APPENDIX C
Site Evaluation Checklists

C-1 GENERAL

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

C-2 SITE RECONNAISSANCE

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

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

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

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

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

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

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

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

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

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

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

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

C-3 TOPOGRAPHY AND SURVEY

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

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

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

- Extend aerial topography beyond the project limits to encompass estimated upstream basins contributing flow, and adjacent areas that may provide flood storage.
- Contour intervals of 1 foot accurate to ± ½ foot for vertical information should be obtained
- Horizontal accuracy of ± 5 feet should be required
- Obtain rectified aerial photography at a scale appropriate to the project site.
- Rectified color infrared photography at the same scale as the rectified aerial photograph are useful in identifying wetlands and drainage features when properly interpreted and should be obtained if possible.

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

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

- Inlet locations, elevations, openings, details, and pipe size, type, location and invert elevations connected to the inlet.
- Outlet locations, elevations, openings, details and pipe size, type, location, number and invert elevations connected to the outlet.
- Elevation of water standing or flowing in pipes
- Elevations of stain lines or rack lines on inlet and outlet structures.
- Elevation of blockage or siltation reducing pipe effective area.
- Location and details of control structures including weir lengths and elevations, notch angles, orifice dimensions and inverts, skimmer top and bottom elevations and arrangements, outlet pipe type, size and inverts, underdrain connections, spillway characteristics, and similar.
- Cross-sections of open channels. Spacing of the sections is based on the project size and the level of detail needed. Spacing of sections does affect the computed water surface elevation, sometimes by significant amounts. The cross section surveys may include:
    - Top of bank, toe of slope and information sufficient to define the cross section of the channel
    - Information extending away from top of bank on both sides sufficient to define overflow storage limits/ floodplains during high water
    - Current water elevations and recent high water elevations based on staked indicators, rack/debris or stain lines.

- Wetland limits and elevations based on staking by environmental professionals after concurrence from jurisdictional agencies. This should be sufficient to prepare a boundary survey and legal description.
- Dimensions of any existing water management ponds, wet or dry, sufficient to calculate storage volume versus elevation data (stage-storage relation) for the facility.

C-4 LAND COVER AND USE

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

C-5 WETLANDS

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

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

C-6 GEOTECHNICAL

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

a. Soil Survey Reports. The NRCS Soil Survey for a County can yield important preliminary data for water management system planning. Soil Surveys group surficial soils into general taxonomic groups and suggest typical agricultural and engineering properties for each group. Information is developed from a combination of aerial photo-interpretation and field truthing. It is necessarily coarse, since mapping units are areally large and construction changes conditions significantly between mapping efforts. However, the reports can provide initial guidance information of the following types. It is emphasized this must be supplemented with field exploration and field and laboratory testing for design. <u>The data may not be relevant if the site has been disturbed, drained, or if engineered fills have been placed on it</u>.

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

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

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

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

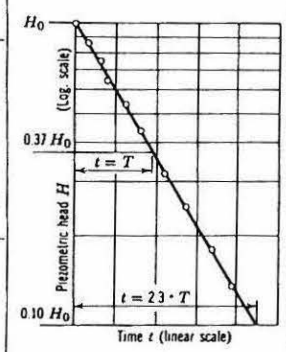
C-7 FLOODPLAINS AND FLOODWAYS

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

C-8 RECEIVING WATERS

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

Case	Constant Head	Variable Head	Basic Time Lag	Notation
A	$k_v = \frac{4 \cdot q \cdot L}{\pi \cdot D^2 \cdot H_c}$	$k_v = \frac{d^2 \cdot L}{D^2 \cdot (t_2 - t_1)} \ln \frac{H_1}{H_2}$ $k_v = \frac{L}{t_2 - t_1} \ln \frac{H_1}{H_2}$ for $d = D$	$k_v = \frac{d^2 \cdot L}{D^2 \cdot T}$ $k_v = \frac{L}{T}$ for $d = D$	D = Diam, intake, sample (cm) d = Diameter, standpipe (cm) L = Length, intake, sample (cm)
B	$k_m = \frac{q}{2 \cdot D \cdot H_c}$	$k_m = \frac{\pi \cdot d^2}{8 \cdot D \cdot (t_2 - t_1)} \ln \frac{H_1}{H_2}$ $k_m = \frac{\pi \cdot D}{8 \cdot (t_2 - t_1)} \ln \frac{H_1}{H_2}$ for $d = D$	$k_m = \frac{\pi d^2}{8 \cdot D \cdot T}$ $k_m = \frac{\pi \cdot D}{8 \cdot T}$ for $d = D$	H_c = Constant piez. head (cm) H_1 = Piez. head for $t = t_1$ (cm) H_2 = Piez. head for $t = t_2$ (cm)
C	$k_m = \frac{q}{2.75 \cdot D \cdot H_c}$	$k_m = \frac{\pi \cdot d^2}{11 \cdot D \cdot (t_2 - t_1)} \ln \frac{H_1}{H_2}$ $k_m = \frac{\pi \cdot D}{11 \cdot (t_2 - t_1)} \ln \frac{H_1}{H_2}$ for $d = D$	$k_m = \frac{\pi \cdot d^2}{11 \cdot D \cdot T}$ $k_m = \frac{\pi \cdot D}{11 \cdot T}$ for $d = D$	q = Flow of water (cm³/sec) t = Time (sec) T = Basic time lag (sec) k_v' = Vert. perm. casing (cm/sec)
D	$k_v' = \frac{4 \cdot q \left(\frac{\pi}{8} \cdot \frac{k_v'}{k_v} \cdot \frac{D}{m} + L\right)}{\pi \cdot D^2 \cdot H_c}$	$k_v' = \frac{d^2 \cdot \left(\frac{\pi}{8} \cdot \frac{k_v'}{k_v} \cdot \frac{D}{m} + L\right)}{D^2 \cdot (t_2 - t_1)} \ln \frac{H_1}{H_2}$ $k_v = \frac{\frac{\pi}{8} \cdot \frac{D}{m} + L}{t_2 - t_1} \ln \frac{H_1}{H_2}$ for $\begin{cases} k_v' = k_v \\ d = D \end{cases}$	$k_v' = \frac{d^2 \cdot \left(\frac{\pi}{8} \cdot \frac{k_v'}{k_v} \cdot \frac{D}{m}\right) + L}{D^2 \cdot T}$ $k_v = \frac{\frac{\pi}{8} \cdot \frac{D}{m} + L}{T}$ for $\begin{cases} k_v' = k_v \\ d = D \end{cases}$	k_v = Vert. perm. ground (cm/sec) k_h = Horz. perm. ground (cm/sec) k_m = Mean coeff. perm. (cm/sec) m = Transformation ratio $k_m = \sqrt{k_h \cdot k_v}$ $m = \sqrt{k_h/k_v}$ $\ln = \log_e = 2.3 \log_{10}$
E	$k_v' = \frac{4 \cdot q \cdot \left(\frac{\pi}{11} \cdot \frac{k_v'}{k_v} \cdot \frac{D}{m} + L\right)}{\pi \cdot D^2 \cdot H_c}$	$k_v' = \frac{d^2 \cdot \left(\frac{\pi}{11} \cdot \frac{k_v'}{k_v} \cdot \frac{D}{m} + L\right)}{D^2 \cdot (t_2 - t_1)} \ln \frac{H_1}{H_2}$ $k_v = \frac{\frac{\pi}{11} \cdot \frac{D}{m} + L}{t_2 - t_1} \ln \frac{H_1}{H_2}$ for $\begin{cases} k_v' = k_v \\ d = D \end{cases}$	$k_v' = \frac{d^2 \cdot \left(\frac{\pi}{11} \cdot \frac{k_v'}{k_v} \cdot \frac{D}{m} + L\right)}{D^2 \cdot T}$ $k_v' = \frac{\frac{\pi}{11} \cdot \frac{D}{m} + L}{T}$ for $\begin{cases} k_v' = k_v \\ d = D \end{cases}$	
F	$k_h = \frac{q \cdot \ln \left[\frac{2mL}{D} + \sqrt{1 + \left(\frac{2mL}{D}\right)^2}\right]}{2 \cdot \pi \cdot L \cdot H_c}$	$k_h = \frac{d^2 \cdot \ln \left[\frac{2mL}{D} + \sqrt{1 + \left(\frac{2mL}{D}\right)^2}\right]}{8 \cdot L \cdot (t_2 - t_1)} \ln \frac{H_1}{H_2}$ $k_h = \frac{d^2 \cdot \ln \left(\frac{4mL}{D}\right)}{8 \cdot L \cdot (t_2 - t_1)} \ln \frac{H_1}{H_2}$ for $\frac{2mL}{D} > 4$	$k_h = \frac{d^2 \cdot \ln \left[\frac{2mL}{D} + \sqrt{1 + \left(\frac{2mL}{D}\right)^2}\right]}{8 \cdot L \cdot T}$ $k_h = \frac{d^2 \cdot \ln \left(\frac{4mL}{D}\right)}{8 \cdot L \cdot T}$ for $\frac{2mL}{D} > 4$	
G	$k_h = \frac{q \cdot \ln \left[\frac{mL}{D} + \sqrt{1 + \left(\frac{mL}{D}\right)^2}\right]}{2 \cdot \pi \cdot L \cdot H_c}$	$k_h = \frac{d^2 \cdot \ln \left[\frac{mL}{D} + \sqrt{1 + \left(\frac{mL}{D}\right)^2}\right]}{8 \cdot L \cdot (t_2 - t_1)} \ln \frac{H_1}{H_2}$ $k_h = \frac{d^2 \cdot \ln \left(\frac{2mL}{D}\right)}{8 \cdot L \cdot (t_2 - t_1)} \ln \frac{H_1}{H_2}$ for $\frac{mL}{D} > 4$	$k_h = \frac{d^2 \cdot \ln \left[\frac{mL}{D} + \sqrt{1 + \left(\frac{mL}{D}\right)^2}\right]}{8 \cdot L \cdot T}$ $k_h = \frac{d^2 \cdot \ln \left(\frac{2mL}{D}\right)}{8 \cdot L \cdot T}$ for $\frac{mL}{D} > 4$	

