Stormwater Drainage Master Plan

December 2018

DFW DALLAS FORT WORTH INTERNATIONAL AIRPORT

Acknowledgements

The Stormwater Drainage Master Plan was developed by the

Energy, Transportation and Asset Management Department

Systems Performance Group/Watershed Management

In collaboration with the:

Environmental Affairs Department

Commercial Development Department

Planning Department

Design, Code & Construction Department

and:

HUITT-ZOLLARS

And authored by:

CDM Smith

Table of Contents

List of Figures

List of Tables

Appendices

This page intentionally left blank.

Acronyms

ACROS	Airport Climate Risk Operational Screening
ACRP	Airport Cooperative Research Program
AEP	Annual exceedance probability
BMPs	Best management practices
BOD	Biochemical oxygen demand
CBOD	Carbonaceous biochemical oxygen demand
CIP	Capital Improvement Program
DCM	Design Criteria Manual
DFWIA	Dallas-Fort Worth International Airport
EISA	Energy Independence and Security Act
EMCs	Event mean concentrations
EPA	United States Environmental Protection Agency
FAA	Federal Aviation Administration
FEMA	Federal Emergency Management Agency
FIRMS	Flood Insurance Rate Maps
fps	Foot per seconds
GCMs	Global Climate Models
GSI	Green stormwater infrastructure
H&H	Hydraulic and hydrologic conditions
HVAC	Heating, ventilation, and air conditioning
IDDE	Illicit discharge detection and elimination
iSWM	Integrated stormwater management by NCTCOG
LID	Low impact development
LiDAR	Light detection and ranging
MCM	Minimum control measures
MSGP	Multi-Sector General Permit
NCTCOG	North Central Texas Council of Governments
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination Systems
NRCS	Natural Resources Conservation Service
O&M	Operation and maintenance
PSMS	Primary stormwater management system
SDMP	Stormwater Drainage Master Plan
SOPs	Standard operating procedures
SWMM	EPA Stormwater Management Model
SWMP	Stormwater Management Program
SWP3	Stormwater Pollution Prevention Plan

SWPTP	DFWIA Stormwater Pretreatment Plant
TMDL	Total maximum daily load
TPDES	Texas Pollutant Discharge Elimination System
TPH	Total petroleum hydrocarbons
UNT	University of North Texas
USACE	US Army Corps of Engineers
WOUS	Waters of the US
WQ_V	Water quality volume

Section 1

Introduction

Dallas-Fort Worth International Airport (DFWIA) is located in north-central Texas on the border of Tarrant and Dallas counties. Land parcel covers more than 17,000 acres, including portions of the cities of Grapevine, Irving, Euless, Coppell and Fort Worth. Despite being one of the busiest airports in the world and an important economic engine for the North Texas Region, DFWIA is committed to being one if not the most sustainable airport in the United States. DFWIA became the first carbon neutral airport in the Americas and is striving in multiple areas to improve sustainability, including stormwater management. DFWIA's Sustainability Management Plan was developed in 2014 and updated in 2018 (DFWIA, 2014).

Being one of the most frequently visited airports in the world and as the North Texas region continues to grow at an above average rate, DFWIA has renovated and significantly expanded services at its terminals. In addition, DFWIA manages land under its authority for development or redevelopment. Currently, there are still thousands of acres available that are designated for commercial development, with several strategic plans for increasing development already underway.

Part of the strategic approach to sustainability includes development of a formalized Stormwater Drainage Master Plan (SDMP). This allows for a more pre-emptive approach to managing stormwater quantity and quality issues and preserves existing floodplains and ecosystems. In 2014, stormwater low impact development design guidelines (**Appendix A**) were implemented to manage the impact of new impervious surfaces on the watersheds within DFWIA's jurisdiction. Stormwater managements aspects such as water quality, watershed management, flood mitigation, streambank protection and conveyance are being informally addressed under the current stormwater management program and will be formalized as part of the SDMP.

1.1 SDMP Goals and Objectives

The SDMP has two major components: this Stormwater Master Plan (henceforth known as "the Plan") and the Stormwater Maintenance Management Program (henceforth known as "the Program"). It is envisioned that the Program will move from a monitor and react function to a way that will provide for the Plan to be updated periodically and recalibrated based on new information, regulatory changes, and/or organizational priorities.

The foundation for the SDMP is laid out by watershed-level studies, namely stormwater models, the on-going stormwater management and compliance programs, an updated database of the stormwater system components, and DFWIA's sustainability principles and best management practices (BMPs) (**Figure 1-1**). The Plan and Program are intended to be consistent with DFWIA's Sustainability Master Plan (2014), Stormwater Management Plan (SWMP) and Stormwater Pollution Prevention Plan (SWP3) which are developed to satisfy current Texas Pollutant Discharge Elimination System (TPDES) General Permit requirements, as well as Federal and State Guidelines such as Airport Cooperative Research Program (ACRP) reports and Federal Aviation Administration (FAA) regulations.

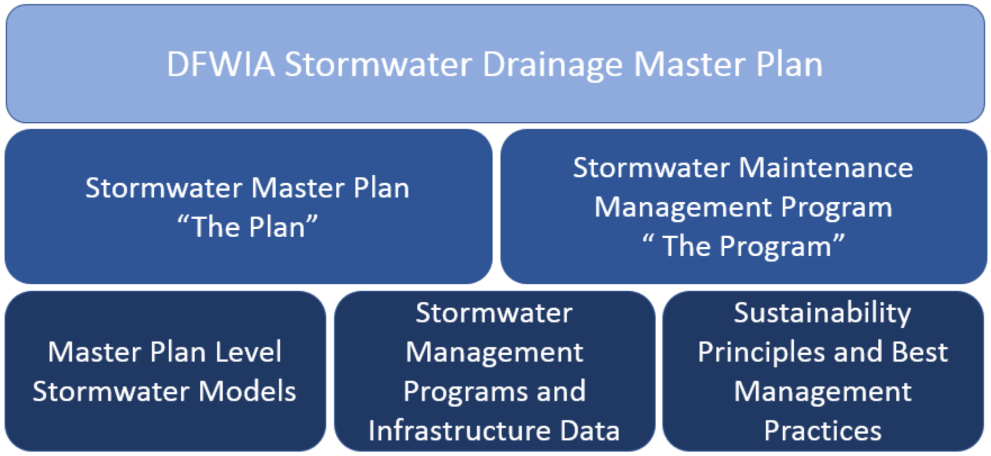


Figure 1-1. DFWIA Stormwater Management Initiative

As a whole, the Stormwater Drainage Master Plan Initiative main objectives are to:

- Utilize the stormwater spatial information and data management framework to support the upkeep of the Plan and the execution of the Program.
- Manage stormwater models for the entire DFWIA property using consistent modeling software to increase level of detail, digital access and accuracy.
- Identify stormwater management alternatives to resolve flooding and erosion problems and equitably manage new development.
- Administer guidance documents to regulate future development at DFWIA to manage both water quantity and water quality issues based on potential problems predicted in the stormwater models.
- Manage procedures and practices which serve as a framework to implement, advance and maintain this SDMP.

The goal of this document (the Plan) is to present the overall approach to address flood control, watershed management, conveyance deficiencies and maintenance, water quality, habitat protection, recreation and ecosystem enhancements while accommodating future development and land uses. Moreover, the approach presented here is intended to accomplish DFWIA's sustainability principles by focusing on the implementation of guidelines and BMPs in various forms per applicable ACRP Reports and FAA controls including Low Impact Development (LID) and Green Stormwater Infrastructure (GSI) strategies.

While the Plan lays down the principles and practices that guide stormwater management at DFWIA, the Program will establish the policies, procedures and practices for advancing and maintaining the Plan's recommendations. The Program will include:

- A formalized process for compiling, submitting and updating data associated with stormwater management (including GIS spatial data, design documents and hydraulic and hydrologic (H&H) model data sets),
- Outline the process for selecting improvement projects for Capital Improvement Programs,
- Develop site-specific GSI guidelines, and

- Establish an integrated approach for the operation and maintenance (O&M) of the drainage system components.

O&M practices established by the Program will integrate existing O&M elements with those developed per Plan recommendations and will cover: stormwater collection, conveyance and storage (including the First Flush System), owned and/or operated stormwater controls (quantity and quality), management of third-party owned and/or operated stormwater controls (quantity or quality), and Trigg Lake Dam O&M.

1.2 Facility Description

DFWIA is governed by the DFWIA Board (henceforth known as the Board), a joint assembly of the owner cities of Dallas and Fort Worth created by an agreement dated April 15, 1968. The Board is responsible for all day-to-day operations and compliance with all permits and regulations, including the National Pollutant Discharge Elimination Systems (NPDES) Program, TPDES Program, and FAA, among others.

The Airside area is comprised of passenger terminals and gates, referred to as the Central Terminal Area, which services multiple national and international airlines, and two major cargo areas, the Northeast Cargo and the West Cargo which serves several cargo companies.

