c.2 Wet Swales, Drainage Ditches, Channels, and Canals

Wet swales, drainage ditches, channels, and canals function as extended “linear” treatment ponds where the effectiveness depends on vegetation in the system, flow rates, hydraulic residence time (RT), hydraulic residence time distribution (RDT) and similar. Their use should be coordinated with an FAA Qualified Wildlife Biologist to verify that they will not become a wildlife attractant. In some cases, the swale/ditch/channel/canal can be allowed or even encouraged to support emergent vegetation such as that shown in Figure 605-6. This type of vegetation may be appropriate where it discourages use by bird species that are commonly found in the specific airport environment. In other cases, the wet swale/ditch/channel/canal should be designed such that its side slopes and depths limit emergent vegetation since it will attract bird species common to the specific airport area. This is shown in Figure 605-7. The selection must be made early in the design process since flow rates through the swale/ditch/channel/canal and its treatment effectiveness will be influenced by the presence or absence of vegetation.

STATEWIDE AIRPORT STORMWATER BEST MANAGEMENT PRACTICES MANUAL



Figure 605-6 Vegetated Wet Swale



Figure 605-7 Steep-Sided Wet Swale

1. BMP Efficiency Information

The treatment efficiency of a wet swale/ditch/channel/canal will depend on its specific design features. These will include vegetation, geometry, crenellations/submerged vanes, and flow volumes and rates. They may be estimated using particle settling data and correlations between particles and concentrations of the specific nutrient or other pollutant. The particle size distribution (PSD) in Table 605-3 that follows may be used for runoff directly entering the wet swale/ditch/channel/canal. Alternatively, a PSD can be developed from site-specific testing. The treatment efficiency is based on particle settling and trap efficiency that the wet swale/ditch/channel/canal provides and the correlations with the nutrients. A typical correlation for Total Nitrogen removal is 50% of the particles or sediment removed. A typical correlation for Total Phosphorus removal is 70% of the particles or sediment removed, since Total Phosphorus is primarily adsorbed to particles. Specific testing or reference literature

STATEWIDE AIRPORT STORMWATER BEST MANAGEMENT PRACTICES MANUAL

correlating nitrogen and/or phosphorus removal with particle removal may be used in lieu of these general values subject to the concurrence of the regulatory agencies. The settling characteristics may be developed using the provided PSD with a Navier-Stokes equation using Computational Fluid Dynamics (CFD), analytic equations, spreadsheets, or other equivalent method or software. The efficiency estimated using the software or analytic equations may be directly used in the continuous simulation models for average annual load calculations. If the system is downstream of another BMP other than overland flow, the PSD must be developed based on the outflow modelled for that system. Similarly, if the system is upstream of another BMP, the modelled discharge PSD from this element will be an inflow PSD to the downstream system.

As an alternate to developing site specific treatment efficiencies, FDEP or WMD published efficiencies may be available and used for load reduction calculations. When this is done as part of a treatment train, the efficiencies, design criteria, and element limitations imposed by FDEP or WMD must be consistently followed.

Table 605-3 Particle Size Distribution for Settling Computations

% Finer	Particle Size (µm)	Particle Size (ft x 10 ⁻⁶)
90	95	312
80	50	164
60	32	105
50	27	88.6
40	19	62.3
20	11	36.1
10	6	19.7
1	1.5	4.92

2. Design Criteria

The design criteria for wet systems on airport projects often cannot be established a-priori except for those that are safety related, or for those with published efficiencies for specific designs. Construction materials shall not be contributors of nitrogen or phosphorus to the system.

Safety-related criteria are provided in FAA Design Circular 150/5300-13 with respect to geometries and safety areas and in 150/5200-33 with respect to hazardous wildlife attractants including proximity to aircraft operating areas and design features. Design features for wildlife hazard minimization should follow USDA and FAA guidance and be coordinated with an FAA Qualified Wildlife Biologist. Safety-related criteria on the landside are access related to minimize the possibility of drowning in a wet system due to either intentional or inadvertent entry. Since FAA criteria to discourage wildlife generally require side slopes of 2H:1V or steeper even on landside areas, this will usually involve a combination of fencing to prevent intentional entry and select safety features, such as steps and possibly throw rings, for unintentional entry.

Wet swales, drainage ditches, channels, and canals must not be designed or located where they will preclude crash or fire vehicle access on the airport airside in designated safety or object free areas.

STATEWIDE AIRPORT STORMWATER BEST MANAGEMENT PRACTICES MANUAL

d. Wet Detention Systems (FAA Ponds)

Wet detention systems are not a preferred water quality management method on airports but may be required by the physical and site use conditions. They were initially excluded from this BMP Manual for three reasons. First, no field verification testing of ponds meeting FAA/USDA criteria to reduce wildlife attractants had been completed. Second, verification of using particle settling equations, either directly or in more sophisticated models, such as CFD, had not been verified for stormwater treatment although long accepted in wastewater treatment design. Finally, presumptive designs with littoral shelves generally accepted for water quality management were identified as potential wildlife attractants and hazards and contrary to safety concerns on and near airports. Since the March and April 2013 revisions of this BMP Manual were published, a full-scale FAA/USDA pond system was created by retrofitting existing ponds into a crenellated (baffled) configuration and monitoring the retrofit for both water quality performance and wildlife hazard reduction. This project was completed at the Naples Municipal Airport, and the study results for both water management and wildlife hazard reduction are available in separate reports. These are, respectively, *Technical Report on the Water Management Performance of the FAA Pond at Naples Municipal Airport* and *Technical Report on the Wildlife/Bird Monitoring of the FAA Pond at Naples Municipal Airport*. The results indicated the performance equal to presumptive designs can be achieved in much smaller footprints and without the typical littoral shelves. These results reflect inflows of both landside and airside stormwater, with the predominant pollutant load coming from landside sources. Also, the design demonstrated a 60% reduction of hazardous bird and wildlife activity in the ponds compared to activity in these ponds before they were retrofitted. This is a substantial safety benefit. Additionally, published and peer-reviewed papers have demonstrated using data collected from the Naples Demonstration Project, other projects, and physical scale models that use of particle settling models, equations, designs, and correlations can be used to effectively establish treatment efficiencies for wet BMPs for stormwater quality management.

1. BMP Efficiency Information

The treatment efficiency of a FAA pond will depend on its specific design features. These will include vegetation, geometry, crenellations/submerged vanes, baffles, and flow volumes and rates. They may be estimated using particle settling data and correlations between particles and concentrations of the specific nutrient or other pollutant. The particle size distribution (PSD) in Table 605-3 above may be used for runoff directly entering the wet swale/ditch/channel/canal. Alternatively, a PSD can be developed from site-specific testing. The treatment efficiency is based on particle settling and trap efficiency that the wet swale/ditch/channel/canal provides and the correlations with the nutrients. A typical correlation for Total Nitrogen removal is 50% of the particles or sediment removed. A typical correlation for Total Phosphorus removal is 70% of the particles or sediment removed. Specific testing or reference literature correlating nitrogen and/or phosphorus removal with particle removal may be used in lieu of these general values subject to the concurrence of the regulatory agencies. The settling characteristics may be developed using the provided PSD with a Navier-Stokes equation using Computational Fluid Dynamics (CFD), machine learning (ML) models, analytic equations, spreadsheets, or other equivalent method or software that combine CFD and ML. The efficiency estimated using the software or analytic equations may be directly used in the continuous simulation models for average annual load calculations. If the system is downstream of another BMP other than overland flow, the PSD must be developed based on the outflow modelled for that system. Similarly, if the system is

STATEWIDE AIRPORT STORMWATER BEST MANAGEMENT PRACTICES MANUAL

upstream of another BMP, the modelled discharge PSD from this element will be an inflow PSD to the downstream system.

As an alternate to developing site-specific treatment efficiencies, FDEP, or WMD published efficiencies may be available and used for load reduction calculations. When this is done as part of a treatment train, the efficiencies, design criteria, and element limitations imposed by FDEP or WMD must be consistently followed.

2. Design Criteria

The design criteria for wet systems on airport projects often cannot be established a-priori without modeling from CFD possibly in combination with ML or the combination thereof except for those that are safety related, or for those with published efficiencies for specific designs. An airport-compatible, specific pond design with verified efficiencies based on the study done at Naples Airport is provided in **Appendix J**.

Safety-related criteria are provided in FAA Design Circular 150/5300-13 with respect to geometries and safety areas and in 150/5200-33 with respect to hazardous wildlife attractants including proximity to aircraft operating areas and design features. Design features for wildlife hazard minimization should follow USDA and FAA guidance and be coordinated with an FAA Qualified Wildlife Biologist. Safety-related criteria on the landside are access related to minimize the possibility of drowning in a wet system due to either intentional or inadvertent entry. Since FAA criteria to discourage wildlife generally require side slopes of 2H:1V or steeper even on landside areas, this will usually involve a combination of fencing to prevent intentional entry and select safety features, such as steps and possibly throw rings, for unintentional entry.

Construction materials shall not be contributors of nitrogen or phosphorus to the system.

e. **Other Retention Treatment Methods**

Other treatment systems that retain and infiltrate stormwater may be incorporated into the BMP treatment train to achieve the load reduction or water quality specified in Florida Administrative Code. Items such as underground retention and exfiltration systems can reduce stormwater pollutant concentrations and/or loads. These are not part of General Permit 62-330-449 F.A.C. but may be permittable for Individual Permits for airport projects per 62-330.301 F.A.C. The load reduction efficiencies of these BMPs should be used based on Florida-based monitoring and literature and documented in the project calculations. Specifically, refer to *Applicant's Handbook Volume I*, reference documents listed in **Appendix A**, information published in peer reviewed literature or data provided by the Water Management Districts for design criteria applicable to these systems. Proximity to areas where ground water can re-emerge into surface waters or in spring protection areas must be considered in the design and use of these systems.

f. **Compensating Stormwater Treatment**

Compensating Stormwater Treatment is a valid option for airport stormwater management where hazard reduction is the primary concern and other options are not available. This is not included in General Permit 62-330-449 but may be an option under an Individual Permit. Where site, drainage basin, or hazard conditions suggest Compensating Stormwater Treatment is appropriate, however, conferencing with the Water Management District in advance of design is essential. It is necessary to identify facilities or areas within the drainage basin that can be built

STATEWIDE AIRPORT STORMWATER BEST MANAGEMENT PRACTICES MANUAL

or retrofitted to provide Compensating Treatment. A Benefit Cost Analysis should precede the decision to go ahead with this option. It will be necessary to establish the process to use if the on-airport land use changes from that the off-site system was designed and permitted for. Legal responsibility for the system must also be defined. Refer to Section 9.7 of the *Applicant's Handbook Volume 1*.

1. Applicability

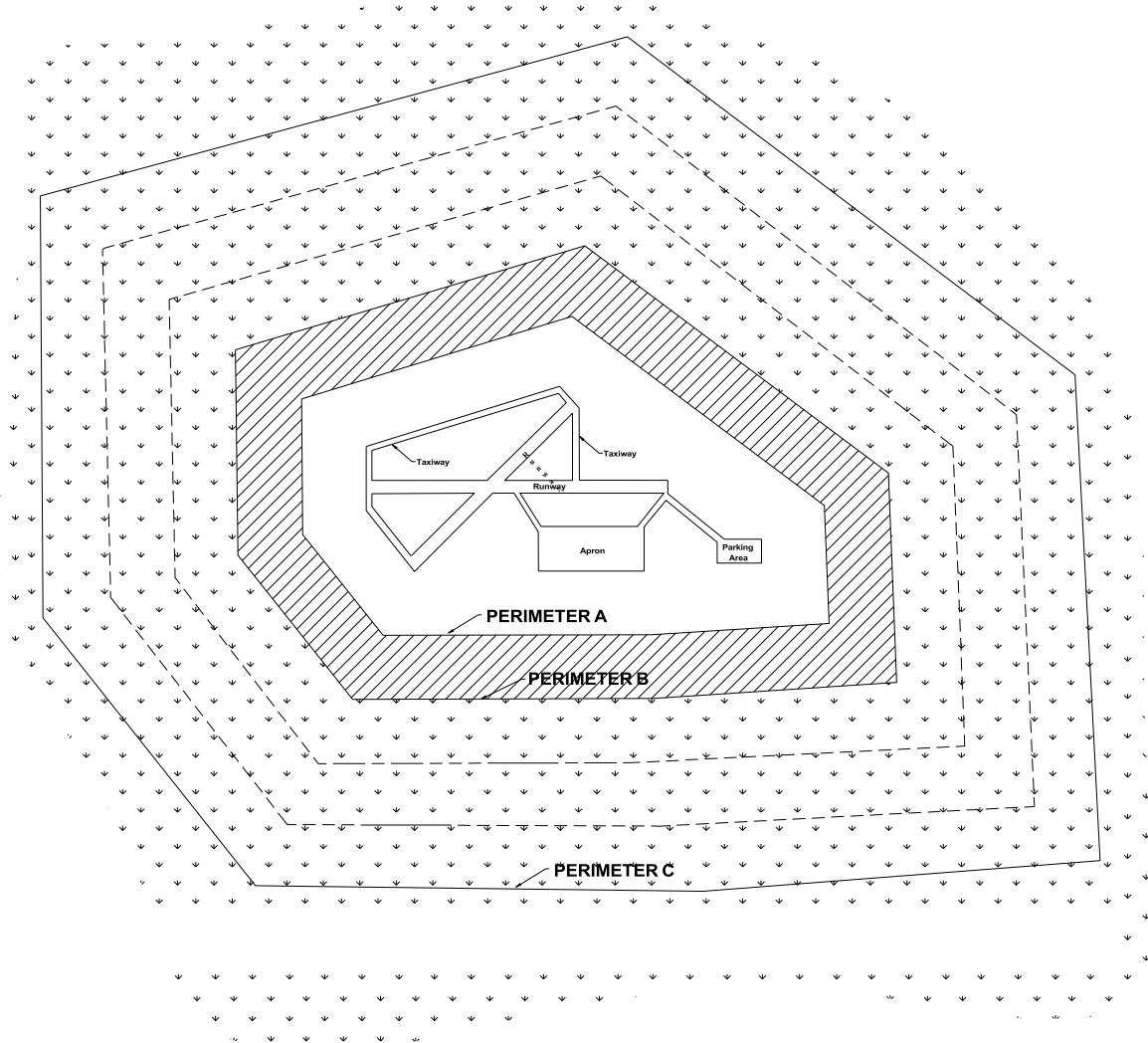
- Other airside stormwater management options are not feasible because of hazard issues or land availability.
- The drainage basin containing the airport includes facilities that can be retrofitted to achieve equivalent pollutant load reduction and flood attenuation.
- The airport location within the drainage basin is consistent with off-site stormwater management. Airports that discharge directly to areas with flooding problems or impaired waters may be unable to use this option.
- The off-site system can be located where it does not create new or exacerbate existing hazardous wildlife attraction.
- Benefit Cost Analysis indicates a favorable ratio for this approach.

2. Design Criteria

- Water quantity modeling must extend into the drainage basin sufficiently to evaluate the effect of discharge from the airport and the effectiveness of off-site stormwater quantity management. Typically, the 10-, 25-, and/or 100-year events of 1 to 3 days duration require evaluation. Other events may also require evaluation.
- Water quality evaluation must include the following steps:
 1. Calculate the pre-development and post-development loadings expected from the airport development using the Event Mean Concentrations and the method of Section 505 of this manual.
 2. Calculate the required load reduction to meet the loads from minimum performance standards of Section 8 of the *Applicant's Handbook Volume 1* and from a natural vegetative community.
 3. Estimate the existing annual loads expected from the off-site area to be treated.
 4. Calculate the load reduction necessary and select a treatment train to provide the load reduction from the off-site area.
- The Compensating Stormwater Treatment area should be located outside the hazard limits shown in Figure 605-8 to the maximum extent practicable.

STATEWIDE AIRPORT STORMWATER BEST MANAGEMENT PRACTICES MANUAL

Separation distances within which hazardous wildlife attractants should be avoided, eliminated, or mitigated.



PERIMETER A: For airports serving piston-powered aircraft, hazardous wildlife attractants must be 5,000 feet from the nearest air operations area.

PERIMETER B: For airports serving turbine-powered aircraft, hazardous wildlife attractants must be 10,000 feet from the nearest air operations area.

PERIMETER C: 5-mile range to protect approach, departure, and circling airspace.

FIGURE 605-8 Hazard Zones for Wildlife Attractants Around Airports
(excerpted directly from FAA Advisory Circular 150/5200-33B Hazardous Wildlife Attractants
On or Near Airports)

STATEWIDE AIRPORT STORMWATER BEST MANAGEMENT PRACTICES MANUAL

606. PROCEDURAL BEST MANAGEMENT PRACTICES

The following Procedural Best Management Practices shall be used on all projects unless the airport demonstrates that they are not appropriate. The listing is not intended as an exclusive set of available Procedural Best Management Practices, and other approaches not listed may be equally valid.

Procedural Best Management Practices are source control BMPs. They are intended to prevent pollutants from getting into the stormwater on the airside through airport management and operational procedures. There must be a commitment on the part of the airport's management to actively assure compliance. Incorporation of Procedural BMPs in the airport's Storm Water Pollution Prevention Plan (SWPPP) is strongly recommended. Training and education, compliance monitoring, and record keeping are elements needed for successful procedural controls.

a. Aircraft Fuel Sumping Control

An operational item affecting stormwater quality on general aviation aprons/ramps is fuel sumping. This is a standard pre-flight procedure for small, piston-powered aircraft. The procedure involves draining several ounces of the airplane's low-lead, high-octane gasoline (100LL AvGas) from low points (sumps) in the fuel system. There may be as few as one to as many as 13 sump points on the airplane.

The purpose of sumping is to prevent fuel contaminated with water or debris, which collects at the low points in the fuel system, from entering the engine during flight. Fuel contamination is particularly hazardous during takeoff. Historically, sumped fuel has been discarded directly onto the pavement surface. On some aircraft models this is unavoidable. However, most aircraft can be sumped into a sight-glass or other container that permits fuel disposal options. This procedural control is applicable to those aircraft and those airports that have implemented this BMP.

1. Applicability

- General aviation aprons/ramps and fueling areas for small, piston-powered aircraft using low-lead aviation fuel
- Aircraft that have sumps that can be drained by one person into a sight-glass or other device

2. Procedure

- Use special devices that permit replacing the sump fuel directly into the aircraft fuel tank while preventing contaminants and water from being reintroduced into the fuel system.
- The airport provides waste fuel tanks at specific locations on the general aviation aprons/ramps and at self-service fuel facilities. These tanks may be used to dispose of sump or contaminated fuel where the pilot-in-command determines the fuel cannot be safely re-introduced into the airplane fuel system.
- Provide appropriate signage directing use of special devices or fuel disposal in designated containers surrounding the apron and in the general aviation terminal facilities.

STATEWIDE AIRPORT STORMWATER BEST MANAGEMENT PRACTICES MANUAL

- Partner with airport users to arrange training and education for line personnel, pilots, and airport staff on the appropriate fuel sumping procedure.

3. Expected Concentration Reduction Efficiencies

This procedure has the potential to reduce the amount of leaded fuel discarded onto general aviation aprons/ramps by an average of 2 gallons per year per aircraft.

b. Turf Management

Overland flow is effective in reducing non-nutrient pollutants common in stormwater from the airport airside on both a concentration and load basis. However, nutrients of the nitrogen and phosphorus series may increase in concentration as water flows overland. Any load reduction from overland flow of these is then solely from infiltration. Moreover, excepting dry retention, no structural system effectively reduces both the nitrogen and phosphorus components to required levels. Consequently, source control is the best option for managing these pollutants. It is much easier to prevent nutrients from getting into stormwater than it is to remove them. Airside turf management should be used to reduce nutrient loading in existing and developing areas.

1. Applicability

- All airside infield and vegetated areas.