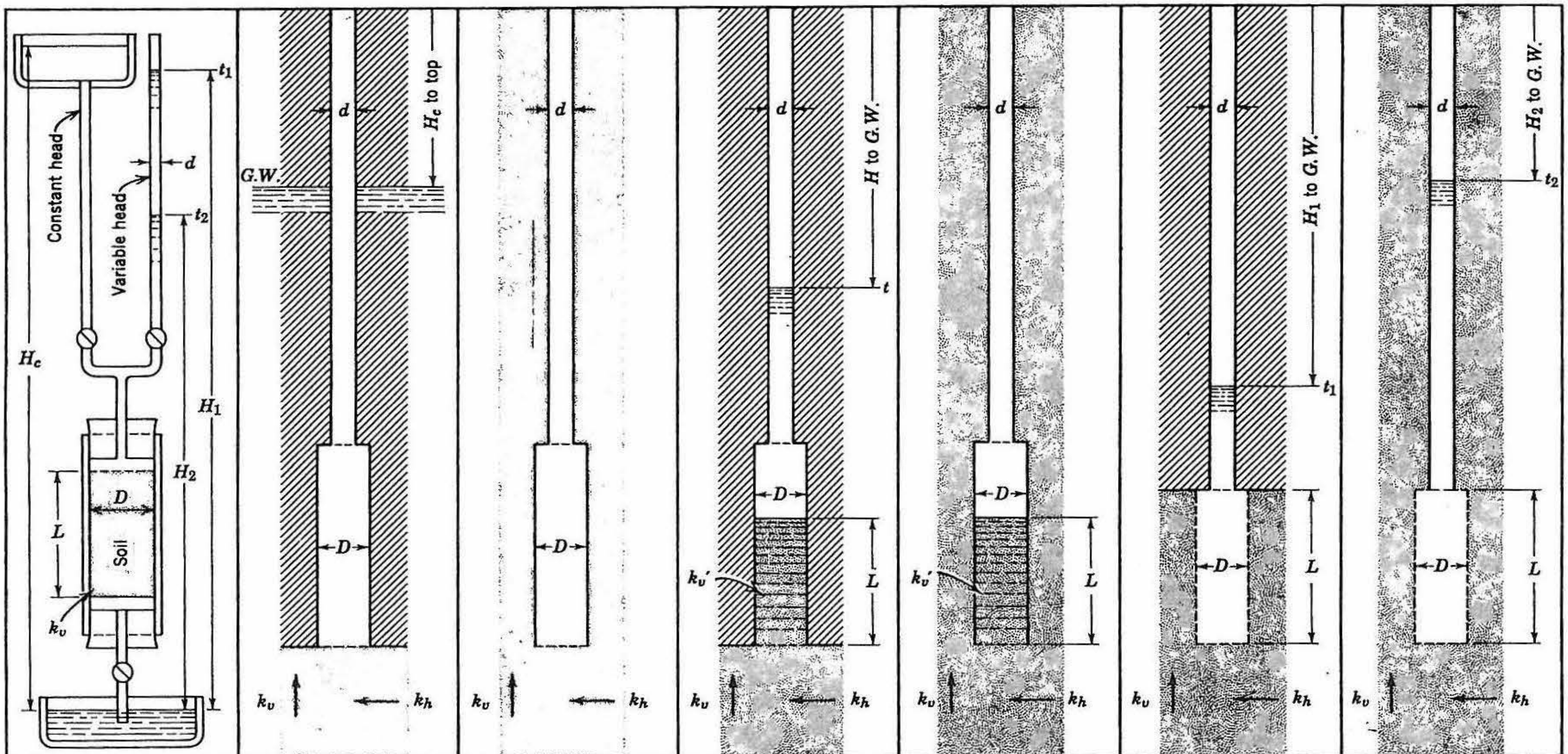


Determination basic time lag T

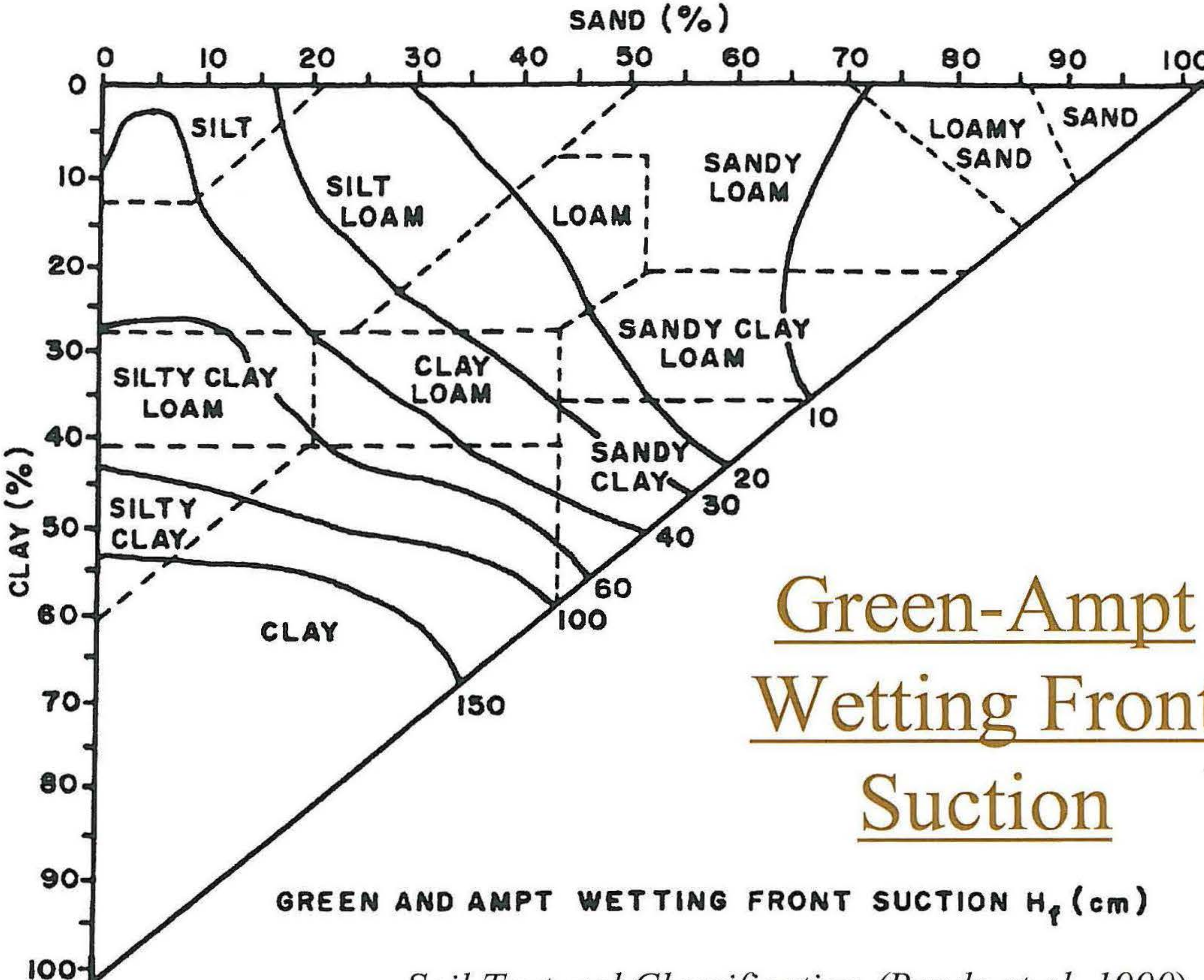
ASSUMPTIONS

Soil at intake, infinite depth, and directional isotropy (k_v and k_h constant). No disturbance, segregation, swelling, or consolidation of soil. No sedimentation or leakage. No air or gas in soil, well point, or pipe. Hydraulic losses in pipes, well point, or filter negligible.

Formulas for determination of permeability (From Hvorslev, 1951).

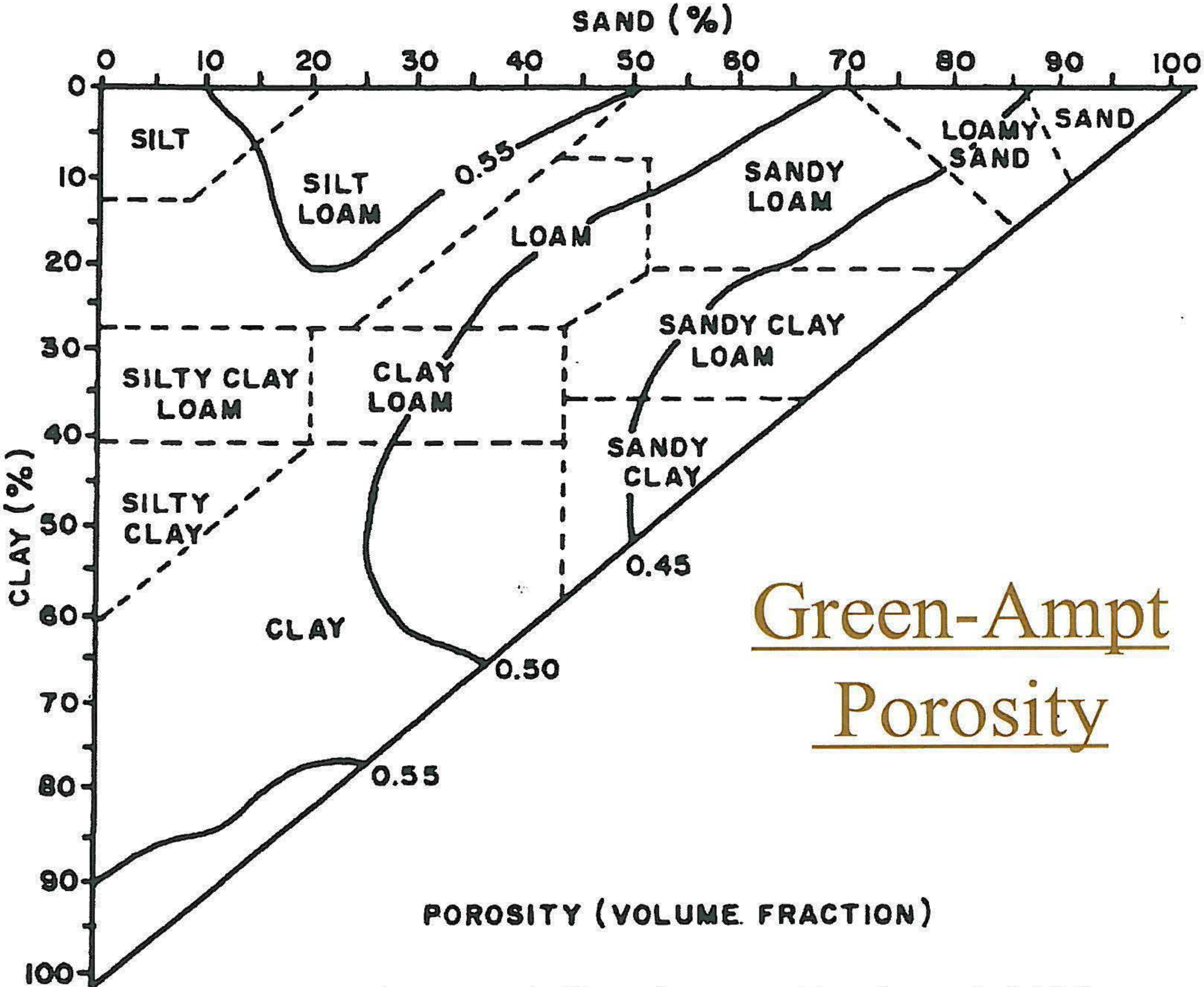


Laboratory permeameter *A*	Flush bottom at impervious boundary *B*	Flush bottom in uniform soil *C*	Soil in casing at impervious boundary *D*	Soil in casing in uniform soil *E*	Well point-filter at impervious boundary *F*	Well point-filter in uniform soil *G*



Green-Ampt Wetting Front Suction

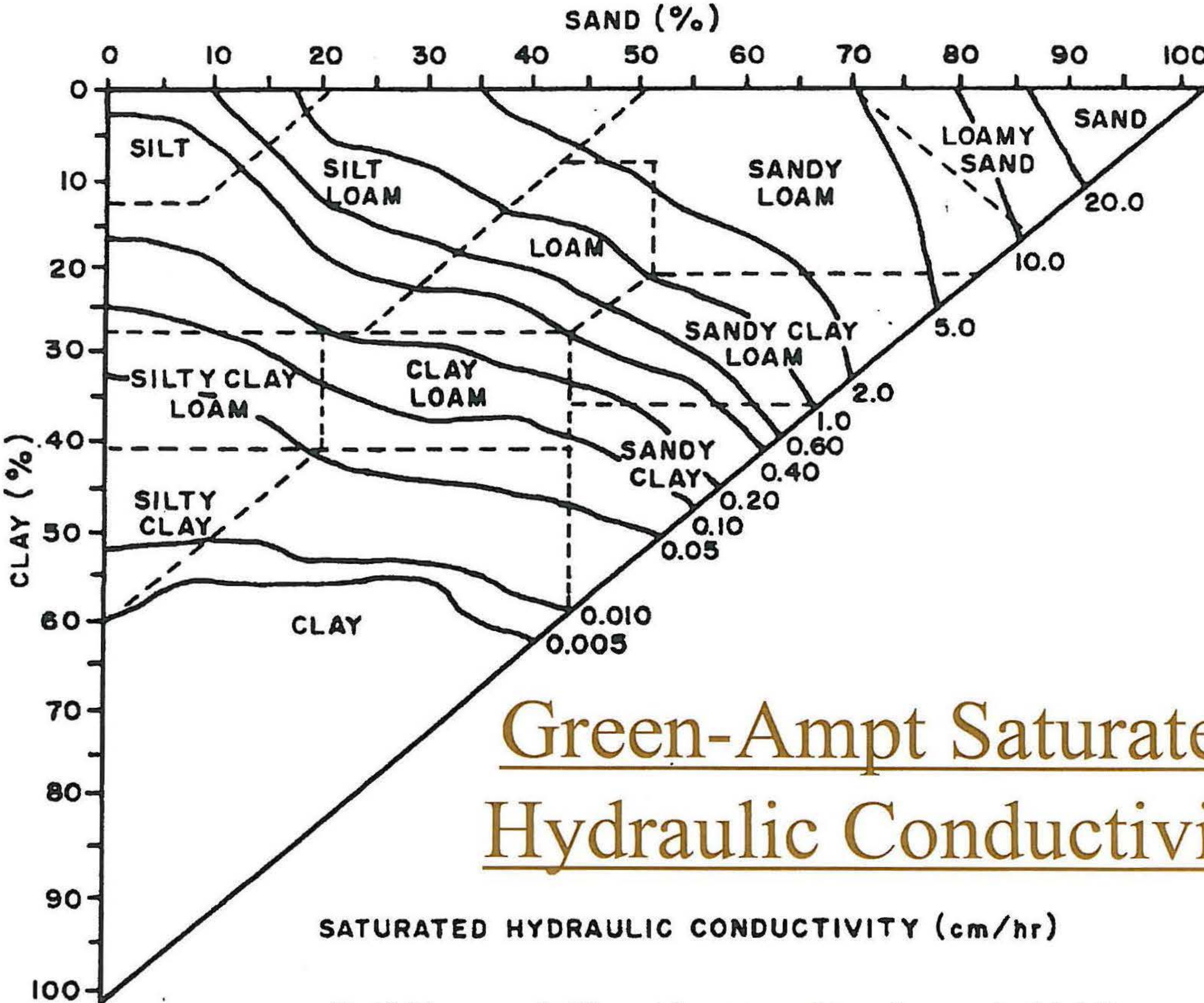
Soil Textural Classification (Rawls et al, 1990)



Green-Ampt Porosity

Soil Textural Classification (Rawls et al, 1990)

Green-Ampt Saturated Hydraulic Conductivity



Soil Textural Classification (Rawls et al, 1990)

APPENDIX F
Methodologies, Recovery Analysis, and Soil Testing for Retention Systems

Description
"Retention systems" are a family of Best Management Practices (BMPs) designed to store a defined quantity of runoff, allowing it to percolate through vegetation and permeable soils into the shallow ground water aquifer, evaporate, or evapotranspire. Stormwater retention works best using a variety of BMPs throughout the project site. Examples of common retention BMPs include (but are not limited to):

- Retention basins which are constructed or natural depressional areas where the basin bottom is graded as flat as possible and turf, seed & mulch (or other equivalent materials) are established to promote infiltration and stabilize the basin slopes.
- Underground Exfiltration Trenches.
- Underground Retention Systems
- Underground Vaults/Chambers.
- Vegetated Swales with or without swale blocks.

The soil's saturated hydraulic conductivity, depth to the Seasonal High Ground Water Table (SHGWT) and depth to the confining unit (i.e., clay, hardpan, etc.) must be such that the retention system can percolate the Required Treatment Volume (RTV) within a specified time following a storm event. After drawdown has been completed, retention BMPs do not hold any water, thus the systems are normally "dry." Unlike detention BMPs, the RTV for retention systems is not discharged to surface waters.

Retention systems provide excellent removal of many stormwater pollutants. Substantial amounts of suspended solids, oxygen demanding materials, heavy metals, bacteria, some varieties of pesticides and nutrients such as phosphorus may be removed as runoff percolates through the soil profile. All infiltration 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.

Besides pollution control, retention systems can be used to promote the recharge of ground water, to prevent saltwater intrusion in coastal areas and maintain ground water levels in aquifer recharge areas. Retention systems can also be used to help meet the runoff volume criteria for systems that discharge to closed basins or land-locked lakes. However, the use of retention systems are not appropriate if they contribute to a violation of Minimum Flows or Levels in the receiving waters, or if they adversely impact wetlands by hydrologic alteration.

Required Treatment Volume (RTV)

The Required Treatment Volume is the volume of runoff that must be infiltrated in the specific BMPs to achieve the required load reductions. It is determined through the continuous simulation model results. The RTV necessary to achieve the required treatment efficiency shall be routed to the retention BMP and percolated into the ground.

Recovery Time of the RTV

All retention systems must provide the capacity for the RTV of stormwater to recover to the bottom of the system within 24 to 36 hours following a design storm event, assuming an average Antecedent Runoff Condition (ARCII). A safety factor of two (2.0) must be used in the recovery analysis of the RTV. Two possible ways to apply this safety factor are:

(a) Reducing the design saturated hydraulic conductivity rates by half; or

(b) Designing for the required RTV drawdown to occur within half of the required drawdown time.