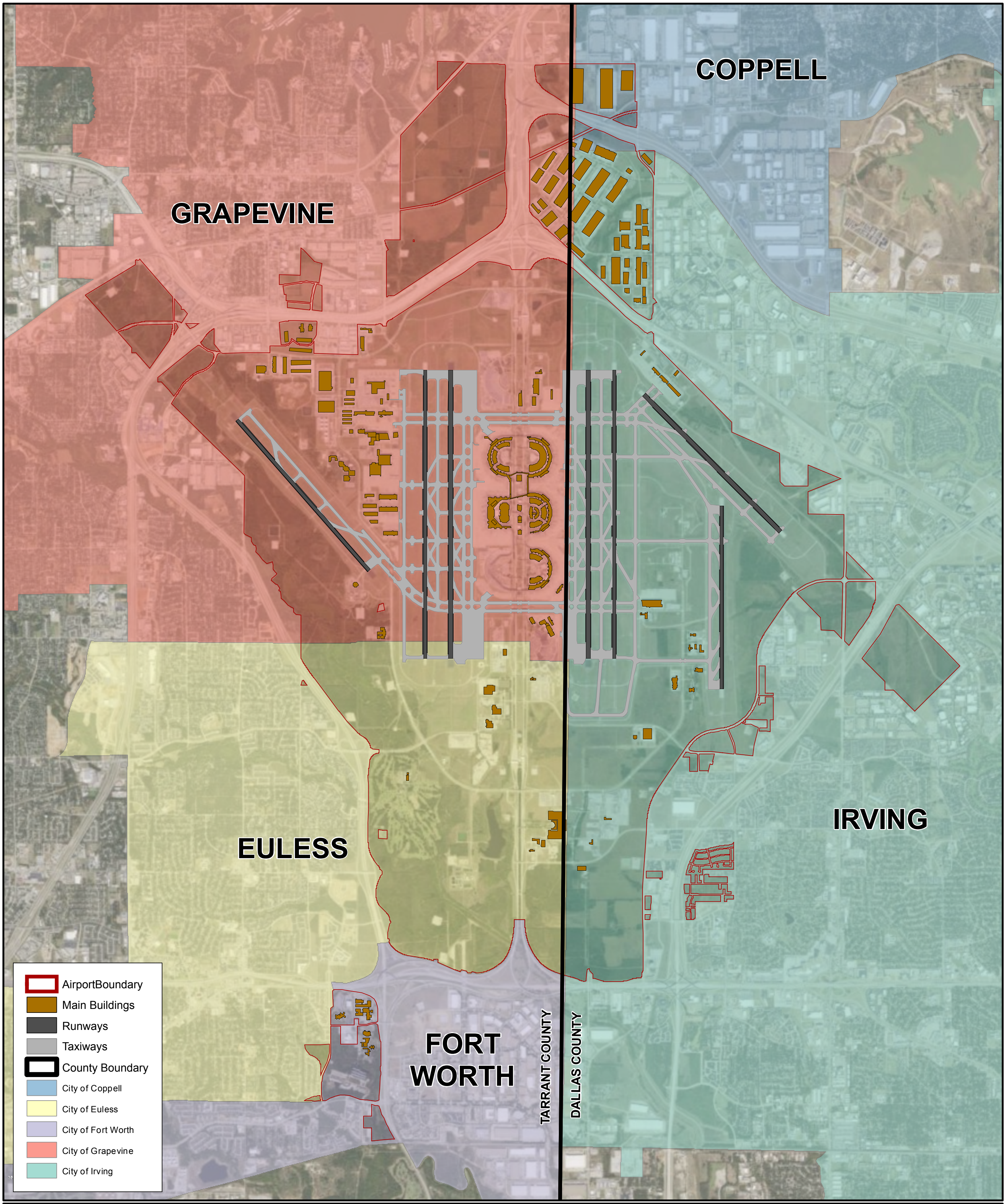
Many tenants and sub-tenants lease facilities or conduct activities within the DFWIA property boundaries. Over 70% of the tenants are related to air transportation or cargo industries. These include the airlines, cargo companies, ground-support equipment providers, and air fueling companies. The remaining tenants include recreational facilities, restaurants, warehousing, light industrial facilities, and even natural gas drilling and exploration

A shift in tenant demographics is ongoing, with strategical new expansions on Landside areas for retail, light industrial, office, hospitality and mixed-use commercial development. Tenants are mostly concentrated Landside (outside the airfield). **Figure 1-2** provides a layout of the airport within the county and city limits.

1.3 Report Organization

The remainder of this report consists of the following sections:

- Section 2 – Stormwater Compliance Overview – overview of regulations, ordinances, policies and programs that frame and implement compliance efforts.
- Section 3 – Constraints, Strategies, and Improvements – lays out the process the Plan uses for evaluating existing and future constraints and needs and identifying strategies for improving system performance.
- Section 4 – Water Quantity Criteria - preliminary evaluation of water quantity data and modeling criteria for hydrology/hydraulic assessments.
- Section 5 – Stormwater Quality Criteria - outlines the process being implemented to develop stormwater management recommendations and identify and prioritize mitigation projects relevant to water quality issues (including GSI and LID BMPs).



DALLAS FORT WORTH
INTERNATIONAL AIRPORT

DFWIA SDMP FIGURE 1-2
AIRPORT OVERVIEW MAP

MAP DATE: DECEMBER 2018

ENERGY, TRANSPORTATION, & ASSET MANAGEMENT / SYSTEMS PERFORMANCE GROUP / GEOSPATIAL ANALYTICS

Section 2

Stormwater Compliance Overview

DFWIA is required to comply with various programs administered under the TPDES program and is considered a public entity and does not fall under the municipal authority of the cities of Dallas or Fort Worth. Therefore, DFWIA is considered a small MS4 and subject to TPDES General Permit TXR040000. Compliance with TPDES Multi-Sector General Permit (MSGP) TXR050000 is required, due to classification of airport's being dischargers of stormwater associated with industrial activity. A SWMP (DFWIA, 2016A) and a SWP3 (DFWIA, 2016B) have been developed to satisfy these requirements.

2.1 MS4 Program History

In order to address water pollution, Congress enacted the Clean Water Act (CWA) Amendments of 1987 which required the United States Environmental Protection Agency (EPA) to develop a two-phase comprehensive regulatory program aimed at reducing water pollution produced from stormwater discharges. On November 16, 1990, the EPA promulgated Phase I of these published regulations which authorized stormwater discharges under the NPDES. The Phase I NPDES Program addressed stormwater discharges associated with medium and large municipalities. Phase II of the NPDES program was promulgated on December 8, 1999 and expanded the previous regulatory program by requiring permit authorization from small municipalities.

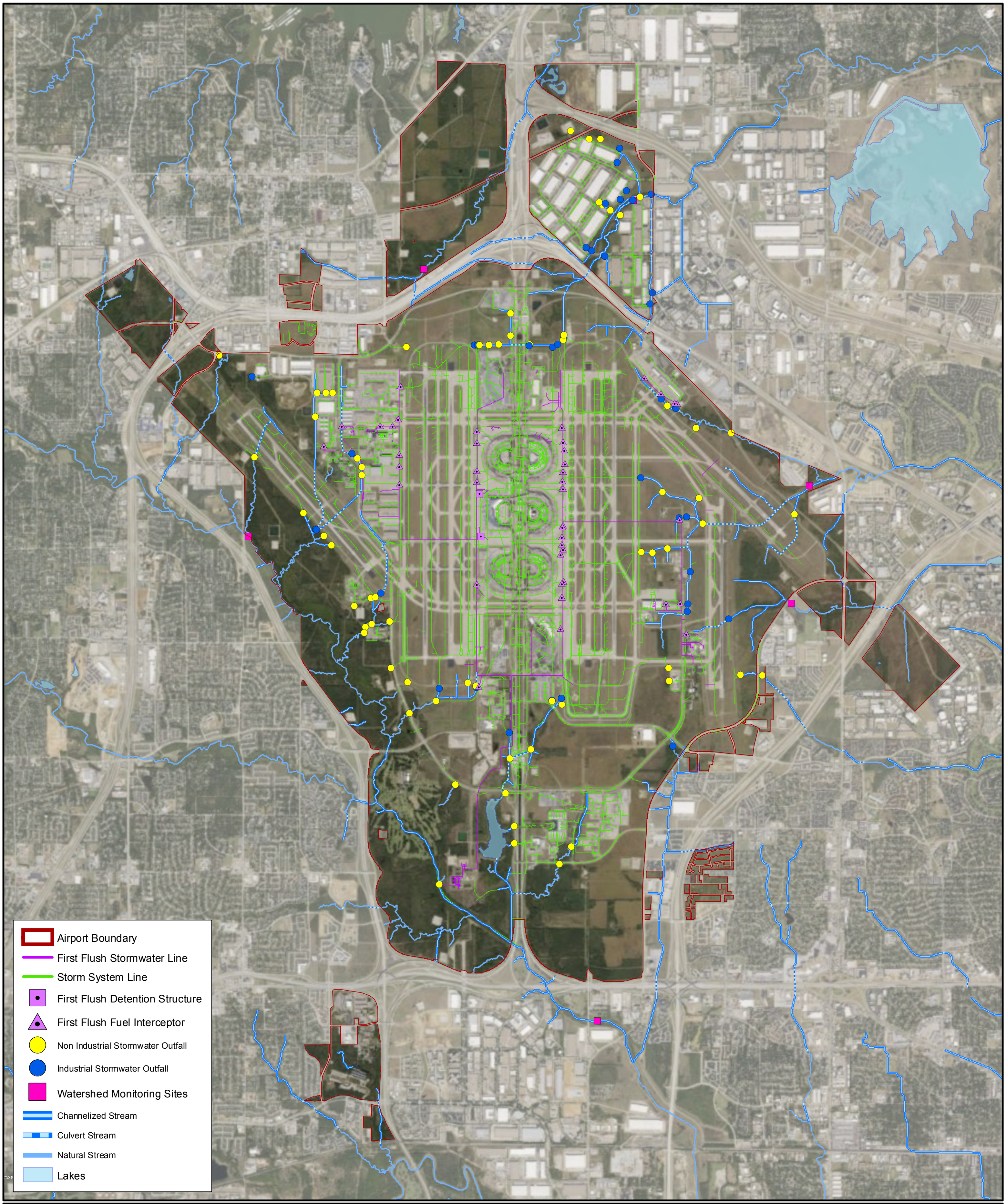
The TCEQ was delegated authority from the EPA to administer the NPDES stormwater program on September 14, 1998; therefore, after September 29, 2000, when all NPDES permits expired, all industries covered under the NPDES program were required to apply for TPDES permit coverage through the TCEQ.

On August 13, 2007, the TCEQ issued the TPDES TXR040000, which authorizes the discharge of stormwater to surface water of the state from MS4s located in an urbanized area.

2.2 Stormwater Infrastructure System

Stormwater collection, storage, treatment, and outfall systems operated at the airport also receives flows and discharges into stormwater systems operated by neighboring municipalities (e.g. Fort Worth, Grapevine, Irving). The majority of stormwater runoff eventually discharges into local creeks and tributaries. Waters of the U.S. (WOUS) either originating on or traversing airport property include the following: Grapevine Creek, Cottonwood Creek, Hackberry Creek, South Fork Hackberry Creek, Mud Springs Creek, Estelle Creek, Cottonwood Branch Creek, Bear Creek, Big Bear Creek, Little Bear Creek, and associated tributaries.

Drainage areas from stormwater outfalls can be categorized into permitted industrial and non-industrial discharge. **Figure 2-1** presents the stormwater and first flush systems including encompassing components and piping, permitted outfalls location, monitoring locations, property boundary, surface water bodies, and associated contributing drainage areas. Further information on the location and classification of the outfalls, is provided in the SWP3 (DFWIA, 2016B).



DFW
DALLAS FORT WORTH
INTERNATIONAL AIRPORT

MAP DATE: DECEMBER 2018

ENERGY, TRANSPORTATION, & ASSET MANAGEMENT / SYSTEMS PERFORMANCE GROUP / GEOSPATIAL ANALYTICS

N W E S

0 700 1,400 2,800 4,200 5,600 Feet

DFWIA SDMP FIGURE 2-1
STORMWATER AND FIRST FLUSH SYSTEM

2.2.1 Primary Stormwater Management

The primary stormwater management system (PSMS) is comprised of pipes, channels, permitted outfalls, basins, pumps, collection systems that discharge straight into surrounding watersheds without treatment. Areas where stormflows may encounter pollutants related to airport industrial activities are collected by the first flush system. This runoff is then treated before discharge to the MS4.