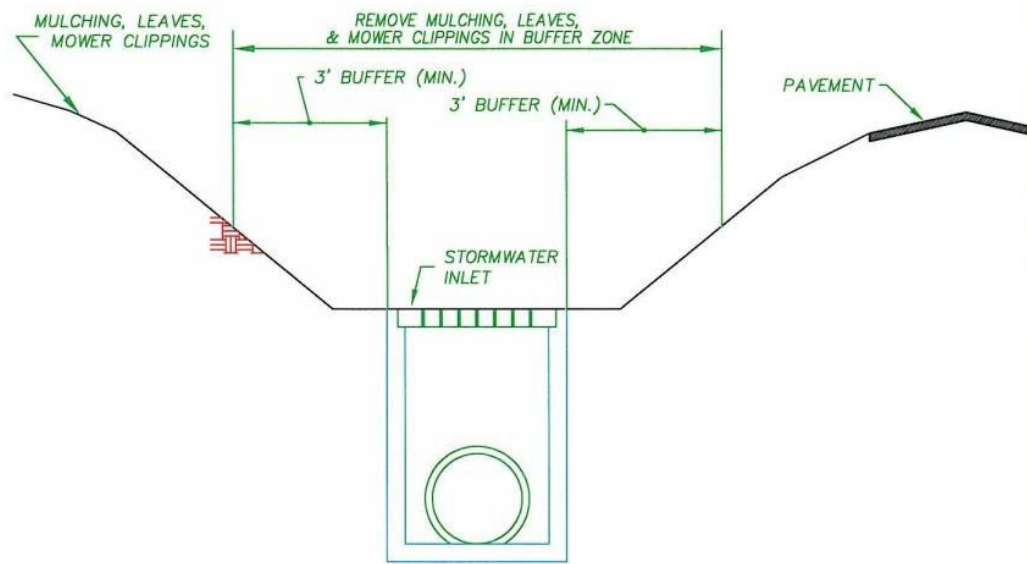
2. Procedure

- Test soil to determine fertilizer needs for phosphorus, potassium, and micro-nutrients.
- Nitrogen shall be applied at a rate not exceeding 1 pound per 1,000 square feet and at least 50% of the nitrogen in fertilizer shall be slow release.
- Mow grasses with mulching mowers to heights of 3 to 4 inches every 7 to 10 days during the growing season. Leave clippings in place except for a 3-foot buffer zone around inlets (Figure 606-1) or from wet pond water surfaces. If practicable, remove grass cuttings in the buffer zone. As grass clippings accumulate during mowing, less fertilizer of all types may be needed.
- Reference the *Florida Yards and Neighborhoods* and *Florida Green Industries Best Management Practices for Protection of Water Resources in Florida* publications available from the University of Florida Extension Service for turf management guidelines. These publications can be downloaded from:
<http://www.dep.state.fl.us/water/nonpoint/pubs.htm>
<http://www.floridayards.org/index.php>

c. Sweeping

Airfield aprons/ramps and rarely runways and taxiways are subject to sweeping as a safety measure at most air carrier and some general aviation airports. The procedure can be modified to serve as a water quality BMP.

STATEWIDE AIRPORT STORMWATER
BEST MANAGEMENT PRACTICES MANUAL



**FIGURE 606-1: MOWING BUFFER AROUND INLETS
NTS**

**FLORIDA AIRPORTS STORMWATER
BEST MANAGEMENT PRACTICES MANUAL**

STATEWIDE AIRPORT STORMWATER BEST MANAGEMENT PRACTICES MANUAL

1. Applicability

- Terminal, cargo, and general aviation aprons/ramps where the airport is equipped to do the procedure.

2. Procedure

- Sweep the apron with a vacuum sweeper that collects dust and debris from the pavement for maximum benefit. Broom only sweepers that collect the sweepings may also be used at reduced effectiveness. Sweepers that simply clear debris from the pavement into adjacent grass areas do not qualify as a BMP since the material is not removed. Sweepings should be collected and sent to the appropriate landfill.
- Sweeping should be as frequent as practicable with once per week recommended for consistent and continuing load reductions. Less frequent sweeping is beneficial but may not be sufficient as a BMP as opposed to a simple safety practice.
- Keep account of the weight of the material collected by sweeping and properly disposed to determine the BMP effectiveness.

3. Expected Constituent Reduction Efficiencies

Table 606-1
Expected Nutrient Reduction from Sweeping with Collecting Vacuum and Broom Sweepers

CONSTITUENT	Pounds Removed per 2,000 Pounds Sweepings Collected
Total Phosphorus	0.61
Total Nitrogen	1.31

STATEWIDE AIRPORT STORMWATER BEST MANAGEMENT PRACTICES MANUAL

Section 7 MAINTENANCE

701. SYSTEM MAINTENANCE

The stormwater management system at any airport is a major infrastructure investment, on par with the airfield pavement system. Airfield pavement management is required by FAA if an airport receives Airport Improvement Program grants. It is an established management program and requirement. The stormwater management system must also be managed but this requirement of Florida's Environmental Resource Permit system is not as well understood or practiced. Regular maintenance of all BMPs is required by Environmental Resource Permit. Additionally, a commonsense approach to maintaining BMPs can increase the effectiveness and reliability of the airport stormwater management system.

1. Applicability

- All airport stormwater management systems.

2. Procedure

- Prepare a System Maintenance Manual at the time of the project design. The manual must describe the maintenance inspection requirements, the criteria triggering maintenance activity and the applicable maintenance activities for the specific system. Examples include:
 - Allowable sediment accumulation in a pond or swale before dredging to re-establish the system is needed. This must include a timetable for measurements, how to conduct the measurements, and the criteria to do the maintenance. Sediment accumulation may be calculated based on the difference in the modelled incoming and outgoing loads of the system on an annual average basis. The allowable accumulation may be based on either a resuspension velocity of the Mean Annual (2.33-year storm) of average annual flows or hydraulic efficiency required for the system quantity management function.
 - Reduced infiltration due to particulate clogging of a dry retention or dry swale sides and bottoms. Visual indicators such as water standing for extended periods or significant softening of the bottoms observed during maintenance are examples of indicators that can be included.
 - Indicators of nutrient overload such as algal blooms and similar and actions to initiate when these are observed.
- Clean oil-water separators to prevent excess accumulations of petroleum products and possible overflows of the product out of the system and dispose with licensed petroleum waste handler.
- Clean inlets and sediment traps of accumulated solids periodically and dispose of the material at appropriate landfills.
- Clean pipes of accumulated sediments and collect, weigh, and properly dispose of these when the sediment at outlets or inlets exceeds the prescribed values in the System Maintenance Manual.
- Maintain vegetation consistent with the Wildlife Hazard Management Plan and the hydraulic and section criteria established during design and provided in the Maintenance Manual.
- Repair erosion on pond slopes, swales, and other areas when observed.
- Keep inlet and outlet structures in good repair.

STATEWIDE AIRPORT STORMWATER BEST MANAGEMENT PRACTICES MANUAL

The following Figures 701-1 through 701-7 illustrate some good and poor maintenance practices and conditions.



Figure 701-1 Well Maintained and Functioning Wet FAA Pond



Figure 701-2 Algal Build Up and Bloom Requiring Maintenance

**STATEWIDE AIRPORT STORMWATER
BEST MANAGEMENT PRACTICES MANUAL**



Figure 701-3 Well Maintained and Functioning Dry Swale



Figure 701-4 Erosion Damage in Wet Swale

**STATEWIDE AIRPORT STORMWATER
BEST MANAGEMENT PRACTICES MANUAL**



Figure 701-5 Clogged Inlet Pipes



Figure 701-6 Well Maintained and Functioning Dry Retention Area

**STATEWIDE AIRPORT STORMWATER
BEST MANAGEMENT PRACTICES MANUAL**



Figure 701-7 Inlet Structure Requiring Maintenance

APPENDIX A

REFERENCES

APPENDIX A

References

- 1) American Concrete Pipe Association, “Design Data 2 Aircraft Loads.”
- 2) American Concrete Pipe Association, “Design Data 6 Loads and Supporting Strengths - Elliptical and Arch Pipe.”
- 3) American Concrete Pipe Association, “Design Data 11 Hydraulic Capacity of Culverts.”
- 4) Bedient, P.B. and W.C. Huber, Hydrology and Floodplain Analysis, Third Edition, Prentice Hall, Inc., New Jersey, 1992
- 5) Berretta, C. and John Sansalone, “Fate of Phosphorus Fractions in an Adsorptive-Filter subject to Intra- and Inter-Event Runoff Phenomena,” Journal of Environmental Management, Volume 103, July 2012, pp. 83-94
- 6) Berretta, C. and John Sansalone, “Hydrologic Transport and Partitioning of Phosphorus Fractions,” Journal of Hydrology, Volume 403, S 1-2, June 2011, pp. 25-36
- 7) Beretta, C. and John Sansalone, “Speciation and Transport of Phosphorus in Source Area Rainfall—Runoff,” Water Air and Soil Pollution, Volume 222, Issues 1-4, November 2011
- 8) Bras, R.L and Ignacio Rodriguez-Iturbe, Random Functions and Hydrology, Dover Publications, Mineola, NY, 1993
- 9) Brater, E.F. and Horace Williams King, Handbook of Hydraulics, for the Solution of Hydraulic Engineering Problems, Sixth Edition, McGraw-Hill Book Company, New York, 1976
- 10) Breault R.F., Smith, K.P., Sorenson, J.R., Residential Street-Dirt Accumulation Rates and Chemical Composition, and Removal Efficiencies by Mechanical - and Vacuum-Type Sweepers, Scientific Investigations Report 2005-5184, U.S. Department of the Interior, U.S. Geological Survey, 2005
- 11) Cho, H. and John Sansalone, “Physical Modeling of Particulate Matter Washout from a Hydrodynamic Separator,” Journal of Environmental Engineering, Volume 139, Issue 1, January 2013
- 12) Chow, V.E., Ph.D., Open-Channel Hydraulics, McGraw-Hill Company, New York, 1959
- 13) Chow, V.E., Ph.D., David R. Maidment and Larry W. Mays, Applied Hydrology, McGraw- Hill Company, New York, 1988
- 14) Cleary, Edward C and Richard A. Dolbeer, Wildlife Hazard Management at Airports, U.S. Department of Transportation and U.S. Department of Agriculture, January, 2000

- 15) Cristina, C.M. and John J. Sansalone, "First Flush, Power Law and Particle Separation Diagrams for Urban Storm-Water Suspended Particulates," Journal of Environmental Engineering, Volume 129, Issue 4, April 2003
- 16) DeWiest, Roger J.M., Geohydrology, John Wiley & Sons, Inc., New York, 1965
- 17) Florida Administrative Code 62-330.301, Conditions for Issuance of Individual and Conceptual Approval Permits
- 18) Florida Administrative Code 62-330.302, Additional Conditions for Issuance of Individual and Conceptual Approval Permits
- 19) Florida Administrative Code 62-330.449, General Permit for Construction, Operation, Maintenance, Alteration, Abandonment or Removal of Airport Airside Stormwater Management Systems
- 20) Florida Automated Weather Network, (FAWN)
- 21) Federal Aviation Administration, Advisory Circular 150/5300-13A, *Airport Design*, Superintendent of Documents, U.S. Government Printing Office, Washington, DC, February 2014
- 22) Federal Aviation Administration, Advisory Circular 150/5200-33C, *Hazardous Wildlife Attractants on or near Airports*, Superintendent of Documents, U.S. Government Printing Office, Washington, DC, February 2020
- 23) Federal Aviation Administration, Advisory Circular 150/5320-5D, *Airport Drainage Design*, Superintendent of Documents, U.S. Government Printing Office, Washington, DC, August, 2013
- 24) Finnemore, E.J. and Normal N. Hantzsche, "Ground-Water Mounding Due to On-Site Sewage Disposal," Journal of Irrigation and Drainage Engineering, Volume 109, Issue 2, 1983, pp. 199-210
- 25) Florida Department of Environmental Protection and Water Management Districts, "Environmental Resource Permit Applicant's Handbook Volume I."
- 26) Florida Department of Environmental Protection, "The Florida NPDES Stormwater Permitting Program for Construction Activity."
- 27) Florida Department of Transportation, "Application Assessment for the Florida Statewide Airport Stormwater Study," Tallahassee, Florida, 2007.
- 28) Florida Department of Transportation, "Drainage Handbook, Hydrology," Tallahassee, Florida, February 2012

- 29) Florida Department of Transportation, "Drainage Manual," Tallahassee, Florida, January 2016
- 30) Florida Department of Transportation, "Drainage Manual, Volume 2A - Procedures," Tallahassee, Florida, 1987
- 31) Florida Department of Transportation, "Florida Land Use, Cover and Forms Classification System Handbook," Florida Department of Transportation Surveying and Mapping Geographic Mapping Section, Tallahassee, Florida, January 1999
- 32) Florida Department of Transportation, "FAA Pond Design Criteria, Water Treatment Modeling Report," Tallahassee, Florida, December 2010
- 33) Florida Department of Transportation, "User Manual for the BMP Trains 2020 Model," Tallahassee, Florida, Version 4.3.1, January 30, 2021
- 34) Florida Department of Transportation, "Technical Report for the Florida Statewide Airport Stormwater Study," Tallahassee, Florida, April 2008 revision
- 35) Florida Department of Transportation, "Technical Report on the Water Management Performance of the FAA Pond at Naples Municipal Airport," Tallahassee, Florida, January 2016
- 36) Florida Department of Transportation, "User Manual for the BMP Trains 2020 Model," Tallahassee, Florida, Version 4.3.1, January 30, 2021
- 37) Florida House of Representatives, House Bill 599
- 38) Florida Stormwater Association Educational Foundation, "Methodology for Calculating Nutrient Load Reductions Using the FSA MS4 Load Reduction Assessment Tool," June 2019
- 39) Garofalo, G. and John Sansalone, "Modeling Annual Particulate Matter Separation and Washout by Unit Operations with CFD," Journal of Environmental Engineering, Volume 146, No. 1, January 2020
- 40) Garofalo, G. and John Sansalone, "Urban Drainage Clarifier Load-Response as a Function of Flow, Unsteadiness, and Baffling," Journal of Environmental Engineering, Volume 144, Issue 3, March 2018
- 41) Hantush, M.S., "Growth and Decay of Groundwater-Mounds in Response to Uniform Percolation," Water Resources Research, Volume 3, No. 1, First Quarter, 1967, pp. 227-234
- 42) Herr, C. and John J. Sansalone, "In Situ Volumetric Filtration Physical Model to Separate Particulate Matter from Stormwater," Journal of Environmental Engineering, Volume 141, Issue 9, September 2015
- 43) Jack H. Berryman Institute, Human-Wildlife Conflicts, Volume 3, Number 2 –

Special Topic: Bird Strikes, Utah, 2009

- 44) Kim, J.Y. and John J. Sansalone, “Event-based Size Distributions of Particulate Matter Transported During Urban Rainfall-Runoff Events,” Water Research, Volume 42, Issues 10-11, May 2008
- 45) Kim, J.Y. and John J. Sansalone, “Zeta Potential of Clay-size Particles in Urban Rainfall—Runoff During Hydrologic Transport,” Journal of Hydrology, Volume 356, Issues 1-2, July 2008, pp. 163-173
- 46) Kuang, X., J. Sansalone, G. Ying, V. Ranieri, “Pore-Structure Models of Hydraulic Conductivity for Permeable Pavement,” Journal of Hydrology, Volume 399, 2011, pp. 148-157
- 47) Lambe, T. William, Soil Mechanics, John Wiley & Sons, Inc., New York, 1969
- 48) Li, H., David Spelman, and John Sansalone, “Baffled Clarification Basin Hydrodynamics and Elution in a Continuous Time Domain,” Journal of Hydrology, Volume 595, April 2021
- 49) Li, H. and John Sansalone, “CFD as a Complementary Tool to Benchmark Physical Testing of PM Separation by Unit Operations,” Journal of Environmental Engineering, Volume 146, Issue 11, November 2020
- 50) Liu, B., G. Ying, and J. Sansalone, “Volumetric Filtration of Rainfall Runoff. I: Event-Based Separation of Particulate Matter,” Journal of Environmental Engineering, Volume 136, Issue 12, December 2010
- 51) Liu, H. and John Sansalone, “CFD and Physical Models of PM Separation for Urban Drainage Hydrodynamic Unit Operations,” Water Research, Volume 154, May 2019, pp. 258-266
- 52) Ma, J., Gaoxiang Ying, and John J. Sansalone, “Transport and Distribution of Particulate Matter Phosphorus Fractions in Rainfall-Runoff from Roadway Source Areas,” Journal of Environmental Engineering, Volume 136, Issue 11, November 2010
- 53) Mitchell, J.K., Fundamentals of Soil Behavior, John Wiley & Sons, Inc., New York, 1976
- 54) Parmley, R.O., P.E., Hydraulics Field Manual, McGraw-Hill, Inc., New York, 1992
- 55) Pathapati, S.S. and John J. Sansalone, “Modeling Particulate Matter Resuspension and Washout from Urban Drainage Hydrodynamic Separators,” Journal of Environmental Engineering, Volume 138, Issue 1, January 2012
- 56) Powers, J. Patrick, Construction Dewatering, New Methods and Applications, Second Edition, John Wiley & Sons, Inc, New York, 1992

- 57) Sansalone, J., "Perspective on the Synthesis of Unit Operations and Process (UOP) Concepts with Hydrologic Controls for Rainfall-Runoff," Journal of Environmental Engineering, Volume 131, Issue 7, July 2005
- 58) Sansalone, J., B. Liu, and G. Ying, "Volumetric Filtration of Rainfall Runoff. II: Event-Based and Interevent Nutrient Fate," Journal of Environmental Engineering, Volume 136, Issue 12, December 2010
- 59) Sansalone, J.J., B. Liu, and J.Y. Kim, "Volumetric Clarifying Filtration of Urban Source Area Rainfall Runoff," Journal of Environmental Engineering, Volume 135, Issue 8, August 2009
- 60) Sansalone, J., Christian Berretta, Saurabh Rajee, Quantifying Nutrient Load Associated with Urban Particulate Matter (PM), and Biogenic/Litter Recovery Through Current MS4 Source Control and Maintenance Practices, Florida Stormwater Association Educational Foundation Final Report, May 31, 2011
- 61) Sansalone, J.J. and Chad M. Cristina, "First Flush Concepts for Suspended and Dissolved Solids in Small Impervious Watersheds," Journal of Environmental Engineering, Volume 130, Issue 11, November 2004
- 62) Sansalone, J., Gaoxiang Ying, and Hong Lin, "Distribution of Metals for Particulate Matter Transported in Sources Area Rainfall-Runoff," Journal of Environmental Engineering, Volume 136, Issue 2, February 2010
- 63) Sansalone, J. and G. Ying, "Partitioning and Granulometric Distribution of Metal Leachate from Urban Traffic Dry Deposition Particulate Matter Subject to Acidic Rainfall and Runoff Retention," Water Research, Volume 42, No. 15, September 2008, pp. 4146-4162
- 64) Sansalone, J. and Jia Ma, "Parametric Analysis and Breakthrough Modeling of Phosphorus from Al-Oxide Filter Media," Journal of Environmental Engineering, Volume 137, Issue 2, February 2011
- 65) Sansalone, J. and Jia Ma, "Parametric Evaluation of Batch Equilibria for Storm-Water Phosphorus Adsorption on Aluminum Oxide Media," Journal of Environmental Engineering, Volume 135, Issue 9, September 2009
- 66) Sansalone, J.J. and J.Y. Kim, "Transport of Particulate Matter Fractions in Urban Source Area Pavement Surface Runoff," Journal of Environmental Quality, Volume 37, Issue 5, September 2008, pp. 1883-1893
- 67) Sansalone, J., Saurabh Rajee, Ruben Kertesz, Kerrilynn Maccarrone, Karle Seltzer, Michele Siminari, Peter Simms, Brandon Wood, "Retrofitting Impervious Urban Infrastructure with Green Technology for Rainfall-Runoff Restoration, Indirect Reuse and Pollution Load

Reduction,” Environmental Pollution, Volume 183, December 2013, pp. 204-212

- 68) Sansalone, J. and Zheng Teng, “In Situ Partial Exfiltration of Rainfall Runoff. I: Quality and Quantity Attenuation,” Journal of Environmental Engineering, Volume 130, Issue 9, September 2004
- 69) Selbig W.R., and Bannerman R., “Evaluation of Street Sweeping as a Stormwater- Quality- Management Tool in Three Residential Basins in Madison, Wisconsin,” Scientific Investigations Report 2007–5156, U.S. Department of the Interior, U.S. Geological Survey, 2007
- 70) Sheng, Y., G. Ying, and J. Sansalone, “Differentiation of Transport for Particulate and Dissolved Water Chemistry Load Indices in Rainfall—Runoff from Urban Source Area Watersheds,” Journal of Hydrology, Volume 361, Issue 1, October 2008, pp. 144-158
- 71) South Florida Water Management District, Environmental Resource Permit Applicant’s Handbook Volume II
- 72) Southwest Florida Water Management District, Environmental Resource Permit Applicant’s Handbook Volume II
- 73) Sowers, G.B., and George F. Sowers, Introductory Soil Mechanics and Foundations, Third Edition, MacMillan Publishing Co., New York, 1970
- 74) Spelman, D. and John J. Sansalone, “Is the Treatment Response of Manufactured BMPs to Urban Drainage PM Loads Portable,” Journal of Environmental Engineering”, Volume 144, Issue 4, April 2018
- 75) Spelman, D. and John Sansalone, “Models of Wet Basin Design Response with Residence Time Metrics for Presumptive Guidance,” Journal of Environmental Engineering, Volume 147, Issue 12, December 2021
- 76) St. Johns River Water Management District, Permit Information Manual
- 77) Teng, Z. and John Sansalone, “In Situ Partial Exfiltration of Rainfall Runoff. II: Particle Separation,” Journal of Environmental Engineering, Volume 130, Issue 9, September 2004
- 78) Todd, D.K., Groundwater Hydrology, Second Edition, John Wiley & Sons, New York, 1980
- 79) U.S. Dept. of the Army, Corps of Engineers “Time Lag and Soil Permeability in Groundwater Observations, Bulletin No. 36,” Waterways Experiment Station, Vicksburg, Mississippi (written by M. Juul Hvorslev), 1951
- 80) United States Environmental Protection Agency, Preliminary Data Summary of Urban Storm Water Best Management Practices, United States Environmental Protection Agency, Office of Water, Washington, DC, August, 1999

- 81) United States Environmental Protection Agency, Storm Water Management Model Reference Manual Volume III – Water Quality, United States Environmental Protection Agency, Office of Research and Development, Water Supply and Water Resources Division, Washington, DC, July 2016
- 82) United States Environmental Protection Agency, Storm Water Management Model User's Manual, United States Environmental Protection Agency, Office of Research and Development, Water Supply and Water Resources Division, Washington, DC.
- 83) Wang, H.F., and Mary P. Anderson, Introduction to Groundwater Modeling, Finite Difference and Finite Element Methods, W.H. Freeman and Company, San Francisco, 1982
- 84) Wanielista, M.P. and Y.A. Yousef, Stormwater Management, John Wiley & Sons, New York, 1993
- 85) Wu, T. and John Sansalone, "Mass Transfer Kinetics of Phosphorus to Filter Media from Wastewater, Storm Water, and Surrogate Matrices," Journal of Environmental Engineering, Volume 139, Issue 1, January 2013
- 86) Wu, T. and J. Sansalone, "Phosphorus Equilibrium. I: Impact of AIOx Media Substrates and Aqueous Matrices," Journal of Environmental Engineering, Volume 139, Issue 11, November 2013
- 87) Wu, T. and J. Sansalone, "Phosphorus Equilibrium. II: Comparing Filter Media, Models, and Leaching," Journal of Environmental Engineering, Volume 139, Issue 11, November 2013
- 88) Ying, G. and J. Sansalone, "Gravitational Settling Velocity Regimes for Heterodisperse Urban Drainage Particulate Matter," Journal Environmental Engineering, Volume 137, Issue 1, January 2011
- 89) Ying, G. and J. Sansalone, "Transport and Solubility of Hetero-disperse Dry Deposition Particulate Matter Subject to Urban Source Area Rainfall-Runoff Processes," Journal of Hydrology, Volume 383, Issues 3-4, March 2010, pp. 156-166
- 90) Zhang, H. and J. Sansalone, "Partitioning and First-Flush of Nitrogen in Rainfall-Runoff from an Urban Source Area," Journal of Environmental Engineering, Volume 140, Issue 8, August 2014

APPENDIX B

GLOSSARY

APPENDIX B

Glossary

AIRPORT DISTRICT OFFICE (ADO). Administrative regional office of FAA that oversees airport development projects.