The safety factor of two (2.0) is based on the high probability of

- Soil compaction during clearing and grubbing operations,
- Normal construction techniques that result in additional soil compaction under the retention BMP,
- Inadequate long term maintenance of the retention BMP, and
- Geologic variations and uncertainties in obtaining the soil test parameters for the recovery / mounding analysis (noted in subsequent sections below). These variations and uncertainties are especially suspect for larger retention BMPs.

Additional to the requirement for the RTV to recover to the bottom of the system within 24 to 36 hours following a design storm, the ground water mounding that occurs during the rainy season (see **Table 401-1**) must not adversely impact functioning of the system.

In retention systems, the RTV recovers (is drawn down or dissipated) by infiltration into the ground water table, evaporation, evapotranspiration, or horizontal flow of groundwater. The opposite is true for underdrain effluent detention systems, which rely on artificial recovery methods such as underground perforated drainage pipes. These underdrained systems are NOT presumed to remove 100% of loads in stormwater that infiltrates.

Antecedent Runoff Condition (ARC), formally known as Antecedent Moisture Condition (AMC), refers to the amount of moisture and storage in the soil profile prior to a storm event. Antecedent soil moisture is an indicator of wetness and availability of soil to infiltrate water. The ARC can vary from dry to saturated, depending on the amount of rainfall received prior to a given point in time. Therefore, "average ARC" (ARCII) means the soil is neither dry nor saturated, but at an average moisture condition at the beginning of a storm event when calculating recovery time for retention systems.

Infiltration and Saturated Horizontal Flow Processes
When stormwater runoff enters the retention BMP, standing water begins to infiltrate. This water percolates into and through the soil in two distinct stages, either vertically (Stage One) through the BMP bottom (infiltration), or horizontally (Stage Two) (horizontal saturated flow). One flow direction or the other will predominate depending (primarily) on:

- The rainfall or pond inflow rate (usually normalized per unit area of pond bottom footprint),
- The cumulative inflow volumes to the pond
- The depths to the water table and confining unit (i.e., clay or hardpan) below the bottom of the retention BMP, and
- The soil's saturated hydraulic conductivity.

The following paragraph briefly describes the two stages, and subsequent subsections present accepted methodologies for calculating infiltration rates and recovery times for infiltration (Stage One) and saturated horizontal (Stage Two) flow.

Initially, the subsurface conditions are assumed to be:

- The depth to the initial water table below the bottom of the BMP.
- Unsaturated soils above the water table.

When the water begins to infiltrate, it is driven downward as unsaturated flow by the combined forces of gravity and capillary action (also expressed as Soil Suction, ψ). Once the unsaturated soil below the BMP becomes saturated (fills the voids in the soil), the water table "mound" (refer to **Figure F-1**) intersects the ground surface. At this time, saturation below the BMP limits vertical movement to the horizontal groundwater flow rate. For successful designs of retention BMPs, both the infiltration and saturated, horizontal flow must be accounted for and incorporated into the analysis.

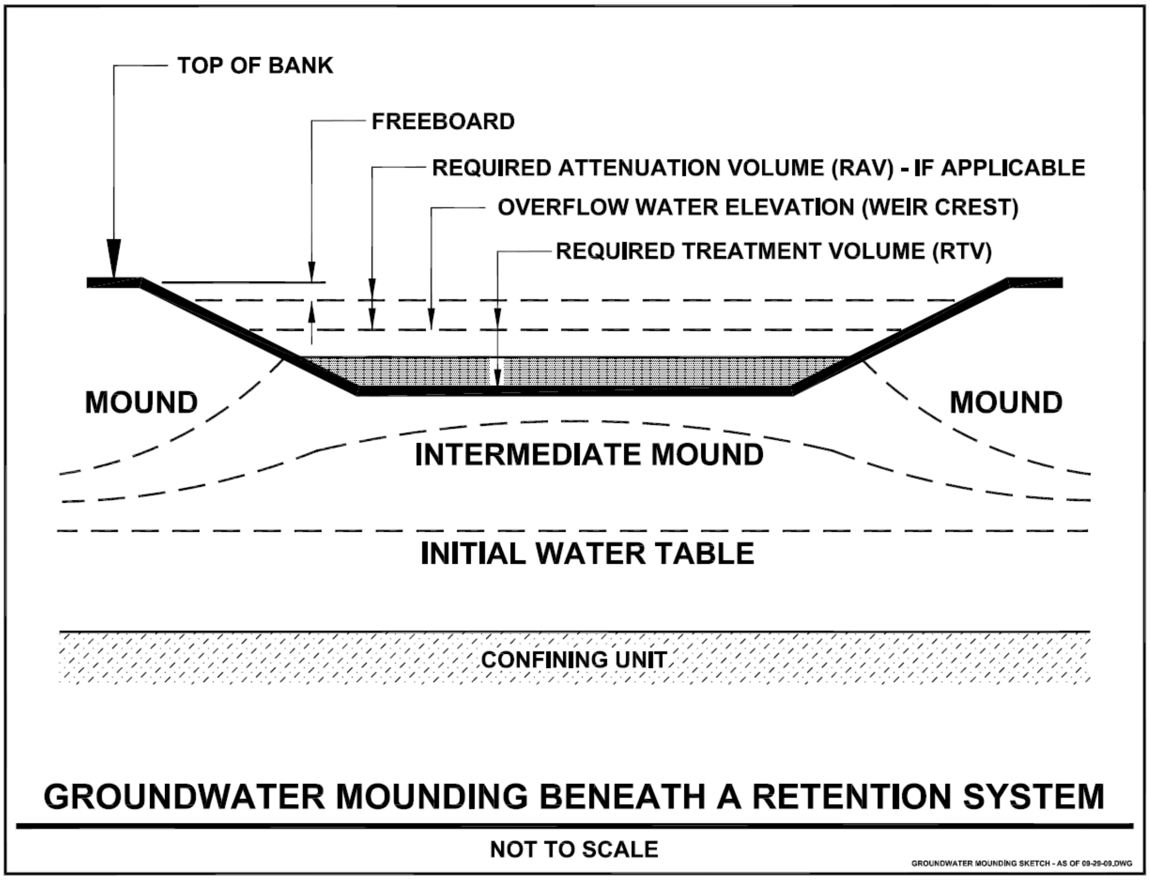


Figure F-1 Ground Water Mounding Beneath a Retention System

Accepted Methodologies for Determining Retention BMP Recovery

Acceptable methodologies for calculating retention BMP recovery are presented in **Table 605-1** reproduced below in **Table F-1**.

Table F-1 Accepted Methodologies for Retention BMP Recovery

Infiltration	Horizontal Saturated Flow
Green and Ampt Equation	Simplified Analytical Method with Darcy Equation
Richards Equation	Hantush Equation
Phillips Equation	MODFLOW
Horton Equation	Finite difference spreadsheet with Dupuit Assumption

Several of these methodologies are available in commercial software products. The Agencies can neither endorse any software program nor certify software results.

Additional requirements for calculating retention BMP recovery
Unless the normal Seasonal High Ground Water Table (SHGWT) is greater than or equal to 2 feet below the bottom of the BMP system, unsaturated vertical flow prior to saturated horizontal mounding shall be conservatively ignored in the recovery analyses. This is not an unrealistic assumption since the height of the capillary fringe in fine sands is on the order of six (6) inches, and a partially mounded water table condition may be remnant from a previous storm event.

The potential for the ground water mound growth to intersect the pond volume over a season must also be evaluated. This shall be done using one of the Horizontal Saturated Flow methodologies of **Table F-1** (also **605-1**). The recommended seasonal evaluation is to use the total volume of inflow to the pond less any surface outflow from the pond from the continuous simulation model during the wet season (June 1 – Sept 30). The volume is converted to a uniform, daily application rate by dividing by 122 days and by the pond bottom area. The ground water mound growth that occurs during the 122 day wet season must not intersect the ground surface. This is additional to the recovery analysis for a design event. Designing only for an event recovery using the SHGWT without evaluating the enhanced recharge that happens directly at the BMP over the entire rainy season has high potential cause the BMP to remain wet for extended periods during the wet season. This can become a wildlife attractant hazard on an airport.

Requirements, Guidance and Recommendations for Field and Laboratory Test Data for Manual Computations or Computer Simulations
Computer-based ground water flow models and/or analytic equations are routinely used by practicing engineers and hydrogeologists to predict the time for percolation of the Required Treatment Volume (RTV) and the recovery and ground water mound dissipation for the BMP. The reliability of the output of these models or the calculation from the equations cannot exceed the reliability of the input data. **Input data assessment is probably the most neglected single task in the ground water modeling process.** The accuracy of computer simulations or analytic equations hinges on the quality and completeness of the input data.

The methods listed in the previous section require input values of the retention BMP dimensions, retained stormwater runoff volume (the RTV) and some or all of the following set of aquifer parameters:

- Thickness or elevation of base of mobilized (or effective) aquifer
- Weighted horizontal saturated hydraulic conductivity of mobilized aquifer
- Weighted vertical saturated hydraulic conductivity of layers in the mobilized aquifer
- Soil Suction (ψ)
- Fillable (or effective) porosity of mobilized aquifer
- Ambient water table elevation which, for design event purposes, is usually the normal Seasonal High Ground Water Table (SHGWT), but which for seasonal

ground water mound analysis will be the average ground water elevation that prevails at the start of the rainy season (refer Section 307)

Calculated recovery times are most sensitive to the input value for the aquifer's **saturated hydraulic conductivity.** The following subsections provide additional details on

Determination of Aquifer Thickness

Standard Penetration Test (SPT) borings (ASTM D1586) are recommended for definition of the aquifer thickness, especially where the ground water table is deep. This type of boring provides discrete interval estimates of the relative density or consistency of the soil (as manifested by the SPT "N" values). In concert with soil classification (ASTM D2487-10 laboratory or ASTM D 2488-09 visual), and sieve analysis (percent passing the U.S. Standard No. 200 sieve) better identifies an aquitard or confining unit.

Manual "bucket" auger borings (when supplemented with classification testing) can also be used to define the thickness of the uppermost aquifer (i.e., the depth to the confining unit), especially for small retention ponds and swales.

Additional soil exploration methods include the Cone Penetration Test (CPT) (ASTM D3441-05, ASTM D5778-07 and ASTM D6067-10), auger borings (ASTM D 1486) and test pits. The CPT returns a continuous record of resistance that can be used to evaluated relative density or consistency of very fine strata, and with supplement auger borings can define soil types with a fair degree of accuracy. They are particularly valuable where thin layers of low permeability materials interbed with sands. Test pits, generally excavated with a backhoe, enable detailed observation and bulk sampling of soil strata, but are normally limited to depths of 8 to 12 feet depending on equipment. Machine advanced auger borings return bulk samples of material and provide general indications of soil layering, but must normally be done in conjunction with SPT, CPT or test pits to provide information of the quality needed for aquifer property evaluations.

Definition of SPT "N" Values

The Standard Penetration Test (SPT) consists of driving a split-barrel sampling "spoon" or sampler a distance of 30 cm (12 in) after first "seating" the sampler 15 cm (6 in) by dropping a 63.5 kg (140 lb) hammer from a height of 76 cm (30 in). In field practice, the sampler is driven to a designated depth through a borehole using a long rod, and the hammer strikes the top end of the rod above the ground surface. The operator counts the number of blows that it takes to advance the sampler each of three 15 cm (6 in) increments. When the sampler has penetrated 45 cm (18 in) into the soil at the bottom of the borehole, the operator adds the number of blows for the second and third increments. This combined number of blows to drive the spoon the last 12 inches is the Standard Penetration Test resistance and is called the **"blow count" and is customarily designated as "N" or the "N value**". It directly reflects the penetration resistance of the ground or the soil under investigation. The blow counts or N value is empirically correlated to relative density of sands and non-plastic silts, or consistency of clays and plastic silts.

Definition of a Confining Unit

The confining unit is a hydraulically restrictive layer (i.e., a clay layer, hardpan, etc.). For many recovery / mounding simulations, the confining unit can be considered as a restrictive layer that has a saturated hydraulic conductivity an order of magnitude (10 times) less that the soil strata (sands) above. In some cases, the "Physical & Chemical Properties table" [within the older NRCS soil surveys (legacy documents)] identifies these soil strata as having a vertical hydraulic conductivity (permeability by NRCS) of 0.06 to 0.6 inches per hour, with the soil above having a permeability of 0.6 to 6.0 inches per hour.

In other cases, such as layered sands or sands subject to dynamic compaction, the various layers comprising the aquifer will differ in vertical saturated hydraulic conductivity by an order of magnitude; while the confining layer will differ by three or more orders of magnitude (refer to **Section 304**). In these cases, the vertical conductivities of the aquifer layers may be combined using the following equation:

$$k_v = \frac{z_1 + z_2 + \cdots z_n}{\frac{z_1}{k_{v1}} + \frac{z_2}{k_{v2}} + \cdots \frac{z_n}{k_{vn}}}$$

Where:
k_v is the composite vertical permeability,
z_n is the thickness of layer n, and
k_{vn} is the vertical permeability of layer n.

Another method to supplement the identification of a confining unit is to carefully review the SPT boring logs for increases in the SPT "N" values, or CPT logs for CPT resistance increases. SPT "N" values (blow counts) or CPT resistance alone should be avoided as the primary method to identify a confining unit.

Definition of a Hardpan
A hardpan is a hardened or cemented soil horizon or layer. The soil material is sandy, loamy, or clayey and is cemented by iron oxide, silica, calcium carbonate or other substances.

Definition of a Spodic Horizon
Florida's pine Flatwoods areas typically have a spodic horizon into which organic matter has accumulated. In many cases, this spodic horizon is locally called a hardpan. Pine Flatwoods are the most predominant natural landscape in Florida, comprising approximately 8.4 million acres.