Stormwater flows originating from runway and taxiway areas discharge directly to receiving waters, via the stormwater collection systems. Likewise, storm drain inlets supporting roadways, the public side of terminal areas, general parking areas, offices, municipal buildings, most tenant leaseholds, recreational facilities, and the Rent-a-Car complex, discharge directly to the PSMS, which in turn discharges flows to the nearest receiving water or MS4. However, some maintenance facilities and tenant facilities are constructed with stormwater structural controls designed specifically to treat first flush stormwater before runoff discharges into downstream waters or collection systems.

Approximately thirty-eight stormwater outfalls have been identified which drain either aircraft operations areas or the Board operated facilities associated with industrial activity. In general, drainage from the north is discharged into Grapevine Creek, from the northeast into Hackberry Creek, from the east into Mud Springs Creek, from the southeast into Trigg Lake, and from the west and southwest into Bear Creek,.

2.2.2 First Flush System

In addition to the PSMS, a first flush system was constructed to collect industrial stormwater runoff. The first flush system is comprised of terminal and air cargo ramp inlets, fuel separators, and piping that conveys first flush stormwater to the DFWIA Stormwater Pretreatment Plant (SWPTP). First flush stormwater (treated) is authorized for discharge from Outfall 001 under TPDES Wastewater Permit No. WQ0001441000.

Ramp storm drain inlets maintain a water level designed to retain oil and grease while discharging the captured stormwater to fuel separators at ramp locations. The fuel separators direct dry weather and first flush discharges to the SWPTP. Fuel separators and stormwater inlets associated with the first flush system are inspected quarterly and cleaned annually. Terminal D has pretreatment detention structures that are inspected and cleaned annually.

Dry weather and first flush discharges from the terminals (Airside), Allied Aviation fuel farm, UPS Cargo Facility (ramp/apron area), West Cargo (ramp/apron areas), and the former U.S. Mail Cargo Facility are discharged through fuel separators to the SWPTP.

2.3 DFWIA Stormwater Program

DFWIA is a registered level 2 MS4 under the regulated number RN105481485. The Board (CN601700610) holds the permit number TXR040044 for the small MS4. As part of compliance, a SWMP was enacted to outline efforts for compliance with state and federal regulations. The SWMP outlines BMPs implemented or to be adopted to meet the five minimum control measures (MCMs) developed by TCEQ:

1. Public Education, Outreach, and Involvement.
2. Illicit Discharge Detection and Elimination (IDDE).
3. Construction Site Stormwater Runoff Control.
4. Post Construction Stormwater Management in New Development and Re-development.
5. Pollution Prevention and Good Housekeeping for Municipal Operations.

Stormwater programs have been enacted to map, control, and monitor stormwater runoff from the site. Adoption of stormwater ordinances and policies with legal authority to impose fines or similar penalties has been developed with several factors in mind:

- Flood control.
- Watershed management.
- Conveyance deficiencies and maintenance.
- Water quality.
- Habitat protection.
- Recreation.
- Ecosystem enhancements.

DFWIA's Code of Rules and Regulations; Chapter 6A Stormwater, establishes uniform requirements and methods to control the introduction of pollutants into the airport separate storm sewer system in order to comply with the requirements of the NPDES and TPDES permits. Article II of the regulation lists the only non-stormwater discharges permitted to the MS4. Permit years run from October 1 through September 30.

A benthic macro invertebrate bioassessment was performed in and around the airport by the University of North Texas (UNT) (UNT, 2017A). The purpose of this multi-year monitoring study was to collect data that could be used to characterize water quality and biological conditions, identify significant long-term trends, and evaluate the effectiveness of programs designed to protect water resources within its watershed. Overall, benthic macroinvertebrate communities present in the MS4 receiving waters revealed a high aquatic life use, especially considering the urban setting in which these streams reside. The Bioassessment found that water quality programs enacted at DFWIA were protective of the habitat especially in riparian areas of Bear Creek and Trigg Lake. Focused efforts on Bear Creek riparian areas have been established due to the potential to improve water quality. Efforts include, mapping and research of environmentally sensitive areas including endangered species and wetlands within WOUS. Applicable regulations are monitored for habitat protection based on TCEQ, Texas Park and Wildlife, and all other regulatory entities.

In the past, two projects have impacted or removed natural wetlands within the boundary of the airport. In 1993, the construction of a parallel runway on the east side was approved which impacted 4.25 acres of wetlands and 4.11 acres of other WOUS. To alleviate this loss, a mitigation plan was created with the primary objective of replacing the lost functions of water quality enhancement and wildlife protection. This mitigation included the protection and enhancement of 2.9 acres of existing wetlands and the creation of 10.5 acres of new wetlands. The Project was completed in 1996. In 2008, approval by TCEQ was obtained to rescind the watershed deed restriction within the MS4 to allow for the construction of a gas pad, drilling of gas wells, and the construction of lateral gas line to service the wells all located near the eastside runways. Construction was completed in 2008 and annual compliance reports were submitted to determine whether the development activities within the watershed were negatively affecting the function of the wetland mitigation area or negatively changing the quantity or quality of water entering the wetland mitigation area. Within the 5 years documented, no quantity or quality changes were documented, and construction activities did not appear to be affecting the wetland mitigation area.

2.3.1 Stormwater Quality Criteria

Potential pollutants and parameters have been outlined that may enter the stormwater through operations on site. The IDDE program concentrates on identifying illicit discharges or connections and finding solutions to correct or eliminate those discharges. The Environmental Affairs Department has created standard operating procedures (SOPs) to provide guidance to all operators that are part of the MS4 program. These SOPs are provided in **Appendix B**.

A good housekeeping program was enacted for all owned and tenant facilities with the intent to minimize the exposure of pollutants to the environment. Good housekeeping techniques are stressed to employees during training sessions and minimum acceptable protocols are defined in the SWP3.

BMPs can include non-structural controls (measures or activities taken to minimize pollution), or structural controls and are intended to eliminate or minimize the impact of environmental pollutants. A BMP Guidance Document (DFWIA, 2018A) is utilized to educate tenants on the various control measures that should be incorporated into their daily activities to prevent or reduce stormwater pollution. The BMP Guidance Document provides a list of common BMPs that can be implemented. All operators and tenants are expected to become familiar with the various BMPs applicable to their onsite activities.

Structural controls can be defined as the physical features incorporated into the construction of a facility, which are designed to reduce or eliminate environmental pollution of a specific collection system or increase safety. Common structural controls providing treatment include:

- Oil/water separators.
- Runway-taxiway swales.
- Stormwater systems and drain filters (or similar systems designed to treat stormwater runoff).
- Rainwater harvesting
- Spill containment systems and ponds.
  - Diversion valves and shut-off valves.
  - Secondary containment structures.

DFWIA monitors water quality and quantity of the MS4 through visual inspections and sampling from representative outfalls and monitoring locations shown in the SWMP**.** Outfalls are sampled for a wide range of parameters that include:

- pH
- Temperature
- Flow
- Dissolved oxygen (DO)
- Conductivity
- Chlorine
- Ammonia
- Surfactants
- Total petroleum hydrocarbons (TPH)
- Carbonaceous biochemical oxygen demand (CBOD)
- Bacteria *(E. coli)*
- Oil and grease
- Copper
- Zinc

Sampling results are reviewed and provided to TCEQ as part of DFWIA's Annual Report.

Tenant operating under the shared SWP3 are required to conduct all applicable hazardous metal effluent sampling for their respective leasehold if the tenant does not qualify for a hazardous metals waiver. Tenants operating under individual SWP3s are required to conduct all required benchmark, effluent, and visual monitoring identified in the MSGP for their respective leasehold or primary areas of operation.

Additionally, stormwater sampling is required for discharging to Grapevine Creek and Cottonwood Branch Creek as a result of a Total Maximum Daily Load (TMDL) for indicator bacteria, adopted by TCEQ on September 21, 2011. This sampling effort assists in the mitigation of bacteria loads in the two creeks and help align efforts with water quality goals for contact recreation use.

2.3.2 Stormwater Monitoring and Sampling

The Stormwater Sampling and Monitoring Plan (DFWIA, 2016C) provides information on the quality of stormwater runoff. The stormwater analytical data obtained during the monitoring program is used to identify the types and sources of pollutants and to provide a means for evaluating potential environmental risks.

Stormwater monitoring and sampling efforts are identified in the MS4 and MSGP stormwater permits. The MS4 permit requires monitoring and sampling for those outfalls not covered under an individual permit. Tenants subject to MSGP requirements are also required to monitor stormwater quality.

2.3.3 Illicit Discharge Monitoring

As part of the IDDE monitoring program, all outfalls are inspected at least once a year. Reasonable attempts are made to collect background information regarding the drainage area for the outfall being inspected. Examples include stormwater system maps, as-builts drawings, and similar resources referring to facilities and upstream areas the outfall supports. During site visits, outfalls are evaluated for structural and erosion problems and documents if flow is present during dry conditions.

If flow is observed at outfall locations, a sample is taken and tested for general parameters. Visual assessments are also performed looking at sheen, color, odor, wildlife, and foam to try to determine the origin of the discharge. Should the discharge be deemed non-stormwater related, samples are provided to a lab for testing that may further tract the source of the illicit discharge. Photos are taken during inspection and any structural or erosion problems found are reported for further evaluation.

2.3.4 Channel Inspections

Separate from illicit discharge efforts, maintenance of the airport channels and controls are reviewed and monitored. Maintenance includes inspection and cleaning of trash and debris, control of vegetation and general upkeep of the channels. Channels on the land side, are monitored and maintained by a contractor periodically. All channels are inspected at least once per permit term with channels on the Airside monitored on a continuous basis.

Channel inspections are performed throughout the MS4 including areas around outfalls reported to have structural or erosion problems. These inspections are outlined in the SOP titled "Storm Water Drainage System Management" found in **Appendix B** and are geared toward monitoring and restoring channels but are also used to document other drainage issues found. Inspection criteria include slope instability and erosion factors, pipe submerging and blockages, location and placement near infrastructure, appearance of illicit discharge sheens or debris, and overall status of the channel. As later discussed in Section 4, several ongoing restoration efforts to the channels have been postponed until the watershed assessments being performed as part of this SDMP are completed to better address the underlying causes of the issues identified.

This page intentionally left blank.

Section 3

Constraints, Strategies and Improvements

The stormwater system at DFWIA, including its contributing watersheds are being evaluated by developing hydrologic and hydraulic models to facilitate the analysis of conveyance and water quality issues. The modeling of the PSMS will be performed using the EPA Stormwater Management Model (SWMM), version 5+. This modeling effort allows for the assessment of underlying causes of flooding and erosion issues in the system and predict areas of concerns, preventing further issues from occurring. Models are being built to simulate both existing and future land use conditions include all eight major watersheds contributing to DFWIA. Model files for Cottonwood Creek are available. Remaining watersheds currently being modeled include: Grapevine Creek, Hackberry Creek, South Fork Hackberry Creek, Mud Springs Creek, Estelle Creek, Bear Creek, and Cottonwood Branch Creek as shown in **Figure 3-1**.