ADVISORY CIRCULAR (AC). A series of external FAA publications consisting of all non-regulatory material of a policy, guidance, and informational nature.

AIRPORT LAYOUT PLAN (ALP). The plan of an airport showing the layout of existing and proposed airport facilities.

AIR CARGO. Freight, mail, and express packages transported by air. Includes perishable foods and livestock.

AIR CARRIER. A person who holds or who is required to hold an air carrier operating certificate issued by FAA while operating aircraft having a seating capacity of more than 30 passengers.

AIR CARRIER AIRCRAFT. An aircraft with a seating capacity of more than 30 passengers that is being operated by an air carrier.

AIR CARRIER OPERATION. The takeoff or landing of an air carrier aircraft that includes the period of time from 15 minutes before and until 15 minutes after the takeoff or landing.

AIR TRAFFIC CONTROL TOWER (ATCT). A terminal facility that uses air/ground communications, visual signaling, and other devices to provide ATC services to aircraft operating in the vicinity of an airport or on the movement area. Authorizes aircraft to land or takeoff at the airport controlled by the tower or to transit the Class D airspace area regardless of flight plan or weather conditions (IFR or VFR). A tower may also provide approach control services (radar or nonradar).

AIRPORT. Any area of land or water, or any manmade object or facility located therein, which is used, or intended for public use, for the landing and takeoff of aircraft, and any appurtenant areas which are used, or intended for public use, for airport buildings or other airport facilities or rights-of-way.

AIRPORT HAZARD. Any structure or object or **WILDLIFE HAZARD** found on or in the vicinity of a public-use airport, or any use of land near such airport, which obstructs or causes an obstruction to the airspace required for the flight of aircraft in landing or taking off at such airport, has the potential for damaging aircraft collision, or is otherwise hazardous to operating at such airport.

AIRPORT IMPROVEMENT PROGRAM (AIP). The AIP provides federal funding from the Aviation Trust Fund for airport development, airport planning, noise compatibility planning, and similar programs. The AIP is implemented under various

authorization acts that cover a specific time period.

AIRPORT MASTER PLAN. Concept of the ultimate development of a specific airport. It presents the research and logic from which the plan evolved and displays the plan in graphic and written form.

AIRSIDE FACILITIES (AIRFIELD). Aircraft operations side of an airport including runways, taxiways, aprons, gate areas, and the terminal area airspace for approach and departure paths.

ALTERNATIVE DESIGN CRITERIA. Stormwater management system design criteria that offer reasonable assurance of meeting the pollutant load reductions, water quality standards, and flood protection requirements of the “Conditions of Issuance” for a permit. This is synonymous with “Non-Presumptive Design Criteria.”

APPLICANT’S HANDBOOK. A document incorporated by reference in the Environmental Resource Permitting rules of the FDEP or Water Management Districts that provides design, administrative and technical criteria for permit applicants.

APPROACH and DEPARTURE AIRSPACE. The airspace, within 5 statute miles of an airport, through which aircraft move during takeoff or landing.

APRON (also RAMP, TARMAC). Holding bay located at various points off a taxiway for loading or unloading of passengers or cargo, refueling, maintenance, or storage of aircraft.

ATTENUATION. With respect to stormwater, storage and/or a controlled release of discharge to an approximate a pre-determined rate of flow.

BMP (BEST MANAGEMENT PRACTICE). A structural or procedural control implemented to reduce stormwater pollutant loadings and minimize flooding. Structural BMPs are physical systems or structures such as ponds, swales or overland flow that reduce pollutant loadings and are technology based. That is, the best available and applicable technology, which may involve one or more systems or structures for pollutant load reduction, should be used. Procedural BMPs are activities and processes followed to reduce or eliminate exposure or introduction of pollutants to storm or surface waters.

BASIS OF REVIEW. A document incorporated by reference in the rules of the SFWMD and the SWFWMD that provides design, administrative and technical criteria for permit applicants.

CLEARWAY (CWY). A defined rectangular area beyond the end of runway cleared or suitable for use in lieu of a runway to satisfy takeoff distance requirements.

CLOSED DRAINAGE BASIN. A closed drainage basin is an internally drained watershed in which the runoff does not have a surface outfall up to the 100-year level.

COMMERCIAL SERVICE AIRPORTS. Public-use airports receiving scheduled

passenger service and certified under FAR Part 139.

COMPENSATION. Measures provided to offset adverse impacts to water quality or wetlands.

CONCEPTUAL APPROVAL. Conceptual Approval or Letter of Conceptual Approval means an Environmental Resource Permit issued by the Water Management District approving the concepts of a master plan for a surface water management system. Conceptual approvals are binding upon the District and the permittee based upon the rules in effect at the time the conceptual application is filed on the public record. Construction and operation permits for each phase will be reviewed under the permitting criteria in effect when the application for conceptual approval was filed. A Conceptual Approval does not authorize construction.

CONDITIONS OF ISSUANCE. A set of impacts, standards and considerations that a stormwater management system and its owner/operator and designer must successfully address to receive a permit allowing construction and operation of the system.

CONSTRUCTION PERMIT. An Environmental Resource Permit issued by the Water Management District or FDEP authorizing construction, alteration or abandonment of a surface water management system in accordance with the terms and conditions of the permit.

CONTINUING FLORIDA AVIATION SYSTEM PLANNING PROCESS (CFASPP). CFASPP is the structured process for preparing and maintaining a statewide, twenty-year plan for aviation facility development in Florida. Guiding CFASPP are one statewide and nine regional Steering Committees make aviation system improvement recommendations to the Department of Transportation. These are ad hoc committees composed of volunteer professionals representing airport, airport authorities, local and regional planners, local government, and private enterprise.

CONTROL TOWER. A central operations facility in the terminal air traffic control system consisting of a tower cab structure (including an associated IFR room if radar-equipped) using air/ground communications and/or radar, visual signaling, and other devices to provide safe and expeditious movement of terminal air traffic.

DESIGN STORMS. For modeling purposes, a storm of such magnitude that its probability of occurrence is only once in a specified interval (e.g., 25 years, 100 years, etc.) for a specified duration (e.g., 24-hour, 3-day, etc.).

DETENTION. The collection and temporary storage of stormwater with subsequent gradual release, a few hours to a few days.

DETENTION VOLUME. The volume of open surface storage upstream of the discharge structure, measured between the overflow elevation and control elevation.

EPA United State Environmental Protection Agency

ENVIRONMENTAL RESOURCE PERMIT (ERP). Environmental Resource Permitting, formerly called Management and Storage of Surface Waters, or MSSW permitting, requires permits for construction and operation of "new" surface water management systems, or alteration to an existing system. In simple terms, a "system" is a collection of project related facilities, man-made or natural, that collect, convey, contain or control surface waters. An Environmental Resource Permit (ERP) must be obtained before beginning construction or an activity that would affect wetlands, alter surface water flows, or contribute to water pollution. The ERP combines wetland resources permitting and MSSW permitting into a single surface water permit in an effort to streamline the permitting process.

EXFILTRATION. A stormwater system that uses perforated pipe to store stormwater and allow it to exfiltrate out of the pipe, through the surrounding gravel envelope, and into the soil.

FAA. Federal Aviation Administration

FAC. Federal Administrative Code

FAR. Federal Aviation Regulations

FBO. Fixed-Base Operator

FDEP. Florida Department of Environmental Protection

FDOT. Florida Department of Transportation

F.S. Florida Statutes

FLORIDA AVIATION SYSTEM PLAN (FASP). The aviation plan for Florida that provides documentation related to airports and related facilities needed to meet current and future statewide aviation demands.

GENERAL AVIATION AIRPORT. Those airports that do not have scheduled service or have scheduled service with less than 2,500 passengers boarding each year.

HANGAR. A hangar is a closed structure to hold aircraft in protective storage. Most hangars are built of metal. They are used for protection against weather, direct sunlight, maintenance and repair, assembly and storage of aircraft on airfields.

HAZARDOUS WILDLIFE. Species of wildlife (birds, mammals, reptiles) including feral animals and domesticated animals not under control, that are associated with aircraft strike problems, are capable of causing structural damage to airport facilities, or act as attractants to other wildlife that pose a strike hazard. Lists and examples can be found in the FAA/USDA Manuals [Wildlife Hazard Management at Airports](#).

HUB AIRPORT. An airport that receives up to 1 percent or more of the annual U.S. commercial enplanements.

HYDROLOGIC SOIL GROUPS. Refers to soils grouped according to their runoff-producing characteristics following the system promulgated by the U.S. Soil Conservation Service/National Resource Conservation Service. The chief consideration is the inherent capacity of soil bare of vegetation to permit infiltration. Soils are assigned to four groups. **Group A** soils have high infiltration when thoroughly wet and have a low runoff potential. **Group D** soils have very low infiltration and have a high runoff potential. **Group B** and **Group C** soils are intermediate between the Group A and Group D limits.

IDF CURVES. Curves developed by the Florida Department of Transportation, or other agency, to determine rainfall Intensity-Duration-Frequency.

IMPERVIOUS. Land surfaces which do not allow, or minimally allow, the penetration of water; examples are buildings, non-porous concrete and asphalt pavements, and some fine grained soils such as clays.

LANDSIDE FACILITIES. Those parts of an airport serving passengers, including surface transportation, buildings, pavements, and ancillary areas used for commercial, industrial, or other operations.

LARGE HUBS. Those airports that account for at least 1 percent of total U.S. passenger enplanements.

LITTORAL SHELF. A shallow gradual slope of a wet detention system that contains emergent vegetation, provides for a simulation of nutrients, and is a habitat for fish and wildlife.

MEDIUM HUBS. Airports that account for between 0.25 percent and 1 percent of the passenger enplanements.

MOVEMENT AREA. The runways, taxiways, and other areas of an airport which are used for taxiing or hover taxiing, air taxiing, takeoff, and landing of aircraft, exclusive of loading ramps and aircraft parking areas. At towered airports, the movement area is controlled by ATCT during the hours of operation.

NATIONAL PLAN OF INTEGRATED AIRPORT SYSTEMS (NPIAS). The Federal Aviation Administration's long-range national plan for airport development as established in the federal Airport and Airway Improvement Act of 1982. An airport must be included in the NPIAS to be eligible for federal funding.

NATIONAL POLLUTION DISCHARGE ELIMINATION SYSTEM (NPDES). The 1972 Amendments to the Federal Water Pollution Control Act (commonly known as the Clean Water Act or CWA) prohibit the discharge of any pollutant to waters of the United States from a point source unless the discharge is authorized by a National Pollutant Discharge Elimination System (NPDES) permit. The NPDES permitting program was originally designed to track point sources, monitor the discharge of pollutants from specific sources to surface waters, and require the implementation of the controls necessary to minimize the discharge of pollutants. The 1987 Clean Water Act Amendment included certain storm water discharges for new and existing facilities. The NPDES Stormwater Program has been delegated to Florida Department of Environmental Protection.

NON-MOVEMENT AREA. Areas on the airport airside generally used for aircraft parking or access to and from aircraft parking to the runways and taxiways. At towered airports, the non-movement area is not subject to ATCT control. The area, other than that described as the movement area, used for the loading, unloading, or the movement of aircraft. This may include the apron areas and on-airport fuel farms.

NON-PRESUMPTIVE DESIGN CRITERIA. Refer "Alternative Design Criteria."

NORMAL WATER LEVEL. The design starting water elevation used when determining stage/storage design computations in a retention or detention area. A retention or detention system may have two (2) designated "normal water levels" associated with it if the system is designed for both water quality and water quantity.

OBSTACLE FREE ZONE (OFZ). The airspace defined by the runway OFZ and, as appropriate, the inner-approach OFZ and the inner-transitional OFZ, which is clear of object penetrations other than frangible NAVAIDs.

OBSTRUCTION. Any object/obstacle exceeding the obstruction standards specified by FAR Part 77.

OBJECT FREE AREA (OFA). An area on the ground centered on a runway, taxiway, or taxilane centerline provided to enhance the safety of aircraft operations by having the area free of objects except for objects that need to be located in the OFA for air navigation or aircraft ground maneuvering purposes.

PERCOLATION. To seep, drain or permeate through a porous substance or filter, such as the infiltration of water into sand/soil.

PERMEABILITY (k). Also used interchangeably with ***HYDRAULIC CONDUCTIVITY*** is proportionality constant depending on the properties of a soil that reflects its transmission of water. The units are velocity (i.e., feet/day, centimeter/second, etc.)

POLLUTANT. Any substance that is harmful to plant, animal or human life.

PREDEVELOPMENT: Long standing use of the site, calculated by the average annual loading of the 5 years prior to the submittal of the application.

PRESUMPTIVE DESIGN CRITERIA. Stormwater management system design criteria published by the Florida Department of Environmental Protection or the Water Management Districts that, if followed, are rebuttably presumed to meet the water quality standards and pollutant load reductions required by FAC 62-302 and 62-40, respectively.

RELIEVER AIRPORT. A specially designated general aviation airport that reduces congestion at busy commercial service airports by alternate landing areas for business aircraft.

RETENTION. A stormwater treatment system designed to prevent the discharge of a given volume of stormwater runoff into surface waters by complete, on-site storage of that volume.

RUNWAY PROTECTION ZONE (RPZ). Trapezoidal area “off the end of the runway end that serves to enhance the protection of the people and property on the ground” in the event an aircraft lands or crashes beyond the runway end.

RUNWAY SAFETY AREA (RSA). A defined surface surrounding the runway prepared or suitable for reducing the risk of damage to airplanes in the event of an undershoot, overshoot, or excursion from the runway.

RUNWAY. A defined rectangular surface on an airport prepared or suitable for the landing or take off of airplanes.

SEAPLANE BASE. A body of water licensed for operation and basing of seaplanes.

SHOULDER. An area adjacent to the edge of paved runways, taxiways, or aprons providing a transition between the pavement and the adjacent surface; support for aircraft running off the pavement; enhanced drainage; and blast protection.

SMALL HUBS. Airports that enplane 0.05 percent to 0.25 percent of the total passenger enplanements.

SURFACE WATER MANAGEMENT SYSTEM. The collection of facilities, improvements, or natural systems whereby surface waters are collected, controlled, conveyed, impounded, or obstructed. The term includes dams, impoundments, reservoirs, appurtenant works and works as defined in Subsections 373.403(1)-(5), Florida Statutes.

SWPPP (STORMWATER POLLUTION PREVENTION PLAN). A document which identifies sources of and activities at a particular facility that may contribute pollutants to stormwater and commits the operator to specific control measures and time frames to prevent or treat such pollutants.

TSA. Transportation Security Agency

TAXILANE. A taxiway designed for low speed (approximately 15 mph) and precise taxiing. Taxilanes are usually, but not always, located outside the movement area, providing access from taxiways (usually an apron taxiway) to aircraft parking positions and other terminal areas.

TAXIWAY. A defined path established for the taxiing of aircraft from one part of the airport to another.

T-HANGAR. An aircraft hangar in which aircraft are parked alternately tail to tail, each in the T-shaped space left by the other row of aircraft or aircraft compartments.

TOTAL MAXIMUM DAILY LOAD (TMDL). The maximum allowable pollutant loading of a pollutant into a water body such that the water body will meet its applicable water quality standards and designated uses. TMDLs are established for waters that are impaired and not meeting standards.

WATERS OF THE STATE. Those surface waters regulated pursuant to subsection 403.031(12), Florida Statutes.

WET DETENTION SYSTEM. A stormwater management BMP that includes a permanent water pool to provide flood control and to remove pollutants through settling, adsorption by soils and nutrient uptake by the vegetation.

WETLANDS. Those areas that are inundated or saturated by surface water or ground water at a frequency and duration sufficient to support, and under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soils. Soils present in wetlands generally are classified as hydric or alluvial or possess characteristics that are associated with reducing soil conditions described above. These species, due to morphological, physiological or reproductive adaptations, have the ability to grow, reproduce, or persist in aquatic environments or anaerobic soil conditions. Florida wetlands generally include swamps, marshes, bayheads bogs, cypress domes and strands, slough, wet prairies, riverine swamps and marshes, hydric seepage slopes, tidal marshes, mangrove swamps and other similar areas.

WILDLIFE ATTRACTANTS. Any man-made structure, land-use practice, or man-made or natural geographic feature which can attract or sustain **HAZARDOUS WILDLIFE** within the **APPROACH or DEPARTURE AIRSPACE, MOVEMENT AREA, or APRONS** of an **AIRPORT**. These attractants can include but are not limited to architectural features, landscaping, waste disposal sites, wastewater treatment facilities, agricultural or aquacultural activities, surface mining or **WETLANDS**.

WILDLIFE STRIKE. A wildlife strike is deemed to have occurred when:

1. A pilot reports striking one or more birds or other wildlife;
2. Aircraft maintenance personnel identify aircraft damage as having been caused by a wildlife strike;
3. Personnel on the ground report seeing an aircraft strike one or more birds or other

wildlife;

4. Bird or other wildlife remains, whether in whole or in part, are found within 200 feet of a runway centerline, unless another reason for the animal's death is identified;
5. The animal's presence on the airport had a significant negative effect on a flight such as aborted takeoff, aborted landing, high-speed emergency stop, aircraft left pavement area to avoid collision with animal, or similar.

WMD. Water Management District. One of the five Water Management Districts chartered in the State of Florida. These are: Northwest Florida Water Management District (NFWMD), South Florida Water Management District (SFWMD), Southwest Florida Water Management District (SWFWMD), St. John's River Water Management District (SJRWMD), and Suwannee River Water Management District (SRWMD). They issue Environmental Resource Permits under Chapter 40, Florida Administrative Code (FAC), and operate under Chapter 373, 403 and 120 Florida Statutes (FS).

APPENDIX C

SITE EVALUATION CHECKLIST

APPENDIX C

Site Evaluation Checklists

C-1 GENERAL

Water Management analysis and design for airfields are based on a variety of site data for both the existing condition and the proposed project(s). The data needs are physical, operational and regulatory. This appendix provides a general outline of those needs. It is not a comprehensive guide. It does provide a framework for competent engineers and scientists to plan and execute a data acquisition program for Airport Stormwater Best Management Practice design and implementation. Many data acquisition tasks will require specialty consultants to plan and execute the effort.

C-2 SITE RECONNAISSANCE

Reconnaissance of the project site and surroundings is a critical element for planning the data acquisition program. It is also important at subsequent review stages of design and permitting. Two elements make up the reconnaissance. These are: Collection of Existing and Published Data and Visual Reconnaissance.

a. Collection of Existing and Published Data. Public use airports typically have existing data that is useful for water management analysis and design. Additionally, there are several common federal, state, and local publications that can provide data either directly usable or useful for planning the project specific data acquisition program.