Estimated Normal Seasonal High Ground water Table (SHGWT)
In estimating the normal SHGWT, the contemporaneous measurements of the water table are adjusted upward or downward taking into consideration numerous factors, including:

- Antecedent rainfall
- Soils on the project site.
- Examination of the soil profile, including redoximorphic features, SPT "N" values, depth to "hardpan" or other impermeable horizons (such as clayey fine sands and clays), etc.

- Consistency of water levels with adjacent surface water bodies and knowledge of typical hydraulic gradients (water table slopes).

- Vegetative indicators

- Effects of existing and future development, including drainage ditches, modification of land cover, subsurface drains, wells in the surficial aquifer, irrigation, septic tank drainfields, etc.

- Hydrogeologic setting, including the potentiometric surface of Floridan aquifer and degree of connection between the water table aquifer and the Floridan aquifer.

- Soil Morphological Features

In general, the measurement of the depth to the ground water table is less accurate in SPT borings when drilling fluids are used to maintain an open borehole. Therefore, when SPT borings are drilled, it may be necessary to drill an auger boring adjacent to the SPT to obtain a more precise stabilized water table reading. In poorly drained soils, the auger boring should be left open, preferably using Piezometer pipe, long enough (at least 24 hours) for the water table to stabilize in the open hole.

If there is ground water relief (a sloping potentiometric surface) within the footprint of the pond, the average ground water contour should be considered representative of the pond.

Estimation of Horizontal Hydraulic Conductivity of Aquifer
The following hydraulic conductivity tests are required for retention BMPs:

- Laboratory hydraulic conductivity test on an undisturbed sample (constant or falling head)
- Laboratory tests on a remolded or compacted sample (where compaction is likely to occur during construction)
- Basic time lag method (USACOE – refer **Section 304** and **Appendix D**)
- Uncased or fully screened auger hole
- Cased hole with uncased or screened extension with the base of the extension at least one (1) foot above the confining layer
- Pump test, when accuracy is important and hydrostratigraphy is conducive to such a test method.
- Slug Test(s)

Of the above methods, the most cost-effective is the laboratory hydraulic conductivity test on an undisturbed horizontal sample. However, it becomes difficult and expensive to obtain undisturbed, hydraulic conductivity tube samples under the water table or at depths greater than 5 feet below ground surface.

Pump tests are the most expensive of the recommended hydraulic conductivity test methods. Therefore, it is recommended that pump tests be used in cases where the effective aquifer is relatively thick (greater than 10 feet) and where the environmental, performance, or size implications of the system justifies the extra cost of such a test.

When the aquifer is layered, it is possible to combine several layers and consider the resulting medium as homogenous. If the flow through such layers is mainly horizontal, the arithmetic mean of the hydraulic conductivity estimates of the individual layers should be used to obtain the weighted horizontal hydraulic conductivity of the mobilized aquifer as follows:

$$k_h = \frac{k_1 z_1 + k_2 z_2 + \cdots k_n z_n}{Z}$$

where the formation consists of n horizontal isotropic layers of different thickness z, and Z is the combined thickness. Note that these layers are above the restrictive layer of hardpan or clayey material. Since the most permeable layer will control the value of the weighted hydraulic conductivity, it is important that the hydraulic conductivity of this layer be tested.

For design purposes of all retention BMPs, a saturated hydraulic conductivity value over forty (40) feet per day will not be allowed for fine-grained sands, and sixty (60) feet per day for medium-grained sands.

If the mobilized aquifer is thick with substantial saturated and unsaturated zones, it is worthwhile to consider performing a laboratory permeameter test on an undisturbed sample from the upper unsaturated profile and also performing one of the in-situ tests to characterize the saturated portion of the aquifer.

Estimation of Fillable Porosity

In Florida, the receiving aquifer system for retention BMPs predominantly comprises poorly graded (i.e., relatively uniform particle size) fine sands. In these materials, the water content decreases rather abruptly with the distance above the water table and thus has a well-defined capillary fringe.

Unlike the hydraulic conductivity parameter, the fillable porosity of the poorly graded, fine sand aquifers in Florida are in a narrow range (20 to 30%), and can be estimated with much more reliability.

For fine sand aquifers, it is therefore recommended that a fillable porosity in the range of 20% to 30% be used in infiltration calculations.

The higher values of fillable porosity will apply to the well- to excessively-drained, hydrologic group "A" fine sands, which are generally deep, contain less than 5% by weight passing the U.S. No. 200 (0.074 mm) sieve, and have a natural moisture content of less than 5%.

No specific field or laboratory testing requirement is recommended, unless there is a reason to obtain a more precise estimate of fillable porosity. In such a case, it is recommended that the following equation be used to compute the fillable porosity:

$$\textbf{Fillable porosity} = (0.9\,N) - (w\,\gamma_d / \gamma_w)$$

Where N = total porosity
W = natural moisture content (as a fraction)
γ_d = dry unit weight of soil
γ_w = unit weight of water

Maximum depth to the SHGWT and confining unit for the required recovery/mounding analysis
The maximum depths that will be allowed to the SHGWT and the top of the confining unit will be the higher values of:

- The field confirmed SHGWT or confining unit depth(s) from the boring(s) / test pit(s), or
- The termination depth of the field boring / test pit if a SHGWT or confining unit is not encountered.

Requirements and recommendations regarding constructed breaches in the confining unit

- A detention or retention BMP shall not be excavated to a depth that breaches an aquitard such that it would allow for lesser quality water to pass, either way, between the two systems. In those geographical areas where there is not an aquitard present, the depth of the pond shall not be excavated to within two (2) feet of the underlying limestone which is part of a drinking water aquifer.
- Standard Penetration Test (SPT) borings will be required for any type of deep BMP that has the potential for breaching an aquitard.

Requirements, Guidance and Recommendations for BMP Soil Testing
One of the most important steps in the evaluation of a stormwater BMPs is determining which test methods and how many tests should be conducted per system. Typically, soil borings and saturated hydraulic conductivity measurements are conducted for each BMP. **Soil testing requirements listed in this Section of the Manual represent the minimum. It is the responsibility of the registered professional to determine if additional soil borings and hydraulic saturated conductivity tests beyond the minimum are needed due to site conditions. Additional tests shall be required if initial testing results deviate to such an extent that they do not provide reasonable assurance that the site conditions are represented by the data provided.**

Standard Penetration Test (SPT) borings or auger borings are commonly used to determine the subsurface soil and ground water table conditions. Test borings provide a reasonable soil profile and an estimate of the relative density of the soils. However, measurement of the ground water table depth from SPT borings is usually less accurate than from auger borings. Measurement of hydraulic conductivity requires more specialized tests as described in the previous section.

To measure saturated infiltration, several methods are employed in both the laboratory and in the field. Generally, laboratory tests require collection of an "undisturbed" sample of soil, in either the vertical or horizontal condition, often by means of a Shelby tube. Measurements are performed on the sample via a constant head or falling head condition in a laboratory permeameter. Other methods that involve "remolding" of the soil sample are generally not as accurate as the undisturbed sample methodology, except where compaction is likely to occur, in which case the remolded sample is probably a better estimator of the final, "as-built" conditions.

Field methods for measuring saturated hydraulic conductivity include auger hole tests, piezometer tests, and pumping tests. Although these tests can be more time consuming, they test a larger volume of soil and generally provide more representative results.

Restrictions on the use of double ring infiltrometer tests
The double-ring infiltrometer field test (formerly ASTMD3385, recently repealed) is used for estimating in-situ infiltration rates. If used, these tests must be conducted at the depth of the proposed pond bottom, and shall only be used to obtain the initial "unsaturated" hydraulic conductivity. Once the ground water mound rises to the BMP bottom, the results of a double-ring infiltrometer test are not valid.

Requirements for soil testing
Information related to soils must include the following:

- Soils test results shall be included as part of a supporting soils/geotechnical report of a project's ERP application. This report must be certified by the appropriate Florida registered professional.

- For all soil borings that are used to estimate the depth to the Seasonal High Ground Water Table (SHGWT), the soil colors shall be denoted by both their English common name and their corresponding Munsell color notation (i.e., light yellowish brown – 10YR 6/4).

- Soil test locations shall be located on the construction drawings, or as an option, the permit review drawings that are submitted as part of the ERP application to the Agency. The horizontal locations of the soil borings/tests shall be placed on the appropriate plan sheet(s), and vertical locations of the soil borings/tests shall be placed on the appropriate retention BMP cross-section(s). The designation number of each test on the plan or cross-section sheets shall correspond to the same test number in the supporting soils/geotechnical report (i.e., SPT #1, Auger boring #2, hydraulic conductivity test #3, etc.).

- The vertical datum of the soil tests results shall be converted to the same datum of the plan sheets and retention BMP cross-sections. For instance, the geo-technical consultant's certified report shows the top of the confining unit in SPT #1 as six (6.0) feet Below Land Surface (BLS). The design consultant of record must then convert this BLS data to the vertical datum of the cross-section sheet for the BMP

(NGVD29, NAVD88, or another vertical datum specified by the appropriate regulatory agency).

The location and number of soil borings and saturated hydraulic conductivity tests performed are usually based on the various site characteristics and requires considerable professional judgment and experience in the decision process. **At a minimum, the following number of tests will be required for each proposed BMP unless the specific BMP design criteria do not require soil testing:**

The minimum number of required Soil Borings - The greater of the following two criteria:

- One (1) for each BMP, drilled to at least ten (10) feet below the bottom of the proposed BMP system. For instance, if a BMP has a pond bottom 5 feet below existing land surface, the minimum boring depth will be 15 feet below existing land surface.

- For BMPs larger than 0.25 acre, retention systems within Sensitive Karst Areas, complex hydrogeology, appreciable topographic relief under the retention BMP, or areas that been filled or otherwise disturbed to change the site's soil characteristics such as in certain urban areas or reclaimed mined lands:

$$B = 1 + \sqrt{2A} + \frac{L}{2\pi W}$$

Where:

B = number of required borings under each retention BMP, drilled to at least ten (10) feet below the bottom of the proposed BMP system. For instance, if a retention pond has a pond bottom 5 feet below existing land surface, the minimum boring depth will be 15 feet below existing land surface (rounded up or down to the next whole number).
A = average BMP area in acres (measured at the control elevation)
L = length of the BMP in feet (length is the longer of the dimensions)
W = width of the BMP, in feet
π = PI, approximately 3.14

- For swales, a minimum of one boring shall be taken for each 500 linear feet or for each soil type that the swale will be built on.

For the recovery / mounding analysis, SPT borings should be continuously sampled at least two (2.0) feet into the top of the hydraulically restrictive layer. If a restrictive layer is not encountered, the boring shall be extended to at least ten (10) feet below the bottom of the pond / system. As a minimum, the depth of the exploratory borings should extend to the base elevation of the aquifer assumed in analysis, unless nearby deeper borings or well logs are available.

Minimum number of required Saturated Hydraulic Conductivity tests - At a minimum, the following number of tests will be required for each proposed BMP unless the specific BMP design criteria do not require saturated hydraulic conductivity testing. The greater of the following two criteria:

- One (1) for each BMP, taken no shallower than the proposed bottom of the BMP system, or deeper if determined by the design professional to be needed for the particular site conditions. However, if the system will be built on excessively drained soils, the applicant may propose a lesser number of tests based on plans, test results, calculations or other information, that the number of tests is appropriate for the specific site conditions.

- For BMPs larger than 0.25 acre, retention systems within Sensitive Karst Areas, complex hydrogeology, appreciable topographic relief under the retention BMP, or urbanized (or reclaimed mining) areas that have undergone previous soil disturbance:

$$P = 1 + (B / 4)$$

Where:

P = number of saturated hydraulic conductivity tests for each retention BMP, taken no shallower than the proposed bottom of the retention system, or deeper if determined by the design professional to be needed for the particular site conditions (rounded up or down to the next whole number). However, if the system will be built on excessively drained soils, the applicant may propose a lesser number of tests based on plans, test results, calculations or other information, that the number of tests is appropriate for the specific site conditions.

B = number of required borings (from above).

- For wet detention, stormwater harvesting, or underdrain BMPs that have the potential for impacting adjacent wetlands or potable water supply wells, the hydraulic conductivity tests will be required between the location of the BMP and the adjacent wetlands or well.

RAINFALL DATA

Average annual rainfall amounts from **Reference 12** and expressed in inches are provided for Florida in this Appendix. As discussed in **Section 401**, these and/or the data in **Table 401-1** shall be used to check the annual rainfall applied in continuous simulation modeling done with EPA SWMM, commercial software or other acceptable, continuous simulation modeling software. **Figure G-1** shows the State's five designated meteorological zones. A listing of the counties included in each meteorological zone is given in **Table G-1**. **Figure G-2** is a rainfall isopleth map for the state while **Figures G-3** through **G-6** are expanded rainfall isopleth maps for different parts of Florida.