The developed models represent the PSMS and will be used to:

- Determine baseline hydrology and hydraulic conditions for the basins.
- Assess the system's drainage characteristics for established design storm events.
- Provide sufficient level of detail for FEMA floodplain delineation requirements.
- Identify possible causes of existing flooding and erosion problems.
- Determine and size recommended system components.
- Analyze stormwater management approaches such as GSI/LID strategies.

The evaluations also consider other system aspects that may place constraints on future development.

3.1 System Assessment

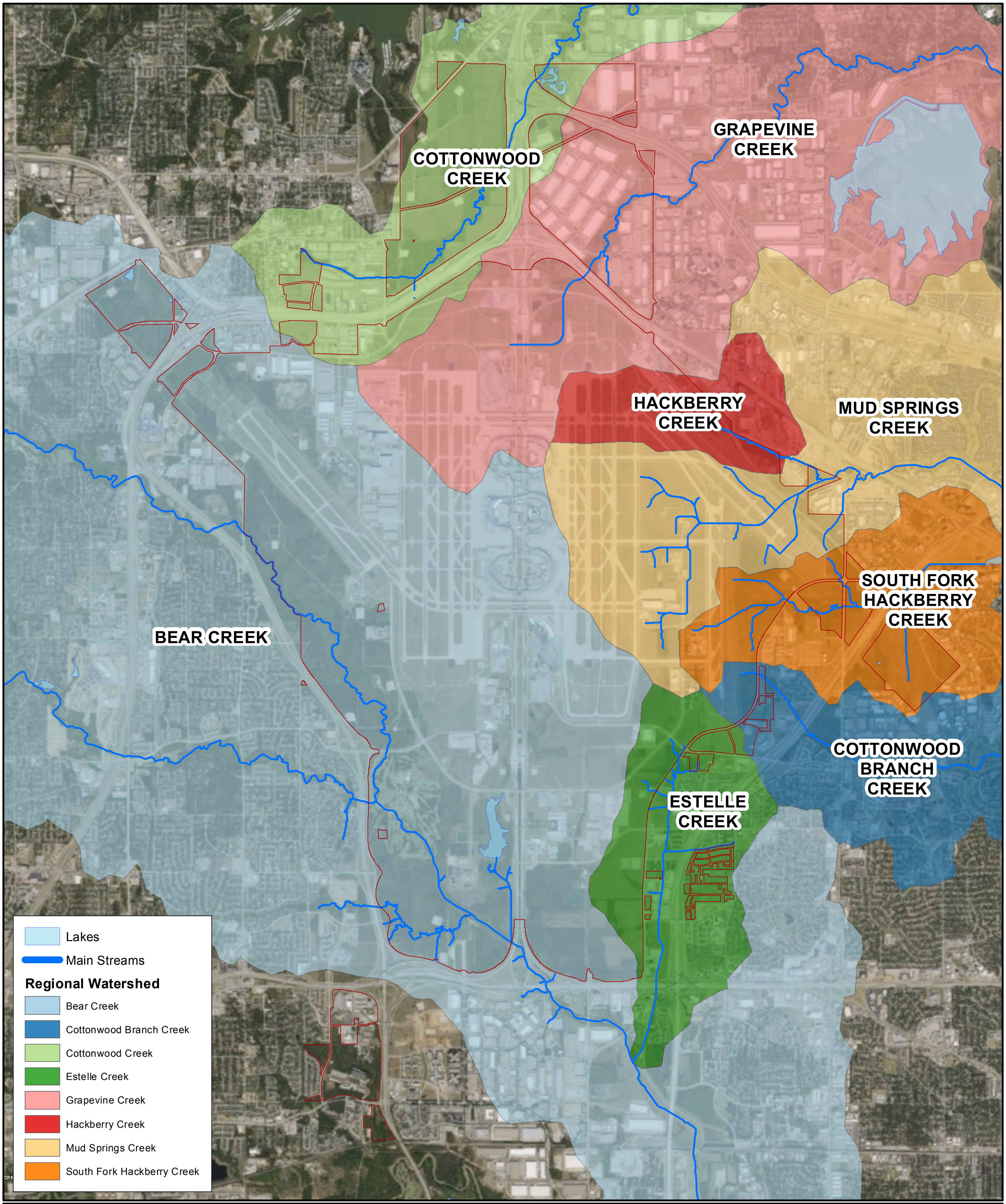
Stormwater system assessments address water quality, quantity, flood and erosion issues. These assessments document current flooding issues, streambank issues, stormwater features that are deficient in meeting stormwater requirements, structures, developments with flood prone areas, channels that have ponding and erosion issues.

The assessments also evaluate compliance with environmental aspects of the system such as water quality, wildlife, wetlands, riparian zones, and endangered species and constraints these aspects place on future developments.

3.1.1 Existing Conditions

The models existing condition scenarios will include a representation of the PSMS infrastructure. For simplification purposes, only pipe diameters of 24 inches or larger will modeled (see Section 4.3.2.1 for further explanation).

Data on existing infrastructure from Geographic Information Systems (GIS) underground utilities database was modified and updated for model development. Invert elevations, diameters and other infrastructure details obtained from design and as-built drawings and site-specific surveys complement the data used to build the models.



DFW
DALLAS FORT WORTH INTERNATIONAL AIRPORT

0 700 1,400 2,800 4,200 5,600 Feet

MAP DATE: DECEMBER 2018
ENERGY, TRANSPORTATION, & ASSET MANAGEMENT / SYSTEMS PERFORMANCE GROUP / GEOSPATIAL ANALYTICS

DFWIA SDMP FIGURE 3-1
WATERSHEDS MAP

All Capital Improvement Program (CIP) and tenant development projects that impact stormwater drainage and are under construction or under development with completed drainage plans are included in the development of existing conditions models. This approach provides support to several strategic planning/design processes for new developments.

3.1.2 Future Conditions

Like the existing conditions scenarios, future conditions scenarios are based on the simplified PSMS infrastructure. However, future land use conditions are based mainly on the Land Use Plan (DFWIA, 2017B) and Airport Layout Plan. The Land Use Plan details the types of development that are strategically planned for different areas within the airport boundary.

Of the developable areas shown on the Land Use Plan map, some have greater potential than others for development in the foreseeable future. For instance, the North Destination District offers approximately 700 acres of developable land within the Cottonwood Creek watershed. This parcel is located North of DFWIA, on the intersection of TX-121 and TX-114. In a joint venture between DFWIA and the City of Grapevine, an infrastructure contract is underway which would develop a spine road through the property. A high level conceptual plan for the 200 acres along the spine road is being developed that contemplates high-end development focused on office space, hospitality, entertainment and retail mixed use.

Future conditions scenarios for each watershed model are defined on a case by case basis, dependent on the progress of development plans for the different areas in accordance with the Land Use Plan and the Program.

3.2 Climate Change

DFWIA is committed to pursuing resiliency in the face of global climate change. The foundation of this pursuit is to develop an understanding of the best available science regarding anticipated impacts to climate in the area. ACRP Report 147: Climate Change Adaptation Planning: Risk Assessment for Airports (2015) provides guidance to understand the impacts climate change may have upon specific airports.

The ACRP 147 Report provides valuable insight on the risks that may result from the anticipated changes in temperature. The average number of hot days and humid days per year are expected to significantly increase. These increases are expected to adversely impact pavement integrity; increase heating, ventilation, and air conditioning (HVAC) demand and duration; potentially impact the electrical grid resulting in higher utility costs; and increase building maintenance needs.

While impacts resulting from increased temperature are more easily quantified, potential impacts to precipitation and, therefore, design rainfall depths, are significantly less certain. The Airport Climate Risk Operational Screening (ACROS) precipitation projection tool shows no significant variation from climate change in the airport area.

The Global Climate Models (GCMs) utilized in the U.S. National Climate Assessment show significant agreement that temperatures are expected to increase as a result of climate change. However, the models reveal significant uncertainty in the impact that the increased temperatures may have upon precipitation in Texas. Regardless of this uncertainty, the EPA has developed a tool that allows users to estimate future rainfall probabilities by averaging the results of the various GCMs. This tool is available within the SWMM modeling software.

The models being developed as part of the Plan include an assessment of the potential impact of climate change. For this purpose, a storm event corresponding to NOAA Atlas 14 upper bound 90% confidence limit for 24-hour, 1% AEP for DFW area will be used to assess the impact of increased precipitation. While this method does not explicitly incorporate climate change predictions, it facilitates resiliency against extreme events through proven statistical methods to reduce uncertainty in design storm estimates. Recommendations will be made based on this approach for appropriate design criteria to protect critical infrastructure from stormwater impact.

3.3 Improvement Strategies

Improvements to the stormwater drainage system are typically identified based on deficiencies observed during scheduled channel inspections and day-to-day-operations. Priority is given to addressing those issues that impact airfield operations or threaten the structural integrity of key infrastructure elements. Historically, improvements have been reactionary, namely the rehabilitation of faulty infrastructure or serious erosion problems in the systems channels.

A more proactive approach to the management of the drainage system is being implemented that takes advantage of collaborative initiatives between projects and overall improvements to the system. Models are being developed to identify potential flooding, erosion, and water quality issues to develop sound solutions. Channel improvement projects will not only work to repair heavily eroded areas but restore open channel hydraulic and ecological functions.

Although GSI/LID strategies have already been introduced into the planning process, the Plan focuses on formalizing the implementation of these strategies into the planning, design, operation and maintenance of future development. These strategies not only address water quantity but also water quality issues associated with development; thus, strengthening compliance programs and improving the quality of biological systems inside and outside the airport.

Finally, the Program (see Section 1) being developed in conjunction with the Plan, will not only provide the means to execute recommendations but also establishes the processes for the periodical revision of the Plan and other Program components (including design criteria and O&M procedures). In this manner, stormwater management remains dynamic and continues to improve in response to new information, changes in regulation and/or organizational priorities.

3.4 Stormwater Master Plan Map

A record of GIS-based data is being updated and developed to support the Plan and help guide future developments. GIS data provides an inventory of assets, allows assessment of important system components and constraints, and identifies potential locations for implementing best management practices.

Information in GIS format is made available to developers with the purpose of assisting in the process of planning and designing new projects. Geospatial data on drainage infrastructure, floodplains, drainage basins, topography, soils, environmentally sensitive areas, land use, streamflow, rain gauges and watershed monitoring sites, among others will be made available to developers to facilitate a comprehensive evaluation of stormwater management strategies. To this purpose, an intranet GIS application is being set up and will be maintained to facilitate internal access to updated geospatial data pertaining to stormwater management.