(1) Existing Data. Common data sources are the Airport Master Plan, the Airport Layout Plan (ALP), prior project plans, geotechnical studies, Engineer Reports, and the Stormwater Pollution Prevention Plan (SWPPP). The airport may have other documents from which useful information can be extracted. Master Drainage Plans, prior Water Management Permits, Wildlife Hazard Management Plans, Environmental Assessments (EA), Environmental Impact Statements (EIS), Development of Regional Impact (DRI) Studies, Contamination Reports, and similar documents should be requested and reviewed if available. Data that can be extracted and summarized may include:

- General land use on the airport and surrounding areas.
- Existing and forecast aircraft operations on the airport.
- Existing airside and landside pavement and buildings.
- Major drainage basins and directions of surface flow.
- Existing water management structural controls, such as ponds.
- Stormwater conveyance details such as inlets, pipes, and swales.
- Expected peak runoff rates and volumes from prior projects.
- Previously defined tailwater and/or seasonal high-water elevations.
- Procedural Best Water Management Practices recommended at the airport.
- Jurisdictional agencies for Water Management Permitting. Note that this may include local and special jurisdictional agencies such as cities, counties, and special flood control districts. The

list of airports and jurisdictional Water Management District in Appendix G of this manual does not show these local and special agencies.

- ❑ Special water management permit conditions in effect for prior projects at the airport.
- ❑ Pre-defined wetlands limits and characteristics.
- ❑ Soil and groundwater information for prior projects.
- ❑ Areas of known or suspected hazardous materials contamination.
- ❑ Floodplain limits previously defined.
- ❑ Wildlife surveys, including wildlife and bird strike problems and control needs at the airport.

(2) *Published Data.* Published data that may be available includes aerial topographic maps with contour intervals of 1 or 2 feet. These may be available from the Water Management Districts, the Florida Department of Transportation, or the local government. Also, local government may have city-, county- or special district-wide master drainage plans, flood studies, groundwater data, or water management computer models that can be used. Contact the local government for availability of these products. Published data generally available includes:

- ❑ Soil Surveys for individual counties published by the National Resource Conservation Service (NRCS), formerly Soil Conservation Service (SCS). These are usually available at the NRCS office in the county.
- ❑ Rainfall records published by the National Weather Service. These can be airport specific for those airports with either Automated Surface Observation Systems (ASOS) or weather/rainfall measuring and reporting procedures.
- ❑ Florida Department of Transportation (FDOT) Drainage handbooks. This document includes rainfall amounts, intensities and standard distributions for design use. It also includes procedures for drainage design. This is available from: FDOT Maps and Publications On-line Store at www.dot.state.fl.us
- ❑ Quadrangle topographic maps available from the United States Geological Survey.
- ❑ National Wetland Inventory Maps published by the US Fish and Wildlife Service will be available in the future. Wetland information may currently be found on the National Map viewer of the USGS site under Hydrography.
- ❑ Aerial photography, possibly including color and infrared, available from the National High Altitude Photography program from the United States Geological Survey (USGS). Historical aerials for prior land use.
- ❑ Flood Insurance Rate Maps (FIRM) available from the Federal Emergency Management Agency (FEMA).
- ❑ Tide data from NOAA.
- ❑ Landside water quality data.

b. Visual Reconnaissance. Visual reconnaissance of the project site for water management issues should be conducted as part of the data planning process. As data collection and the water management concept progress, additional visual reconnaissance is a valuable and sometimes necessary tool in the permitting process. It is a recommended part of a permit preapplication meeting, and is usually necessary when wetland issues are involved.

The information collected in site visual reconnaissance will vary with the project. The following lists suggest information that can benefit the data acquisition planning process and subsequent design and analysis.

- Topography
 - Level, rolling, sloping, sinkholes/karst, gullies, erosion
 - Elevation difference across site
 - General direction of runoff flow or ground slope
- Ground Cover
 - Cleared, wooded, pavement, grass, debris, building
 - Grass height, density, coverage, bare soil
 - Estimate Manning's n for overland flow
- Surface Soil
 - Sand, silt, clay, gravel, peat, muck, rock outcrops
 - Hard, loose, wet, dry, color
 - Site has appearance of fill, cut, original ground
- Surface Water
 - Streams, creeks, ditches, wetlands, ponds
 - Water elevation
 - Flow direction
 - Evidence of high water or floods, stain lines, debris/rack lines
 - Estimate Manning's n for channel flow at low, normal and flood stages
- Groundwater
 - Wells, springs, artesian wells,
 - Seepage lines in cuts, ditches
- Rainfall Conditions
 - Previous weather, wet, dry
 - Comparison with typical year, wet dry
- Drainage Structures
 - Inlets – grates, types, size, condition
 - Pipes – types, size, condition, any base flow
 - Outlets – types, condition, stain lines, special structures
 - Underdrains – type, size, approximate depth, any base flow
- General
 - Evidence of conflicting underground utilities
 - Past experience in the area, recollection of airport personnel

- Note differences between collected documents and observed site, if any
- General appearance of site

C-3 TOPOGRAPHY AND SURVEY

Drainage and water management are highly dependent on topography and ground surface characteristics. The typical survey program for the design of an airfield paving project may not provide sufficient information for water management. Specifically, topographic survey limits may need extension beyond the boundary of the project to define drainage basins. Data may be needed for water management control structures distant from the project boundaries. Conveyance systems such as inlets, pipes, swales and open channels both upstream and downstream of the project location will likely be required. Elements of topographic evaluation and survey programs may include:

a. USGS Quadrangle Topographic Maps. The very flat terrain typical of many Florida airports often limits the usefulness of this tool to broad definitions of flow direction and identification of receiving waters.

b. Aerial Topographic Maps. When available or included with the project, aerial topographic maps are a very valuable tool for water management analysis and design. General guidelines for aerial topographic maps for water management planning and design are:

- Extend aerial topography beyond the project limits to encompass estimated upstream basins contributing flow, and adjacent areas that may provide flood storage.
- Contour intervals of 1 foot accurate to $\pm \frac{1}{2}$ foot for vertical information should be obtained
- Horizontal accuracy of ± 5 feet should be required
- Obtain rectified aerial photography at a scale appropriate to the project site.
- Rectified color infrared photography at the same scale as the rectified aerial photograph are useful in identifying wetlands and drainage features when properly interpreted and should be obtained if possible.

c. Field Survey. Ground survey is required in almost all cases. The field survey may include boundary survey components as well as topographic and engineering surveys. Boundary surveys sufficient for legal description and land area calculations will be needed if wetlands are present on the project(s) site. Topographic and engineering surveys may include data collection of the following types:

- Topographic survey based on discrete data points at 3rd Order accuracy. Pavement data is generally recorded to the 0.01^{foot} and ground surface data to the 0.1^{foot} precision.
- Aerial target setting for aerial photogrammetry.
- Drainage conveyance system surveys. These should include:

- Inlet locations, elevations, openings, details, and pipe size, type, location and invert elevations connected to the inlet.
- Outlet locations, elevations, openings, details and pipe size, type, location, number, and invert elevations connected to the outlet.
- Elevation of water standing or flowing in pipes
- Elevations of stain lines or rack lines on inlet and outlet structures.
- Elevation of blockage or siltation reducing pipe effective area.
- Location and details of control structures including weir lengths and elevations, notch angles, orifice dimensions and inverts, skimmer top and bottom elevations and arrangements, outlet pipe type, size and inverts, underdrain connections, spillway characteristics, and similar.
- Cross-sections of open channels. Spacing of the sections is based on the project size and the level of detail needed. Spacing of sections does affect the computed water surface elevation, sometimes by significant amounts. The cross-section surveys may include:
 - Top of bank, toe of slope and information sufficient to define the cross section of the channel
 - Information extending away from top of bank on both sides sufficient to define overflow storage limits/ floodplains during high water
 - Current water elevations and recent high-water elevations based on staked indicators, rack/debris or stain lines.
- Wetland limits and elevations based on staking by environmental professionals after concurrence from jurisdictional agencies. This should be sufficient to prepare a boundary survey and legal description.
- Dimensions of any existing water management ponds, wet or dry, sufficient to calculate storage volume versus elevation data (stage-storage relation) for the facility.

C-4 LAND COVER AND USE

Land use and cover information is associated with stormwater runoff quantity and quality. Specific land cover information is needed to assess runoff volumes and rates, infiltration potential, and parameters associated with runoff quantity management. This usually consists of the amount of pervious and impervious surface, vegetation coverage, and condition. Land cover and use data also permit estimates of pollutant types and

amounts, which is critical to Airport Best Water Management Practice design and permitting.

C-5 WETLANDS

Florida's physiography is such that wetlands are often located on or adjacent to airports and the airside. They are a major natural and national resource. In fact, the federal government is endeavoring to increase the available wetland resource by 100,000 acres per year. However, they are also potential attractants to hazardous wildlife, and may be incompatible with safe airport operation if too near the airside area. Wetland type, limits, function, value, and hazard potential must be assessed by qualified environmental professionals as part of water management planning, design, and permitting. Generally, this assessment includes the following elements:

- Initial review of the USGS Topographic Map, the National Wetland Inventory Map, Soil Survey data, and aerial photographs for the project site and locales.
- Field review of likely wetland areas. Preliminary staking of wetland boundaries, evaluation of function, condition, type, and value. Also, preliminary review of wildlife using the wetland. Field review can include estimates of seasonal high-water levels based on plant indicators.
- Site visits with Jurisdictional Agency environmental professionals to confirm preliminary findings and wetland limits. Boundary survey and legal descriptions of staked wetland limits normally follow this effort.
- Possible assessment of wildlife hazard by qualified biologists.
- Possible assessment of off-site mitigation options and banks in the region.

C-6 GEOTECHNICAL

Geotechnical exploration and testing for water management are directed toward groundwater impacts on and from the water management system. Airside compatible stormwater best management uses systems that do not create standing water for extended periods. Key to airside water management planning and design is knowledge and estimation of groundwater levels and response. The geotechnical program should be designed to yield information on infiltration rates and capacity, seasonal high groundwater levels, hydraulic conductivity or permeability, and groundwater mounding or drawdown response.

a. Soil Survey Reports. The NRCS Soil Survey for a County can yield important preliminary data for water management system planning. Soil Surveys group surficial soils into general taxonomic groups and suggest typical agricultural and engineering properties for each group. Information is developed from a combination of aerial photo-interpretation and field truthing. It is necessarily coarse, since mapping units are really large and construction changes conditions significantly between mapping efforts. However, the reports can provide initial guidance information of the following types. It is emphasized this must be supplemented with field exploration and field and laboratory

testing for design. The data may not be relevant if the site has been disturbed, drained, or if engineered fills have been placed on it.

- Typical soil profile for the upper 6 feet of material.
- Engineering classification for soils in the upper 6 feet by the AASHTO and/or Unified Soil Classification System. Estimated gradation and Atterberg Limits for materials are usually provided along with the classification.
- Estimated seasonal high water table levels for the soils and the typical occurrence times and durations of the high levels.
- Estimated permeability for each layer in the profile for the upper 6 feet.

b. Field Exploration and Testing. Field exploration and testing are needed to evaluate the groundwater levels and response for design. The specific elements needed in the geotechnical exploration program must be developed on a project specific basis. The following are some typical elements:

- Soil Borings with Standard Penetration Tests (ASTM D 1586) and visual classification per the Unified Soil Classification System (ASTM D2488-00). Borings should include initial and 24-hour/stabilized ground water levels if the boring can remain open overnight before backfilling. Borings should extend at least 15 feet beneath the deepest excavation planned or to auger refusal if that occurs first. If dry retention ponds are planned, borings should extend at least 25 feet beneath the expected bottom elevation of the ponds.
- Test Pits with identification of soil layers and visual classification per the Unified Soil Classification System (ASTM D2488-00). Test pits are typically excavated to depths of 10 feet by backhoe and are most useful in areas where random or uncontrolled fill is suspected. Ground water levels and seepage lines in the test pit should be recorded on initial excavation. Usually, safety concerns on the airfield preclude leaving a test pit open for 24-hour/stabilized ground water level measurements.
- Field Permeability Tests. Field permeability tests can be conducted in borings designated for the purpose. Generally, these tests provide a better measure of the in-situ permeability of the soils than laboratory permeability tests on undisturbed samples. Also, refer to Appendix D.
- Laboratory Permeability Tests. Laboratory tests for permeability are generally constant head (ASTM D2434-68) types and are most appropriate for sands. They are best used for assessing the properties of earthfill or backfill soils needed for the site or site features. They may be done on samples that are remolded to the expected compaction levels of the earthfill/backfill.

- Grain Size Analysis of Soils (ASTM D422-63 (2002)) may be done on returned soil samples representative of those encountered by borings and test pits. They may also be done on potential fill material that will be used on the site. Grain size analysis and Atterberg Limits permit direct classification of samples per the Unified Soil Classification System (ASTM D2487-00). They also provide a useful, indirect estimate of soil permeability/hydraulic conductivity.
- Atterberg Limits (ASTM D4318-00) are meaningful on soils containing a significant percentage of fines (soil passing the U.S Standard No. 200 sieve). It allows differentiation of silt and clay soils and, in combination with grain size data, provides an indirect estimate of permeability of these fine-grained soils.
- Geotechnical Report. This document should provide recommendations addressing:
 - Seasonal High Groundwater Levels
 - Groundwater mounding or drawdown expected from the project water management system
 - Temporary dewatering needed for construction
 - Permeability/hydraulic conductivity of in-situ and compacted soils, including fill material
 - Infiltration parameters for in-situ and compacted soils, including fill material
 - Sinkhole potential and impacts from water management concepts

C-7 FLOODPLAINS AND FLOODWAYS

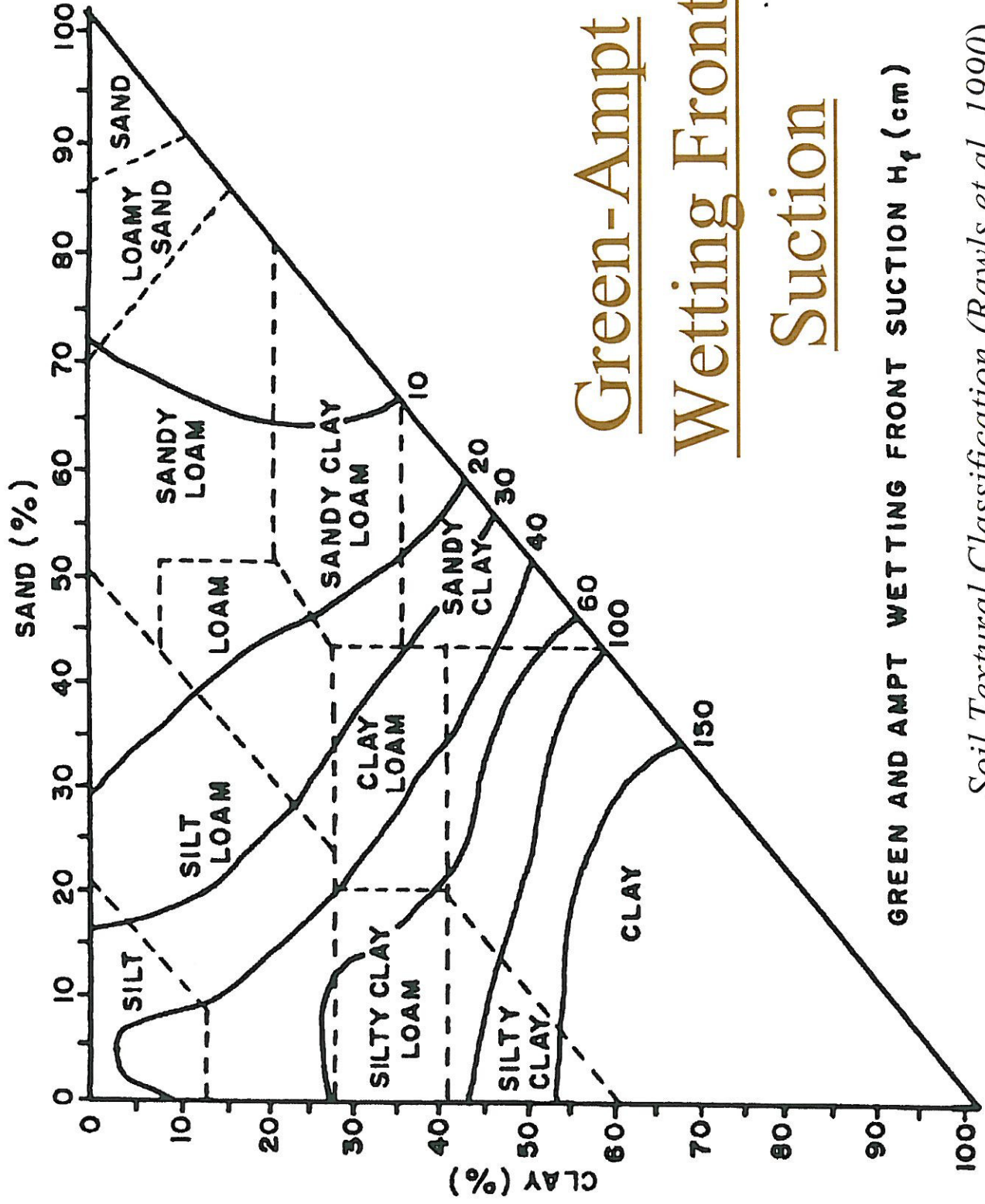
Floodplain and floodway information is needed to recognize and plan for adverse flooding impacts that can occur when projects encroach into either. The initial data source for most determinations is the Flood Insurance Rate Map (FIRM) for the project and surrounding area. However, it is important to note that many floodplain areas are not fully indicated or defined in the FIRM maps. Consequently, consult the Jurisdictional Water Management District and county or city government for detailed and/or supplemental information on known floodplains and floodways on and around the airport.

C-8 RECEIVING WATERS

The level of water management needed is, in part, a function of the characteristics of the water bodies the project(s) discharge to. Primary issues for receiving waters are: water quality class per FAC 62-302, flood sensitivity, and tailwater elevation in the receiving waters for the design storm event. Flood sensitivity and tailwater information can be obtained from the Jurisdictional Water Management District, and local government. Prior permits, studies and FIRM's for the project can also be of assistance in defining receiving water conditions.