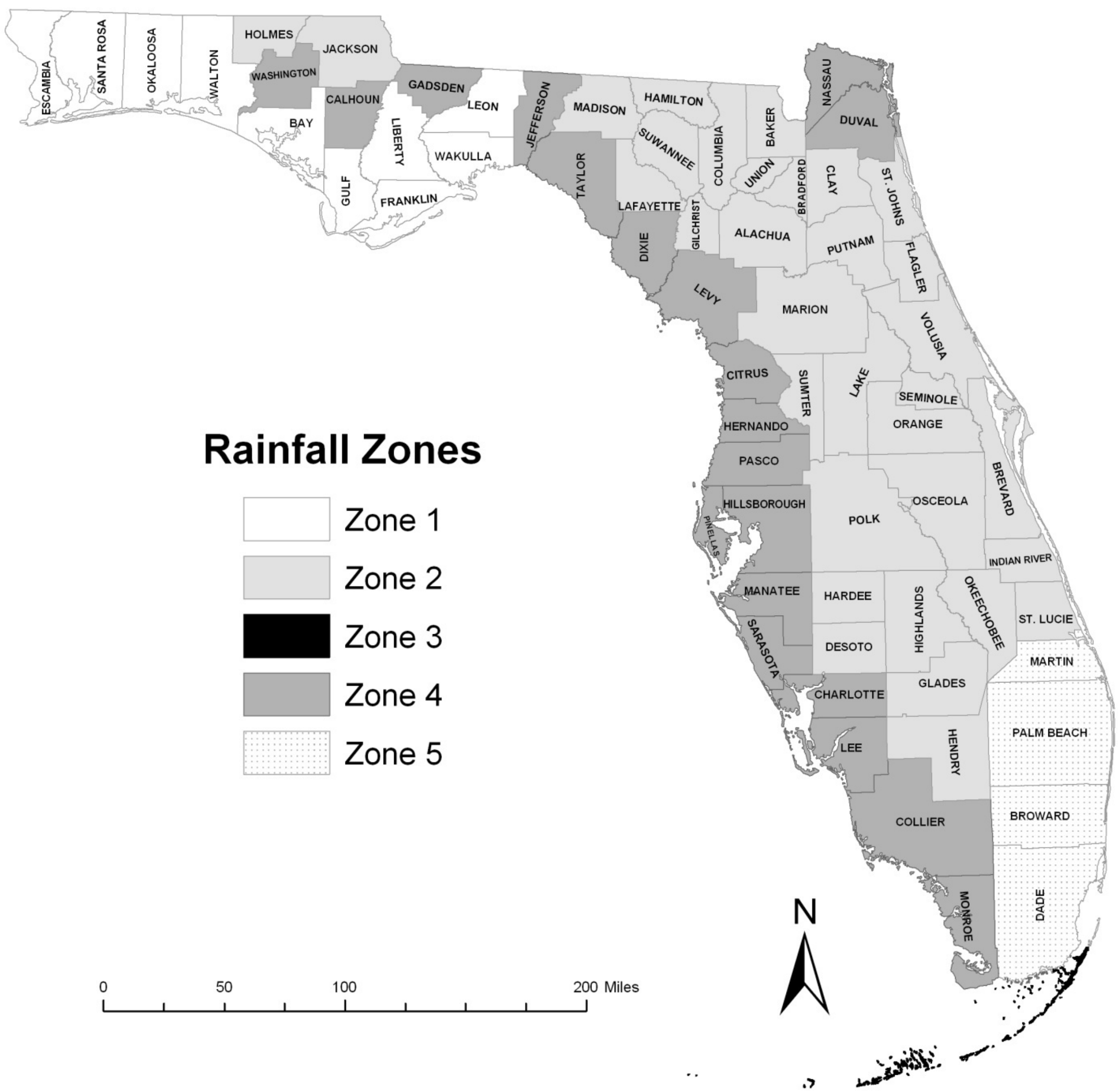


Figure G-1. Designated Meteorological Regions (Zones) in Florida

Table G-1 Counties Included in the Designated Meteorological Zones

Meterological Zone				
ZONE 1	**ZONE 2**	**ZONE 3**	**ZONE 4**	**ZONE 5**
Bay Escambia Franklin Gulf Leon Liberty Okaloosa Santa Rosa Wakulla Walton	Alachua Baker Bradford Brevard Calhoun Clay Columbia Desoto Flagler Gadsden Gilchrist Glades Hamilton Hardee Hendry Highlands Holmes Indian River Jackson Lafayette Lake Madison Marion Okeechobee Orange Osceola Polk Putnam Seminole St. Johns St. Lucie Sumter Union Volusia	Monroe County - Florida Keys from Key Largo to Key West	Charlotte Citrus Collier Dixie Duval Hernando Hillsborough Jefferson Lee Levy Manatee Mainland Monroe Nassau Pasco Pinellas Sarasota Taylor Washington	Broward Miami-Dade Martin Palm Beach

