Florida Department of Transportation – Aviation Office

Statewide Airport Stormwater

Best Management Practices Manual

Clean Water – Safe Airports

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Revision

FLORIDA STATEWIDE AIRPORT STORMWATER STUDY
BEST MANAGEMENT PRACTICES MANUAL

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Section 1 INTRODUCTION

101. PURPOSE AND INTENT

The ***Florida Airports Stormwater Best Management Practices Manual*** is intended for use by consultants, regulators and airport sponsors charged with design, permitting and operation of airside stormwater management facilities. The document is directly referenced in the General Permit for Construction, Operation, Maintenance, Alteration. Abandonment or Removal of Airport Airside Surface Water Management Systems, Chapter 62-330.449, F.A.C., and focuses primarily on airport stormwater quality. It sets forth the procedures and criteria for those facilities eligible for the general permit. It is applicable to most, but not all airside facilities, and its use must consider the site specific conditions. This BMP manual is a stand alone document. However, companion documents, the ***Technical Report for the Florida Statewide Airport Stormwater Study*** and the ***Application Assessment for the Florida Statewide Airport Stormwater Study*** provide additional reference material that may be consulted. Also, Federal Aviation Administration (FAA) Advisory Circular (AC) 150/5320-5C must be consulted for airside specific drainage design and stormwater quantity guidance. These documents can be accessed at http://www.dot.state.fl.us/aviation/stormwater.shtm and
http://www.faa.gov/regulations_policies/advisory_circulars/

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

Information in this manual is intended for design of individual airside facilities or master planning airport airside stormwater management systems. References in **Appendix A** should be consulted for further information on airside stormwater management.

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 routine inspections, and it is generally confined to aprons/ramps.

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. 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 the relations to each other at a Florida general aviation/limited commercial service airport.

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

The above list is not all-inclusive, but is meant to outline primary categories of projects done by airports. Fuel farms and aircraft wash-racks may require stormwater management permits, but are more commonly regulated through industrial wastewater permits. Private developers and corporations often do other landside development. Landside development is outside the stormwater management scope of this manual, but noted safety considerations may still apply.

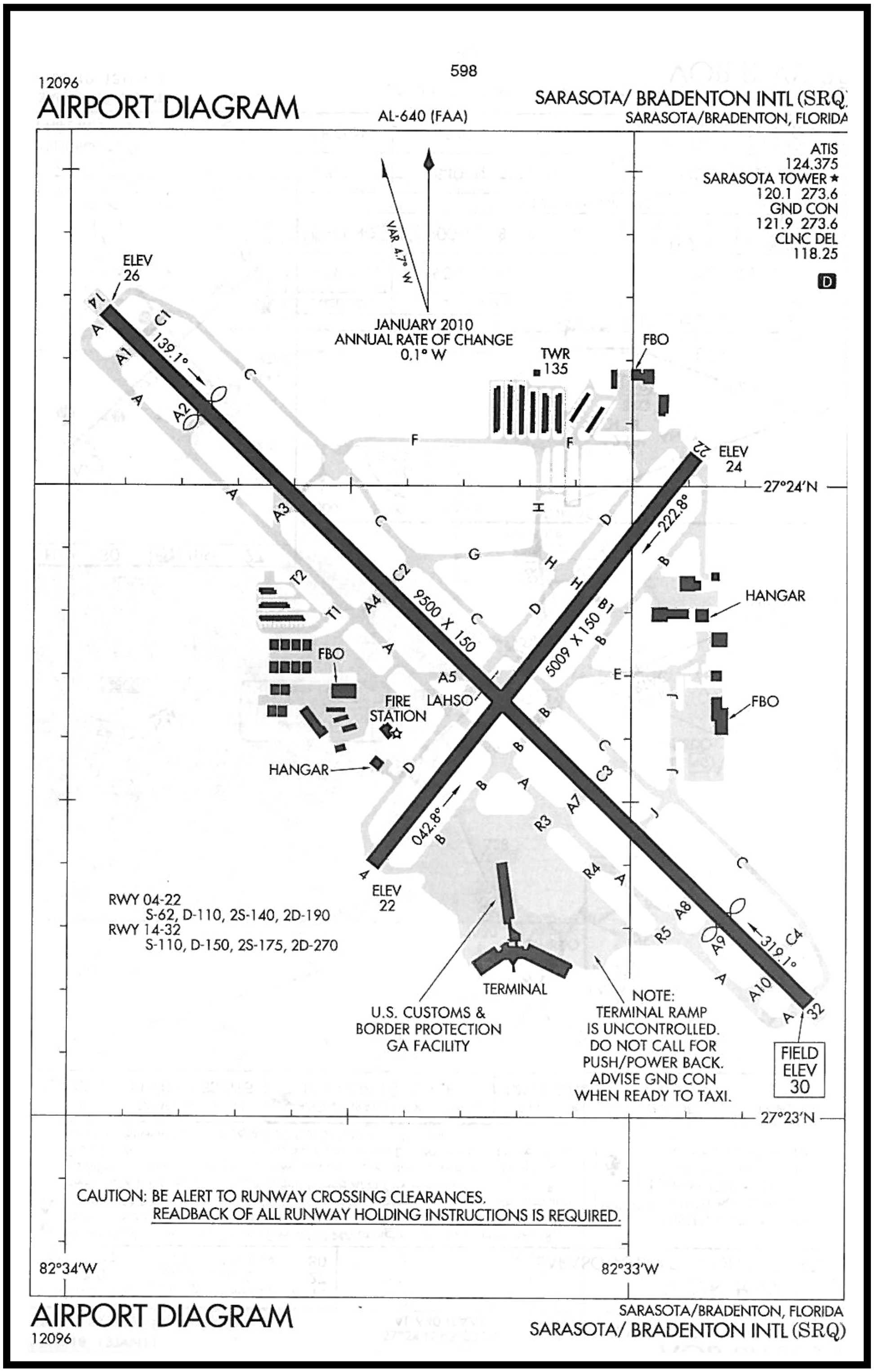

Figure 102-1 Typical Airport Airside and Transitional Facilities

[INSERT FIGURE 102-2]