APPENDIX D

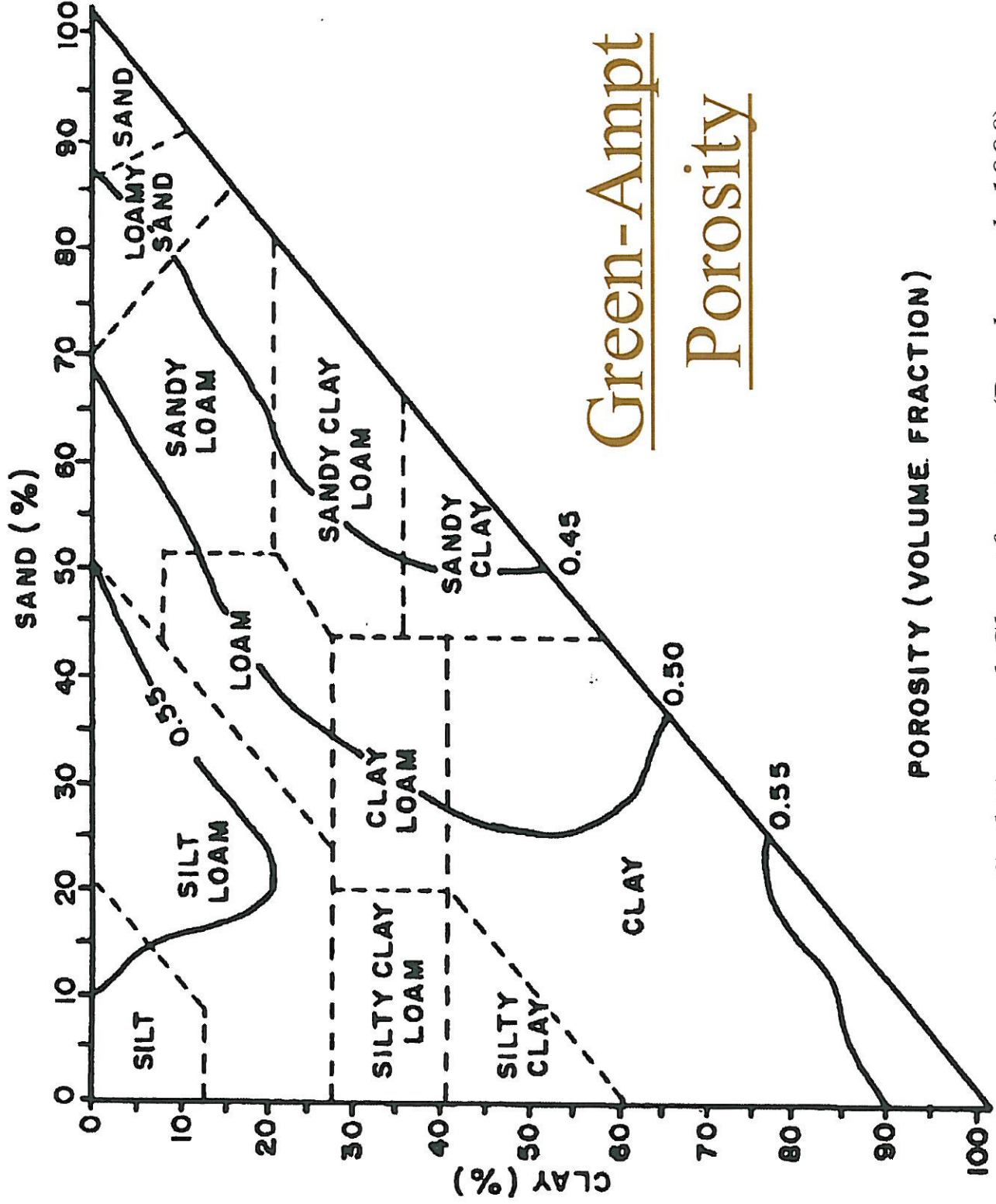
TYPICAL GREEN AMPT PARAMETERS BASED ON GRAIN SIZE ANALYSIS



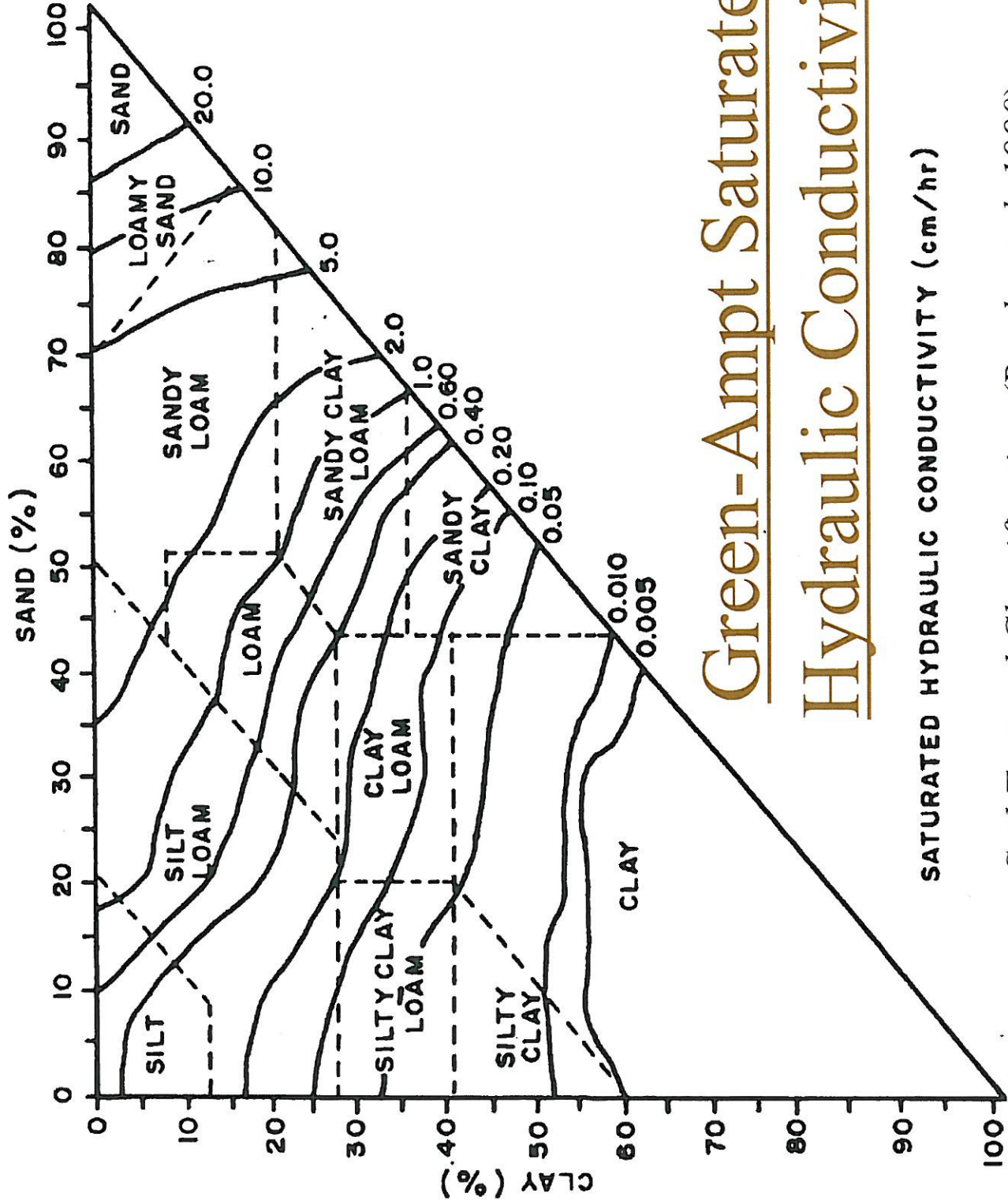
Green-Ampt Wetting Front Suction

GREEN AND AMPT WETTING FRONT SUCTION H_f (cm)

Soil Textural Classification (Rawls et al, 1990)



Soil Textural Classification (Rawls et al, 1990)



Green-Ampt Saturated Hydraulic Conductivity

SATURATED HYDRAULIC CONDUCTIVITY (cm/hr)

Soil Textural Classification (Rawls et al, 1990)

APPENDIX E

AIRLINE SAFETY AND WILDLIFE PROTECTION ACT OF FLORIDA

ENROLLED

CS/HB 1065, Engrossed 1

2009 Legislature

1 A bill to be entitled
 2 An act relating to aircraft safety; providing a short
 3 title; creating s. 379.2293, F.S.; providing legislative
 4 findings and intent; exempting airport authorities and
 5 other entities from penalties, restrictions, or sanctions
 6 with respect to authorized actions taken to protect human
 7 life or aircraft from wildlife hazards; defining the term
 8 "authorized action taken for the purpose of protecting
 9 human life or aircraft safety from wildlife hazards";
 10 providing that federal or state authorizations for such
 11 actions prevail over certain other regulations, permits,
 12 comprehensive plans, and laws; providing immunity from
 13 penalties with respect to authorized action for certain
 14 individuals; providing exceptions; providing an effective
 15 date.

16
 17 Be It Enacted by the Legislature of the State of Florida:

18
 19 Section 1. This act may be cited as the "Airline Safety
 20 and Wildlife Protection Act of Florida."

21 Section 2. Section 379.2293, Florida Statutes, is created
 22 to read:

23 379.2293 Airport activities within the scope of a
 24 federally approved wildlife hazard management plan or a federal
 25 or state permit or other authorization for depredation or
 26 harassment.--

27 (1) The Legislature finds and declares that the ability of
 28 airports to manage wildlife hazards in a manner consistent with

ENROLLED

CS/HB 1065, Engrossed 1

2009 Legislature

29 state and federal law is necessary to prevent jeopardy to human
 30 life or aircraft safety. It is the intent of the Legislature
 31 that actions taken by airports within the scope of
 32 authorizations to manage wildlife for such purposes not be
 33 subject to penalties, restrictions, liabilities, or sanctions
 34 and that such authorizations not be superseded by actions of
 35 other state or local agencies.

36 (2) An airport authority or other entity owning or
 37 operating an airport, as defined in s. 330.27(2), is not subject
 38 to any administrative or civil penalty, restriction, or other
 39 sanction with respect to any authorized action taken in a non-
 40 negligent manner for the purpose of protecting human life or
 41 aircraft safety from wildlife hazards.

42 (3) (a) For purposes of this section, an "authorized action
 43 taken for the purpose of protecting human life or aircraft
 44 safety from wildlife hazards" is an action authorized by or
 45 within the scope of any of the following:

46 1. The airport's wildlife hazard management plan, as
 47 approved by the Federal Aviation Administration.

48 2. A depredation permit issued by the United States Fish
 49 and Wildlife Service.

50 3. A standing order of the United States Fish and Wildlife
 51 Service.

52 4. Rule 68A-9.010(4) or rule 68A-27.002, Florida
 53 Administrative Code, or a permit authorizing the harassment of
 54 wildlife issued by the Fish and Wildlife Conservation
 55 Commission.

56 (b) The term "authorized action taken for the purpose of

ENROLLED

CS/HB 1065, Engrossed 1

2009 Legislature

57 protecting human life or aircraft safety from wildlife hazards"
 58 does not include:

59 1. Dredging or filling of wetlands or other surface waters
 60 or alteration of a stormwater management system, unless
 61 authorized by and performed in compliance with a permit issued
 62 under part IV of chapter 373 or an emergency order under chapter
 63 373. However, such a permit or emergency order is not required
 64 prior to the activity when the airport authority or other entity
 65 described in subsection (2) determines that an emergency
 66 condition exists which requires immediate action to protect
 67 human life and the airport authority or other entity described
 68 in subsection (2) obtains the appropriate permit under part IV
 69 of chapter 373 within one year after conducting the emergency
 70 action.

71 2. Trespass on lands or unauthorized interference with an
 72 easement not owned or leased by the airport authority or other
 73 entity referred to in subsection (2).

74 (4) If an authorized action taken for the purpose of
 75 protecting human life or aircraft safety from wildlife hazards
 76 as defined in subsection (3) conflicts or appears to conflict
 77 with a development permit, land development regulation, local
 78 comprehensive plan, or other environmental or land-use law,
 79 rule, restriction, or requirement, the authorization described
 80 in subsection (3) shall prevail.

81 (5) In addition to applying to the airport authority or
 82 other owner or operator of the airport, the immunities conferred
 83 by this section also apply to any officer, employee, contractor,
 84 or employee of a contractor of the airport authority or other

ENROLLED

CS/HB 1065, Engrossed 1

2009 Legislature

85 owner or operator of the airport, or any member of the airport's
86 governing body, to the extent that the actions of the officer,
87 employee, contractor, contractor's employee, or member are
88 authorized by or within the scope of one or more of the legal
89 authorities described in subsection (3).

90 (6) Nothing in this section is intended to provide
91 immunity from liability with respect to intentional or negligent
92 torts, and nothing in this section is intended to affect the
93 waiver of sovereign immunity under s. 768.28.

94 Section 3. This act shall take effect upon becoming a law.
95
96

APPENDIX F

GENERAL PERMIT FOR CONSTRUCTION, OPERATION, MAINTENANCE, ALTERATION, ABANDONMENT OR REMOVAL OF AIRPORT AIRSIDE STORMWATER MANAGEMENT SYSTEMS

62-330.449 General Permit for Construction, Operation, Maintenance, Alteration, Abandonment or Removal of Airport Airside Stormwater Management Systems.

(1) A general permit is granted to the owner of a public or private airport for the construction, alteration, abandonment, removal, operation, and maintenance of stormwater management systems that serve permanently-paved airside activities, which, for the purposes of this rule, are defined as those components of an airport used for aircraft taxiing, landing, takeoff, loading, unloading, service materials storage and service equipment parking.

(2) The stormwater management systems shall be:

(a) Designed such that the stormwater nutrient loading does not exceed the stormwater nutrient loading from natural vegetative communities. The calculation of such loadings shall be done using the methodology and data set forth in the *Statewide Airport Stormwater Best Management Practices Manual*, ("Airside BMP Manual") Florida Department of Transportation–Aviation Office (April 27, 2013), incorporated by reference herein (pages 1-63: <https://www.flrules.org/gateway/reference.asp?NO=Ref-03183>, pages 64-Appendix L: <http://www.flrules.org/Gateway/reference.asp?No=Ref-03184>). A copy may be obtained from the Agency, as described in subsection 62-330.010(5), F.A.C.

(b) Constructed, altered, operated, and maintained such that the runoff from airside activities drains directly to pervious areas that employ one or more of the following applicable structural Best Management Practices (BMPs):

1. Overland flow, as described in Section 605.a of the Airside BMP Manual.
2. Dry retention basin, as described in Section 605.b of the Airside BMP Manual.
3. Swales, as described in Section 605.c of the Airside BMP Manual.

(c) This general permit is only authorized for use where post development site conditions comply with the criteria set forth above.

(3) The projects in subsection (2), above, must also be constructed, operated, and maintained to comply with the following design criteria and performance standards:

(a) There shall be no dredging or filling in wetlands or other surface waters other than those within existing stormwater management systems.

(b) Discharges cannot adversely affect the conveyance capacity of receiving waters, and cannot increase flooding of off-site property or to property not owned by the permittee, based on the design storm specified for the site locale.

(4) Stormwater management systems serving airside areas that consist of underdrains, wet detention systems, other retention methods, and/or alternative treatment systems do not qualify for authorization under this general permit.

Rulemaking Authority 373.026(7), 373.043, 373.118(1), 373.118(6), 373.406(5), 373.4131, 373.414(9), 373.418, 403.805(1) FS. Law Implemented 373.118(1), (6), 373.406(5), 373.413, 373.4131, 373.414(9), 373.416, 373.418 FS. History—New 10-1-13.

APPENDIX G

FEDERAL AND STATE JURISDICTIONAL

AGENCIES

APPENDIX G

Jurisdictional Agencies

Water management criteria are not uniform or uniformly applied within Florida. This is partly due to physical differences between regions, and partly to rule and legal constraints of the jurisdictional agencies. Consequently, it is necessary to identify all agencies jurisdictional to water management of an airport project and the specific issues of those agencies. Contact with the county, city, and any special districts jurisdictional to the airport is a required data collection task. Table H-1 lists agencies that are normally involved on a state and federal level.

TABLE G-1 STATE AND FEDERAL AGENCIES INVOLVED IN FLORIDA WATER MANAGEMENT PERMITTING

ISSUE	<i>Regulatory Agency</i>							
	FAA	EPA	ACOE	FDOT	FDEP	FFWCC	WMD	USDA
Wetland Impacts		O	P		P		P	
Flood Protection			C		P		P	
Water Quality		O			P		P	
Water Quantity	C			P	P		P	
Wildlife	O			C	C	P	C	O
Airport Safety	O			O		C	C	C

Legend

P - Permitting

C - Concern

O - Other Authority

The remainder of this Appendix is solely concerned with the Water Management Districts Jurisdictional to the airports. Figure G-1 broadly outlines the jurisdictional boundaries of the five Water Management Districts in the state. Tables G-2 through G-6 list the Jurisdictional Water Management District for each of Florida's public airports.

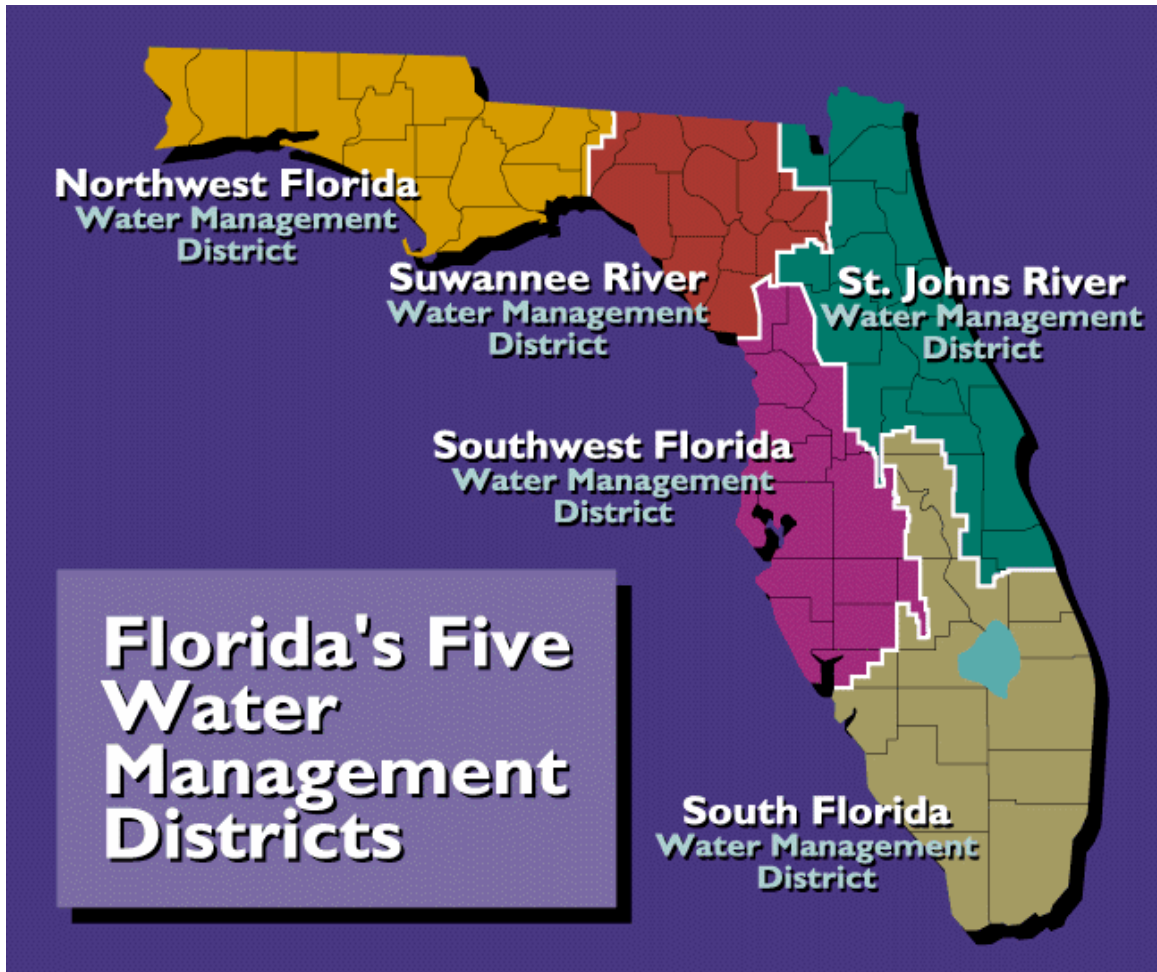


Figure G-1 Outline of Florida Water Management District Jurisdictional Boundaries

TABLE G-2 PUBLIC AIRPORTS SERVED BY THE ST. JOHN'S RIVER WATER MANAGEMENT DISTRICT

Flying Ten Airport
Alachua County OJ8
3410 S.W. 154th St
Archer, 32618

High Springs Oak Tree Handing Airport
Alachua County 6J8
1400 SE 80th Ave
Newberry, 32669

Flagler Executive Airport
Flagler County FIN
201 Airport Rd
Palm Coast, 32164

Hillard Airpark
Nassau County 01J
37776 Eastwood Rd
Hilliard, 32046

Merritt Island Airport
Brevard County COI
355 Golden Knights Blvd.
Titusville, 32780

Jacksonville Executive at Craig Airport
Duval County CRG
10968 Craig Blvd., Bldg 1
Jacksonville, 32225

Daytona Beach International Airport
Volusia County DAB
700 Catalina Dr. Ste. 300
Daytona Beach, 32114

Jacksonville Herlong Recreational Airport
Duval County HEG
9300 Normandy Blvd
Jacksonville, 32221

Deland Bob Lee Flight Strip
Volusia County 1J6
4111 Bob Lee Airport Rd
Deland, 32724

Jacksonville International Airport
Duval County JAX
14110 Pecan Park Rd
Jacksonville, 32218

Deland Municipal
Airport-Sydney H Taylor
Field
Volusia County DED
1000 Flightline Blvd
Deland, 32724

Leesburg Regional Airport
Lake County LEE
8807 Airport Blvd
Leesburg, 34788

Eustis Mid-Florida Airport
Lake County X55
19708 Eustis Airport Road
Eustis, 32736

Melbourne International Airport
Brevard County MLB
One Air Terminal Pkwy. Ste. 220
Melbourne, 32901-1888

Fernandina Beach Municipal Airport
Nassau County FHB
700 Airport Rd
Fernandina Beach, 32034

New Smyrna Beach Massey Ranch Airpark
Volusia County X50
635 Airpark Rd
Edgewater, 32132

Gainesville Regional Airport
Alachua County GNV
3880 N. E. 39 Ave., Ste A
Gainesville, 32609

New Smyrna Beach Municipal Airport
Volusia Count EVB
602 Skyline Dr
New Smyrna Beach, 32168

Orlando Executive Airport
Orange County ORL
365 Rickenbacker Dr
Orlando, 32803

Orlando Sanford International Airport
Seminole County SFB
1200 Red Cleveland Blvd
Sanford, 32773

Ormond Beach Municipal Airport
Volusia County OMN
770 Airport Rd
Ormond Beach, 32174

Palatka Municipal-Lt Kay
Larkin Field
Putnam County 28J
4015 Reid St
Palatka, 32177

Pierson Municipal Airport
Volusia County 2J8
305 N. Center St
Pierson, 32180

Northeast Florida Regional Airport
St. Johns County SGJ
4796 U.S. Hwy 1 North
St Augustine, 32095

Sebastian Municipal Airport
Indian River County X26
202 Airport Dr E
Sebastian, 32958

Titusville Arthur Dunn Air Park
Brevard County X21
476 N. Williams Ave
Titusville, 32780

Titusville Space Coast Regional Airport
Brevard County TIX
355 Golden Knights Blvd
Titusville, 32780

Umatilla Municipal Airport
Lake County X23
480 E Cassady St
Umatilla, 32784-2286

Valkaria Airport
Brevard County X59
1 Pilots Place
Valkaria, 32950

Vero Beach New Hibiscus Airpark
Indian River County X52
1890 98th Ave
Vero Beach, 32966

Vero Beach Regional Airport
Indian River County VRB
3400 Cherokee Dr
Vero Beach, 32961