Section 4

Water Quantity Criteria

Proper evaluation of existing stormwater facilities (conveyance and storage) is critical in effectively managing flood and erosion risk, capital improvements, water quality issues, and future development. As part of establishing a comprehensive approach for managing stormwater, models of the H&H for the eight major contributing watersheds is necessary. These models provide the foundation and necessary framework to address water quantity and water quality (see Section 5) concerns. The models provide the ability to evaluate opportunities for improvement and resolve other issues associated with future development.

4.1 Flooding and Erosion Problem Areas

Major flooding has not been a major issue in the past. Currently, only two areas have known minor flooding problems during high volume rain events. These problems are localized but raise concerns for activities performed around them and for future development. **Figure 4-1** provides a 100-year floodplain map for the airport and surrounding area. Modeling in these areas are being focused on delineating the constraints to determine causes and provide options for resolving the flooding issues.

As discussed in Section 2.3.3, periodic channel inspections aide in tracking and monitoring erosion and drainage problems. To establish risk, areas are graded based on the severity of the following aspects:

- Structural condition of outfalls.
- Sediment buildup
- Plant growth / Debris accumulation
- Ponding
- Erosion and general channel integrity
- Animal activity
- Bank plant coverage
- Dam conditions (if applicable)
- Riparian buffers
- Environmentally sensitive areas

A ranking system classifies the risk of an area. The higher the risk factor, the higher the score assigned for that aspect. Criteria scores are added together and multiplied by a scaling factor to prioritize areas on the Airside or those that threaten the structural integrity of infrastructure. Priority sites chosen through this ranking system are being used to develop erosion control and stream restoration projects. Information from these inspections provide approximate conditions of the PSMS to better predict drainage concerns before they risk the integrity of key infrastructure.

DALLAS FORT WORTH
INTERNATIONAL AIRPORT

MAP DATE: DECEMBER 2018

ENERGY, TRANSPORTATION, & ASSET MANAGEMENT / SYSTEMS PERFORMANCE GROUP / GEOSPATIAL ANALYTICS

0 700 1,400 2,800 4,200 5,600 Feet

DFWIA SDMP FIGURE 4-1
FLOODPLAIN MAP

4.2 Existing Water Quantity Models

In the past, several disparate H&H modeling studies of the stormwater infrastructure and portions of contributing watersheds have been developed. The scope and extent of these individual studies vary depending on the issues that were assessed and the different studies' objectives (i.e. development, design, floodplain delineation, performance evaluations, etc.).

These dispersed studies are useful as groundwork and reference for the comprehensive planning purposes. When FEMA model(s) are available, relevant information is used to inform the development of the SWMM models. FEMA models may also be used for model validation.

4.3 Development of SWMM Models

SWMM (version 5+) is being used to simulate the surface water hydrology and hydraulics. SWMM is approved by FEMA for floodplain mapping and is accepted as an industry standard modeling platform for urban systems with systems of combined open channels and piped networks.

The hydrologic system operates by applying precipitation across the modeled hydrologic units and through hydrologic calculations, determining surface runoff to loading points on the user-defined PSMS. Runoff hydrographs for these loading points provide input for hydraulic routing the PSMS to the outlet. The DFWIA SDMP Model Methodology Technical Memo in **Appendix C** provides background and detailed information on the various methodologies applied for the basin models.

For the eight watersheds, the Cottonwood Creek model is available for existing conditions. The remaining seven watershed models are under development. **Figure 3-1** delineates the watersheds.

4.3.1 Hydrologic Characterization

Hydrologic features can be characterized using parameters that represent a simplified version of the water system to better understand and predict its behavior. This section summarizes the hydrologic parameters that characterize the watersheds contributing to the airport.

4.3.1.1 Topographic Data

Topographic data defines the hydrologic boundaries, overland flow slopes, channel floodplains, critical flood elevations, and stage-storage area relationships and is provided from four major sources:

- Existing survey data,
- 2015 and 2017 Light Detection and Ranging (LiDAR) survey by the North Central Texas Council of Governments (NCTCOG),
- As-built plans for upgraded roadway crossings and improvements to the PSMS, and
- Site specific topographic survey.

4.3.1.2 Rainfall Data

For previous studies, rainfall distributions were generated for six recurrence intervals (1-,2-, 5-, 10-, 25-, 50-, and 100-year events) of a 24-hour duration design storms for each of the eight modeled watersheds. The datasets were developed according to methodologies developed by the NCTCOG and published in the 2014 integrated Stormwater Management (iSWM) Hydrology guidance documents. For basins that span multiple counties, an area weighted approach will be used. The National Oceanic and Atmospheric Administration (NOAA) recently finalized the Atlas 14 point precipitation frequency estimates for Texas. These values are now used as the new standard for rainfall estimates. For all design storms, the Natural Resources Conservation Service (NRCS, formerly SCS) Type II 24-hour hyetographs are used with storm frequency volumes.

4.3.1.3 Soils Data

Soils within the airport property were obtained from NCTCOG, for which data originate from the U.S. Department of Agriculture, Natural Resources Conservation Service, published January 2007 as the Soil Survey Geographic database.

The hydrologic model within SWMM uses both soil storage and infiltration rates to determine the volume of surface water runoff and infiltration in pervious land areas. Soil capacity (or soil storage) is a measure of the amount of storage (in inches) available in the soil type for a given antecedent moisture condition. The average antecedent moisture condition is used for all design storm analyses. Soil capacities are estimated based on the NCTCOG iSWM Hydrology manual.

4.3.1.4 Land Use Data

Existing land use is established by the published Land Use Plan (DFWIA, 2017B). Each land use class has unique parameters for percent impervious, percent of directly and non—directly connected impervious areas and pervious and impervious cover roughness factors. The land use distribution is presented in **Table 4-1.** For Airside areas the actual percent imperviousness will be measured, with the remaining portion classified as "Forest, Open & Park".

Table 4-1. DFWIA Land Use Distribution

Land Use Class	Area (Acres)	Percent
Forest, Open & Park	2,231.7	12.9
Pasture	0.0	0.0
Agricultural & Golf Courses	201.6	1.2
Residential (Low, Medium, and High Density)	0.0	0.0
Light Industrial, Commercial & Institutional	10,145.4	59.0
Heavy Industrial	4,563.3	26.6
Wetland[1,2]	12.7	0.1
Watercourses & Waterbodies	41.2	0.2
Total	**17,183.2**	**100.0**

Notes:
1. Wetland area is comprised of both jurisdictional (9.7 acres) and non-jurisdictional (3 acres) land.
2. The acreage of wetlands noted in this table will be updated as DFWIA continues to survey for environmental resources on undeveloped areas of the airport.

4.3.2 Hydraulic Characterization

This section provides an overview of the development of the hydraulic parameters for SWMM.

4.3.2.1 Model Schematics

As previously noted, models are simpler, easier to understand and modify than the system they represent. Even though they can never perfectly represent reality, they must be similar enough to accurately replicate or predict the system's performance. The level of simplification adopted by modelers when constructing a model greatly depends on the objectives and scale of the modeling exercise. For instance, models used for design support are often more detailed, with most of the systems infrastructure elements being represented. Models used in planning studies are usually less detailed, preserving only those characteristics of the system that are essential for assessing performance and aiding in the decision-making process.

The SWMM H&H models use a node/link representation of the PSMS. The nodes are located at places of significance, from a modeling perspective. For example, nodes can be located at points along a pipe system where there is a change in material, size, flow direction, or a significant inflow; upstream and downstream from bridges and structures; stream intersections; gage locations; problem areas; or potential future development connections. Links represent the linear elements that move water from one node to another in the conveyance system, such as pipes and channels. For the Plan, only pipes with diameters greater than or equal to 24 inches are modeled.

4.3.2.2 Boundary Conditions

H&H boundary conditions provide for accurate simulated peak stages and flows throughout the system. Existing FEMA models provide for boundary conditions where available. In locations where FEMA information does not exist local stream gages are used, and in cases where neither exist engineering judgement established the model boundary conditions.

4.4 Stormwater Flood Control and Quantity Criteria

Multiple agencies and jurisdictions have developed criteria for flood control which apply to DFWIA. These various criteria are summarized in the following sections.

4.4.1 Federal Requirements and Regulations

4.4.1.1 Federal Aviation Administration (FAA)

The FAA has developed an Advisory Circular, *AC 150/5320-5D, Airport Drainage Design*, for the design and maintenance of large hub airport surface drainage systems. This Advisory Circular combines existing surface drainage topics covered in different agency manuals into one Unified Facilities Criteria Surface Drainage Design document. The Advisory Circular establishes general concepts and procedures for the hydrologic design of surface structures. In the Circular FAA sets minimum standards; however, each facility may be designed to a higher standard as required by local and/or state regulations. **Table 4-1** summarizes the design storm requirements of FAA.

Table 4-1. FAA Minimum Surface Drainage Standards[1]

Facility Type	Design Storm Return Period	Design Storm Duration (hr)	Notes
Taxiway & Runway Pavement	5	24	No ponding encroaching on edge of pavement A ponding limit of 4-inches around apron inlets
Runway, Taxiway, & Helipad Centerlines	10	24	Center 50% free from ponding
Landside Areas	10	24	
Depressed pavement sections and underpasses	50	24	

Notes:
1. For areas other than Airfields and heliports, check the appropriate local regulatory agency for guidance on design storm requirements.

Aviation facilities also have restrictions on surface storage of water due to the potential development of fog and attraction of wildlife, especially waterfowl. The FAA recommends a separation distance of 10,000 feet from the end of the nearest runaway to be wildlife attractants a stormwater detention pond. The FAA circular, *AC 150/52000-33B, Hazardous Wildlife Attractants on or Near Airports,* contains the land-use practices that potentially attract wildlife. The FAA also recommends a distance of 5 statute miles between the furthest edge of operating area and the wildlife attractant, if the attractant could cause hazardous wildlife movement into or across the approach, departure, or circling airspace. However, if a detention pond drains within 48 hours of the end of the storm event, the distance restrictions are circumvented. All detention ponds are required to drain within 24 hours after the end of a storm event.

4.4.1.2 Federal Emergency Management Agency (FEMA)

FEMA determines floodplain boundaries based on hydrologic and hydraulic modeling. The US Army Corps of Engineers (USACE) and local communities support FEMA in the production of the Flood Insurance Rate Maps (FIRMs). The floodplain boundaries are presented on the FIRMs, and the area within the airport boundaries is identified on the current FEMA issued FIRMs. There are several areas within the airport that are within the FEMA regulated floodplain and are hence subject to FEMA regulations.