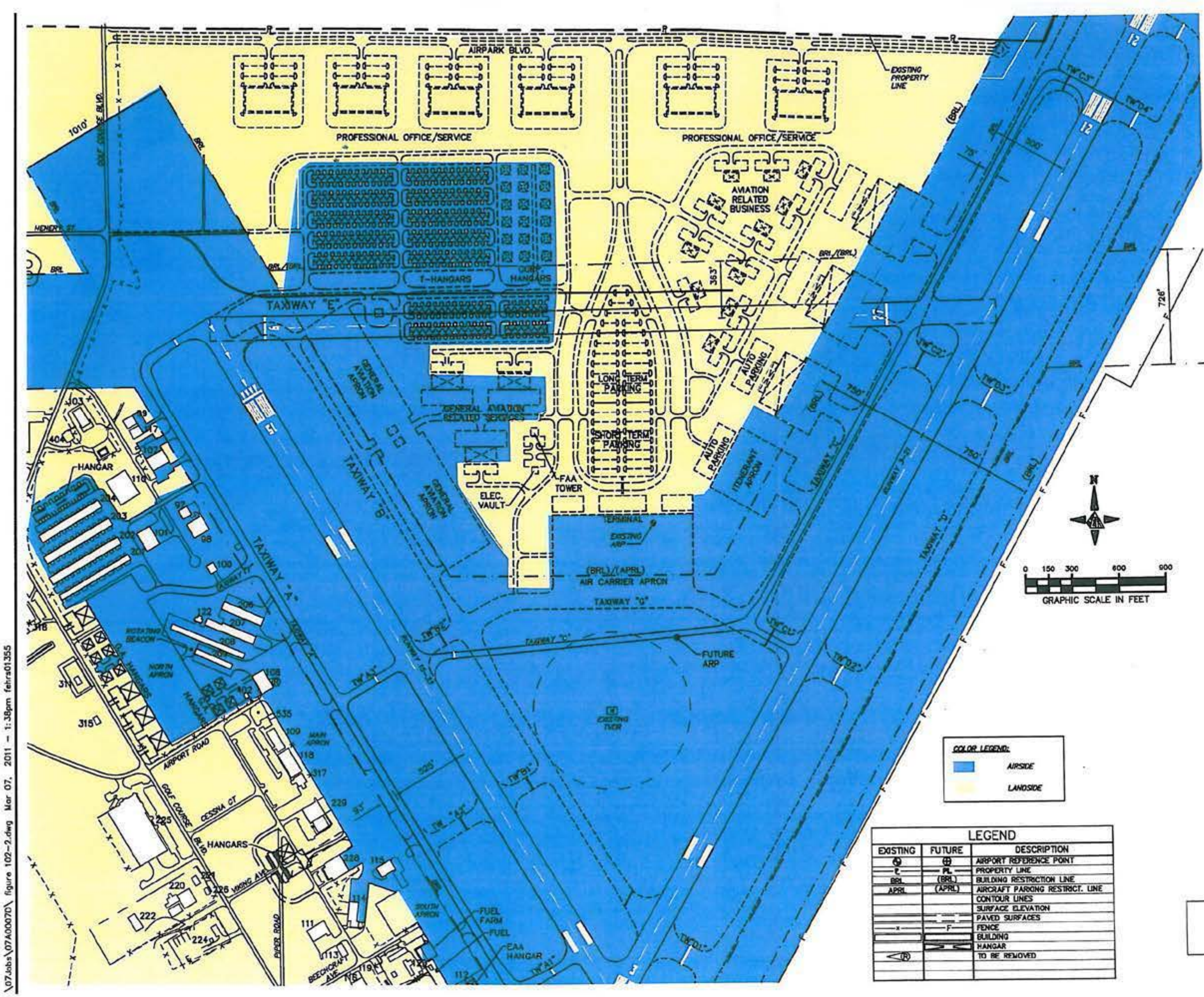

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FIGURE 102-2: ILLUSTRATION OF AIRSIDE AND LANDSIDE AREAS

A final item of importance in the general airport discussion is access control. Airport security is continually tightening in the wake of the events September 11, 2001. The Transportation Security Administration (TSA) now regulates airside security and access. TSA briefings indicate aviation remains a weapon and target of choice for terror attack. 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 ***Florida Airports Stormwater Best Management Practices Manual*** and the General Permit for Construction, Operation, Maintenance, Alteration. Abandonment or Removal of Airport Airside Surface Water Management Systems, address only the airport airside stormwater management. They are concerned with runoff from runways, taxiways and aprons. Also, until further research is completed, the manual addresses only infiltration BMPs such as overland flow, swales, and/or dry retention as the primary stormwater quality treatment methods. Wet detention ponds, including those with features recommended by the FAA and the United States Department of Agriculture (USDA) to make them less attractive to wildlife are outside the scope of this document. Landside stormwater management is not included, and must be addressed using other applicable FAA, FDOT, FDEP, and/or Water Management District regulations. However, it is important to consider that the twin needs for safety and stormwater management do not end at the airside when doing landside design and permitting. Land use compatibility around airports is addressed in FAA Advisories Circulars and in Chapter 333, Florida Statutes, both of which should be consulted prior to selecting a stormwater management system – airside or landside.

The Best Management Practices (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 pre-requisite. 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 these tools 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 to the USDA/FAA Wildlife Hazard Management at Airports Manual for that guidance. Appendices H, K and L present additional information on wildlife hazards. The importance of considering wildlife hazards and attractants when selecting airport stormwater management strategies to the safety of the travelling public is emphasized in the documents in these appendices.

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 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 (NWFWMD), the FAA, the FDOT and the public have been afforded the opportunity to comment on this BMP Manual and the draft general permit set forth in Chapter 62-330.449, F.A.C.

1.04 ADDITIONAL PERMIT INFORMATION

This document is directed towards the water management design for an Environmental Resource Permit. However, other permits will be required for most new airside 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 done under Rule 62-621.300(4) FAC as part of the National Pollution Discharge Elimination System. It is required for projects that:

1. Contribute stormwater discharges to surface waters of the State or into a municipal separate storm sewer system, and
2. Disturbs on or more acres of land including clearing, excavating and grading. If the specific project is less than 1 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 www.dep.state.fl.us/water/stormwater/npdes.

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 U.S. Army Corps of Engineers. 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.

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 primary water constituent causing water quality degradation, this manual focuses on reducing Nitrogen and Phosphorus loads in stormwater discharges from airports.

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 - no flow over unpaved surface is reflected in these values. If concerns arise over other constituents during the design and permitting of a stormwater management system under Chapter 62-330.449, F.A.C, 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)	Total Phosphorus (TP)
General Aviation Apron	0.335	0.051
Airline Terminal Apron	0.398	0.057
T-Hangar Apron	0.551	1.836
Ari Cargo Apron	0.259	0.053
General Aviation Runway	0.365	0.081
Air Carrier Runway	0.401	0.049
Taxiways	0.569	0.11
Natural Vegetative Community	0.93	0.10

Nutrient constituents can be sorbed, converted or filtered with overland flow. At low concentrations typical of airport runoff the EMC may remain unchanged or increase as the runoff flows across grassed areas.

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 necessary 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 airsides 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. However, field tests for infiltration rate can provide a useful tool to estimate some of the properties, and can provide a boundary rate that infiltration rates based on equations should converge to. The double ring infiltrometer test (formerly ASTM D3385, recently repealed) is the most common method of establishing field infiltration rate.

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.

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 (Reference 25) presents options for isolating vertical and horizontal components. **Appendix D** provides the formulations developed by Hvorslev for the USACOE to estimate permeability using field tests. Cautions with field testing include the effect of compaction during construction.

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 done at the same time.

Soil permeability can also be estimated based on grain size characteristics (determined per ASTM 6913-04), or 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 E** presents charts of typical values of permeability based on soil gradation, along with estimates of soil suction, and porosity. Figure 3.4 in Reference 21 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 (after Reference 21)

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 (SC)	0.1 - 0.2
Low Plasticity Clay (CL)	.0.00001 – 0.2

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. This is also described as "Fillable Porosity" in **Appendix F**.

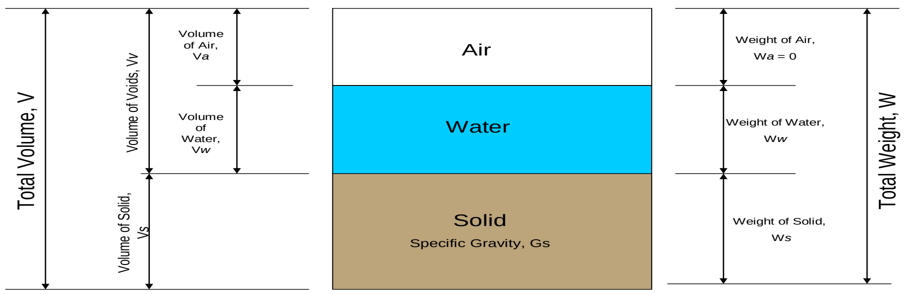

Figure 305-1 Soil Components Block Diagram

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 following 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

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 base 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 E 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 capilliarity of the soils, and increases as the grain size of the soil decreases. Typical values are provided in Table 306-1 following.

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

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 loam	8.6
Clay Loam	8.2
Silty clay loam	10.7
Sandy clay	9.4
Silty clay	11.5
Clay	12.5

Appendix E 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.

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 done on sites that have served as airports since the 1940's. 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 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 using 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:
  http://soils.usda.gov/technical/classification/osd/index.html
  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 the 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 that are located in the general 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 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. The caution in stormwater management is the shift in datum from NGVD 1929 to NAVD 1988. 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 is often referenced to 1929 NGVD. 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 the following chart, Figure 309-1.

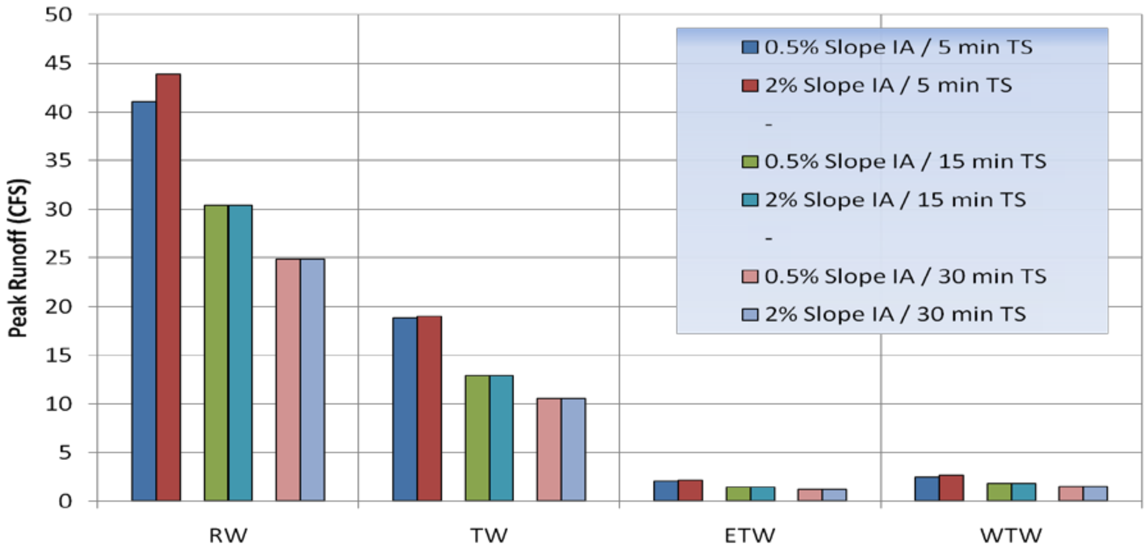

Figure 309-1 Peak Runoff Sensitivity Results for Impervious Areas

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 in order for those 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.