Zellwood Bob White Field
Orange County X61
7011 W. Jones Ave
Mount Dora, 32798

TABLE G-3 PUBLIC AIRPORTS SERVED BY THE SOUTH FLORIDA WATER MANAGEMENT DISTRICT

Belle Glade State Municipal
Airport
Palm Beach County X10
105 Gator Blvd
Belle Glade, 33430

Boca Raton Airport
Palm Beach County BCT
903 NW 35th St
Boca Raton, 33431

Clewiston Airglades Airport
Hendry County 2IS
1090 Airglades Blvd
Clewiston, 33440

Everglades Airpark
Collier County X01
650 EC Airpark Rd
Everglades City, 34139

Fort Lauderdale Executive Airport
Broward County FXE
6000 NW 21st Ave
Ft. Lauderdale, 33309

Fort Lauderdale/Hollywood Int'l Airport
Broward County FLL
320 Terminal Drive
Ft. Lauderdale, 33315

Fort Myers Southwest Florida Int'l Airport
Lee County RSW
11000 Terminal Access Rd
Ft. Myers, 33913

Fort Myers Page Field Lee
County FMY
5200 Captain Channing
Page Dr
Ft. Myers, 33907

Fort Pierce Treasure Coast Int'l Airport
St. Lucie County FPR
3000 Curtis King Blvd
Fort Pierce, 34946

Hollywood North Perry Airport
Broward County HWO
SW 77th Way
Pembroke Pines, 33023

Miami Homestead General Aviation
Airport
Dade County X51
28700 S.W. 217 Avenue
Homestead, 33030

Homestead Air Reserve Base
Dade County HST
29050 Coral Sea Blvd
Homestead, 33039

Immokalee Regional Airport
Collier County IMM
165 Airpark Blvd.
Immokalee, 34142

Indiantown Airport
Martin County X58
20654 SW Citrus Blvd
Indiantown, 34956

Key West International Airport
Monroe County EYW
3491 S. Roosevelt Blvd.
Key West, 33040

La Belle Municipal Airport
Hendry County X14
311 E. Cowboy Way
LaBelle, 33935

The Florida Keys Marathon
International Airport
Monroe County MTH
9400 Overseas Hwy, Suite 200
Marathon, 33050

Marco Island Executive Airport
Collier County MKY
2003 Mainsail Drive
Naples, 34114

Miami Dade-Collier Training & Transition
Airport
Dade and Collier Counties TNT
54757 E. Tamiami Tr
Ochopee, 34141

Miami Executive Airport
Dade County TMB
12800 S. W. 145 Ave
Miami, 33186

Miami International Airport
Dade County MIA
4200 NW 21st St
Miami, 33126

Miami Opa-Locka Executive Airport
Dade County OPF
14201 NW 42nd Ave
Opa-locka, 33054

Naples Municipal Airport
Collier County APF
160 Aviation Drive North
Naples, 34104-3568

Okeechobee County Airport
Okeechobee County OBE
2800 N.W. 20 Trail
Okeechobee, 34972

Orlando International Airport
Orange County MCO
1 Jeff Fuqua Blvd
Orlando, 32827

Orlando Kissimmee Gateway Airport
Osceola County ISM
401 Dyer Blvd.
Kissimmee, 34741

Pahokee Palm Beach County Glades Airport
Palm Beach County PHK
846 Palm Beach Int'l Airport
West Palm Beach, 33406-1470

Pompano Beach Airpark
Broward County PMP
1001 N.E. 10th Street
Pompano Beach, 33060

Stuart Witham Field
Martin County SUA
2011 S.E. Airport Road
Stuart, 34996

West Palm Beach North Palm Beach County
General Aviation Airport
Palm Beach County F45
11600 Aviation Blvd
West Palm Beach, 33412

West Palm Beach Palm Beach
County Park Airport
Palm Beach County LNA
2633 Lantana Rd
Lantana, FL 33462

West Palm Beach International Airport
Palm Beach County PBI
1000 James L. Turnage
Blvd West Palm Beach,
33415

TABLE G-4 PUBLIC AIRPORTS SERVED BY THE SOUTHWEST FLORIDA WATER MANAGEMENT DISTRICT

Arcadia Municipal Airport
DeSoto County X06
2269 S.E. AC Polk, Jr Dr
Arcadia, 34266

Inverness Airport
Citrus County INF
4250 S. Airport Rd
Inverness, 34450

Avon Park Executive Airport
Highlands County AVO
1535 SR64 West
Avon Park, 33825

Lakeland Linder Int'l Airport
Polk County LAL
3900 Don Emerson Dr, Ste. 210
Lakeland, 33811

Bartow Executive Airport
Polk County BOW
5993 Airport Blvd
Bartow, 33830

Lake Wales Municipal Airport
Polk County X07
450 S. Airport Rd
Lake Wales, 33859-1320

Brooksville-Tampa Bay Regional Airport
Hernando County BKV
15800 Flight Path Dr
Brooksville, 34604

Lakeland, South Lakeland Airport
Polk County X49
7500 Coronet Rd
Mulberry, 33860-8314

Brooksville Pilot Country Airport
Pasco County X05
11500 Pilot Country Drive
Spring Hill, 34610

Ocala Int'l-Jim Taylor Field
Marion County OCF
1770 SW 60th Ave, Ste. 600
Ocala, 34474

Clearwater Air Park
Pinellas County CLW
1000 N Hercules Ave
Clearwater, 33765

Palmetto Airport Manatee
Manatee County 48X
14108 US Hwy 41 N
Palmetto, 34221

Crystal River – Captain
Tom Davis Field
Citrus County CGC
718 N. Lindbergh Dr
Crystal River, 34229

Plant City Airport Hillsborough
County PCM
4007 Airport Rd
Plant City, 33563

Dunnellon Marion County Airport
Marion County X35
14968 SW 110th St
Dunnellon, 34432

Punta Gorda Airport
Charlotte County PGD
28000 Airport Road, Ste. 4-1
Punta Gorda, 33982

Englewood Buchan Airport
Sarasota County X36
1390 Old Englewood Rd
Englewood, 34223

Shell Creek Airpark
Charlotte County F13
36880 Washington Loop Rd.
Punta Gorda, 33982

River Ranch Resort Airport
Polk County 2RR
3200 River Ranch Blvd
River Ranch, 33867-0030

St Petersburg Albert Whitted Municipal
Airport
Pinellas County SPG
107 8th Avenue S.E.
St. Petersburg, 33701

St Petersburg-Clearwater Int'l Airport
Pinellas County PIE
14700 Terminal Blvd Ste. 221
Clearwater, 33762

Sarasota-Bradenton International Airport
Sarasota & Manatee Counties SRQ
6000 Airport Circle
Sarasota, 34243-2105

Sebring Regional Airport
Highlands County SEF
128 Authority Lane
Sebring, 33870

Tampa, Peter O. Knight Airport
Hillsborough County TPF
825 Severn Ave
Tampa, 33606

Tampa International Airport
Hillsborough County TPA
4100 George S. Bean Pkwy
Tampa, 33607

Tampa North Aero Park
Pasco County X39
4241 Birdsong Blvd.
Lutz, 33549-6294

Tampa Executive Airport
Hillsborough County VDF
6530 Tampa Executive Airport Rd
Tampa, 33610

Trenton Ames Field
Levy County 6FL8
9520 SW 126th
Archer, Fl 32618

Venice Municipal Airport
Sarasota County VNC
150 East Airport Avenue
Venice, 34285

Wauchula Municipal Airport
Hardee County CHN
1202 Maurice Sonny Clavel Rd
Wauchula, 33873

Williston Municipal Airport
Levy County X60
1800 SW 19th Ave
Williston, 32696

Winter Haven
Jack Brown Seaplane Base
Polk County F57
2704 Hwy. 92
Winter Haven, 33881

Winter Haven Municipal Airport
Polk County GIF
2073 Hwy 92 W
Winter Haven, 33881

Zephyrhills Municipal Airport
Pasco County ZPH
39450 South Ave.
Zephyrhills, 33542

**TABLE G-5 PUBLIC AIRPORTS SERVED BY THE SUWANNEE RIVER
WATER MANAGEMENT DISTRICT**

George T. Lewis Airport
Levy County CDK
14703 SW Airport Rd
Cedar Key, 32625

Cross City Airport Dixie
County CTY
508 NE 241 St Cross
City, 32628

Lake City Gateway Airport
Columbia County LCQ
3524 E US Highway 99
Lake City, 32055

Suwannee County Airport
Suwannee County 24J
13302 80th Terrace
Live Oak, 32060

**TABLE G-6 PUBLIC AIRPORTS SERVED BY THE NORTHWEST
FLORIDA WATER MANAGEMENT DISTRICT**

Apalachicola Municipal Airport
Franklin County AAF
8 Airport Rd
Apalachicola, 32320

Apalachicola/Franklin St. George
Island Airport
Franklin County F47
1712 Magnolia Road
St. George Island, 32328

Blountstown Calhoun County Airport
Calhoun County F95
16701 NW Agri. Park Rd
Altha, 32421

Bonifay Tri-County Airport
Holmes County 1J0
1983 Airport Rd
Bonifay, 32425

Carrabelle-Thompson Airport
Franklin County X13
317 Airport Rd
Carrabelle, 32322

Crestview Bob Sikes Airport
Okaloosa County CEW
5535 John Givens Rd
Crestview, 32539

De Funiak Springs Airport
Walton County 54J
1931 US Hwy 90 W
DeFuniak Springs, 32433

Destin Executive Airport
Okaloosa County DTS
1001 Airport Rd
Destin, 32541

Marianna Municipal Airport
Jackson County MAI
3689 Industrial Park Dr.
Marianna, 32446

Fort Walton Beach Airport
Santa Rosa County 1J9
P. O. Box 1075
Ft. Walton Beach, 32549

Panacea Wakulla County Airport
Wakulla County 2J0
34 Monocoupe Cir,
Panacea, 32346

Northwest Florida Beaches International
Airport
Bay County ECP
6300 W. Bay Pkwy
Panama City, 32409

Pensacola International Airport
Escambia County PNS
2430 Airport Blvd., Suite 225
Pensacola, 32504

Ferguson Airport
Escambia County 82J
9750 Aileron Avenue
Pensacola, 32506

Pensacola Coastal Airport
Escambia County 83J
6001 W. 9 Mile Road
Pensacola, 32526

Port St. Joe Costin Airport
Gulf County A51
167 Cessna Dr
Port St. Joe, 32456

Quincy Municipal Airport
Gadsden County 2J9
1300 Airport Dr
Quincy, 32352

Tallahassee International Airport
Leon County TLH
3300 Capital Circle SW Ste.1
Tallahassee, 32310

Tallahassee Commercial Airport
Leon County 68J
6601 N. Monroe St.
Tallahassee, 32303

Peter Prince Field Santa Rosa
County 2R4
5550 N. Airport Rd
Milton, 32583

APPENDIX H

FEDERAL AGENCIES MEMORANDUM OF AGREEMENT ON AIRCRAFT-WILDLIFE STRIKES

**Memorandum of Agreement Between
the Federal Aviation Administration,
the U.S. Air Force,
the U.S. Army,
the U.S. Environmental Protection Agency,
the U.S. Fish and Wildlife Service, and
the U.S. Department of Agriculture
to Address Aircraft-Wildlife Strikes**

PURPOSE

The signatory agencies know the risks that aircraft-wildlife strikes pose to safe aviation.

This Memorandum of Agreement (MOA) acknowledges each signatory agency's respective missions. Through this MOA, the agencies establish procedures necessary to coordinate their missions to more effectively address existing and future environmental conditions contributing to aircraft-wildlife strikes throughout the United States. These efforts are intended to minimize wildlife risks to aviation and human safety, while protecting the Nation's valuable environmental resources.

BACKGROUND

Aircraft-wildlife strikes are the second leading causes of aviation-related fatalities. Globally, these strikes have killed over 400 people and destroyed more than 420 aircraft. While these extreme events are rare when compared to the millions of annual aircraft operations, the potential for catastrophic loss of human life resulting from one incident is substantial. The most recent accident demonstrating the grievous nature of these strikes occurred in September 1995, when a U.S. Air Force reconnaissance jet struck a flock of Canada geese during takeoff, killing all 24 people aboard.

The Federal Aviation Administration (FAA) and the United States Air Force (USAF) databases contain information on more than 54,000 United States civilian and military aircraft-wildlife strikes reported to them between 1990 and 1999¹. During that decade, the FAA received reports indicating that aircraft-wildlife strikes, damaged 4,500 civilian U.S. aircraft (1,500 substantially), destroyed 19 aircraft, injured 91 people, and killed 6 people. Additionally, there were 216 incidents where birds struck two or more engines on civilian aircraft, with damage occurring to 26 percent of the 449 engines involved in these incidents. The FAA estimates that during the same decade, civilian U.S. aircraft sustained \$4 billion worth of damages and associated losses and 4.7 million hours of aircraft downtime due to aircraft-wildlife strikes. For the same period,

¹ FAA estimates that the 28,150 aircraft-wildlife strike reports it received represent less than 20% of the actual number of strikes that occurred during the decade.

USAF planes colliding with wildlife resulted in 10 Class A Mishaps², 26 airmen deaths, and over \$217 million in damages.

Approximately 97 percent of the reported civilian aircraft-wildlife strikes involved common, large-bodied birds or large flocks of small birds. Almost 70 percent of these events involved gulls, waterfowl, and raptors (Table 1).

About 90 percent of aircraft-wildlife strikes occur on or near airports, when aircraft are below altitudes of 2,000 feet. Aircraft-wildlife strikes at these elevations are especially dangerous because aircraft are moving at high speeds and are close to or on the ground. Aircrews are intently focused on complex take-off or landing procedures and monitoring the movements of other aircraft in the airport vicinity. Aircrew attention to these activities while at low altitudes often compromises their ability to successfully recover from unexpected collisions with wildlife and to deal with rapidly changing flight procedures. As a result, crews have minimal time and space to recover from aircraft-wildlife strikes.

Increasing bird and wildlife populations in urban and suburban areas near airports contribute to escalating aircraft-wildlife strike rates. FAA, USAF, and Wildlife Services (WS) experts expect the risks, frequencies, and potential severities of aircraft-wildlife strikes to increase during the next decade as the numbers of civilian and military aircraft operations grow to meet expanding transportation and military demands.

SECTION I.

SCOPE OF COOPERATION AND COORDINATION

Based on the preceding information and to achieve this MOA's purpose, the signatory agencies:

- A.** Agree to strongly encourage their respective regional and local offices, as appropriate, to develop interagency coordination procedures necessary to effectively and efficiently implement this MOA. Local procedures should clarify time frames and other general coordination guidelines.
- B.** Agree that the term "airport" applies only to those facilities as defined in the attached glossary.
- C.** Agree that the three major activities of most concern include, but are not limited to:
 - 1. airport siting and expansion;

² See glossary for the definition of a Class A Mishap and similar terms.

2. development of conservation/mitigation habitats or other land uses that could attract hazardous wildlife to airports or nearby areas; and
 3. responses to known wildlife hazards or aircraft-wildlife strikes.
- D. Agree that "hazardous wildlife" are those animals, identified to species and listed in FAA and USAF databases, that are most often involved in aircraft-wildlife strikes. Many of the species frequently inhabit areas on or near airports, cause structural damage to airport facilities, or attract other wildlife that pose an aircraft-wildlife strike hazard. Table 1 lists many of these species. It is included solely to provide information on identified wildlife species that have been involved in aircraft-wildlife strikes. It is not intended to represent the universe of species concerning the signatory agencies, since more than 50 percent of the aircraft-wildlife strikes reported to FAA or the USAF did not identify the species involved.
- E. Agree to focus on habitats attractive to the species noted in Table 1, but the signatory agencies realize that it is imperative to recognize that wildlife hazard determinations discussed in Paragraph L of this section may involve other animals.
- F. Agree that not all habitat types attract hazardous wildlife. The signatory agencies, during their consultative or decisionmaking activities, will inform regional and local land use authorities of this MOA's purpose. The signatory agencies will consider regional, local, and site-specific factors (e.g., geographic setting and/or ecological concerns) when conducting these activities and will work cooperatively with the authorities as they develop and implement local land use programs under their respective jurisdictions. The signatory agencies will encourage these stakeholders to develop land uses within the siting criteria noted in Section 1-3 of FAA Advisory Circular (AC) 150.5200-33 (Attachment A) that do not attract hazardous wildlife. Conversely, the agencies will promote the establishment of land uses attractive to hazardous wildlife outside those siting criteria. Exceptions to the above siting criteria, as described in Section 2.4.b of the AC, will be considered because they typically involve habitats that provide unique ecological functions or values (e.g., critical habitat for federally-listed endangered or threatened species, ground water recharge).
- G. Agree that wetlands provide many important ecological functions and values, including fish and wildlife habitats; flood protection; shoreline erosion control; water quality improvement; and recreational, educational, and research opportunities. To protect jurisdictional wetlands, Section 404 of the Clean Water Act (CWA) establishes a program to regulate dredge and/or fill activities in these wetlands and navigable waters. In recognizing Section 404 requirements and the Clean Water Action Plan's goal to annually increase the Nation's net wetland acreage by 100,000 acres through 2005, the signatory agencies agree to resolve aircraft-wildlife conflicts. They will do so by

avoiding and minimizing wetland impacts to the maximum extent practicable, and will work to compensate for all associated unavoidable wetland impacts. The agencies agree to work with landowners and communities to encourage and support wetland restoration or enhancement efforts that do not increase aircraft-wildlife strike potentials.

- H. Agree that the: U.S. Army Corps of Engineers (ACOE) has expertise in protecting and managing jurisdictional wetlands and their associated wildlife; U.S. Environmental Protection Agency (EPA) has expertise in protecting environmental resources; and the U.S. Fish and Wildlife Service (USFWS) has expertise in protecting and managing wildlife and their habitats, including migratory birds and wetlands. Appropriate signatory agencies will cooperatively review proposals to develop or expand wetland mitigation sites, or wildlife refuges that may attract hazardous wildlife. When planning these sites or refuges, the signatory agencies will diligently consider the siting criteria and land use practice recommendations stated in FAA AC 150/5200-33. The agencies will make every effort to undertake actions that are consistent with those criteria and recommendations, but recognize that exceptions to the siting criteria may be appropriate (see Paragraph F of this section).
- I. Agree to consult with airport proponents during initial airport planning efforts. As appropriate, the FAA or USAF will initiate signatory agency participation in these efforts. When evaluating proposals to build new civilian or military aviation facilities or to expand existing ones, the FAA or the USAF, will work with appropriate signatory agencies to diligently evaluate alternatives that may avoid adverse effects on wetlands, other aquatic resources, and Federal wildlife refuges. If these or other habitats support hazardous wildlife, and there is no practicable alternative location for the proposed aviation project, the appropriate signatory agencies, consistent with applicable laws, regulations, and policies, will develop mutually acceptable measures, to protect aviation safety and mitigate any unavoidable wildlife impacts.
- J. Agree that a variety of other land uses (e.g., storm water management facilities, wastewater treatment systems, landfills, golf courses, parks, agricultural or aquacultural facilities, and landscapes) attract hazardous wildlife and are, therefore, normally incompatible with airports. Accordingly, new, federally-funded airport construction or airport expansion projects near habitats or other land uses that may attract hazardous wildlife must conform to the siting criteria established in the FAA Advisory Circular (AC) 150/5200-33, Section 1-3.
- K. Agree to encourage and advise owners and/or operators of non-airport facilities that are known hazardous wildlife attractants (See Paragraph J) to follow the siting criteria in Section 1-3 of AC 150/5200-33. As appropriate, each signatory agency will inform proponents of these or other land uses about the land use's potential to attract hazardous species to airport areas.

The signatory agencies will urge facility owners and/or operators about the critical need to consider the land uses' effects on aviation safety.

- L.** Agree that FAA, USAF, and WS personnel have the expertise necessary to determine the aircraft-wildlife strike potentials of various land uses. When there is disagreement among signatory agencies about a particular land use and its potential to attract hazardous wildlife, the FAA, USAF, or WS will prepare a wildlife hazard assessment. Then, the appropriate signatory agencies will meet at the local level to review the assessment. At a minimum, that assessment will:

 1. identify each species causing the aviation hazard, its seasonal and daily populations, and the population's local movements;
 2. discuss locations and features on and near the airport or land use attractive to hazardous wildlife; and
 3. evaluate the extent of the wildlife hazard to aviation.
- M.** Agree to cooperate with the airport operator to develop a specific, wildlife hazard management plan for a given location, when a potential wildlife hazard is identified. The plan will meet applicable FAA, USAF, and other relevant requirements. In developing the plan, the appropriate agencies will use their expertise and attempt to integrate their respective programmatic responsibilities, while complying with existing laws, regulations, and policies. The plan should avoid adverse impacts to wildlife populations, wetlands, or other sensitive habitats to the maximum extent practical. Unavoidable impacts resulting from implementing the plan will be fully compensated pursuant to all applicable Federal laws, regulations, and policies.
- N.** Agree that whenever a significant aircraft-wildlife strike occurs or a potential for one is identified, any signatory agency may initiate actions with other appropriate signatory agencies to evaluate the situation and develop mutually acceptable solutions to reduce the identified strike probability. The agencies will work cooperatively, preferably at the local level, to determine the causes of the strike and what can and should be done at the airport or in its vicinity to reduce potential strikes involving that species.
- O.** Agree that information and analyses relating to mitigation that could cause or contribute to aircraft-wildlife strikes should, whenever possible, be included in documents prepared to satisfy the National Environmental Policy Act (NEPA). This should be done in coordination with appropriate signatory agencies to inform the public and Federal decision makers about important ecological factors that may affect aviation. This concurrent review of environmental issues will promote the streamlining of the NEPA review process.
- P.** Agree to cooperatively develop mutually acceptable and consistent guidance, manuals, or procedures addressing the management of habitats attractive to

hazardous wildlife, when those habitats are or will be within the siting criteria noted in Section 1-3 of FAA AC 5200-33. As appropriate, the signatory agencies will also consult each other when they propose revisions to any regulations or guidance relevant to the purpose of this MOA, and agree to modify this MOA accordingly.