Figure G-2 Rainfall Isopleth Map for Florida

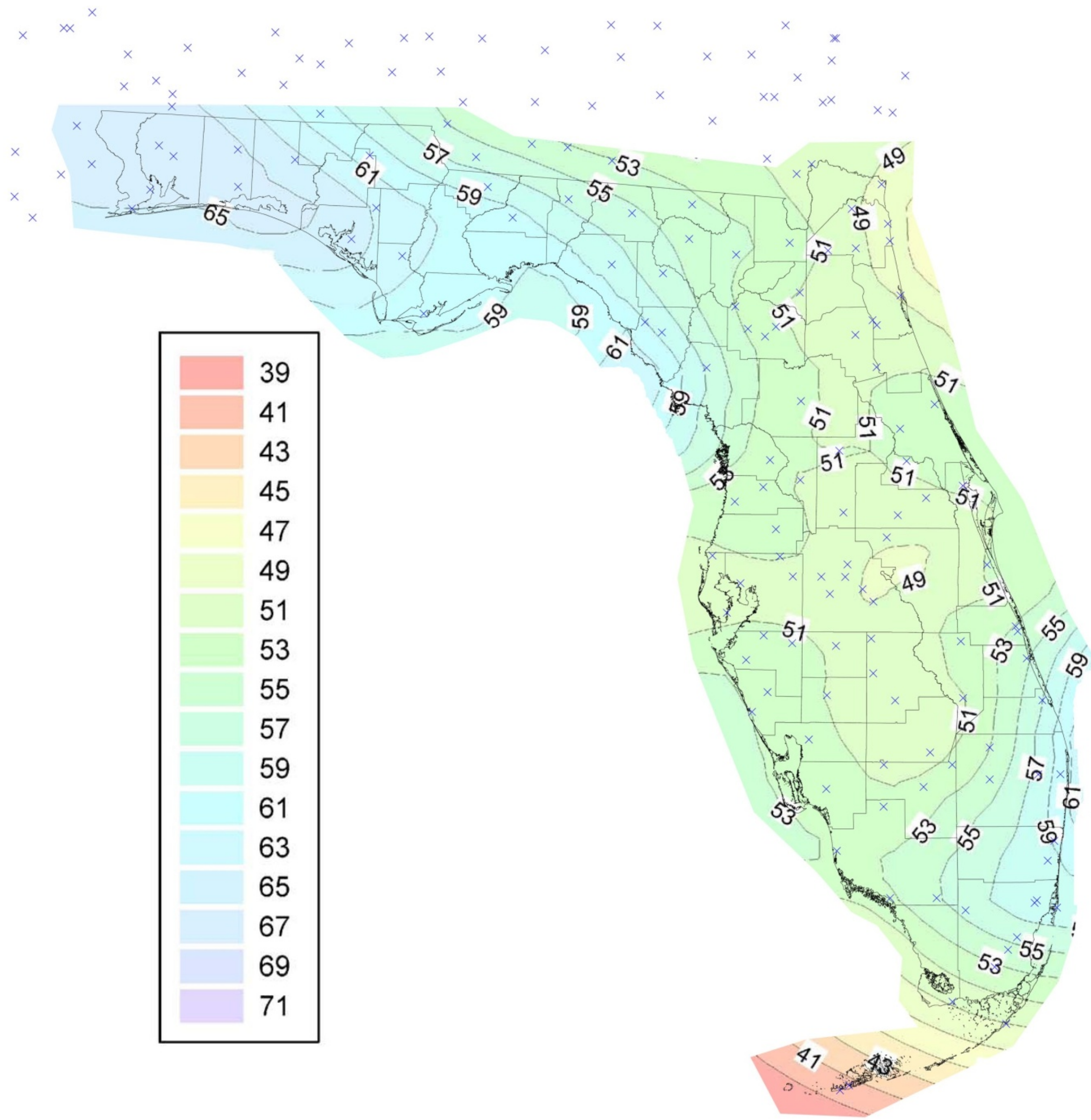


Figure G-3. Expanded Rainfall Isopleth Map for Northwest Florida

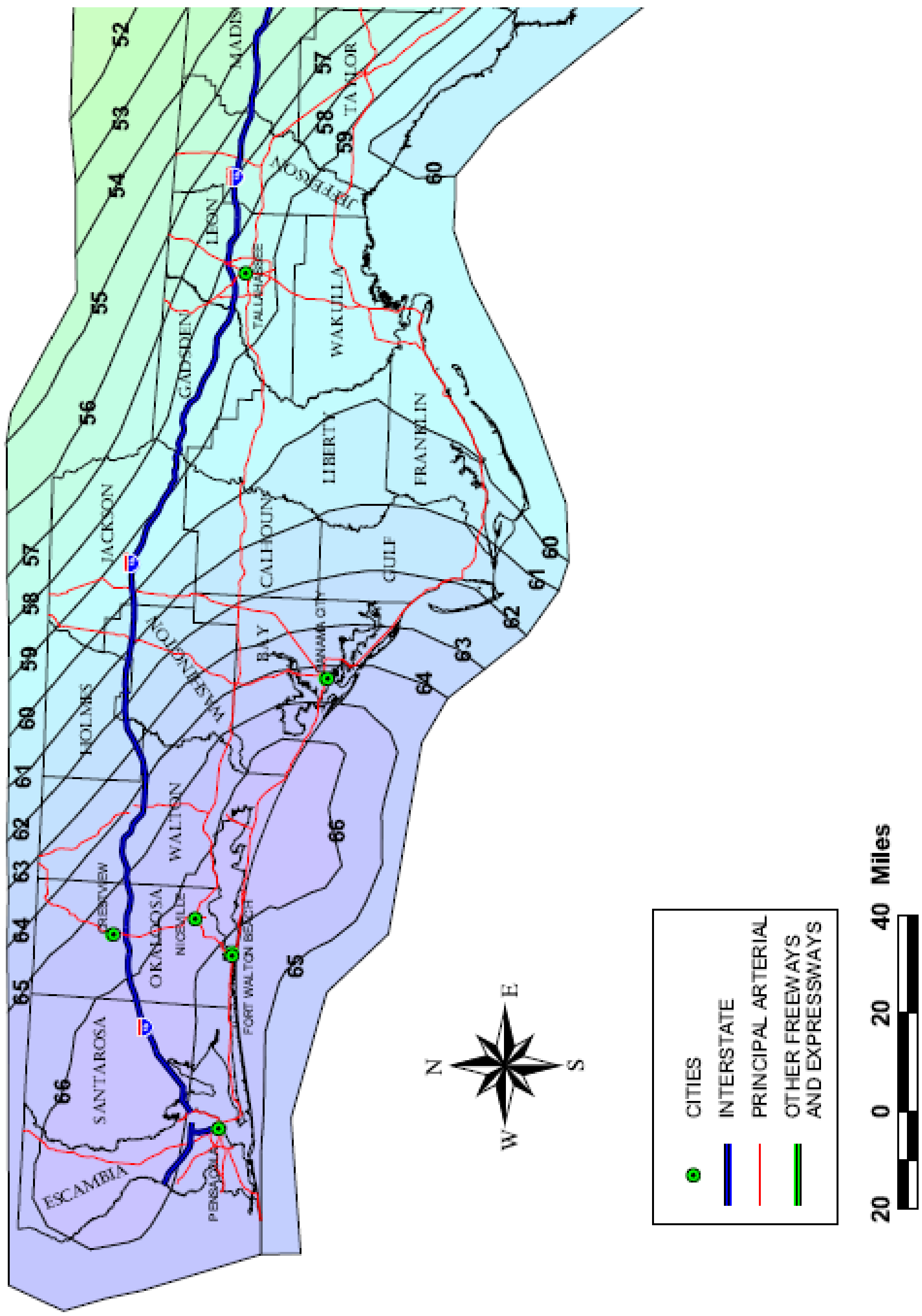


Figure G-4. Expanded Rainfall Isopleth Map for Central Florida

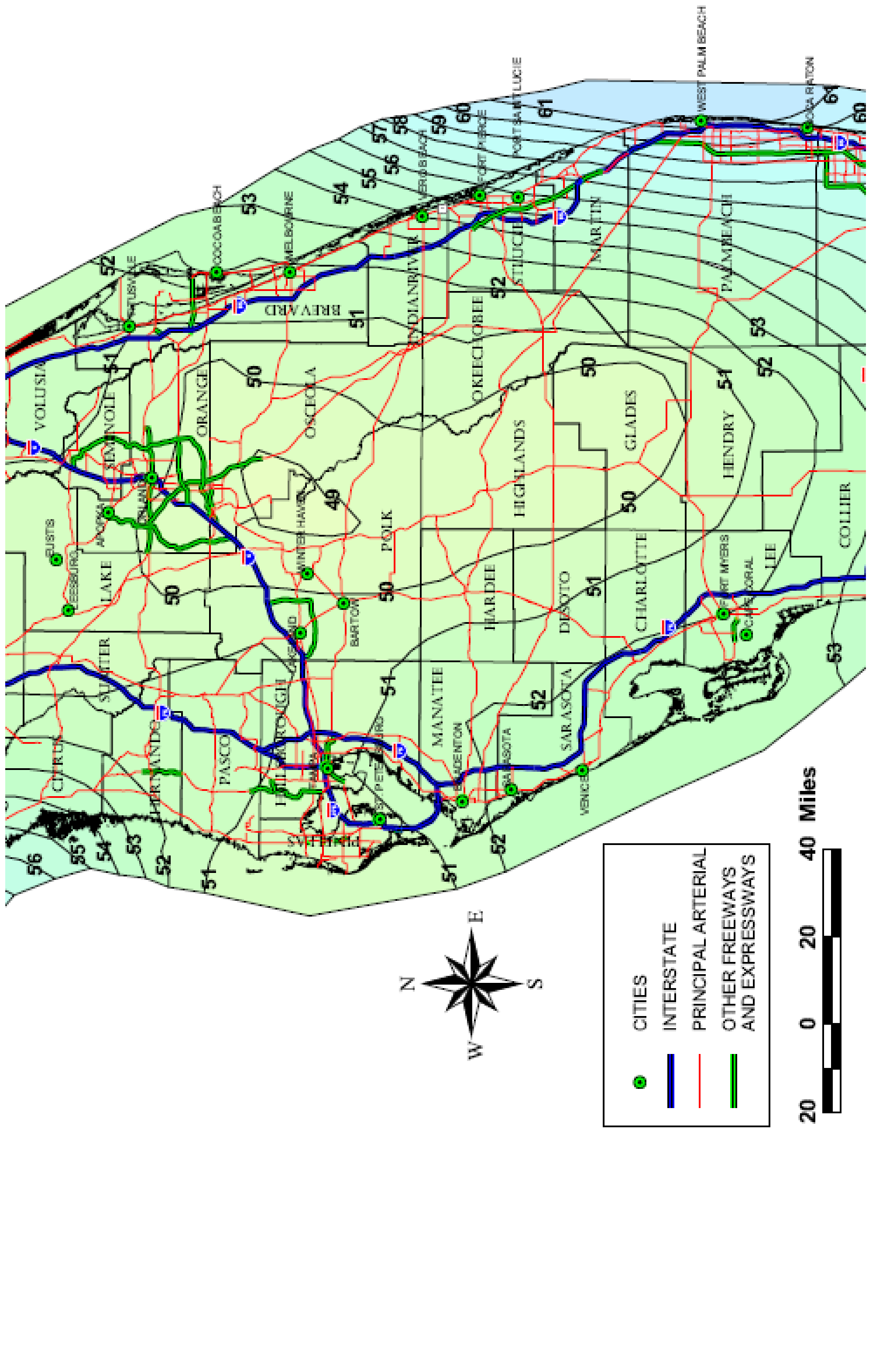


Figure G-5. Expanded Rainfall Isopleth Map for North Central Florida

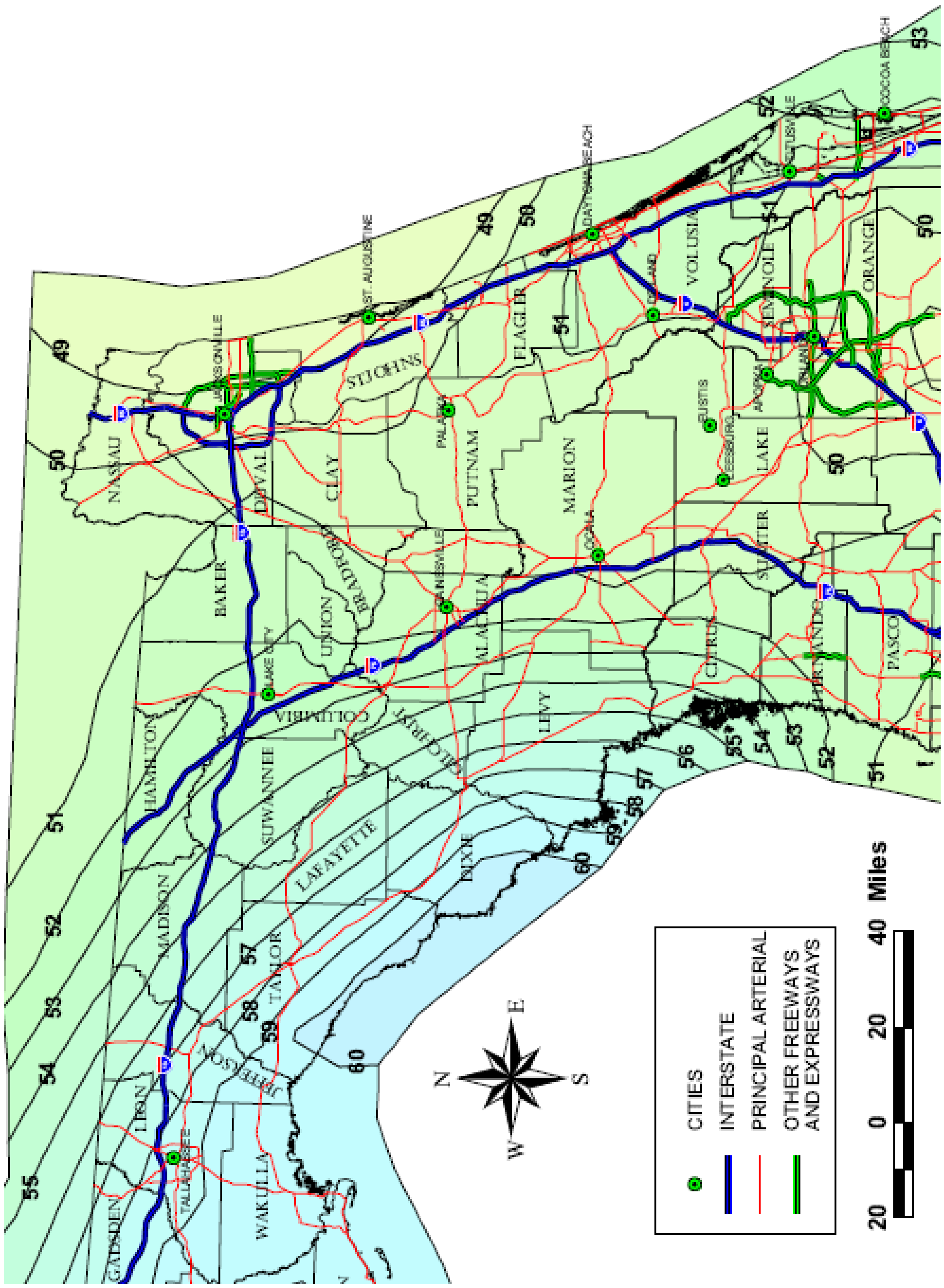
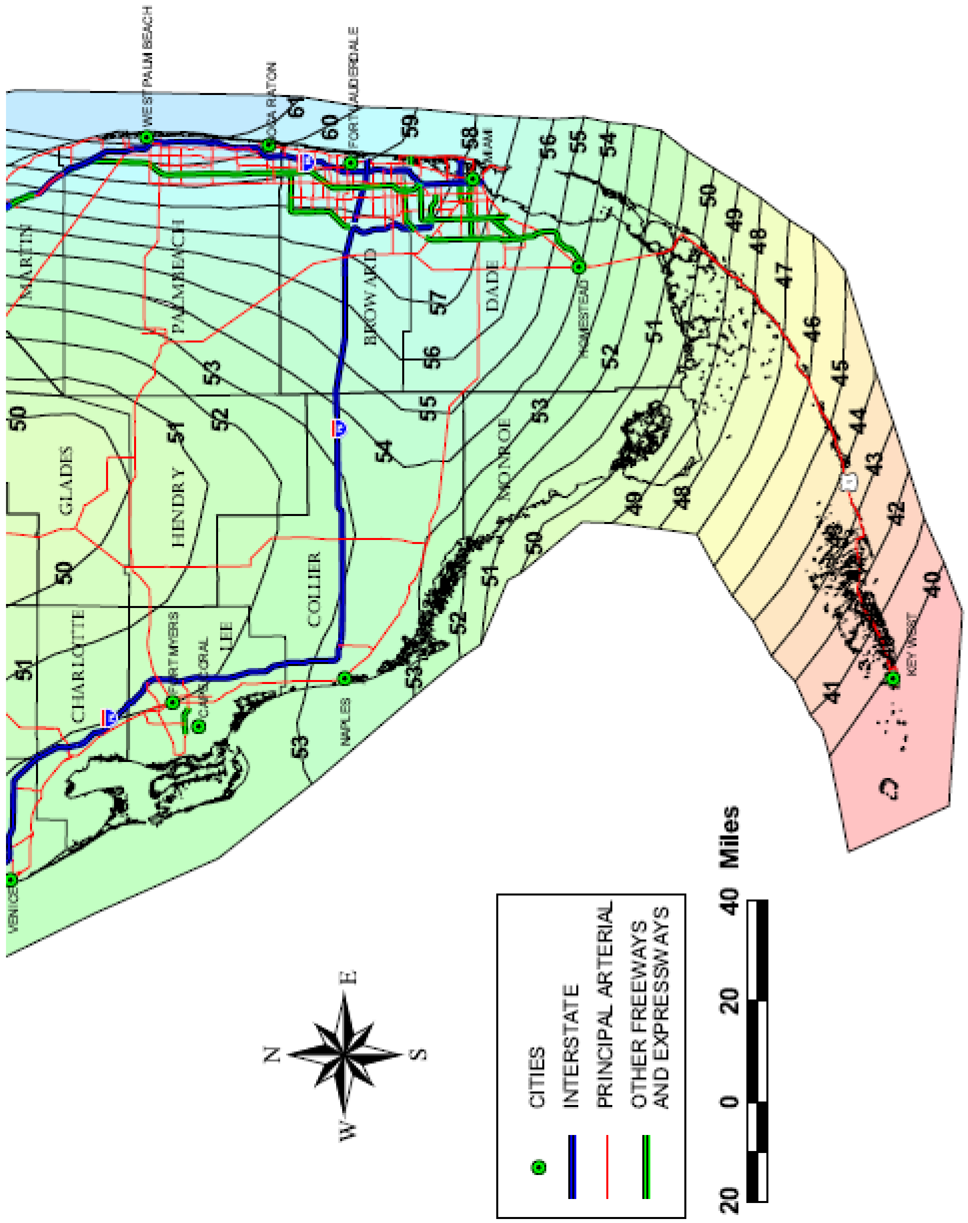


Figure G-6. Expanded Rainfall Isopleth Map for South Florida



ENROLLED

CS/HB 1065, Engrossed 1 2009 Legislature

A bill to be entitled

An act relating to aircraft safety; providing a short title; creating s. 379.2293, F.S.; providing legislative findings and intent; exempting airport authorities and other entities from penalties, restrictions, or sanctions with respect to authorized actions taken to protect human life or aircraft from wildlife hazards; defining the term "authorized action taken for the purpose of protecting human life or aircraft safety from wildlife hazards"; providing that federal or state authorizations for such actions prevail over certain other regulations, permits, comprehensive plans, and laws; providing immunity from penalties with respect to authorized action for certain individuals; providing exceptions; providing an effective date.

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

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

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

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

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

CODING: Words ~~stricken~~ are deletions; words underlined are additions.

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

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

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

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

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

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

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

(b) The term "authorized action taken for the purpose of protecting human life or aircraft safety from wildlife hazards" does not include:

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

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

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

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

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

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

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

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

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

(2) The stormwater management systems shall be:

(a) Designed such that the stormwater nutrient loading does not exceed the stormwater nutrient loading from natural vegetative communities. The calculation of such loadings shall be done using the methodology and data set forth in *The Florida Airports Stormwater Best Management Practices Manual*, ("Airside BMP Manual") Florida Department of Transportation (October 2012), incorporated by reference herein (URL). A copy may be obtained from the Agency, as described in subsection 62-330.010(5), F.A.C.

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

1. Overland flow, as described in Section 605.a of the Airside BMP Manual.

2. Dry retention, as described in Section 605.b of the Airside BMP Manual.

3. Dry swales, as described in Section 605.c of the Airside BMP Manual.

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

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

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

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

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

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

APPENDIX J
Jurisdictional Agencies

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

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

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

Legend
P - Permitting
C - Concern
O - Other Authority

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

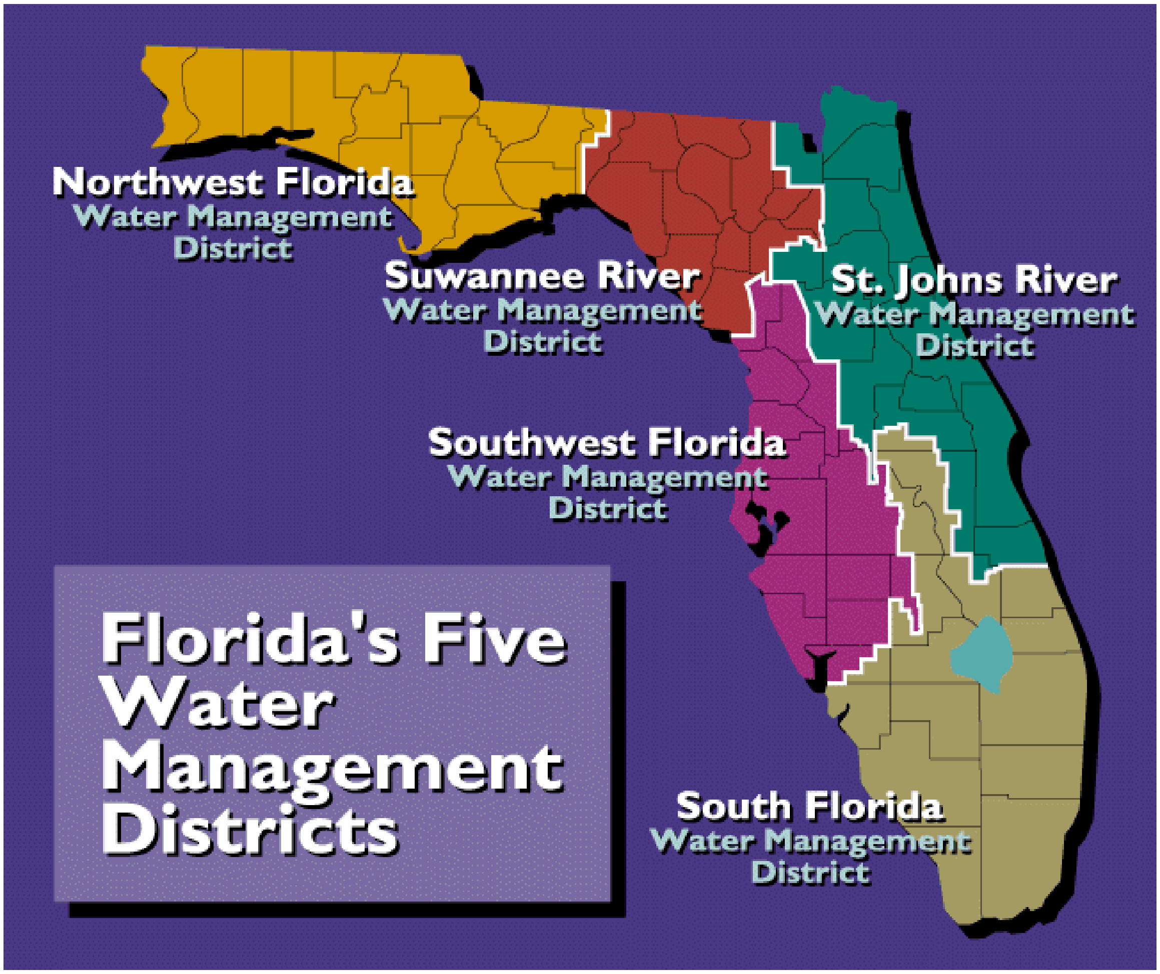


Figure J-1 Outline of Florida Water Management District Jurisdictional Boundaries

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

Archer Flying Ten Airport
Alachua County OJ8
3906 S.W. 15th Street
Archer 32618

Bunnell, Flagler County Airport
Flagler County X47
1200 E Moody Blvd., # 1
Bunnell 32110