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 150/5320-5C, 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 on the following page provides non-parametric statistics for daily rainfall events at a series of representative Florida airports. **Appendix G** presents annual rainfalls in greater detail graphically. The annual rainfall totals shown in **Appendix G** or in Table 401-1 may be used to normalize 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 of **Appendix G**.

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 tables final two rows 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 provide the recommended approach for airside stormwater management.

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	PBI
Modal Rainfall (inches)	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.02**	**0.01**	**0.01**	**0.01**
Median Rainfall (inches)	**0.24**	**0.19**	**0.2**	**0.18**	**0.19**	**0.3**	**0.24**	**0.19**	**0.17**
Percent Rain less than 0.5 inches	**67%**	**73%**	**71%**	**72%**	**71%**	**62%**	**66%**	**71%**	**72%**
80th Percentile Rainfall (inches)	**0.83**	**0.68**	**0.72**	**0.70**	**0.73**	**0.98**	**0.87**	**0.72**	**0.66**
90th Percentile Rainfall (inches)	**1.33**	**1.10**	**1.23**	**1.22**	**1.17**	**1.55**	**1.44**	**1.16**	**1.20**
95th Percentile (inches)	**1.83**	**1.52**	**1.81**	**1.74**	**1.55**	**2.41**	**2.04**	**1.56**	**1.70**
Average Interval Between Rain Events during the Rainy Season June 1 - September 30 (Hours)	**22**	**25**	**26**	**21**	**24**	**29**	**27**	**26**	**23**
Percent of Rain during the Rainy Season June 1 -September 30	**65%**	**48%**	**51%**	**54%**	**52%**	**41%**	**45%**	**58%**	**47%**
Average Annual Rainfall, **1985-1999** (inches**)**	**55**	**49**	**54**	**62**	**52**	**67**	**61**	**46**	**62**
Design Rainfall (inches) for 10-year, 24-hour Event (ref___)	***6.5***	***7***	***7.5***	***8***	***8***	***9.5***	***8.5***	***8***	***9***
Design Rainfall (inches) for 25-year, 24-hour Event (ref___)	***7.8***	***8***	***8.5***	***9***	***8.5***	***10.5***	***9.5***	***9.5***	***10***

Data source same as companion Technical Report 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
PBI is located in West Palm Beach

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 done 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 not be useful for hand calculation depending on the loss and infiltration method used.

Table 402-1 following 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 5-minutes or 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 following illustrates a 5-minute rainfall record for Orlando International Airport for a 20 month period.

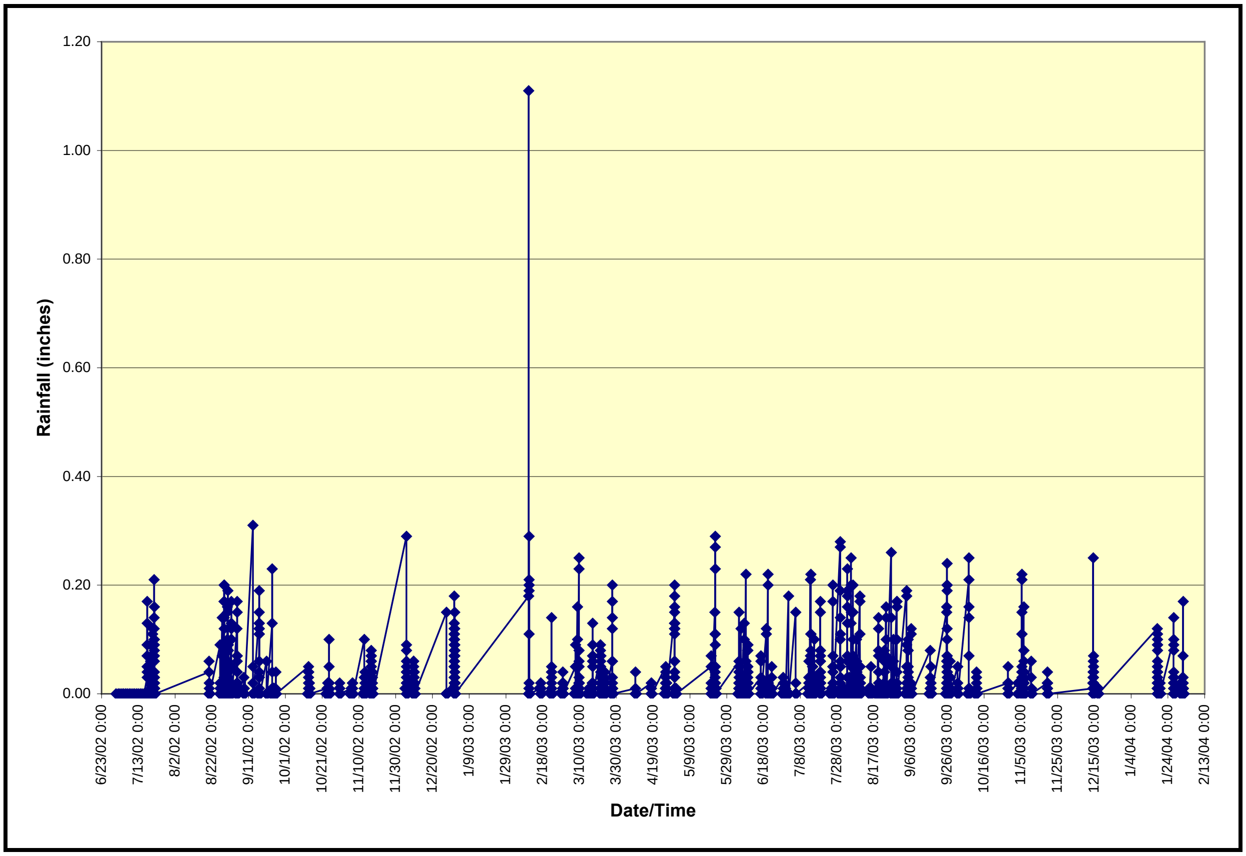

Figure 402-1 Recorded 5-minute Rainfall Record for Orlando International Airport

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/ .

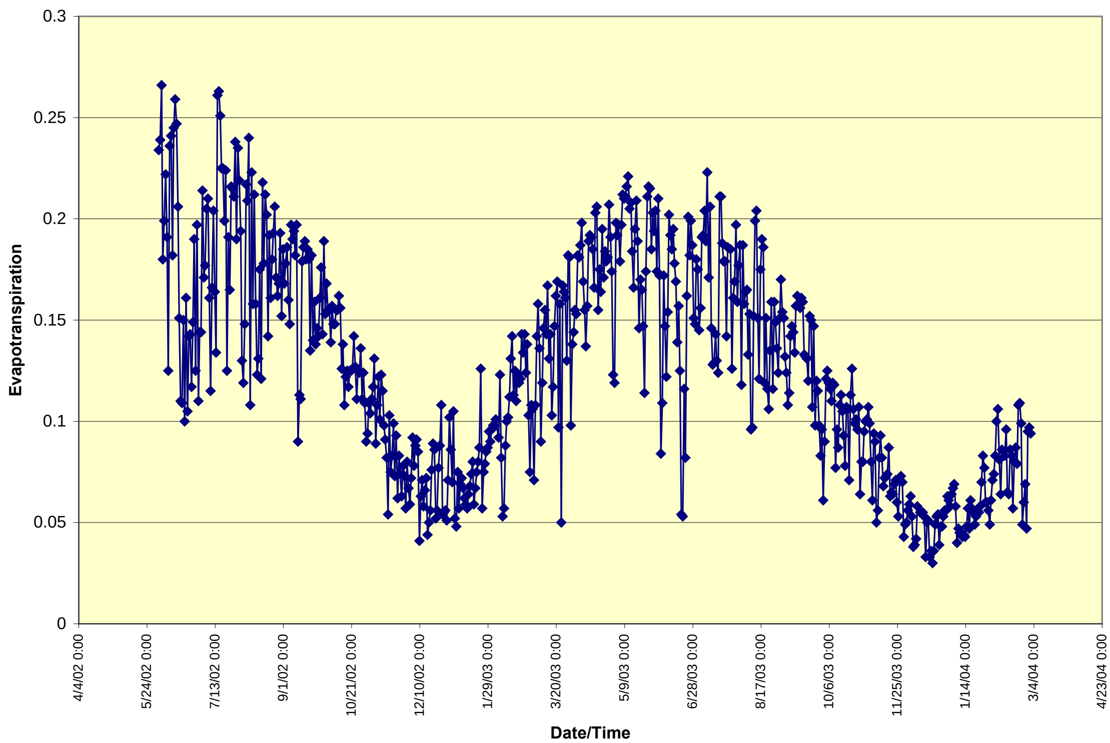

Figure 403-1 Plot of Daily Evapotranspiration Measured in Central Florida

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 mis-estimate 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 Statewide Airport Stormwater Study. Using a pavement example as before, calculated CN ranged from 72 to 95. The typically accepted CN for pavement is Florida in 95. Lower intensity and volume rains yield lower CN. Using CN for continuous simulation modeling is likely to substantially overestimate runoff and loads.