SECTION II. GENERAL RULES AND INFORMATION

- A. Development of this MOA fulfills the National Transportation Safety Board's recommendation of November 19, 1999, to form an inter-departmental task force to address aircraft-wildlife strike issues.
- B. This MOA does not nullify any obligations of the signatory agencies to enter into separate MOAs with the USFWS addressing the conservation of migratory birds, as outlined in Executive Order 13186, *Responsibilities of Federal Agencies to Protect Migratory Birds*, dated January 10, 2001 (66 *Federal Register*, No. 11, pg. 3853).
- C. This MOA in no way restricts a signatory agency's participation in similar activities or arrangements with other public or private agencies, organizations, or individuals.
- D. This MOA does not alter or modify compliance with any Federal law, regulation or guidance (e.g., Clean Water Act; Endangered Species Act; Migratory Bird Treaty Act; National Environmental Policy Act; North American Wetlands Conservation Act; Safe Drinking Water Act; or the "no-net loss" policy for wetland protection). The signatory agencies will employ this MOA in concert with the Federal guidance addressing wetland mitigation banking dated March 6, 1995 (60 *Federal Register*, No. 43, pg. 12286).
- E. The statutory provisions and regulations mentioned above contain legally binding requirements. However, this MOA does not substitute for those provisions or regulations, nor is it a regulation itself. This MOA does not impose legally binding requirements on the signatory agencies or any other party, and may not apply to a particular situation in certain circumstances. The signatory agencies retain the discretion to adopt approaches on a case-by-case basis that differ from this MOA when they determine it is appropriate to do so. Such decisions will be based on the facts of a particular case and applicable legal requirements. Therefore, interested parties are free to raise questions and objections about the substance of this MOA and the appropriateness of its application to a particular situation.
- F. This MOA is based on evolving information and may be revised periodically without public notice. The signatory agencies welcome public comments on this MOA at any time and will consider those comments in any future revision of this MOA.

- G. This MOA is intended to improve the internal management of the Executive Branch to address conflicts between aviation safety and wildlife. This MOA does not create any right, benefit, or trust responsibility, either substantively or procedurally. No party, by law or equity, may enforce this MOA against the United States, its agencies, its officers, or any person.
- H. This MOA does not obligate any signatory agency to allocate or spend appropriations or enter into any contract or other obligations.
- I. This MOA does not reduce or affect the authority of Federal, State, or local agencies regarding land uses under their respective purviews. When requested, the signatory agencies will provide technical expertise to agencies making decisions regarding land uses within the siting criteria in Section 1-3 of FAA AC 150/5200-33 to minimize or prevent attracting hazardous wildlife to airport areas.
- J. Any signatory agency may request changes to this MOA by submitting a written request to any other signatory agency and subsequently obtaining the written concurrence of all signatory agencies.
- K. Any signatory agency may terminate its participation in this MOA within 60 days of providing written notice to the other agencies. This MOA will remain in effect until all signatory agencies terminate their participation in it.

SECTION III. PRINCIPAL SIGNATORY AGENCY CONTACTS

The following list identifies contact offices for each signatory agency.

Federal Aviation Administration
Office Airport Safety and Standards
Airport Safety and
Compliance Branch (AAS-310)
800 Independence Ave., S.W.
Washington, D.C. 20591
V: 202-267-1799
F: 202-267-7546

U.S. Air Force
HQ AFSC/SEFW
9700 Ave., G. SE, Bldg. 24499
Kirtland AFB, NM 87117
V: 505-846-5679
F: 505-846-0684

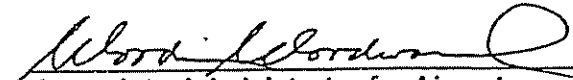
U.S. Army
Directorate of Civil Works
Regulatory Branch (CECW-OR)
441 G St., N.W.
Washington, D.C. 20314
V: 202-761-4750
F: 202-761-4150

U.S. Environmental Protection Agency
Office of Water
Wetlands Division
Ariel Rios Building, MC 4502F
1200 Pennsylvania Ave., SW
Washington, D.C. 20460
V: 202-260-1799
F: 202-260-7546

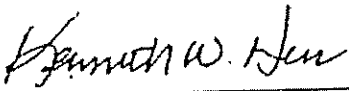
U.S. Fish and Wildlife Service
Division of Migratory Bird Management
4401 North Fairfax Drive, Room 634
Arlington, VA 22203
V: 703-358-1714
F: 703-358-2272

U.S. Department of Agriculture
Animal and Plant Inspection Service
Wildlife Services
Operational Support Staff
4700 River Road, Unit 87
Riverdale, MD 20737
V: 301-734-7921
F: 301-734-5157


Signature Page


Associate Administrator for Airports,
Federal Aviation Administration

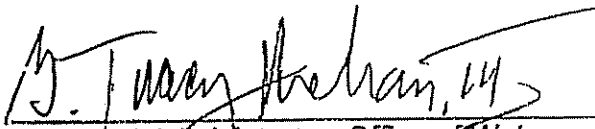
12/17/02
Date


Chief of Safety,
U. S. Air Force

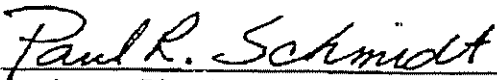
27 May 2003
Date


Acting Assistant Secretary of the Army
(Civil Works)
Department of the Army


December 9, 2002
Date


Assistant Administrator, Office of Water,
U.S. Environmental Protection Agency

1/17/03


Assistant Director, Migratory Birds
and State Programs,
U.S. Fish and Wildlife Service

7/29/03
Date

Acting 
Deputy Administrator, Wildlife Services
U.S. Department of Agriculture

09 January 2003
Date

GLOSSARY

This glossary defines terms used in this MOA.

Airport. All USAF airfields or all public use airports in the FAA's National Plan of Integrated Airport Systems (NPIAS). Note: There are over 18,000 civil-use airports in the U.S., but only 3,344 of them are in the NPIAS and, therefore, under FAA's jurisdiction.

Aircraft-wildlife strike. An aircraft-wildlife strike is deemed to have occurred when:

1. a pilot reports that an aircraft struck 1 or more birds or other wildlife;
2. aircraft maintenance personnel identify aircraft damage as having been caused by an aircraft-wildlife strike;
3. personnel on the ground report seeing an aircraft strike 1 or more birds or other wildlife;
4. bird or other wildlife remains, whether in whole or in part, are found within 200 feet of a runway centerline, unless another reason for the animal's death is identified; or
5. the animal's presence on the airport had a significant, negative effect on a flight (i.e., aborted takeoff, aborted landing, high-speed emergency stop, aircraft left pavement area to avoid collision with animal)

(Source: *Wildlife Control Procedures Manual*, Technical Publication 11500E, 1994).

Aircraft-wildlife strike hazard. A potential for a damaging aircraft collision with wildlife on or near an airport (14 CFR 139.3).

Bird Sizes. Title 40, Code of Federal Regulations, Part 33.76 classifies birds according to weight:

- small birds weigh less than 3 ounces (oz).
- medium birds weigh more than 3 oz and less than 2.5 lbs.
- large birds weigh greater than 2.5 lbs.

Civil aircraft damage classifications. The following damage descriptions are based on the *Manual on the International Civil Aviation Organization Bird Strike Information System*:

Minor: The aircraft is deemed airworthy upon completing simple repairs or replacing minor parts and an extensive inspection is not necessary.

Substantial: Damage or structural failure adversely affects an aircraft's structural integrity, performance, or flight characteristics. The damage normally requires major repairs or the replacement of the entire affected component. Bent fairings or cowlings; small dents; skin punctures; damage to wing tips, antenna, tires or brakes, or engine blade damage not requiring blade replacement are specifically excluded.

Destroyed: The damage sustained makes it inadvisable to restore the aircraft to an airworthy condition.

Significant Aircraft-Wildlife Strikes. A significant aircraft-wildlife strike is deemed to have occurred when any of the following applies:

1. a civilian, U.S. air carrier aircraft experiences a multiple aircraft-bird strike or engine ingestion;
2. a civilian, U.S. air carrier aircraft experiences a damaging collision with wildlife other than birds; or
3. a USAF aircraft experiences a Class A, B, or C mishap as described below:

A. Class A Mishap: Occurs when at least one of the following applies:

1. total mishap cost is \$1,000,000 or more;
2. a fatality or permanent total disability occurs; and/or
3. an Air Force aircraft is destroyed.

B. Class B Mishap: Occurs when at least one of the following applies:

1. total mishap cost is \$200,000 or more and less than \$1,000,000; and/or
2. a permanent partial disability occurs and/or 3 or more people are hospitalized;

C. Class C Mishap: Occurs when at least one of the following applies:

1. cost of reported damage is between \$20,000 and \$200,000;
2. an injury causes a lost workday (i.e., duration of absence is at least 8 hours beyond the day or shift during which mishap occurred); and/or
3. an occupational illness causing absence from work at any time.

Wetlands. An ecosystem requiring constant or recurrent, shallow inundation or saturation at or near the surface of the substrate. The minimum essential characteristics of a wetland are recurrent, sustained inundation or saturation at or

near the surface and the presence of physical, chemical, and biological features indicating recurrent, sustained inundation, or saturation. Common diagnostic wetland features are hydric soils and hydrophytic vegetation. These features will be present, except where specific physiochemical, biotic, or anthropogenic factors have removed them or prevented their development.

(Source the 1987 Delineation Manual; 40 CFR 230.3(f)).

Wildlife. Any wild animal, including without limitation any wild mammal, bird, reptile, fish, amphibian, mollusk, crustacean, arthropod, coelenterate, or other invertebrate, including any part, product, egg, or offspring thereof (50 CFR 10.12, *Taking, Possession, Transportation, Sale, Purchase, Barter, Exportation, and Importation of Wildlife and Plants*). As used in this MOA, "wildlife" includes feral animals and domestic animals while out of their owner's control (14 CFR 139.3, *Certification and Operations: Land Airports Serving CAB-Certificated Scheduled Air Carriers Operating Large Aircraft (Other Than Helicopters)*)

Table 1. Identified wildlife species, or groups, that were involved in two or more aircraft-wildlife strikes, that caused damage to one or more aircraft components, or that had an adverse effect on an aircraft's flight. Data are for 1990-1999 and involve only civilian, U.S. aircraft.

Birds	No. reported strikes
Gulls (all spp.)	874
Geese (primarily, Canada geese)	458
Hawks (primarily, Red-tailed hawks)	182
Ducks (primarily Mallards.)	166
Vultures (primarily, Turkey vulture)	142
Rock doves	122
Doves (primarily, mourning doves)	109
Blackbirds	81
European starlings	55
Sparrows	52
Egrets	41
Shore birds (primarily, Killdeer & Sandpipers)	40
Crows	31
Owls	24
Sandhill cranes	22
American kestrels	15
Great blue herons	15
Pelicans	14
Swallows	14
Eagles (Bald and Golden)	14
Ospreys	13
Ring-necked pheasants	11
Hérons	11
Barn-owls	9
American robins	8
Meadowlarks	8
Buntings (snow)	7
Cormorants	6
Snow buntings	6
Brants	5
Terns (all spp.)	5
Great horned owls	5
Horned larks	4
Turkeys	4
Swans	3
Mockingbirds	3
Quails	3
Homing pigeons	3
Snowy owls	3
Anhingas	2

Birds	No. reported strikes
Ravens	2
Kites	2
Falcons	2
Peregrine falcons	2
Merlins	2
Grouse	2
Hungarian partridges	2
Spotted doves	2
Thrushes	2
Mynas	2
Finches	2
Total known birds	2,612

Mammals	No. reported strikes
Deer (primarily, White-tailed deer)	285
Coyotes	16
Dogs	10
Elk	6
Cattle	5
Bats	4
Horses	3
Pronghorn antelopes	3
Foxes	2
Raccoons	2
Rabbits	2
Moose	2
Total known mammals	340

Ring-billed gulls were the most commonly struck gulls. The U.S. ring-billed gull population increased steadily at about 6% annually from 1966-1988. Canada geese were involved in about 90% of the aircraft-geese strikes involving civilian, U.S. aircraft from 1990-1998. Resident (non-migratory) Canada goose populations increased annually at 13% from 1966-1998. Red-tailed hawks accounted for 90% of the identified aircraft-hawk strikes for the 10-year period. Red-tailed hawk populations increased annually at 3% from 1966 to 1998. Turkey vultures were involved in 93% of the identified aircraft-vulture strikes. The U.S. Turkey vulture populations increased annually at 1% between 1966 and 1998. Deer, primarily white-tailed deer, have also adapted to urban and airport areas and their populations have increased dramatically. In the early 1900's, there were about 100,000 white-tailed deer in the U.S. Current estimates are that the U.S. population is about 24 million.

APPENDIX I

WILDLIFE HAZARDS AND AIRPORT SAFETY

APPENDIX I

Wildlife Hazards and Airport Safety

This appendix discusses the rationale for minimizing or eliminating hazardous wildlife attractants at Florida's airports. The choice of water management system can further that goal.

Continually growing air travel in faster and quieter aircraft, coincident with successful wildlife enhancement and management efforts, has resulted in an increasing hazard of aircraft-wildlife collision. About 80% of the wildlife strikes occur within 1,000 feet of the ground, in the *approach and departure airspace* for airports. Figure I-1 shows the most critical area for birdstrikes based on research by Transport Canada.

The vast majority of wildlife are birds, with nearly 22,000 bird strikes reported between 1990 and 1998 in the United States alone. An additional 580 mammal and 35 reptile strikes were reported in the U.S. in the same period.

Damage is both injury/loss of life and economic. Loss of life in the United States due to aircraft-wildlife collisions averages about 2 per year for civilian and 3 per year for military aircraft. Although even wide body jet airliners have been totally destroyed following bird collisions in the U.S., to date there have been no major civilian airliner losses of life in single incidents here.

The total estimated cost to U.S. civil aviation due to wildlife strikes is \$250 million direct and \$130 million indirect annually. These costs do not consider environmental damage. For example: *On August 27, 2001 a Boeing 747 departing Los Angeles ingested birds and suffered an engine failure. The aircraft was forced to dump over 165,000 pounds of fuel over the Pacific Ocean to return for a safe landing.* Pieces of the engine fell on nearby beaches, but no persons on the ground were injured. The environmental damages and costs of this event and others like it, including crashes with fuel release, are not considered in the \$380 million annual *wildlife strike* costs.

The problem is not limited to the State of Florida, which consistently ranks in the top 3 states for wildlife strikes, or to the United States. Further, it is becoming a source of legal liability both within and outside the U.S. For example, on June 3, 1995 an Air France Concorde ingested 1 or 2 Canada geese into the Number 3 engine about 10 feet above the runway while landing. The engine burst (uncontained failure) and the resulting shrapnel destroyed the Number 4 engine. It also cut several control cables and hydraulic lines. A safe landing was effected, but the aircraft had \$7 million damage. The French Aviation Authority sued the Port Authority of New York and New Jersey for failure to manage the bird hazard and/or to warn the aircraft of the hazard. The case was settled for \$5.3 million before trial. Cases taken to trial have been decided against the airport operator in the U.S., England and other countries, with decisions that a duty of due diligence is owed in managing an airport's wildlife hazards. Criminal charges have been filed in at least one European country over a fatal crash attributed to wildlife hazards.

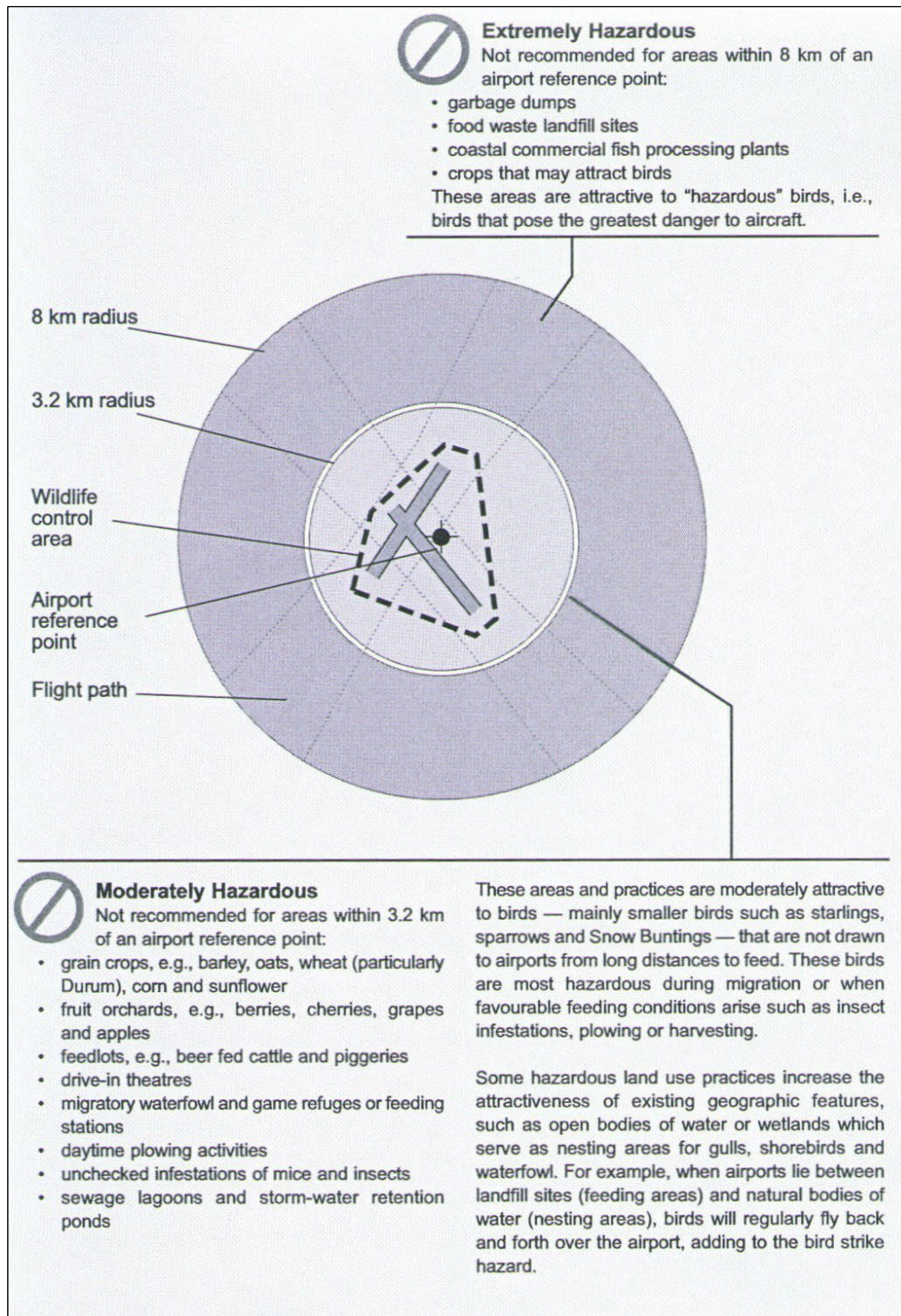


FIGURE I-1 BIRDSTRIKE HAZARD AREAS
 (Excerpted from “Sharing the Skies” Manual Published by Transport Canada)

Florida Statute Chapter 333 *Airport Zoning* recognizes bird attractants as one of several hazards to airport operations. Section 333.02 of the Statute states, in part:

“(1) It is hereby found that an airport hazard endangers the lives and property of users of the airport and of occupants of land in its vicinity.... Accordingly, it is hereby declared:

(a) That the creation or establishment of an airport hazard and the incompatible use of land in airport vicinities are public nuisances and injure the community served by the airport in question;

(b) That it is therefore necessary in the interest of the public health, public safety, and general welfare that the creation or establishment of airport hazards and incompatible land uses be prevented...”

The Statute is principally concerned with zoning ordinances to promote compatible land use adjacent to airports and out to 10 nautical miles (11.5 statute miles) for specific land uses.