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

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

Deland Bob Lee Flight Strip
Volusia County 1J6
5000 Boblee Airport
Deland 32724

Deland Municipal Airport
Volusia County DED
1777 Langley Avenue
Deland 32724

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

Fernandina Beach Municipal Airport
Nassau County 55J
P.O. Box 668
Fernandina Beach 32034

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

High Springs Rudy's Airport
Alachua County 6J8
12623 199th N.E.
Waldo 32694

Hillard Airpark
Nassau County 01J
P.O. Box 549
Hilliard 32046

Jacksonville Craig Municipal Airport
Duval County CRG
P.O. Box 3005
Jacksonville 32206-3005

Jacksonville Herlong Airport
Duval County 23J
P.O. Box 3005
Jacksonville 32206-3005

Jacksonville International Airport
Duval County JAX
P.O. Box 3005
Jacksonville 32206-3005

Leesburg Regional Airport
Lake County LEE
P.O. Box 490630
Leesburg 32749-0630

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

New Smyrna Beach Massey Ranch Airpark
Volusia County X50
P.O. Box 949
New Smyrna, Bch. 32170

New Smyrna Beach Municipal Airport
Volusia Count EVB
210 Sams Avenue
New Smyrna, Bch. 32168

Orlando Executive Airport
Orange County ORL
501 G Hermdon Avenue
Orlando 32803

Orlando Sanford Airport
Seminole County SFB
1 Red Cleveland Blvd
Sanford 32772-0818

Ormond Beach Municipal Airport
Volusia County OMN
P.O. Box 277
Ormond Beach 32175

Palatka Kay Larkin Airport
Putnam County 28J
201 N, 2nd Street
Palatka 32177

Pierson Municipal Airport
Volusia County 2J8
P.O. Box 527
Pierson 32180

St. Augustine Airport
St. Johns County SGJ
4796 U.S. 1 North
St Augustine 32095

Sebastian Municipal Airport
Indian River County X26
1225 Main Street
Sebastian 32958

Titusville Arthur Dunn Airpark
Brevard County X21
355 Golden Knights Blvd
Titusville 32780

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

Umatilla Municipal Airport
Lake County X23
P.O. Box 2286
Umatilla 32784-2286

Valkaria Airport
Brevard County X59
2865 Greenbrooke St.
Valkaria 32950

Vero Beach New Hibiscus Airpark
Indian River County X52
P.O. Box 690772
Vero Beach 323969

Vero Beach Municipal Airport
Indian River County VRB
P.O. Box 1389
Vero Beach 32951-1389

Zellwood Bob White Field
Orange county X61
P.O. Box 494
Zellwood 32798-0494

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

Belle Glade State Airport
Palm Beach County X10
P.O. Box 401
Belle Glade, 33430

Boca Raton Airport
Palm Beach County BCT
3700 Airport Road, Suite 204
Boca Raton, 33431-6403

Clewiston Airglades Airport
Hendry County 2IS
P. O. Box 787
Clewiston, 33440

Everglades Airpark
Collier County X01
P. O. Box 689
Everglades City, 34139

Fort Lauderdale Executive Airport
Broward County FXE
1401 W. Commercial Blvd., Suite 200
Ft. Lauderdale, 33301

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

Fort Myers Southwest Florida Int'l Airport
Lee County RSW
16000 Chamberlain Parkway, Suite 8671
Ft. Myers, 33913

Fort Myers Page Field
Lee County FMY
501 Danley Drive
Ft. Myers, 33907

Fort Pierce St. Lucie County Int'l Airport
St. Lucie County FPR
2300 Virginia Avenue
Ft. Pierce, 34982-5652

Hollywood North Perry Airport
Broward County HWO
7750 Hollywood Blvd., Box 13
Pembroke Pines, 33024

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

Homestead Regional Airport
Dade County HST
P. O. Box 592075
Miami, 33159

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

Indiantown Airport
Martin County X58
P. O. Box 144
Palm City, 34991

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

LaBelle Municipal Airport
Hendry County X14
P. O. Box 1607
LaBelle, 33935-1607

Marathon Airport
Monroe County MTH
9400 Overseas Hwy, Suite 200
Marathon, 33050

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

Miami Dade-Collier Training & Transition Airport
Dade and Collier Counties TNT
12800 S.W. 137 Avenue
Miami, 33186

Miami Kendall-Tamiami Executive Airport
Dade County TMB
12800 S. W. 137 Avenues
Miami, 33186

Miami Heliport
Dade County X48
444 S. W. 2nd Avenue
Miami, 33130

Miami International Airport
Dade County MIA
P. O. Box 592075
Miami, 33159

Miami Opa-locka Airport
Dade County OPF
14300 N. W. 41 Avenue
Opa-locka, 33054

Miami Opa-locka West Airport
Dade County X46
14300 N.W. 41 Avenue
Opa-locka, 33054

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

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

Orlando International Airport
Orange County MCO
One Airport Blvd
Orlando 32827-4399

Orlando Kissimmee Municipal
Osceola County ISM
301 N. Dyer Blvd., Suite 101
Kissimmee, 34741-4613

Pahokee Palm Beach County Glades Airport
Palm Beach County PHK
PBIA, Bldg. 846
West Palm Beach, 33406

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

Stuart Whitham Field
Martin County SUA
1805 S.E. Airport Road
Stuart, 34996

West Palm Beach North Palm Beach County General Aviation Airport
Palm Beach County F45
PBIA, Building 846
West Palm Beach, 33406

West Palm Beach County Park
Palm Beach County LNA
PBIA, Building 846
West Palm Beach, 33406

West Palm Beach International Airport
Palm Beach County PBI
PBIA, Building 846
West Palm Beach, 33406

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

Arcadia Municipal Airport
DeSoto County X06
P.O. Box 351
Arcadia, 33821

Avon Park Municipal Airport
Highlands County AVO
110 E. Main St.
Avon Park, 33825

Bartow Municipal Airport
Polk County BOW
P.O. Box 650
Bartow, 33831

Brooksville
Hernando County Airport, BKV
16110 Aviation Loop Drive
Brooksville, 34609

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

Clearwater Airpark
Pinellas County CLW
P.O. Box 4748
Clearwater 33758-4748

Crystal River Airport
Citrus County X31
P.O. Box 2050
Crystal River 34423

Dunnellon/Marion County Airport
Marion County X35
15070 S.W. 111th St
Dunnellon 34432

Englewood, Buchan Airport
Sarasota County X36
100 Cattlemen Road,
Sarasota 34232

Inverness Airport
Citrus County X40
3600 Sovereign Path, Ste.212
Lecanto, 34461

Lakeland Linder Regional Airport
Polk County LAL
3400 Airfield Drive West
Lakeland 33811-1240

Lake Wales, Chalet Suzanne Airport
Polk County X25
3800 Chalet Suzanne Dr.
Lake Wales, 33853-7000

Lake Wales Municipal Airport
Polk County X07
P.O. Box 1320,
Lake Wales 33859-1320

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

Ocala Regional Airport
Marion County OCF
P.O. Box 1270
Ocala 34478-1270

Palmetto Airport
Manatee County 48X
P.O. Box 554
Palmetto, 34221

Plant City Airport
Hillsborough County PCM
P.O. Box 22287
Tampa 33622

Punta Gorda, Charlotte County Airport
Charlotte County PGD
28000 Airport Road,
Punta Gorda 33982

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

River Ranch Resort Airport
Polk County 2RR
P.O. Box 30030
River Ranch 33867-0030

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

St Petersburg-Clearwater Int'l Airport
Pinellas County PIE
Administration blvd Ste. 221
Clearwater 33762

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

Sebring Regional Airport
Highlands County SEF
128 Authority Lane
Sebring 33870

Tampa, Peter O. Knight Airport
Hillsborough County TPF
P.O. Box 22287
Tampa 33622

Tampa International Airport
Hillsborough County TPA
P.O. Box 22287
Tampa 33622

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

Tampa Vandenberg Airport
Hillsborough County X16
P.O. Box 22287
Tampa 33622

Trenton Ames Field
Levy County 8J2
17551 N. W. 60 Avenue
Trenton 32693

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

Wauchula Municipal Airport
Hardee County FD06
726 East Green Street,
Wauchula 33873

Williston Municipal Airport
Levy County X60
P.O. Drawer 160
Williston 32696

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

Winter Haven Municipal Airport
Polk County GIF
3000 21st Street N.W.
Winter Haven 33881

Zephyrhills Municipal Airport
Pasco County ZPH
39450 South Ave., Box 2
Zephyrhills 33540

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

Cedar Key George T. Lewis Airport
Levy County   CDK
P. O. Box 294
Cedar Key, 32625

Cross City Airport
Dixie County   CTY
P. O. Box 1206
Cross City, 32628

Lake City Municipal Airport
Columbia County   31J
P. O. Box 1687
Lake City, 32055

Live Oak Suwannee County Airport
Suwannee County   24J
224 Pine Avenue
Live Oak, 32060

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

Apalachicola Municipal Airport
Franklin County AAF
P. O. Box 340
Apalachicola, 32320

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

Blountstown Calhoun County Airport
Calhoun County F95
P. O. Box 38
Altha, 32421

Bonifay Tri-County Airport
Holmes County 1J0
P. O. Box 756
Bonifay, 32425

Carrabelle-Thompson Airport
Franklin County X13
P. O. Drawer 569
Carrabelle, 32322

Crestview Bob Sikes Airport
Okaloosa County CEW
State Road 85
Eglin AFB, 32542-1413

De Funiak Springs Municipal Airport
Walton County 54J
P. O. Box 685
DeFuniak Springs, 32435

Destin-Fort Walton Beach Airport
Okaloosa County DTS
State Road 85
Eglin AFB, 32542-1413

Marianna Municipal Airport
Jackson County MAI
P. O. Box 936
Marianna, 32447

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

Panacea Wakulla County Airport
Wakulla County 2J0
P. O. Box 1263
Crawfordville, 32326-1263

Panama City-Bay County International
Bay County PFN
3173 Airport Road, Box A
Panama City, 32405

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

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

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

Port St. Joe Costin Airport
Gulf County FD51
2724 Apalachee Parkway
Tallahassee, 32301

Quincy Municipal Airport
Gadsden County 2J9
P. O. Box 1905
Quincy, 32353

Tallahassee Regional Airport
Leon County   TLH
3300 Capital Circle SW
Tallahassee, 32310

Tallahassee Commercial Airport
Leon County   68J
Route 9, Box 60
Tallahassee, 32303

Milton Peter Prince Field
Santa Rosa County   2R4
6065 Old Bagdad Highway
Milton, 32583

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

PURPOSE

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

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

BACKGROUND

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

The Federal Aviation Administration (FAA) and the United States Air Force (USAF) databases contain information on more than 54,000 United States civilian and military aircraft-wildlife strikes reported to them between 1990 and 1999[1]. During that decade, the FAA received reports indicating that aircraft-wildlife strikes, damaged 4,500 civilian U.S. aircraft (1,500 substantially), destroyed 19 aircraft, injured 91 people, and killed 6 people. Additionally, there were 216 incidents where birds struck two or more engines on civilian aircraft, with damage occurring to 26 percent of the 449 engines involved in these incidents. The FAA estimates that during the same decade, civilian U.S. aircraft sustained $4 billion worth of damages and associated losses and 4.7 million hours of aircraft downtime due to aircraft-wildlife strikes. For the same period,

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

USAF planes colliding with wildlife resulted in 10 Class A Mishaps[2], 26 airmen deaths, and over $217 million in damages.

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

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

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

SECTION I.

SCOPE OF COOPERATION AND COORDINATION

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

A. Agree to strongly encourage their respective regional and local offices, as appropriate, to develop interagency coordination procedures necessary to effectively and efficiently implement this MOA. Local procedures should clarify time frames and other general coordination guidelines.

B. Agree that the term "airport" applies only to those facilities as defined in the attached glossary.

C. Agree that the three major activities of most concern include, but are not limited to:

1. airport siting and expansion;

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

2. development of conservation/mitigation habitats or other land uses that could attract hazardous wildlife to airports or nearby areas; and

3. responses to known wildlife hazards or aircraft-wildlife strikes.

D. Agree that "hazardous wildlife" are those animals, identified to species and listed in FAA and USAF databases, that are most often involved in aircraft-wildlife strikes. Many of the species frequently inhabit areas on or near airports, cause structural damage to airport facilities, or attract other wildlife that pose an aircraft-wildlife strike hazard. Table 1 lists many of these species. It is included solely to provide information on identified wildlife species that have been involved in aircraft-wildlife strikes. It is not intended to represent the universe of species concerning the signatory agencies, since more than 50 percent of the aircraft-wildlife strikes reported to FAA or the USAF did not identify the species involved.

E. Agree to focus on habitats attractive to the species noted in Table 1, but the signatory agencies realize that it is imperative to recognize that wildlife hazard determinations discussed in Paragraph L of this section may involve other animals.

F. Agree that not all habitat types attract hazardous wildlife. The signatory agencies, during their consultative or decisionmaking activities, will inform regional and local land use authorities of this MOA's purpose. The signatory agencies will consider regional, local, and site-specific factors (e.g., geographic setting and/or ecological concerns) when conducting these activities and will work cooperatively with the authorities as they develop and implement local land use programs under their respective jurisdictions. The signatory agencies will encourage these stakeholders to develop land uses within the siting criteria noted in Section 1-3 of FAA Advisory Circular (AC) 150.5200-33 (Attachment A) that do not attract hazardous wildlife. Conversely, the agencies will promote the establishment of land uses attractive to hazardous wildlife outside those siting criteria. Exceptions to the above siting criteria, as described in Section 2.4.b of the AC, will be considered because they typically involve habitats that provide unique ecological functions or values (e.g., critical habitat for federally-listed endangered or threatened species, ground water recharge).

G. Agree that wetlands provide many important ecological functions and values, including fish and wildlife habitats; flood protection; shoreline erosion control; water quality improvement; and recreational, educational, and research opportunities. To protect jurisdictional wetlands, Section 404 of the Clean Water Act (CWA) establishes a program to regulate dredge and/or fill activities in these wetlands and navigable waters. In recognizing Section 404 requirements and the Clean Water Action Plan's goal to annually increase the Nation's net wetland acreage by 100,000 acres through 2005, the signatory agencies agree to resolve aircraft-wildlife conflicts. They will do so by avoiding and minimizing wetland impacts to the maximum extent practicable, and will work to compensate for all associated unavoidable wetland impacts. The agencies agree to work with landowners and communities to encourage and support wetland restoration or enhancement efforts that do not increase aircraft-wildlife strike potentials.