Figure 404-1 following illustrates the measured runoff for pavement and overland flow compared with the runoff estimated using Green Ampt equation for one year of recorded information. Actual measured runoff was 3.61 inches; 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.

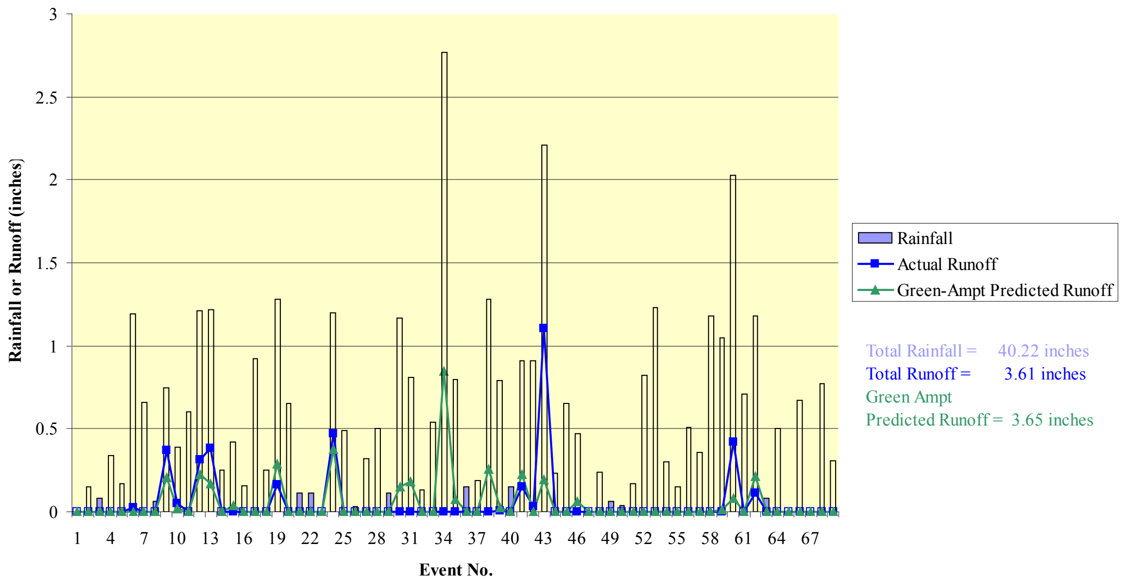

Figure 404-1 Comparison of Actual and Green-Ampt Predicted Runoff

The Green Ampt equation is discussed in references 1 and 6. 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
and, 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.**

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 following, 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 for 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 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 Statewide Airport Stormwater Study. Table 502-1 contains the values to be used when calculating ground water nutrient loadings and were supplied by FDEP.

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

COUNTY	NITRATE and NITRATE+NITRITE as N mg/L	TOTAL PHOSHORUS 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

COUNTY	NITRATE and NITRATE+NITRITE as N mg/L	TOTAL PHOSHORUS 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

COUNTY	NITRATE and NITRATE+NITRITE as N mg/L	TOTAL PHOSHORUS 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 annual average load reduction. During the Florida Statewide Airport Stormwater study load reductions were measured for all parameters, including nutrients. Concentration reductions were measured for all parameters except nutrients during overland flow.

Load reductions can occur via two primary methods. First, the stormwater volume that is discharged from a site can be reduced. This typically is done by using infiltration BMPs in which the stormwater soaks into the ground. Given the low concentrations of nutrients in airport airside runoff, it is assumed that 100% of the nutrient loading is removed when the stormwater is retained on-site. Second, 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.

In some cases, a third load reduction method occurs such as during overland flow. Concentration changes with overland flow reflect either a decrease or an increase in the EMC during overland flow. It is calculated as:

Concentration Reduction (%) = [(Pavement Concentration – BMP Concentration)/Pavement Concentration] x 100%

Depending on the site, reducing concentrations during overland flow may involve one or more or the following mechanisms: infiltration, adsorption, particulate entrapment, re-suspension or other. 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 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 14, **Appendix A**) for detailed information.

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 doing the ***Application Assessment*** is well suited to this analysis. Commercial software products with continuous simulation capability may also be used.

The most difficult component of the model is to define the pre-development load that would result from a natural vegetative community, if present at the airport site. This difficulty stems from establishing the Green Ampt parameters, the ground water elevations and the corresponding rainfall-runoff relation that would prevail if the airport were not present. Most public use airports in Florida were constructed in the 1940's or earlier, and the sites and drainage were extensively altered at that time. Generally, the site modifications were a combination of lowering extant ground water levels through drainage and raising site elevations with earthfill. Removing muck and peat type soils and replacing these with sands for better structural support also altered the drainage properties. In cases, the sites were cleared but not grubbed, and clean earthfill was placed directly on the stumps, vegetation, and site soils. The net effect is that most airport sites now exhibit soil and ground water conditions that have lower runoff potential than the original, natural vegetative communities. Two approaches are recommended to establish the pre-development parameters for a natural vegetative community. These are:

1. If historical information or site geotechnical studies with a combination of borings and test pits can define the extent of the alterations, the rainfall-runoff relations estimated based on this information can be used with the EMC data from Table 202-1.
2. If nearby areas still contain natural vegetative communities that can be reasonably inferred to be representative of regional conditions, the rainfall-runoff relations of these may be used, with the EMC data from Table 202-1, to establish the natural vegetative community loading for an equivalent area.

The parameters establishing the rainfall-runoff relations for the pre development condition 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 pre-development, natural vegetative community load follows. The discussion is generic since the specific model software or approach may vary project to project.

1. Define basins for the project site initially by topography and outfall locations. Further define basins by areas of different projected ground water elevation and soils types if necessary. Since the pre-development site is considered a natural vegetated community, it will not be necessary to further define basins by land use.
2. The EMC data from Table 202-1 will be used, and no BMP efficiencies are applied.
3. Run the continuous simulation, surface water model with rainfall records defined on 15-miute or smaller intervals for a one year period.
4. If necessary, run a ground water model or equation to help validate the infiltration volumes. 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 proximity of the ground water to the ground surface. If the estimated SHGWT is closer than 2 feet to the ground surface, ground water modeling or long term physical data is usually needed. If the results are substantially different than used in the surface water model, another iteration of surface and ground water modeling is needed..
5. Review the results for reasonableness. Revise the models as necessary.
6. Establish the pre-development target loads based on the model and calculation.

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 airside, 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, soils types, airside pavement limits and land use. The pavement areas should include the first 25 feet of overland flow within their defined basins in those models that permit an impervious over pervious flow simulation.
2. Define the EMC's for each different pavement type associated with the project (air carrier runway and taxiway, for example) using Table 202-1.
3. Define the BMP efficiencies for overland flow, using Reference 14, **Appendix A**, or other treatment as appropriate. The definition may be load or concentration based, depending on the selected model. In all cases the ultimate requirement is discharge load calculation. Where concentrations change through the BMP, and where the constituent load is explicitly reduced 100% for all infiltration by the model, a concentration BMP is appropriate. Where load BMP changes must be implicitly modeled, it will generally be necessary to use the infiltration volumes from Step 4, considering 100% of all infiltrated water to be 100% treated.
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. 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 proximity of the ground water to the ground surface. If the estimated SHGWT is closer than 2 feet to the ground surface, ground water modeling or long term physical data is usually needed. If the results are substantially different than used in the surface water model, another iteration beginning with step 1 should be done.

5. Review the results for reasonableness.
6. Compare the post-development load to the target loads based on the model and calculation. 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. Also, a training session on this BMP Manual, including the theoretical concepts involved, was held on March 10, 2011. A complete recording of the presentation is available from the Florida Department of Transportation, Central Aviation Office.