4.4.2 Municipal Requirements and Collaboration

DFWIA is surrounded by a number of cities that will be directly involved in stormwater management via either contributing to, or receiving flows from, the PSMS. Cities directly affected include Irving, Coppell, Grapevine, Euless and Fort Worth. Each of these municipalities has their own stormwater rules and regulations that need to be accounted for when establishing the modeling criteria in areas that are coincident to the municipality and DFWIA.

4.4.3 DFWIA Design Criteria

Both formal policy contained in the Design Criteria Manual (DCM) (DFWIA, 2015) and existing practices which have developed through implementation of the DCM are discussed in this section. The practices will be standardized in this Plan and incorporated into the DCM during the next revision. The DCM outlines the formal design criteria for all airport proposed projects. All projects which alter the runoff coefficient from an area greater than one acre are required to prepare a drainage study that, at a minimum, describes the hydrologic and hydraulic analyses conducted to demonstrate compliance with storm drainage criteria set forth in the iSWM design criteria developed by the North Texas Council of Governments. The four primary iSWM criteria are:

- Stormwater Quality
- Streambank Protection
- Conveyance
- Flood Mitigation

The stormwater drainage design required under the DCM must include a sufficient hydrologic analysis to determine the existing and proposed drainage conditions and all calculations associated with the determination of runoff coefficients, volume of runoff, time of concentration, velocities, inlet size, hydraulic gradient and any other items pertinent to the drainage design including:

- Stormwater drainage analysis for the 1-, 2-, 5-, 10-, 25-, 50- and 100-year design storms.
- Consideration of stormwater management alternatives and recommended facilities.
- Description of measures taken for velocity dissipation to ensure non-erosive velocities at points of discharge.

Additional practices that are in use include providing the following items in the drainage design:

- Comparison point tables for pre- and post-development conditions
- Detention staging tables and Level versus Time hydrographs
- Discharge hydrographs

The DCM establishes that the total capacity of a closed storm drainage system must be designed in accordance with iSWM criteria for conveyance piping. The total capacity of the drainage facility must be equal to or greater than the runoff of a storm of 100-year design frequency. If the 100-year storm runoff exceeds the capacity of the design, then the closed storm will be designed based on a minimum 25-year frequency, or larger, which must include a 100-year emergency overflow system. Storm drains must be designed to meet a minimum mean velocity and not exceed velocities specified in the DCM. Current practice encourages the use of vegetated channels throughout the airport and discourages generation of flows with high velocities.

The use of GSI/LID strategies as an aid to meet pre-development conditions are included in the DCM. GIS/LID strategies currently recommended in the manual include: infiltration trenches, rain gardens, bioswales, permeable pavements, filter strips, and rainwater harvesting. This Plan will include the evaluation of additional strategies for use by developers. (See Section 5.4.1).

4.4.4 SDMP Stormwater Quantity Criteria

Watershed management is subject to both federal and state requirements. Existing and future conditions must be considered in any planned development. This section summarizes the stormwater quantity criteria that takes into consideration these variations and is used in developing alternatives for the Plan.

The water quantity (conveyance, flood control and erosion mitigation) criteria standards may be summarized by separating property into Airside and Landside areas.

4.4.4.1 General

The stormwater drainage system should safely collect, store, and convey the 100-year frequency flow. Various methods should be considered to accommodate these flows.

- Only dry detention or underground systems may be applied for the airport and the surrounding neighborhoods up to 10,000 feet from the airport boundary. No BMPs that may be considered wildlife or fog attractants are allowed within this range. The dry detention areas must be designed according to the iSWM and FAA Advisory Circulars parameters.
- Future building construction or major renovations should be checked against the 100-year storm event.

4.4.4.2 Airside Areas

- More stringent criteria as provided in the FAA Advisory Circular 150/5320-5: Airport Drainage Design will be followed such that no runway or taxiway shoulders shall be encroached by the 25-year 24 hour storm event.
- The 100-year 24-hour design storm will be checked versus runway and taxiway elevations to determine stages at runway-taxiway crown elevations.
- The maximum ponding at apron inlets should be 4 inches for the 5-year storm.
- Temporary storage of stormwater between runways, taxiways, and aprons should be considered.
- Traverse grade outside of runway-taxiway shoulders shall comply with the FAA Advisory Circular.
- Uncovered surface detention structures will not be allowed in the Airfield.

4.4.4.3 Landside Areas

- Hydraulic design should follow criteria and guidelines as presented in the DCM.
- Future development/re-development are required to evaluate and implement onsite measures published in the developer guidance manual to meet existing peak discharges to the receiving system.
- For multilane roadways (principal arterials), at least one lane of traffic in each direction should remain open for the 100-year storm, and the peak flood stage should be below the top of curb.
- For all other roads within, or immediately adjacent to, the airport boundary, peak flooding for the 100-year storm may not exceed 6-inches or the top of the curb, whichever is greater.
- Detention structures shall drain within 24 hours after the 100-year design storm.

4.4.4.4 Offsite Areas

For all offsite areas, the criteria are established so as to “do no harm” downstream. Runoff must be collected and attenuated so that peak stages do not increase for the neighboring areas, velocities do not create erosion problems, and water quality is maintained.

4.4.4.5 Summary

This section is a summary guide for allowable water quantity criteria for flood levels versus design storms. The criteria that cover Airside areas apply for existing as well as future conditions. Alternative BMPs will be considered to mitigate problem areas for which the criteria are not being met. The criteria for Landside areas allows for GSI collection, storage, and treatment features to manage building, flooding, and road flooding, where applicable. The offsite area criteria cover future development, including the alternative designs for onsite mitigation.

This page intentionally left blank.

Section 5

Water Quality Criteria

In addition to the structural BMPs implemented in the SWMP (DFWIA, 2016A), an informal program requires GSI to be implemented for new and re-development projects for both Airside and Landside. GSI enhances natural hydrologic processes for water quality treatment and provides some mitigation for quantity. The 2013 Low Impact Design Guideline Development Report (**Appendix A**) is being replaced by a GSI guidance manual.

The H&H models developed for the eight watersheds are being used to assess water quality in addition to quantity. The existing and proposed future land uses and existing water quality BMPs will be incorporated into the models to define water quality load reductions, assist in prioritizing water quality improvement projects, and evaluate the effectiveness of proposed and installed GSI for areas of concern.

5.1 Background on Regulations and Requirements

As described in Section 2, water quality efforts for the Plan consider both federal and state requirements and regulations.

DFWIA is a level 2 MS4 under the TPDES General Permit TXR040000. The primary driver for this plan is to comply with water quality requirements and provide support for the watershed management, habitat protection, recreation, ecosystem enhancements, and flood control requirements as outlined in BMP #11 (SWMP). In addition, the water quality efforts consider the following requirements and regulations.

Compliance with TPDES MSGP TXR050000 is required, due to classification of airport as dischargers of stormwater associated with industrial activity. This MSGP requires the permittee to have a SWP3 (DFWIA, 2016B) that describes efforts to mitigate against potential stormwater discharges from industrial activities. Although the impacts of the industrial discharges are considered part of the water quality assessment and modeling in this plan, mitigation of these discharges is addressed under that SWP3.

In addition to these permits, there are several other documents that were considered as part of the development of this plan. Two circulars from the FAA provide standards for drainage design and requirements for prevention of wildlife attractants:

- Advisory Circular 150/5200-33: Wildlife Attractants and
- Advisory Circular 150/5320-5: Airport Drainage Design.

Section 438 of the Energy Independence and Security Act (EISA) for Federal facilities requires federal agencies to reduce stormwater runoff from federal development projects to protect water resources. It includes technical guidance for reducing stormwater runoff and pollution to comply with this Act. ACRP Research Report 174 (2015) provides guidelines for implementing Green Stormwater Infrastructure at airports in the United States.

Due to the natural hydrologic processes that provide important functionality to the GSI devices, the FAA circulars and related Federal stormwater management criteria are critical to the success of the GSI effort. The guidelines and criteria will be adopted into the SDMP and are discussed further below.

The Implementation Plan for Seventeen Total Maximum Daily Loads for Bacteria in the Greater Trinity River Region (NCTCOG, 2013) establishes a path to address indicator bacteria in impaired streams in North Central Texas. Coordination with other stakeholders for efforts under this plan helps contribute to monitoring efforts for indicator bacteria. Multiple watershed segments are included under this monitoring plan including stream sections that cross through airport land encompassing segments 0822A (Cottonwood Branch Creek), 0822B (Grapevine Creek), and 0841 (Bear Creek, Big Bear Creek, and Trigg Lake). The design of GSI takes into consideration these impairments.

5.2 Existing Water Quality Features

Existing water quality issues have been identified on the airport property, most notably erosion and drainage issues. Periodic field inspections identified erosion, heaving of structures, and obstruction of conveyance structures due to excessive plant growth. There were also areas where the reason for erosion have not been identified but are under investigation. The SDMP will include a channel improvement program that will not only work to repair heavily eroded areas but restore open channel hydraulic and ecological functions, a more environmentally sustainable and viable approach, to resolve these existing issues.

In addition to identifying erosion and drainage issues, water quality is monitored at several outfalls. The monitoring sites are depicted in **Figure 2-1.**

5.3 Water Quality Modeling

As Section 3 outlines, the SDMP includes the development of SWMM models. As part of the BMP #11 compliance, these models assess surface water quality. The models help estimate the pollutant load reduction benefit of GSI implementation and impact to receiving waters.

Water quality modeling considers surface runoff loadings from various land cover categories, focusing on pollutants of concern. SWMM is used to explicitly model the effects of GSI features, including biofiltration, porous pavement, infiltration trenches, rain barrels, and vegetative filter strips. SWMM also uses infiltration, evapotranspiration, and runoff capture processes through GSI to model pollutant load reductions from stormwater runoff.

5.3.1 Model Parameters

The primary parameters used in SWMM to evaluate water quality are:

- Event mean concentrations,
- Land Use,
- Water quality volume,
- Number and type of GSI in each watershed,
- Infiltration rates, and
- Efficiency of GSI.

SWMM provides an evaluation of existing runoff loadings from various land uses, focusing on the pollutants of concern, including indicator bacteria (as *E.coli*), nutrients (ammonia), total suspended solids, TPH, BOD, COD, and metals (zinc, aluminum, and copper). The concentration of pollutants used in the model is based on event mean concentrations (EMCs) associated with different land use.

The water quality volume (WQ_V) is the amount of runoff captured and treated from the drainage area by a GSI. The WQ_V is defined as the storage needed to capture and treat the stormwater event of concern that maximizes pollutant removal while maintaining infrastructure cost effectiveness. The event will be defined in terms of volume, intensity, and duration and will be specified in the GSI Guidance Manual. GSI will be sized based on the $WQ_{V.}$ GSI practices for developments and re-developments will be designed to capture, through infiltration, evapotranspiration, or harvesting the WQ_V determined. The models will be used as an aide to prioritize implementation strategies.