H. Agree that the: U.S. Army Corps of Engineers (ACOE) has expertise in protecting and managing jurisdictional wetlands and their associated wildlife; U.S. Environmental Protection Agency (EPA) has expertise in protecting environmental resources; and the U.S. Fish and Wildlife Service (USFWS) has expertise in protecting and managing wildlife and their habitats, including migratory birds and wetlands. Appropriate signatory agencies will cooperatively review proposals to develop or expand wetland mitigation sites, or wildlife refuges that may attract hazardous wildlife. When planning these sites or refuges, the signatory agencies will diligently consider the siting criteria and land use practice recommendations stated in FAA AC 150/5200-33. The agencies will make every effort to undertake actions that are consistent with those criteria and recommendations, but recognize that exceptions to the siting criteria may be appropriate (see Paragraph F of this section).

I. Agree to consult with airport proponents during initial airport planning efforts. As appropriate, the FAA or USAF will initiate signatory agency participation in these efforts. When evaluating proposals to build new civilian or military aviation facilities or to expand existing ones, the FAA or the USAF, will work with appropriate signatory agencies to diligently evaluate alternatives that may avoid adverse effects on wetlands, other aquatic resources, and Federal wildlife refuges. If these or other habitats support hazardous wildlife, and there is no practicable alternative location for the proposed aviation project, the appropriate signatory agencies, consistent with applicable laws, regulations, and policies, will develop mutually acceptable measures, to protect aviation safety and mitigate any unavoidable wildlife impacts.

J. Agree that a variety of other land uses (e.g., storm water management facilities, wastewater treatment systems, landfills, golf courses, parks, agricultural or aquacultural facilities, and landscapes) attract hazardous wildlife and are, therefore, normally incompatible with airports. Accordingly, new, federally-funded airport construction or airport expansion projects near habitats or other land uses that may attract hazardous wildlife must conform to the siting criteria established in the FAA Advisory Circular (AC) 150/5200-33, Section 1-3.

K. Agree to encourage and advise owners and/or operators of non-airport facilities that are known hazardous wildlife attractants (See Paragraph J) to follow the siting criteria in Section 1-3 of AC 150/5200-33. As appropriate, each signatory agency will inform proponents of these or other land uses about the land use's potential to attract hazardous species to airport areas.

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

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

1. identify each species causing the aviation hazard, its seasonal and daily populations, and the population's local movements;

2. discuss locations and features on and near the airport or land use attractive to hazardous wildlife; and

3. evaluate the extent of the wildlife hazard to aviation.

M. Agree to cooperate with the airport operator to develop a specific, wildlife hazard management plan for a given location, when a potential wildlife hazard is identified. The plan will meet applicable FAA, USAF, and other relevant requirements. In developing the plan, the appropriate agencies will use their expertise and attempt to integrate their respective programmatic responsibilities, while complying with existing laws, regulations, and policies. The plan should avoid adverse impacts to wildlife populations, wetlands, or other sensitive habitats to the maximum extent practical. Unavoidable impacts resulting from implementing the plan will be fully compensated pursuant to all applicable Federal laws, regulations, and policies.

N. Agree that whenever a significant aircraft-wildlife strike occurs or a potential for one is identified, any signatory agency may initiate actions with other appropriate signatory agencies to evaluate the situation and develop mutually acceptable solutions to reduce the identified strike probability. The agencies will work cooperatively, preferably at the local level, to determine the causes of the strike and what can and should be done at the airport or in its vicinity to reduce potential strikes involving that species.

O. Agree that information and analyses relating to mitigation that could cause or contribute to aircraft-wildlife strikes should, whenever possible, be included in documents prepared to satisfy the National Environmental Policy Act (NEPA). This should be done in coordination with appropriate signatory agencies to inform the public and Federal decision makers about important ecological factors that may affect aviation. This concurrent review of environmental issues will promote the streamlining of the NEPA review process.

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

SECTION II.
GENERAL RULES AND INFORMATION

A. Development of this MOA fulfills the National Transportation Safety Board's recommendation of November 19, 1999, to form an inter-departmental task force to address aircraft-wildlife strike issues.

B. This MOA does not nullify any obligations of the signatory agencies to enter into separate MOAs with the USFWS addressing the conservation of migratory birds, as outlined in Executive Order 13186, *Responsibilities of Federal Agencies to Protect Migratory Birds*, dated January 10, 2001 (66 *Federal Register*, No. 11, pg. 3853).

C. This MOA in no way restricts a signatory agency's participation in similar activities or arrangements with other public or private agencies, organizations, or individuals.

D. This MOA does not alter or modify compliance with any Federal law, regulation or guidance (e.g., Clean Water Act; Endangered Species Act; Migratory Bird Treaty Act; National Environmental Policy Act; North American Wetlands Conservation Act; Safe Drinking Water Act; or the "no-net loss" policy for wetland protection). The signatory agencies will employ this MOA in concert with the Federal guidance addressing wetland mitigation banking dated March 6, 1995 (60 *Federal Register*, No. 43, pg. 12286).

E. The statutory provisions and regulations mentioned above contain legally binding requirements. However, this MOA does not substitute for those provisions or regulations, nor is it a regulation itself. This MOA does not impose legally binding requirements on the signatory agencies or any other party, and may not apply to a particular situation in certain circumstances. The signatory agencies retain the discretion to adopt approaches on a case-by-case basis that differ from this MOA when they determine it is appropriate to do so. Such decisions will be based on the facts of a particular case and applicable legal requirements. Therefore, interested parties are free to raise questions and objections about the substance of this MOA and the appropriateness of its application to a particular situation.

F. This MOA is based on evolving information and may be revised periodically without public notice. The signatory agencies welcome public comments on this MOA at any time and will consider those comments in any future revision of this MOA.

G. This MOA is intended to improve the internal management of the Executive Branch to address conflicts between aviation safety and wildlife. This MOA does not create any right, benefit, or trust responsibility, either substantively or procedurally. No party, by law or equity, may enforce this MOA against the United States, its agencies, its officers, or any person.

H. This MOA does not obligate any signatory agency to allocate or spend appropriations or enter into any contract or other obligations.

I. This MOA does not reduce or affect the authority of Federal, State, or local agencies regarding land uses under their respective purviews. When requested, the signatory agencies will provide technical expertise to agencies making decisions regarding land uses within the siting criteria in Section 1-3 of FAA AC 150/5200-33 to minimize or prevent attracting hazardous wildlife to airport areas.

J. Any signatory agency may request changes to this MOA by submitting a written request to any other signatory agency and subsequently obtaining the written concurrence of all signatory agencies.

K. Any signatory agency may terminate its participation in this MOA within 60 days of providing written notice to the other agencies. This MOA will remain in effect until all signatory agencies terminate their participation in it.

SECTION III. PRINCIPAL SIGNATORY AGENCY CONTACTS

The following list identifies contact offices for each signatory agency.

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

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

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

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

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

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

Signature Page

Associate Administrator for Airports,
Federal Aviation Administration

12/17/02
Date

Chief of Safety,
U. S. Air Force

27 May 2003
Date

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

December 9, 2002
Date

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

1/17/03

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

7/29/03
Date

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

09 January 2003
Date

GLOSSARY

This glossary defines terms used in this MOA.

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

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

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

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

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

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

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

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

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

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

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

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

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

    A. **Class A Mishap:** Occurs when at least one of the following applies:
        1. total mishap cost is $1,000,000 or more;
        2. a fatality or permanent total disability occurs; and/or
        3. an Air Force aircraft is destroyed.

    B. **Class B Mishap:** Occurs when at least one of the following applies:
        1. total mishap cost is $200,000 or more and less than $1,000,000; and/or
        2. a permanent partial disability occurs and/or 3 or more people are hospitalized;

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

Wetlands. An ecosystem requiring constant or recurrent, shallow inundation or saturation at or near the surface of the substrate. The minimum essential characteristics of a wetland are recurrent, sustained inundation or saturation at or near the surface and the presence of physical, chemical, and biological features indicating recurrent, sustained inundation, or saturation. Common diagnostic wetland features are hydric soils and hydrophytic vegetation. These features will be present, except where specific physiochemical, biotic, or anthropogenic factors have removed them or prevented their development.

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

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

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

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

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

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

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

APPENDIX L
Wildlife Hazards and Airport Safety

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

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

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

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

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

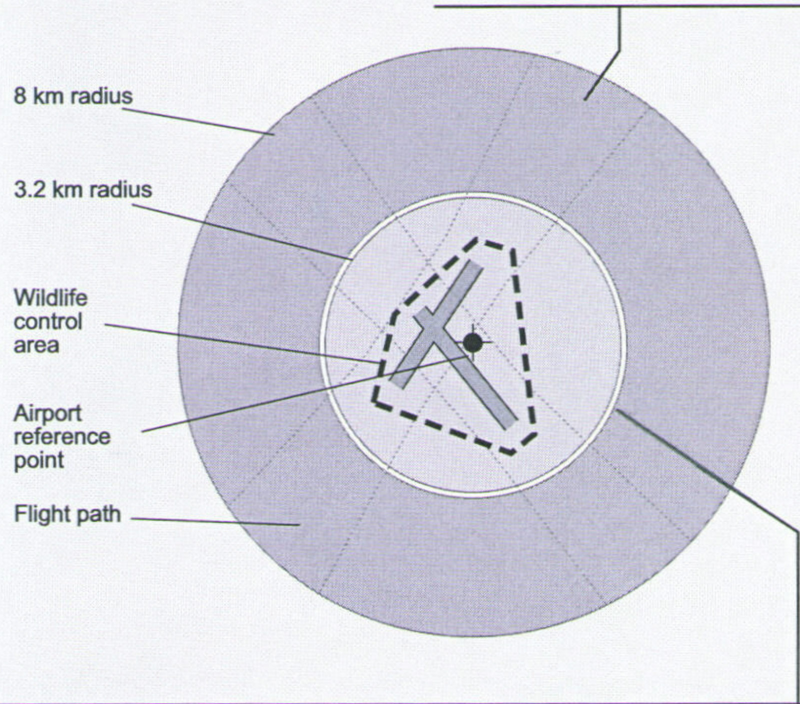
The problem is not limited to the State of Florida, which consistently ranks in the top 3 states for wildlife strikes, or to the United States. Further, it is becoming a source of legal liability both within and outside the U.S. For example, on June 3, 1995 an Air France Concorde ingested 1 or 2 Canada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

Extremely Hazardous

Not recommended for areas within 8 km of an airport reference point:

- garbage dumps
- food waste landfill sites
- coastal commercial fish processing plants
- crops that may attract birds

These areas are attractive to “hazardous” birds, i.e., birds that pose the greatest danger to aircraft.



Moderately Hazardous

Not recommended for areas within 3.2 km of an airport reference point:

- grain crops, e.g., barley, oats, wheat (particularly Durum), corn and sunflower
- fruit orchards, e.g., berries, cherries, grapes and apples
- feedlots, e.g., beer fed cattle and piggeries
- drive-in theatres
- migratory waterfowl and game refuges or feeding stations
- daytime plowing activities
- unchecked infestations of mice and insects
- sewage lagoons and storm-water retention ponds

These areas and practices are moderately attractive to birds — mainly smaller birds such as starlings, sparrows and Snow Buntings — that are not drawn to airports from long distances to feed. These birds are most hazardous during migration or when favourable feeding conditions arise such as insect infestations, plowing or harvesting.

Some hazardous land use practices increase the attractiveness of existing geographic features, such as open bodies of water or wetlands which serve as nesting areas for gulls, shorebirds and waterfowl. For example, when airports lie between landfill sites (feeding areas) and natural bodies of water (nesting areas), birds will regularly fly back and forth over the airport, adding to the bird strike hazard.

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

Florida Statute Chapter 333 *Airport Zoning* recognizes bird attractants as one of several hazards to airport operations. Section 333.02 of the Statute states, in part:
"(1) It is hereby found that an airport hazard endangers the lives and property of users of the airport and of occupants of land in its vicinity…. Accordingly, it is hereby declared:
(a) That the creation or establishment of an airport hazard and the incompatible use of land in airport vicinities are public nuisances and injure the community served by the airport in question;
(b) That it is therefore necessary in the interest of the public health, public safety, and general welfare that the creation or establishment of airport hazards and incompatible land uses be prevented…"
The Statute is principally concerned with zoning ordinances to promote compatible land use adjacent to airports and out to 10 nautical miles (11.5 statute miles) for specific land uses.

The FAA Advisory Circular 150/5200-33B Hazardous Wildlife Attractants On Or Near Airports states, in Section 4-3.a:
"Airports that have received Federal grant-in-aid assistance are required by their grant assurances to take appropriate actions to restrict the use of land next to or near the airport to uses that are compatible with normal airport operations. The FAA recommends that airport operators to the extent practicable oppose off-airport land-use changes or practices within the separations identified in Sections 1-2 through 1-4 [see Figure 605-6, this manual] that may attract hazardous wildlife. Failure to do so may lead to noncompliance with applicable grant assurances. The FAA will not approve the placement of airport development projects pertaining to aircraft movement in the vicinity of hazardous wildlife attractants without appropriate mitigating measures. Increasing the intensity of wildlife control efforts is not a substitute for eliminating or reducing a proposed wildlife hazard. Airport operators should identify hazardous wildlife attractants and any associated wildlife hazards during any planning process for new airport development projects."

The state wildlife organization, the Florida Fish and Wildlife Conservation Commission (FWCC), also recognizes the serious nature of wildlife hazards to aircraft. FAC 68A-12.009 allows harassment of any wildlife within 300 feet of active runways, taxiways and aprons to avoid aircraft collision. Taking of certain species on airports is also authorized by this rule.

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

Impact Forces and Damage

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

TABLE L-1 APPROXIMATE BIRD IMPACT FORCES

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

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

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

Site Factors

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

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

TABLE L-2 WILDLIFE ATTRACTANTS

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