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 is best satisfied with no increase of pollutants above pristine site levels in waters leaving a project site and entering waters of the state. 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. 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 which is 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 to the appropriate BMP design criteria 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) N.T.U’s above background in an Outstanding Florida Waterbody (OFW)
- For stormwater discharges, a minimum of 80% average annual removal of pollutants that cause or contribute to violations of water quality standards
- For stormwater discharges to Outstanding Florida Waters, a minimum of 95% average annual removal of pollutants that cause or contribute to violations of water quality standards.
- For stormwater discharges to verified impaired waters, the project must achieve “net environmental improvement” which means the stormwater pollutant load after development must be less than the stormwater pollutant load before development.

For the purposes of this BMP manual and as set forth in Chapter 62-330.449, F.A.C., the performance standard for airside airport activities shall be:
The nutrient load after development shall not exceed the nutrient loading from natural vegetative communities.

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 design criteria that apply to meet the flood control requirements. **Appendix J** provides a listing of public airports by jurisdictional Water Management District, and website information where the criteria are published. Discharges from the site 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 their criteria apply to discharge to their right of way and drainage systems. These 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 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 150/5320-5 apply 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 soil, geology, and water table conditions. Specific data and analyses required for the design of a retention BMPs required in this manual, including details related to safety factors, mounding analyses, and required soil testing, are set forth in **Appendix F** of this Manual**.**

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 airside improvements. In particular, this means meeting the performance standard discussed in Section 602 above. 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. Specifically excluded are wet detention or pond systems. While these may be a necessity for some or all projects at an airport, the necessary research and testing of wet ponds designed to meet the FAA/USDA criteria to reduce wildlife attractants has not been completed. Use of other wet pond criteria generally established for all land uses and project types may be required until the FAA/USDA criteria have been fully evaluated. However, the potential wildlife attractant hazard of wet ponds must be evaluated when they are proposed for use.

a. <u>Overland Flow</u>
An overland flow system is BMP in which the runoff moves off the runway or taxiway and sheet flows over the adjacent grassed area allowing the stormwater to infiltrate into the ground. Overland flow is the preferred Best Management Practice for runway and taxiway stormwater management. It may also be applicable to aprons depending on specific site geometry and conditions

1. **Applicability**

Favorable Site Conditions

- Contributing pavement area is comparable to or less than the overland flow area. Runways and taxiways with flows to both sides of centerline most easily satisfy this condition.
- Soils on the site are sands with stabilized infiltration rates greater than 3 inches/hour and horizontal hydraulic conductivities greater than 20 feet/day.
- Topography permits flat (.5% -3%) transverse slopes
- Seasonal High Ground Water Table (SHGWT) elevations are more than 3 feet beneath the ground surface at the lowest point of the infield or overland flow area.

Usable Site Conditions - may require site modification including lowering the water table with underdrains. 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.

- Contributing pavement area is not more than 50 % larger than the overland flow area.
- Soils on the site are silty sands, or sands with organics, with stabilized infiltration rates greater than 0.5 inches/hour and horizontal hydraulic conductivities greater than 10 feet/day
- Topography permits flat to moderate (0.5% - 5%) transverse slopes
- SHGWT elevations are between 1 and 3 feet beneath the ground surface
- Discharge is available for underdrains, if needed and ground water contributions of nutrient load do not increase total nutrient loading significantly

Unfavorable Site Conditions - require site modification such as filling with more pervious soil or lowering the ground water table. 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. Without site modification, wet detention systems are likely needed. Use wet detention systems with caution and follow FAA design requirements to minimize wildlife impacts.

- Contributing pavement area is more than 50% larger than the overland flow area. Aprons often fall in this category.
- Soils are silts and clays with infiltration rates less than 0.5 inches/hour and hydraulic conductivities less than 2 feet/day
- Topography requires steep transverse slopes (5% -25%)
- SHGWT elevations are at the ground surface at the lowest point of the infield or overland flow area.

2. Design Criteria

- Overland flow distance shall be 25 feet or greater. This is typically achieved on all runway and taxiway infield areas and is needed to reduce metals concentrations and allow infiltration of the treatment volume to meet the required load reductions.
- Slopes shall be as flat as possible with .5% - 3.0% recommended in the first 25 feet of overland flow.
- Design inlets and conveyance pipes for the 5-year post development storm using the Rational Method. Ponding should be less than 4-inches in apron areas. These criteria are expressed in Advisory Circular 150/5320-5C, 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. This is typically a 10-, 25-, or 100-year recurrence interval storm of 1 to 3 days duration. Verify post project discharge is less than pre-project discharge for this event and method.
- Set inlets (at grade or in the infield, 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 predevelopment 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 in some areas of the state and by some jurisdictional agencies for management and resource conservation reasons.
- The overland flow system shall be appropriately stablilized to minimize or prevent erosion.
- Follow all Turf Management Procedural BMPs described in Section 606.b.
- Employ street sweeping, aircraft fuel sumping controls and other appropriate source controls as needed reduce pollutants that can get into the stormwater.

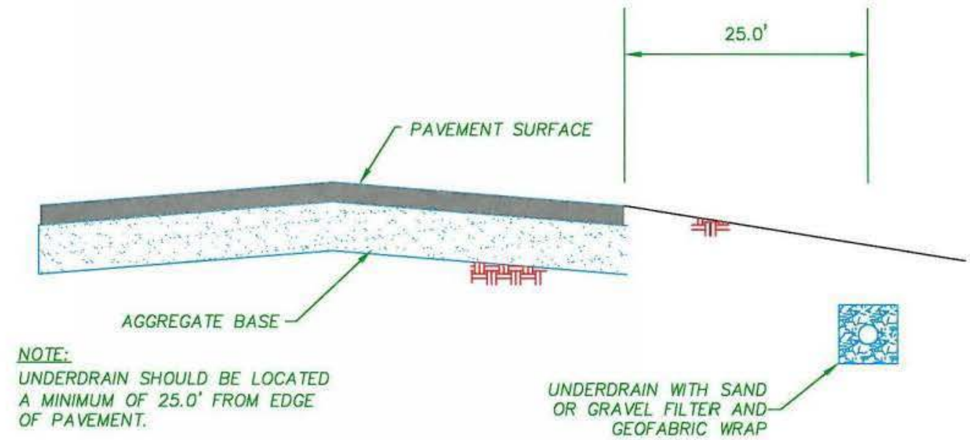

FIGURE 605-1

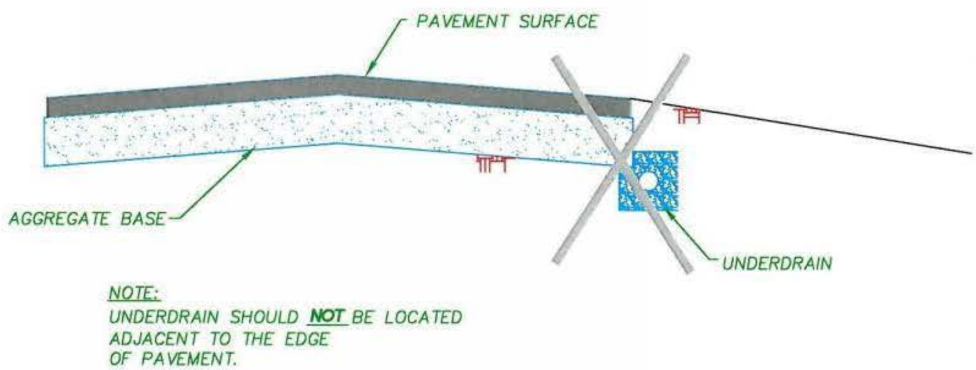

FIGURE 605-2

RECOMMENDED PLACEMENT OF UNDERDRAIN SYSTEMS

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b. <u>Dry Retention Basin</u>

A dry retention basin is the preferred Best Management Practice for aprons. It is also applicable to runways and taxiways. A "retention system" is a recessed 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 of 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.

1. **Applicability**

Favorable Site Conditions

- Soils on the dry retention site are clean sands with stabilized infiltration rates greater than 6 inches/hour and horizontal hydraulic conductivities greater than 30 feet/day. These permeable soils extend at least 20 feet beneath the basin bottom before encountering an aquitard or aquiclude.
- SHGWT elevations are more than 6 feet beneath the proposed bottom of the dry retention site. This is to assure that mounding does not adversely affect the retention system operation and performance.
- Retention system is located at least 25 feet from a swale or other stormwater or surface water feature to minimize possibility of pollutant migration, but within 100 feet of such a feature to help dissipate ground water mounds beneath the system. Figure 605-3 illustrates this separation.

Usable Site Conditions - may require site modification including lowering the SHGWT with underdrains on the exterior of the basin. 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.