The number, types, and location of GSI BMPs in the drainage area will mainly be based on the Land Use Plan (DFWIA, 2017B). The International Stormwater Database (www.bmpdatabase.org, 2016) has collected data from across the United States on the performance of GSI and other structural BMPs. ACRP Report 174 has also collected performance data for GSI across airports in the United States. Where sufficient data is available specific to types of GSI and pollutants of concern at international airports, this data will be used in the models. The pollutant load reduction is also impacted by the GSI hydrologic processes, such as infiltration and evapotranspiration. These processes are added to the models to further determine GSI effectiveness.

For detailed model parameters and methodology see the DFWIA SDMP Model Methodology Technical Memo in **Appendix C**.

5.3.2 Model Validation

FEMA models are used for validation of the H&H model results. Water quality model results will be validated by comparing to existing water quality monitoring data based on the Stormwater Management Program discussed in Section 2.3.2.

5.4 Water Quality Control Criteria

Several types of GSI exist for commercial applications. However, GSI types were selected based on ACRP 174, safety criteria, feasibility, and on the ability to help meet water quality goals.

FAA regulations restrict the use of fog and bird attractant land uses and related wet detention and wetland GSI within 10,000 ft of Airside areas, due to concerns that the facilities may impact safety by increasing fog and attracting hazardous wildlife (such as geese, deer, ducks, etc.). This requirement has been expanded for the entire airport. Therefore, GSI that require permanent or extended detention for water volume or dense vegetation, were not selected for use.

The GSI currently being reviewed and their applicable areas include:

- Infiltration trenches (Both Landside and Airside),
- Vegetated filter strips (Both Landside and Airside),
- Biofiltration / Rain gardens (Landside),
- Bioswales (Both Landside and Airside),
- Rainwater harvesting (Landside),
- Cisterns and Tanks (Both Landside and Airside), and
- Permeable pavement (Landside)
- Green Roofs (Landside).

Wet ponds and wetland systems are not currently included as options for development and re-development projects, since the drain time of BMPs has been limited to less than 24 hours for safety reasons (to reduce wildlife attractants and fog). This also limits the types of GSI that rely on additional settling time to remove pollutants.

There are multiple existing detention ponds on the airport property. Detention ponds provide important benefits for flood reduction, and potential for water quality mitigation where combined with other water quality treatment systems. To enhance water quality mitigation, detention ponds will continue to be part of a treatment train system with additional upstream or downstream GSI BMPs, such as swales or vegetative filter strips.

GSI types and designs are also selected for improved effectiveness to reduce bacteria loads in accordance with the NCTCOG TMDL Implementation Plan. The effectiveness of GSI is also dependent on the infiltration characteristics of the existing soils. This is primarily due to the potential benefit and challenges associated with infiltration. The airport is mostly comprised of type D, clayey soils as designated by the NRCS Soil Classification. Because these have very low infiltration rates, underdrains are needed for most GSI devices that rely on infiltration or filtration through engineered media.

5.4.1 Green Stormwater Infrastructure

5.4.1.1 Applicable Project Areas

GSI implementation will be required for new development and redeveloped projects as a water quality strategy. GSI will also be implemented to resolve known problem areas that include erosion and water quality issues.

5.4.1.2 Types of BMPs

Based on existing water quality controls, guidance documents, requirements, and criteria, such as ACRP Report 174, eight (8) types of GSI have been selected for implementation. These GSI are listed in **Table 5-1**, along with a brief description.

Table 5-1. Potential GSI for Development and Re-Development

GSI	Description	Airside and/or Landside Use
Infiltration-exfiltration Trenches	Shallow excavated trenches filled with gravel or rock aggregate that infiltrates stormwater to reduce runoff and pollutant loading to streams	Both
Bioswales/swales	Vegetated, linear channels used to convey and treat shallow, concentrated stormwater flows	Both
Vegetated Filter Strips	Linear strips of gently slopped vegetated areas designed to maintain sheet flows over the entire width of the strip to filter sediment and other pollutants from stormwater runoff	Both
Rainwater Harvesting	Collection and storage of stormwater into receptacles, such as rain barrels, cisterns, or tanks, from rooftops, for future reuse. Cisterns and tanks are underground storage that meet requirements for surface loads, explosivity, and other requirements	Both
Biofiltration (Rain Gardens)	Basins that utilize vegetation, soil, and microbes to allow stormwater runoff to infiltrate and treat pollutants	Landside
Permeable Pavement	Alternative material used in place of conventional impervious surfaces where stormwater can infiltrate through the surface course to reduce peak flow and remove pollutants	Landside
Green Roofs	Rooftops covered with growing media and vegetation that enable rainfall infiltration and evapotranspiration of stored water.	Landside
Dry Detention Ponds (with upstream and/or downstream GSI)	Depressed basins designed to temporarily hold stormwater runoff following a storm event and remain dry in between events.	Landside

5.4.2 Requirements for BMPs

The GSI Guidance Manual will provide direction for the proper design and maintenance of GSI. Adherence to the guidelines are important for the BMPs to function effectively, meet standards, and prolong their lifetime before major repairs or replacement is required.

Overall public safety and environmental quality (such as infiltration into groundwater aquifers) is a high priority. These factors will be considered when choosing and implementing GSI.

The FAA has multiple restrictions for implementing GSI around airports as discussed in Section 5.1.

5.4.2.1 Support tools

The GSI Guidance Manual will contain a maintenance checklist for each GSI to aid in proper inspection so that signs of impairment can be caught early. The checklists include recommended maintenance activities for common types of impairments for each GSI. Regular inspection and maintenance help to ensure the GSI can function at its full potential as designed and prolong its lifespan.

BMP factsheets will be developed and included in the GSI Guidance Manual to provide guidance on each GSI, their major components, potential benefits and constraints, as well as design and maintenance considerations in a concise format for distribution internally and to airport commercial developers.

References

DFWIA Stormwater Management Program
Dallas/Ft. Worth International Airport (2016A). Dallas/Ft. Worth International Airport Storm Water Management Program (SWMP) TPDES General Permit No.TXR040000 Small Municipal Separate Storm Sewer Systems (MS4).

DFWIA Stormwater Pollution Prevention Plan
Dallas/Ft. Worth International Airport (2016B). Dallas/Ft. Worth International Airport Storm Water Management Program (SWMP) TPDES General Permit No.TXR040000 Small Municipal Separate Storm Sewer Systems (MS4). (Eff. Date 2005).

2014 DFWIA Sustainability Plan
Dallas/Ft. Worth International Airport (2014). Sustainability Management Plan.

DFWIA Biassessment Report 2017
Harlow, M. M., & Kennedy, J. H. (2017A). Dallas/Fort Worth International Airport Bioassessment Report (With Changes Accepted). Denton, TX: University of Texas, Department of Biological Sciences, Institute of Applied Sciences.

DFWIA BMP Guidance Document
Dallas/Ft. Worth International Airport (2018). Best Management Practice Guidance Document.

DFWIA Airport Stormwater Sampling and Monitoring Plan
Dallas/Ft. Worth International Airport (2016C). DFW Airport Storm Water Sampling and Monitoring Plan. (Eff. Date 2005).

DFWIA Land Use Plan
Dallas/Ft. Worth International Airport (2017B). Land Use Plan [Brochure]. Available at: https://www.dfwairport.com/landhere/

DFWIA Design Criteria Manual
Dallas/Ft. Worth International Airport (2015). Design Criteria Manual. Revision 2. Available at: https://www.dfwairport.com/development/index.php

This page intentionally left blank.

Appendix A

DFWIA Low Impact Development Design Guideline

This page intentionally left blank.

DALLAS/FORT WORTH
INTERNATIONAL AIRPORT

Low Impact Development Design Guideline

October 2014

Energy, Transportation & Asset Management Department

LOW IMPACT DEVELOPMENT DESIGN GUIDELINE

FORT WORTH, TX

JACOBS Project No. F8Y88394

Prepared For:

DFW DALLAS/FORT WORTH INTERNATIONAL AIRPORT

Energy, Transportation & Asset Management Department
3010 East Airfield Dr.
P.O.Box 619428
Dallas/Fort Worth Airport, Texas 75261-9428

Prepared By:

JACOBS™

Texas Registered Firm # 2966

777 Main Street
Fort Worth, Texas 75102

October 2014

STATE OF TEXAS
ADAM N. KORANSKY
95988
LICENSED
PROFESSIONAL ENGINEER

10/20/14

Table of Contents

List of Figures

1.0 INTRODUCTION

As development continues within and adjacent to the Dallas/Fort Worth International Airport (DFW) property, it has been determined that, where applicable, Low Impact Development (LID) and Green Infrastructure (GI) strategies should be incorporated. The airport environment creates a unique set of design criteria, which must be followed in order to maintain safety and efficiency within the aerodrome. Many federal, state, and local agencies have developed criteria on how to design and develop within airport facilities and GI/LID strategies are starting to be more common within these criterion and guidelines to provide a more natural means for complying with stormwater quality and maintaining pre-development drainage requirements.

This document provides guidelines on:

1) Incorporating GI/LID strategies in stormwater drainage designs that are acceptable for construction within DFW's aerodrome,
2) Identifies specific Best Management Practices (BMPs) that fit within this criteria,
3) Available software to use to model these BMPs into a hydrologic and hydraulic model, and
4) Operation and maintenance of installed GI/LID strategies.

2.0 DESIGN CONSTRAINTS AND CRITERIA

Developing in the airport environment requires that many design regulations and criteria be adhered to. These regulations are both from federal and local jurisdictions. Compliance with all criteria limits the types and locations of developments within the airport properties. The regulations that impact stormwater drainage designs at an airport and available criteria are as follows:

1. Advisory Circular 150/5200-33 Hazardous Wildlife Attractants On or Near Airport (AC 150)
2. Advisory Circular 150/5320-5 Airport Drainage Design
3. ACRP 02-62 Incorporating Green Infrastructure for Stormwater Management in Airports
4. Environmental Protection Agency 841-B-09-001: Technical Guidance on Implementing the Stormwater Runoff Requirements for Federal Projects under Section 438 of the Energy Independence and Security Act (EPA 841)
5. National Environmental Policy Act (NEPA)
6. Integrated Storm Water Management (iSWM) Design Criteria Manual, North Central Texas Council of Governments (NCTCOG)
7. Dallas Fort Worth Airport Commercial Development Criteria and Sustainable Initiatives
8. South Gate Plaza Development Criteria
9. Founders' Plaza Center Development Criteria
10. Other LID design criteria manuals and resources from other jurisdictions

The AC 150/5200-33 – Hazardous Wildlife Attractants On or Near Airport identifies potential hazards that development can create within an airport. This mostly affects the GI/LID design guidelines by limiting the amount of surface water and placing restrictions on the amount of time that surface water can be present in a storm water surface detention structure before it must drain to a dry condition. This drain time has been determined to be 48 hours. It also states that no detention facility should be located within 1000 feet from a runway. All vegetation in or around a detention facility that provides food or cover for hazardous wildlife should be eliminated. The Federal Aviation Administration encourages underground detention and storm water infiltration, which are key components of GI/LID development. The AC also restricts the type of landscaping that is permitted within the airport property. Both surface water detention and certain landscaping can create potential roosting or shelter environments for wildlife which could be hazardous to low flying aircraft either taking off or landing. Per this guideline, all drainage facilities must drain properly and promptly and all landscaping must comply with the published development design criteria.