The FAA Advisory Circular 150/5200-33C Hazardous Wildlife Attractants On Or Near Airports states, in Section 4.3.4:

“Airports that have received Federal assistance are required under their grant assurances to take appropriate actions to restrict the use of land next to or near the airport to uses that are compatible with normal airport operations. See Grant Assurance 21. The FAA recommends that airport operators oppose off-airport land-use changes or practices, to the extent practicable, within the separations identified in Paragraphs 1.2 through 1.4, [as shown in Figure 605-8 this *BMP Manual*] which may attract hazardous wildlife. Failure to do so may lead to noncompliance with applicable grant assurances. The FAA will not approve the placement of airport development projects pertaining to aircraft movement in the vicinity of hazardous wildlife attractants without appropriate mitigating measures. Increasing the intensity of wildlife control efforts is not a substitute for preventing, eliminating or reducing a proposed wildlife hazard. Airport operators should identify hazardous wildlife attractants and any associated wildlife hazards during any planning process for airport development projects.

The state wildlife organization, the Florida Fish and Wildlife Conservation Commission (FWCC), also recognizes the serious nature of wildlife hazards to aircraft. FAC 68A-9.012 allows harassment and/or taking of wildlife on airports to ensure aircraft and human safety.

Federal agencies concerned with environmental protection, including the U.S. Environmental Protection Agency (EPA), the U.S. Army Corps of Engineers (USACOE), the United States Department of Agriculture (USDA), and the U.S. Fish and Wildlife Service (FWS) are all signatory to a memorandum of understanding on the problem. A copy of this document is included in Appendix H. The goals are similar to those of this project – to provide safe air transport and sound stewardship of national water, wetland and wildlife resources.

Impact Forces and Damage

Bird or other wildlife strikes on aircraft exert large forces on the impacted structure. Fundamentally, these forces are given by Newton's Third Law that Force = Mass x Acceleration. It is possible to approximate the forces based on aircraft velocity and bird weight. Table I-1 summarizes the bird impact forces for various aircraft velocities and typical bird species and weights.

TABLE I-1 APPROXIMATE BIRD IMPACT FORCES

Bird Species & Weight	Approximate Impact Forces in Pounds for Given Speed				
	60 Knots (69 mph)	100 Knots (115 mph)	150 Knots (173 mph)	200 Knots (230 mph)	250 Knots (288 mph)
Starling (3 ozs)	359	995	2,238	3,978	6,216
Snowy Egret (13 ozs)	517	1,436	3,230	5,743	8,973
Ring-Billed Gull (1.5 lbs)	994	2,775	6,244	11,100	17,343
Duck (4.0 lbs)	2,186	6,078	13,676	24,314	37,990
Black Vulture (4.4 lbs)	2,799	7,775	17,493	31,099	48,592
Great Blue Heron (6.5 lbs)	2,953	8,204	18,459	32,815	51,274
Canada Goose (15 .0 lbs)	3,268	9,118	20,515	36,471	56,985

An example of the damage a birdstrike can cause even a relatively slow speeds is shown in Figure I-2 on the following page. The strike occurred on approach, probably at a speed of less than 100 knots and was most likely a duck. The aircraft landed safely but sustained serious damage.



FIGURE I-2 BIRDSTRIKE DAMAGE TO PIPER SEMINOLE DURING LANDING APPROACH TO A FLORIDA AIRPORT (MARCH 2003)

Site Factors

Bird and wildlife strike prevention generally requires a combination of active and passive controls. Active controls include wildlife harassment and take options as provided in FAC 68A-9.012. Passive controls relate to the site conditions on and around the airports. The goal is to eliminate or minimize as many wildlife attractants as possible, particularly in the approach and departure airspace around the airport. Passive controls can include the creation of more attractive habitats away from the airport approach and departure airspace as part of the strategy.

Studies in the U.S. and abroad have identified various site conditions that act as attractants to hazardous wildlife. These can be broadly grouped into three categories: food source, habitats, and cover/safe areas. FAA AC 150/5200-33B discusses many of these, as does the USDA/FAA *Wildlife Hazard Management at Airports* manual. Table I-2 following combines data from these sources and Transport Canada's *Sharing the Skies* manual to list attractants.

TABLE I-2 WILDLIFE ATTRACTANTS

Food Source	Habitat	Cover/Safe Area
Fish/Amphibians	Wetlands	Brush/Wooded Areas
Insects	Ponds/Lakes/Open Water	Ponds/Lakes
Rodents	Drainage Ditches	Open Structures/Sheds
Seed Producing Grasses	Temporary Ponding Areas	Abandoned Pavement
Agricultural Crops	Woodlots and Trees	Grassed Fields
Litter/Garbage		
Food Processing Activities		

APPENDIX J

AIRPORT COMPATIBLE SPECIFIC POND DESIGN

APPENDIX J

Airport Compatible Specific Pond Design

The following criteria are provided for pond design based on the *Technical Report on the Water Management Performance of the FAA Pond at Naples Municipal Airport* (Reference 35). They are applicable to systems serving airside, landside, or a combination of both. However, they cannot be used with the General Permit of Florida Administrative Code (FAC) 62– 30.449, copy included in Appendix F of this document. They can be used for Individual Environmental Resource Permits (ERP) with full hydrology, hydraulic, and load calculations to document the design meets the Conditions of Issuance

1. Applicability

Favorable Site Conditions

- Water level fluctuations between Seasonal High Water and Seasonal Low Water are small, generally less than 1 foot.
- Recycled, crushed, carbonated (exposed to atmosphere for 28 days after crushing and grading) Portland Cement Concrete (PCC) is readily and economically available for gabion fill material.
- The contributing area is only airside if the General Permit of 330.449 FAC is used. Landside or combined airside/landside application of this pond on airports requires an Individual Environmental Resource Permit per Chapter 62-330 FAC.
- The pond will be located perpendicular to the center one-third of the nearest runway and will be outside the closer of a Taxiway Object Free Area (TOFA) or the Runway Object Free Area (ROFA).
- The pond location will be inside a controlled access area to avoid inadvertent entry that may be a water hazard due to steep or vertical side slopes beneath the Seasonal High Water Level.

Usable Site Conditions

- Water level fluctuations between Seasonal High Water and Seasonal Low Water are moderate - less than 3 feet.
- The pond will be located outside a perpendicular to the center one third of the nearest runway but will not be located within the approach or departure areas of any runway as bounded by the Runway Protection Zone (RPZ) as defined in FAA Advisory Circular AC 150/5300–13, latest version, latest change.
- The pond is located outside all Runway Safety (RSA) and Object Free Areas (ROFA) but between a Taxiway Safety Area (TSA) and a Taxiway Object Free Area (TOFA).
- The pond location is accessible to the general public but includes features such as lighting, fencing, defined walkways, or similar to minimize inadvertent entry to the pond.

Unfavorable Site Conditions

- Water level fluctuations between Seasonal High and Seasonal Low Water are large, exceeding 3 feet. This condition will place the gabion surfaces more than 6 feet beneath the Seasonal High Water Level or will expose the gabion surface during the Seasonal Low Water Level. The first case will cause an excess bypass

of water and the second case may create an undesirable perching/foraging location for birds.

- The pond will be located directly in the approach or departure areas for any runway as bounded by The Runway Protection Zone criteria of FAA advisory Circular AC 150/5300-13, latest version and change.
- The pond will be a purely freshwater system located on one side of a runway system directly across from a saltwater system located on the opposite side of the runway system. This may create a flyway for foraging birds, providing varying diet between the freshwater and saltwater habitats.

2. Design Criteria

- The minimum surface area of the pond shall be equal to or greater than 2% of the contributing catchment area.
- Pond side slopes beneath the estimated Seasonal High Water Table shall be 2H: 1V or may be vertical sheet pile, gabions or retaining wall structures. Refer to Figure J-1.
- If vertical sheet pile or retaining wall structures are not used for pond side slopes, the preferred options are to either riprap the slopes using crushed, recycled PCC or to stabilize the slopes with a PCC surface, soil-cement surface layer, gabions, or mortar filled stabilization blanket. Natural earth slopes may be used if water level fluctuations and erosion considerations permit, but their use should include a vegetation management plan to preclude or minimize habitat creation and wildlife attraction along the pond sides. Figure 605-6 illustrates this design concept.
- Gabions shall be used to crenellate the pond system and provide the necessary flow path to train the flow, volumetric utilization, and permeable surface for direct sorption of pollutants or as a biologic growth substrate. Gabions shall have the following characteristics:
 - Recycled, crushed concrete is the required fill material for gabions. Other aggregate or filler materials may be used, but must be tested to verify no phosphorus or pollutant leaching. The General Permit may not be used with other than crushed PCC as the aggregate.
 - Gabions shall be socketed into adjacent side slopes as illustrated in Figure J-1.
 - Gabions shall extend at least 85% of the pond width as illustrated in Figure J-1.
 - Gabions shall be designed to remain at least 3 feet beneath Seasonal Low Water but not more than 6 feet beneath Seasonal High Water. Gabions that will be located more than 3 but less than 6 feet beneath Seasonal High Water may require an adjustable fabric baffle system similar to that shown in Figure J-2 to prevent excess bypass of water or discourage wildlife, but this is optional.
 - Gabions may be designed to extend on a continual basis at least 3 feet above seasonal high water but must be provided with some method of excluding bird use. Wildlife monitoring and a contingency plan may be necessary until this option is tested.

- Gabions shall be designed within the pond to provide a sinuosity or tortuosity of 6:1 or greater from the inlet closest to the pond outlet. This is illustrated in Figure J-3 showing the flow path length along the thalweg (L_e) and the pond length (L) from the closest inlet to the pond outlet. $L/L_e = 6$ or greater. The design should provide a hydraulic residence time (HRT) of 5 days or greater along the thalweg.
- Ponds designed using gabions as outlined above may be designed for load removal efficiencies of 40 percent for Total Nitrogen (TN); of 70 percent for Total Phosphorus (TP); and of 80 percent for Total Suspended Solids (TSS). These removal percentages are comparable to or exceed those available from presumptive wet detention ponds.
- Pond outlet controls shall be consistent with water quantity management requirements for the jurisdiction in which the pond is located. Pre-and post-development flow rates will generally determine the specific control structures used. There is no specific requirement for a treatment bleed-down volume with a weir/orifice system typical of presumptive ponds.
- Crenellated designs may be built into a pond by shaping existing materials and providing appropriate slope protection without the use of gabions. However, a system of this type may require water quality monitoring to verify performance if treatment levels greater than actual values from a presumptive design wet pond system are used for water quality calculations.
- Figures J-4 and J-5 show the test pond at Naples Airport during construction and after completion.

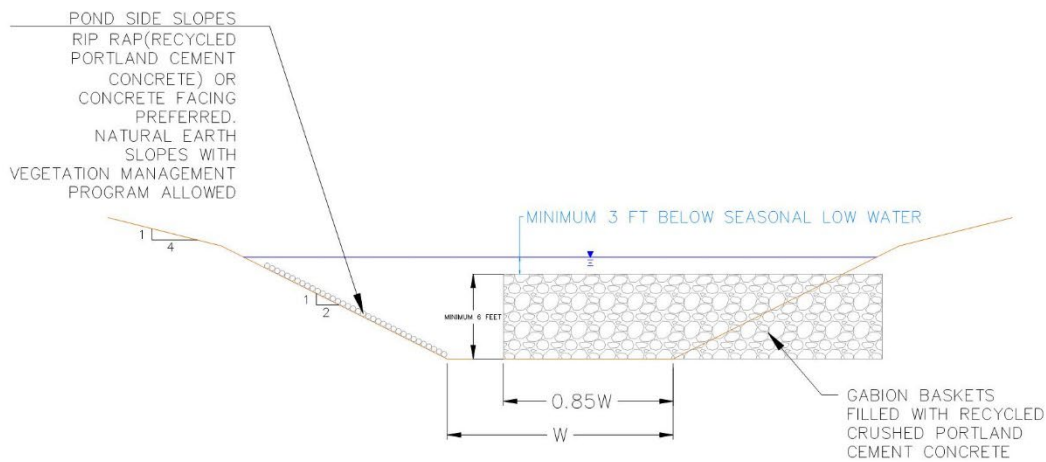


Figure J-1 Crenellated Pond Cross Section Criteria - Sloped Side Option

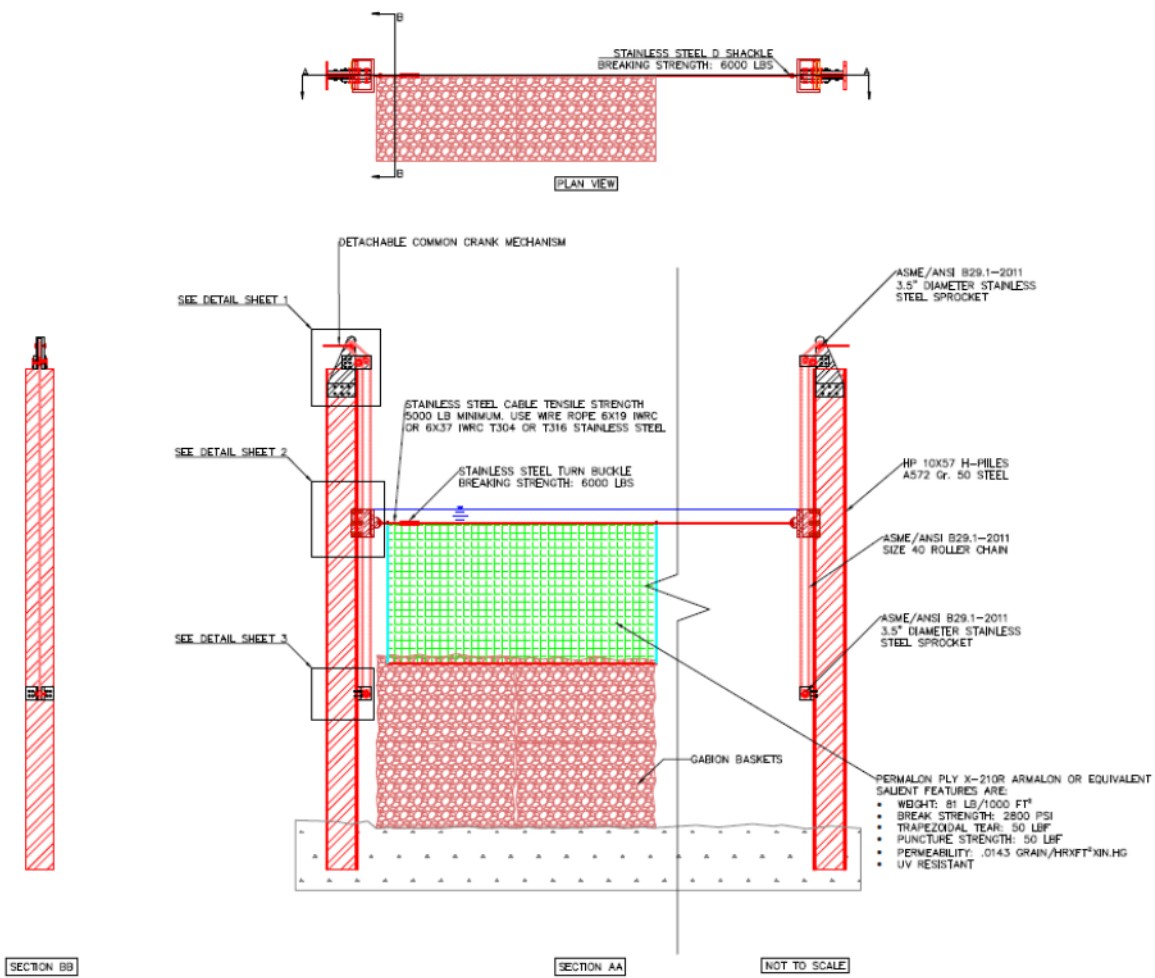


Figure J-2 Adjustable Fabric Baffle Example

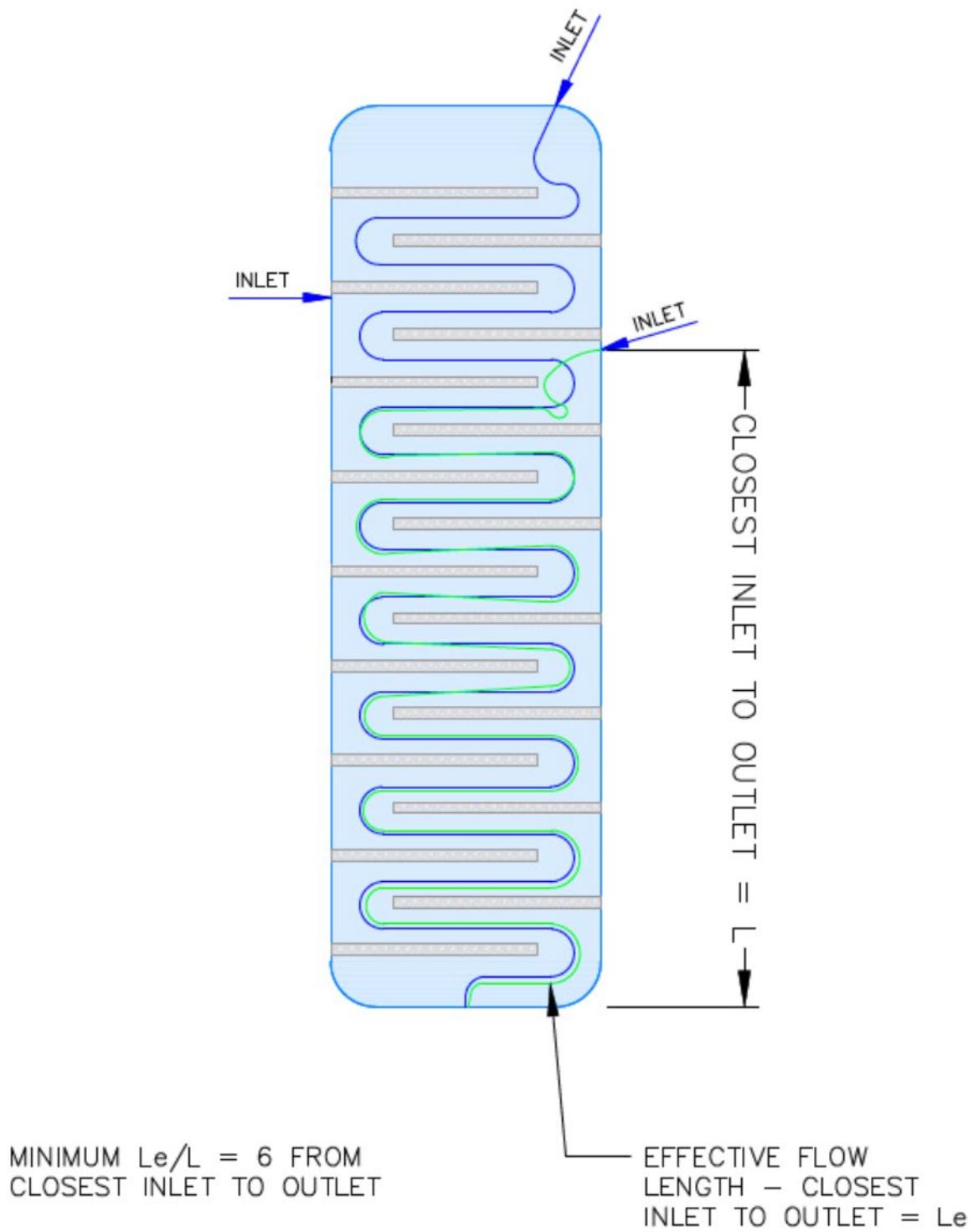


Figure J-3 Sinuosity/Tortuosity Requirements for Crenellated Pond Design



Figure J-4 Naples Pond Gabions Under Construction

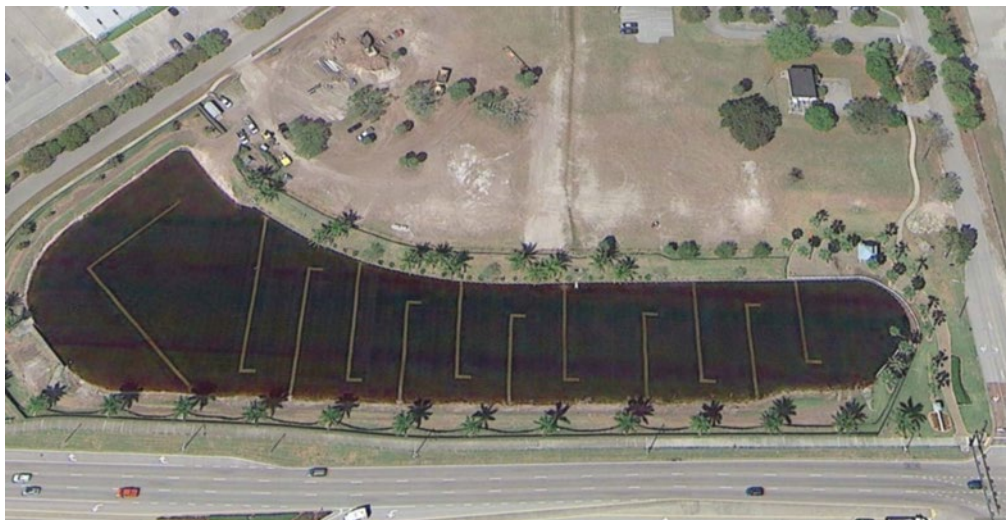


Figure J-5 Naples Pond Aerial