- Soils on the dry retention basin site are silty with stabilized infiltration rates greater than 3 inches/hour and horizontal hydraulic conductivities greater than 20 feet/day. These permeable soils extend 20 feet beneath the pond bottom before encountering an aquitard or aquiclude.
- SHGWT elevations are between 3 and 6 feet beneath the proposed bottom of the dry retention basin.

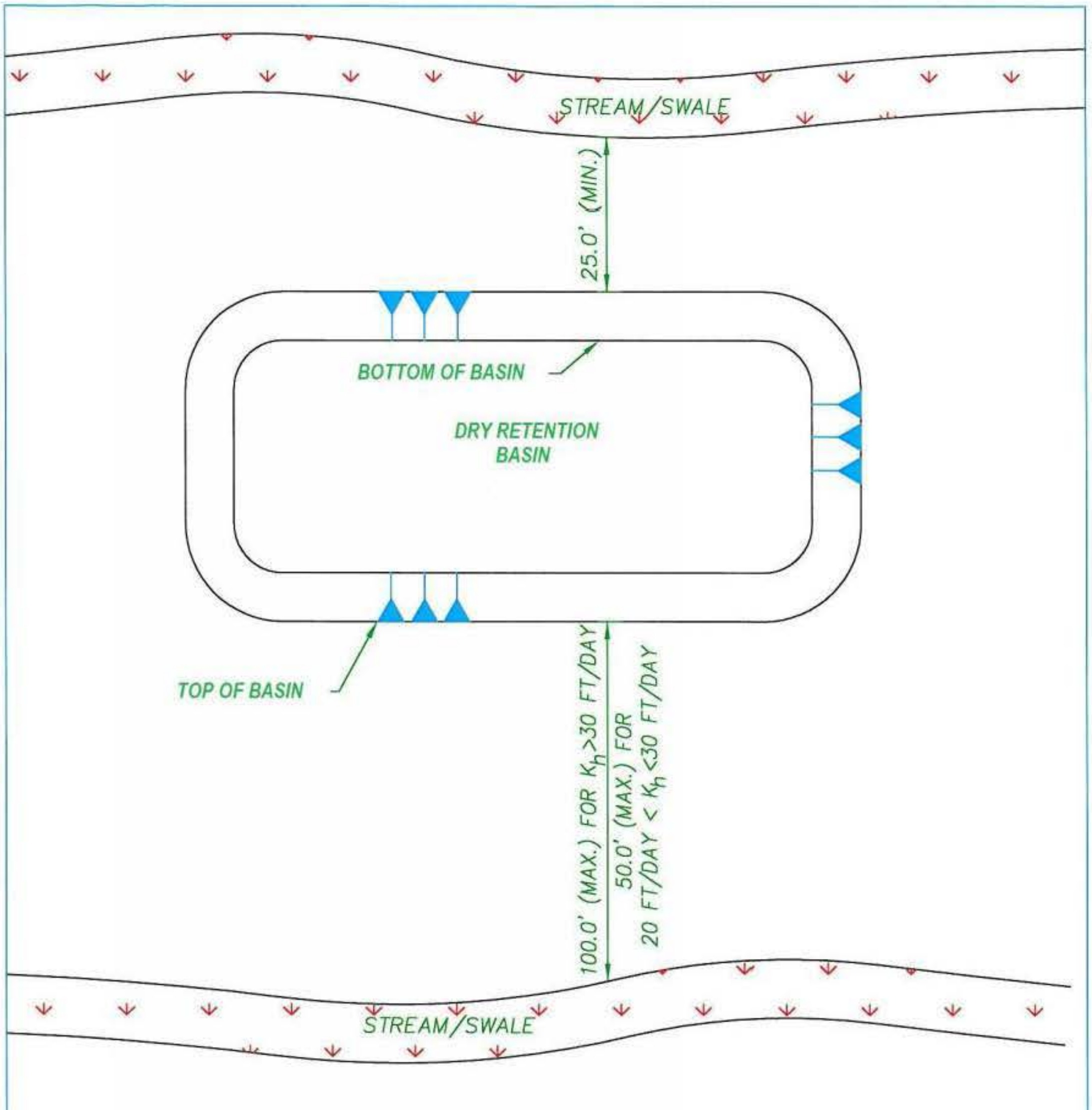

FIGURE 605-3: RETENTION/SWALE PLACEMENT
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- Retention system is located at least 25 feet from a swale or other stormwater or surface water feature to minimize possibility of pollutant migration, but within 100 feet of such a feature to help dissipate ground water mounds beneath the system.

Unfavorable Site Conditions - may require selection of a different BMP

- Soils are silts and clays of 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.

2. Design Criteria

- The Required Treatment Volume (RTV) necessary to achieve the required treatment efficiency shall be routed to the retention basin and percolated into the ground.
- 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*.
- The seasonal high ground water table shall be at least two feet beneath the bottom of the retention basin unless the applicant demonstrates, based on plans, test results, calculations or other information, that an alternative design is appropriate for the specific site conditions.
- The retention basin sides and bottom shall be stabilized with permanent vegetative cover, some other pervious material, or other methods acceptable to the Agency that will 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 date and analyses required for the design of a retention system including details related to safety factors, mounding analyses, and required soil testing are set forth in **Appendix F** of this Manual.

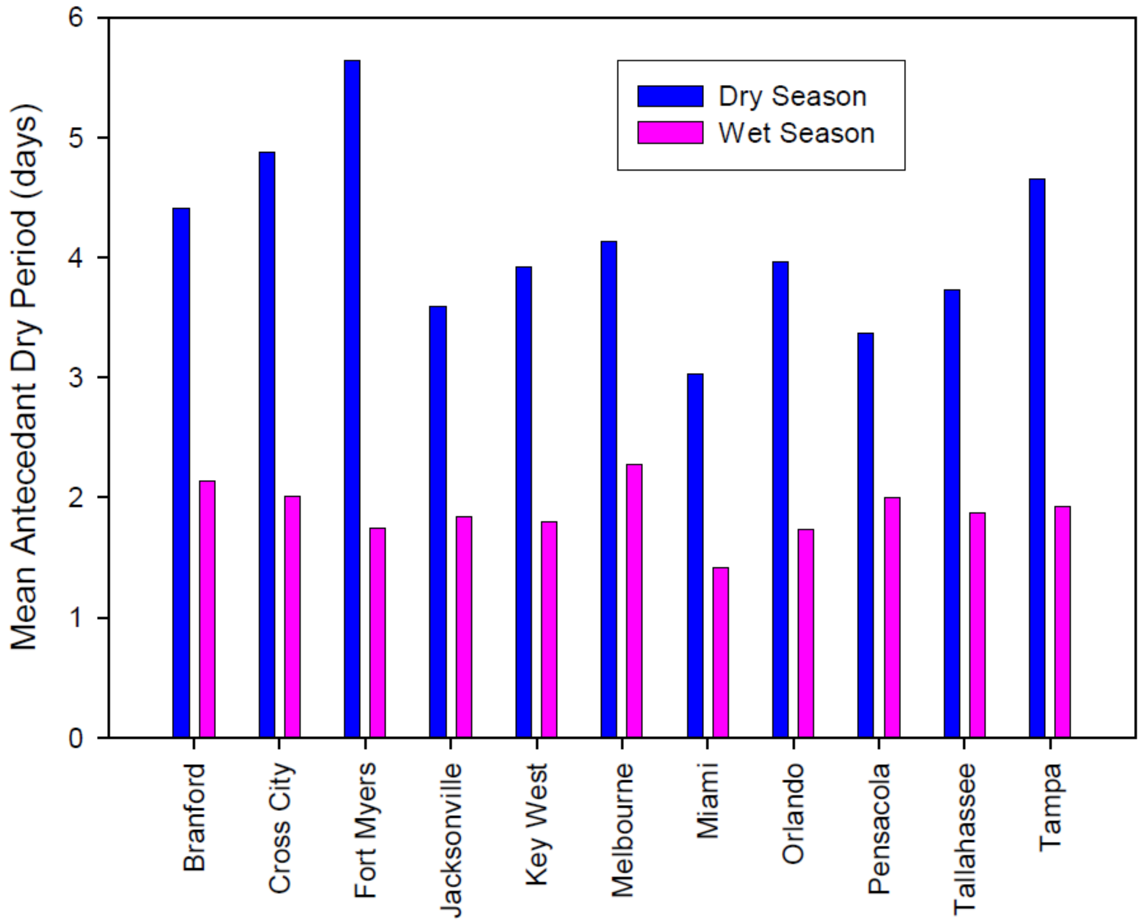

Figure 605-4 Interevent Time at Selected Florida Weather Stations

- Evaluate ground water mounding on a continuous simulation instead of a single event basis using one of the methods in Table 605-1 below. The mounding recovery is evaluated using the Horizontal Saturated Flow methodologies, and generally use infiltration rates averaged over the rainy season. The maximum mound from this analysis should remain at least 1 foot beneath the pond bottom.

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

- If SHWGWT levels must be lowered using underdrains, recommended underdrain location is at least 25 feet from the bottom edge of the retention system (see Figure 605-5A). Underdrains placed directly in the retention system bottom (see Figure 605-5B) 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 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.

c. <u>Swales</u>

Swales are an important part of the stormwater conveyance system at most airports and can function as the BMP for the project or as part of the water quality treatment train. Swales are defined in Section 403.803, F.S. as a manmade trench which:

(a) Has a top width-to-depth ratio of the cross section equal to or greater than 6:1 or side slopes equal to or greater than 3 feet horizontal to 1 foot vertical;
(b) Contains contiguous areas of standing or flowing water only following a rainfall event;
(c) Is planted with or has stabilized vegetation suitable for soil stabilization, stormwater treatment, and nutrient uptake; and
(d) Is designed to take into account the soil erodibility, soil percolation, slope, slope length, and drainage area so as to prevent erosion and reduce pollutant concentration of any discharge.

Swales function similar to 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. **Applicability**

   Swale Favorable Site Conditions

   - Soils on the site are sands with stabilized infiltration rates greater than 3 inches/hour and horizontal hydraulic conductivities greater than 20 feet/day, and
   - SHGWT levels are more than 2 feet beneath the swale bottom averaged over the swale length
   - Drainage permits flat (.1 -.5%) longitudinal and flatter than 3H:1V side slopes

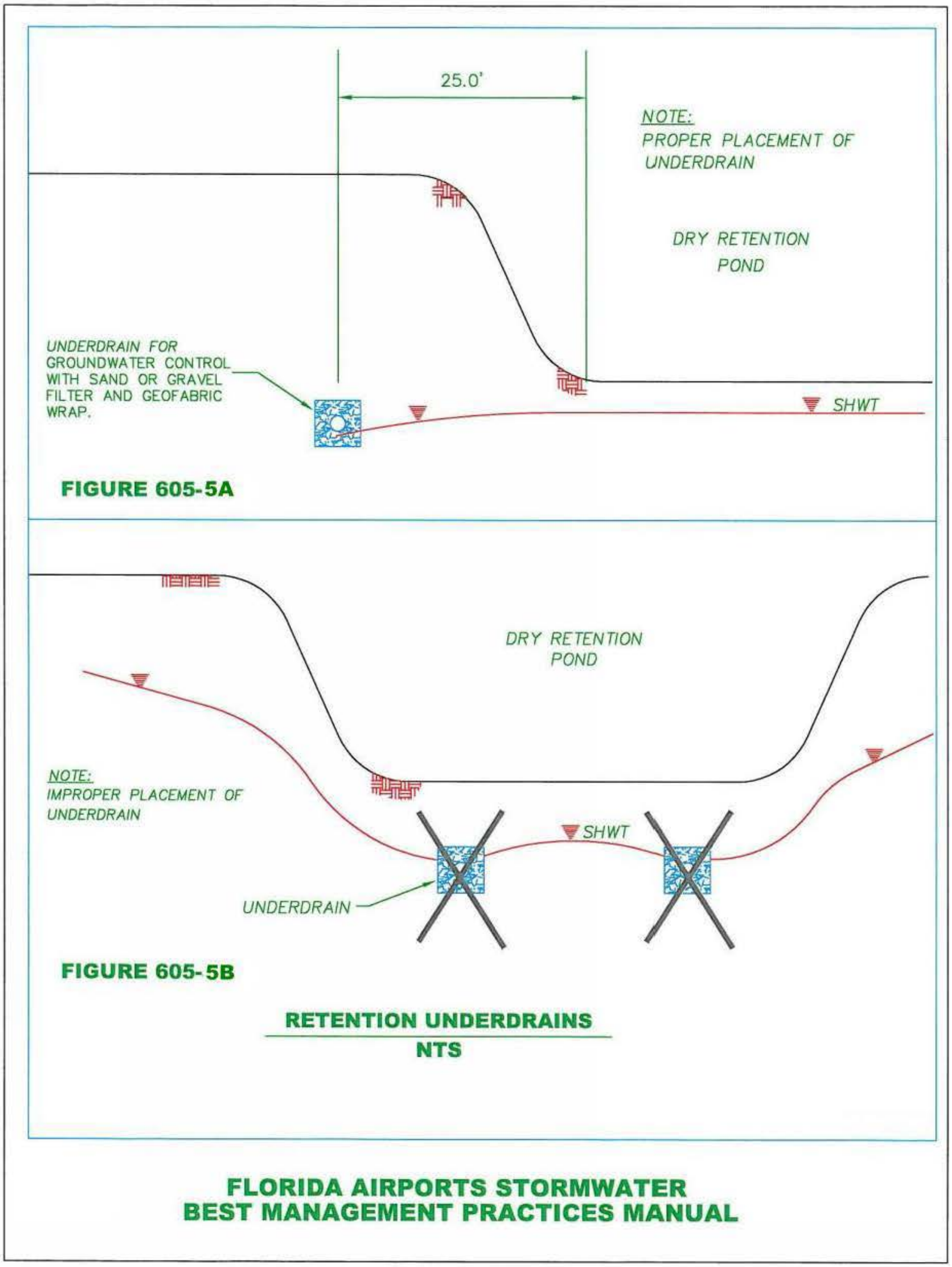

FIGURE 605-5A

FIGURE 605-5B

RETENTION UNDERDRAINS

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Unfavorable Swale Site Conditions – require site modification such as filling with more pervious soil or lowering the ground water table. Without site modification, wet detention systems are likely needed. Use wet detention systems with caution and follow FAA design requirements to minimize wildlife impacts.

- Contributing pavement area is more than 50% larger than the swale area
- Soils are silts and clays with infiltration rates less than 0.5 inches/hour and hydraulic conductivities less than 2 feet/day
- Drainage or topography requires slopes over 1%.
- SHGWT elevations are at the ground surface at the lowest point of the infield or swale
- Location does not interfere with crash-fire-rescue access on the airside

2. **Design Criteria for Swales**
   - Side Slopes of 3H:1V or flatter
   - Longitudinal slopes should be as flat as possible with .1% - .5% recommended
   - Limit swale 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 25-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 predevelopment and post development condition and the resulting required nutrient load reduction, determine the annual volume of runoff that must be infiltrated within the swale.
   - 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 for more than 24 hours after any rainfall.
   - Design outfall control structure to limit post-development peak flows to pre-development peak flows for the design storm. 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.

d. Wet Detention Systems (Ponds)

Wet detention ponds are excluded from the Airport BMP Manual at this time. Research on the water quality efficiency of a wet detention pond designed with FAA and USDA recommended features to reduce wildlife attractants is underway. Depending on the results of that research, incorporation of FAA/USDA wet pond criteria may occur in the future.

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., buy may be permittable under the various criteria of specific water management districts. 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 Reference 10 in **Appendix A** or to the Basis of Review Manuals for the various Water Management Districts for design criteria applicable to these systems.

f. Off-site Equivalent Treatment

Off-site equivalent 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 is an option under an individual permit. For example, there are airport sites where a wet detention system is the only BMP that will work given the site's conditions. It is often the most expensive option and may be precluded solely by cost. Basin definition may also preclude the option such as when direct airport discharge to an already flooding area at the upstream of a watershed normally requires detention on the airport to avoid worsening the flood condition.

Where site, drainage basin, or hazard conditions suggest Off-site Equivalent 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 or retrofitted to provide Equivalent Treatment. A Benefit Cost Analysis should precede the decision to go-ahead with this option.

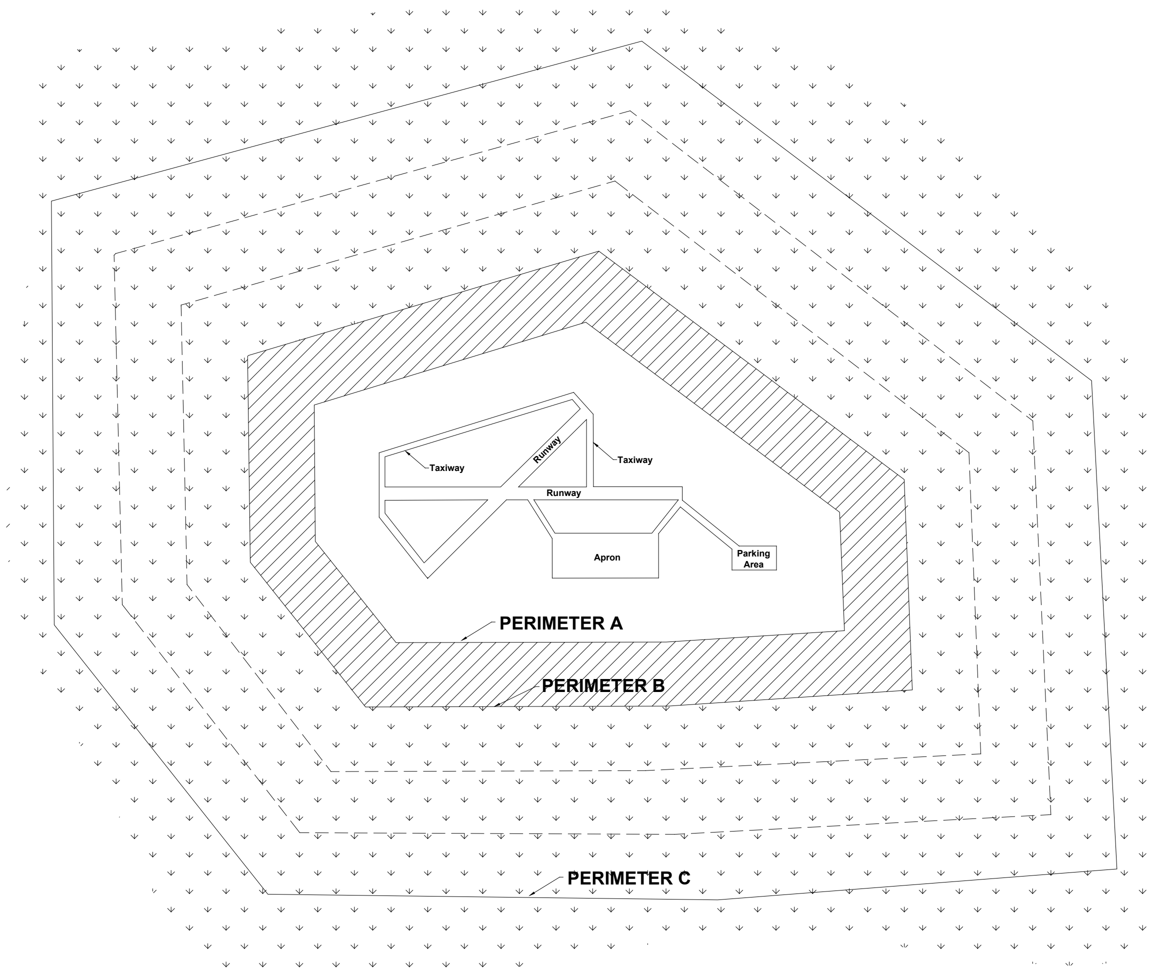
1. **Applicability**
   - Other airside stormwater management options are not feasible as a result of hazard issues or land availability
   - The drainage basin containing the airport includes facilities that can be retrofitted to achieve equivalent pollutant load reduction and flood attenuation
   - 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.
   - 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 predevelopment 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 the 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 off-site equivalent treatment area should be located outside the hazard limits shown in Figure 605-6 to the maximum extent practicable.

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 605-6 Hazard Zones for Wildlife Attractants Around Airports
(excerpted directly from FAA Advisory Circular 150/5200-33B Hazardous Wildlife Attractants On or Near Airports)

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, a majority of 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.

- 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 actually 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). 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.

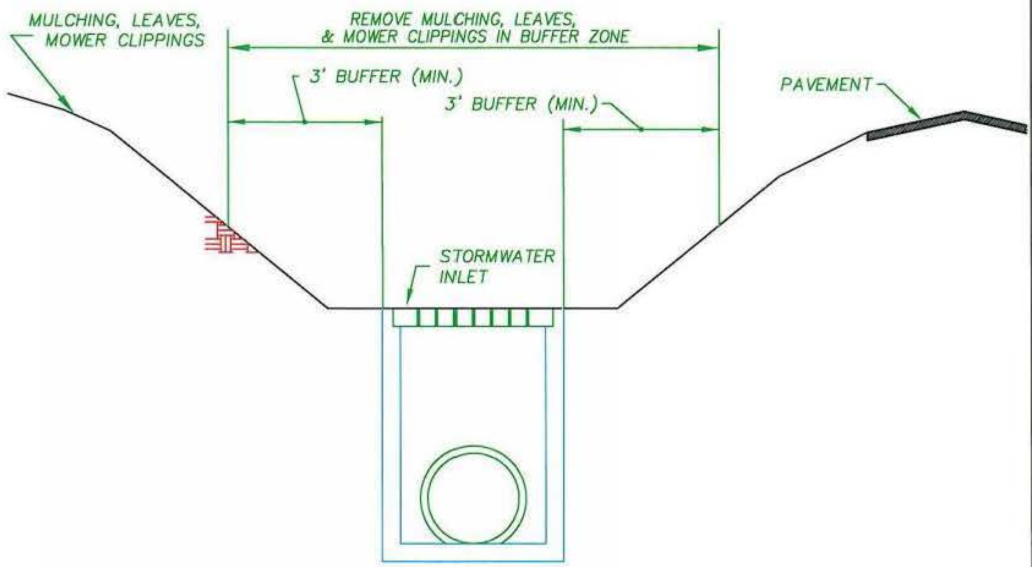


FIGURE 606-1: MOWING BUFFER AROUND INLETS
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1. **Applicability**
    - Terminal, cargo and general aviation aprons/ramps where the airport is equipped to do the procedure.

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 possible. Refer to Table 605-1 to evaluate probable benefits of sweeping daily or weekly. Less frequent sweeping is beneficial, but not sufficiently so to qualify as a BMP as opposed to a simple safety practice.

3. **Expected Concentration Reduction Efficiencies**

Table 606-1
Expected Concentration Reduction from Sweeping with Collecting Vacuum and Broom Sweepers (References 4 and 22 in Appendix A)

Constituent Category	Vacuum Daily	Vacuum Weekly	Mechanical Daily	Mechanical Weekly
Particulate Matter	60 - 90	40 -60	30 -50	20-30
Metals	40 - 80	30 -60	20 -30	15-20
Nutrients	30 - 80	20 -60	10 -30	10-20

d. System Maintenance

The stormwater management system at any airport is a major infrastructure investment, on a 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 the general permit. Additionally, a common sense 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**
    - 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.

- Remove sediments from pipes and outlet structures through flushing and collection for disposal.
- Verify structures and controls are in good repair and condition and not hydraulically blocked.
- Remove sediment buildup in overland flow areas, swales and retention system bottoms and dispose of at appropriate landfills.
- Assure that overland flow areas, swales, and retention systems are stabilized with good vegetative cover that is maintained appropriately.
- Test operate active systems such as pumps and gates and perform regularly maintenance.
- Inspect retention systems and infiltration areas to verify they continue to operate and infiltrate as designed. Check that drawdowns occur within the recommended 24 50 36 hours.
- Visually survey wet systems for unwanted vegetation. Remove nuisance or wildlife attractant vegetation and replace with suitable plantings before these species become extensive or dominant.
- Establish a record system of observation and maintenance of the stormwater system similar to that for pavement management and maintenance.

APPENDIX A
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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.

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."

APPLICANTS 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 are 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 wetlands, including one or more of the following:

(a) Mitigation;
(b) Inclusion of upland areas, beyond any required buffer zones, to maintain upland/wetland habitat diversity
(c) Establishment of vegetated littoral zones in on-site open waterbodies;
(d) Protection of exempt wetlands;
(e) Restoration of wetlands that have been previously impacted;
(f) Compensation on off-site lands; and
(g) Other reasonable measures, such as providing unlike wetland habitat.

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.)

DETENTION. The collection and temporary storage of stormwater with subsequent gradual release.

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 used exclusively by private and business aircraft not providing common-carrier passenger service.

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 serves several metropolitan areas.

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.

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.

METHOD DETECTION LIMIT (MDL). The minimum concentration of an element or compound that can be measured and reported with 99% confidence that the concentration is greater than zero. The values are determined following a defined procedure or are pre-specified for certain laboratory tests.

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.

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 (NDPES) 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-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. Stormwater is <u>the</u> major source of pollutants to Florida's lakes, estuaries and streams.

PRACTICAL QUANTIFICATION LIMIT (PQL). The lowest level of measurement than can be reliably achieved during routine laboratory operating conditions within specified limits of precision and accuracy. If not reported, the PQL is calculated as 4 times the ***MDL.***

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 SAFTEY 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. The portion of the aircraft parking area used for access between taxiways and aircraft parking positions.

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, riverines, 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-mad 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, waster 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 (NWFWMD), 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).