AC 150/5320-5 – Airport Drainage Design is a criteria manual for the design and construction of surface drainage facilities. The Advisory Circular identifies drainage swales as a suitable method for conveying water around a site as well as infiltration of surface drainage as an acceptable method of peak flow attenuation, if the soils are adequate. It also states that the software EPA-SWMM is the recommended software for modeling infiltration and GI/LID strategies.

ACRP 02-62 – The objective of this research is to develop a guidebook to help airports identify and implement viable green infrastructure techniques to supplement or replace traditional stormwater management methods on airport property.

EPA 841 – Technical Guidance on Implementing the Stormwater Runoff provides a step-by-step framework that will help federal agencies maintain pre-developed site hydrology by retaining rainfall on-site through infiltration, evaporation/transpiration, and re-use to the same extent as occurred prior to development through the installation of Green Infrastructure (GI). This guidance is the same basic philosophy of LID. These guidelines are for any federal project that exceeds 5,000 square feet and covers the site planning, design, construction, and maintenance strategies for the property. To maintain the predevelopment hydrology, not only the rate of runoff should be considered but also the temperature, volume and duration of flow, or discharge. Not only can the implementation of EPA 841 be achieved by the incorporation GI/LID controls, but it also provides for maximum flexibility while designing and constructing developments. The fundamental principles for storm water treatment that are discussed in EPA 841 are infiltration, recharge, evapo-transpiration, and the harvesting and re-use of precipitation. By implementing the techniques discussed in this document and using GI/LID will maintain pre-developed hydrology and also help restore the health and vitality of the receiving waters.

EPA 841 identifies specific BMPs that can be used to implement the GI/LID design. All of those listed are not suitable for implementation within the airport environment because they would create environments prohibited by AC 150/5200-33. The BMPs identified that are suitable for airport development are:

1. Trees and Tree Boxes
2. Rain Gardens
3. Vegetated Swales
4. Infiltration Planters
5. Porous and Permeable Pavement
6. Vegetated Median Strips
7. Infiltration Trench

These BMPs have been identified to promote infiltration and recharge, evapotranspiration and harvesting of storm water. They promote underground infiltration and storage, which are qualities encouraged by document AC 150/5200-33 and are also paramount in successfully implementing GI/LID. As well as providing hydrological benefits, these strategies will also produce cleaner air, reduce urban temperatures, have moderate impacts to climate change, are energy efficient and provide community benefit such as multi-use facilities that can be used for recreation and increased property values. It should be noted that the attachments are example installations that could be used to treat stormwater runoff and control the rate and quantity of stormwater drainage. The infiltration planters could be elevated to be above ground to act as tree boxes. The Vegetated Swale could be located in a median to act as a Vegetated Median Swale. Some BMPs identified in EPA 841 are not suitable for airports due to AC 150/5200-33 restrictions. The acceptable BMPs are listed above, although not all of the identified BMPs will be allowed due to the iSWM manual, which governs drainage design in this region.

EPA 841 also identifies design criteria for specific storm events that should be modeled and methods of implementation that should be applied. Some sites present constrains that limit the extent to which the design objectives can be applied. These site constraints include near ground surface water, unsuitable soil or insufficient land area. Considering all of the possible constraints and restrictions, the benefits of compliance with these design criteria include efficient storm water management, pollution prevention and environmental enhancements. This approach is appropriate for a wide range of site conditions, new and re-development, and all scales of development.

The iSWM Design Criteria is widely used in North Central Texas as guidelines and criteria for storm water management. In developing guidelines for GI/LID BMPs for DFW airport, iSWM provides essential information for performing an analysis of site hydrology. iSWM provides hydrologic criteria for selecting proper curve numbers, calculating time of concentration and estimating rainfall. iSWM includes criteria for the design of stormwater systems and detention facilities. This information is necessary to perform a hydrologic and hydraulic analysis of a site, and perform GI/LID calculations.

The iSWM manual identifies some development philosophies that correspond to GI/LID philosophies. iSWM encourages the preservation of natural areas, the reduction of impervious cover and the use of vegetated infiltration swales. The manual lists BMPs to be used for stormwater treatment. The BMPs identified in both the EPA document and the iSWM manual that are suitable for use at DFW airport are:

1. Rain Gardens
2. Vegetated / Infiltration Swales
3. Infiltration Planters
4. Porous and Permeable Pavement with or without underground storage
5. Vegetated Filter Strips
6. Trees and Tree Boxes

It should be noted that infiltration swales are the preferred BMP for GI/LID design on DFW airport property. Infiltration swales serve a dual purpose of conveying storm water runoff and attenuating peak flows. Although the traditional infiltration media used for infiltration swales is an engineered soil, pea gravel can also be used. Pea gravel has some advantages over an engineered soil media. Pea gravel has greater void space that can store a greater volume of stormwater runoff, requires less maintenance, and would not need to be replaced as often.

Since the airport has strict restrictions regarding the treatment of storm water, there are certain GI/LID BMPs that are not suitable for use at DFW Airport. A few of these BMPS are:

1. Retention / Re-irrigation ponds
2. Rainwater Harvesting
3. Green Roofs
4. Stormwater Wetlands

The South Gate Plaza Development Criteria and the Founders' Plaza Development Criteria contain two pertinent sections in regards to Green Infrastructure and Low Impact Development. Section 3.3 discusses Hardscape and the use of pervious pavers. It identifies the benefits they provide such as infiltration and a cooler surface temperature. Section 3.5 defines grading restraints within the landscape areas. In order to promote infiltration within the landscape area, slopes are restricted to 4:1 (25%) maximum.

A website that was found to be a useful resource for GI/LID education and resources is www.texaslid.org. On this website there are links to multiple guidelines and design criteria manuals, LID research results and information about the local advocacy groups for GI/LID. The local group is the North Texas Chapter of the Land / Water Sustainability Forum.

2.1 RAIN GARDENS

A rain garden is a vegetated, depressed landscape area designed to capture and infiltrate and/or filter stormwater runoff. The growing medium for the rain garden consists of native soil or biofiltration media. If the infiltration capacity of the subgrade soil is limited, the rain garden can be underlain by an underdrain system. Rain gardens will provide removal of pollutants in stormwater runoff similar to other treatment systems. However, because they are restricted to smaller drainage areas and shallower ponding depths, which necessitate a larger surface area, infiltration, evapotranspiration, and biological uptake mechanisms may be more significant for rain gardens than other treatment BMPs.

Figure 2.1.1 Photograph of Rain Garden

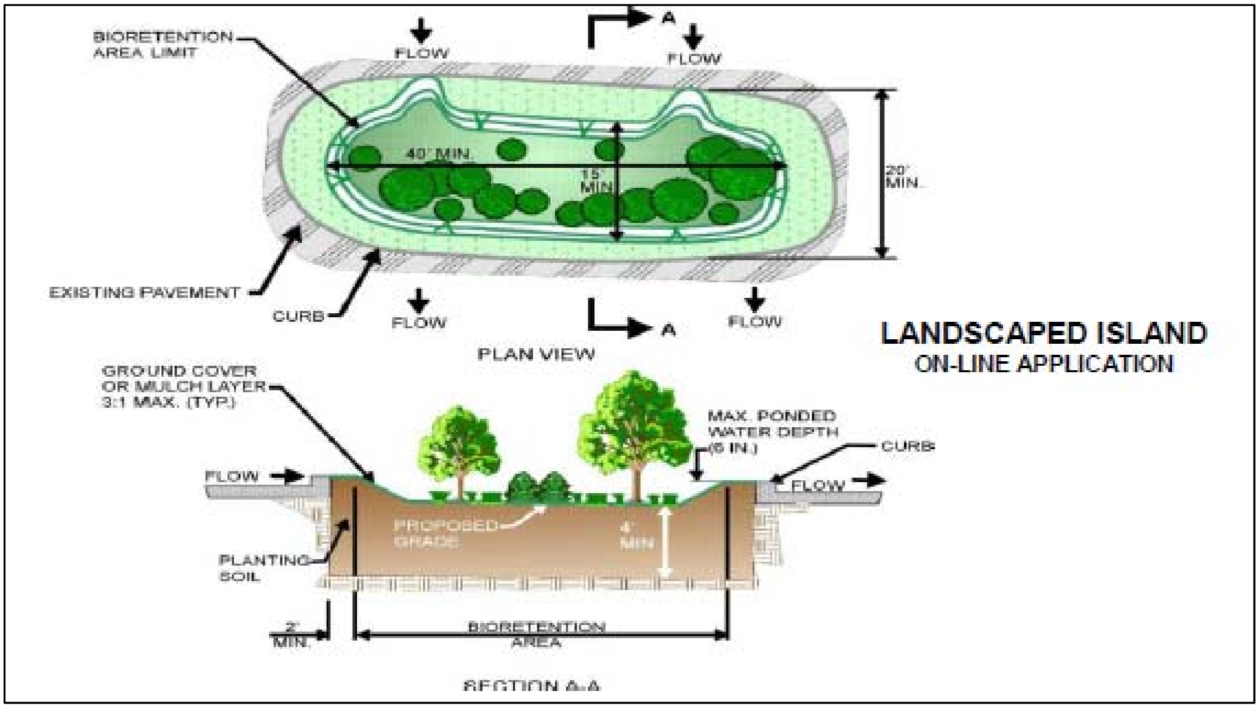


Figure 2.1.2 Design Detail for Rain Garden (Source: NCTCOG iSWM Manual)

2.2 VEGETATED / INFILTRATION SWALES

Vegetated infiltration swales are stormwater conveyance systems designed to enhance the infiltration runoff. A vegetated infiltration swale can be a natural elongated depression or a constructed channel. A vegetated infiltration swale differs from a conventional drainage channel or ditch in that it is constructed specifically to promote infiltration. The primary purpose of this practice is to infiltrate storm water, while limiting groundwater contamination by providing filtering of pollutants. Vegetated swales can also help attenuate peak flows through reducing runoff velocities and volumes.

Figure 2.2.1 Photograph of Infiltration Swale

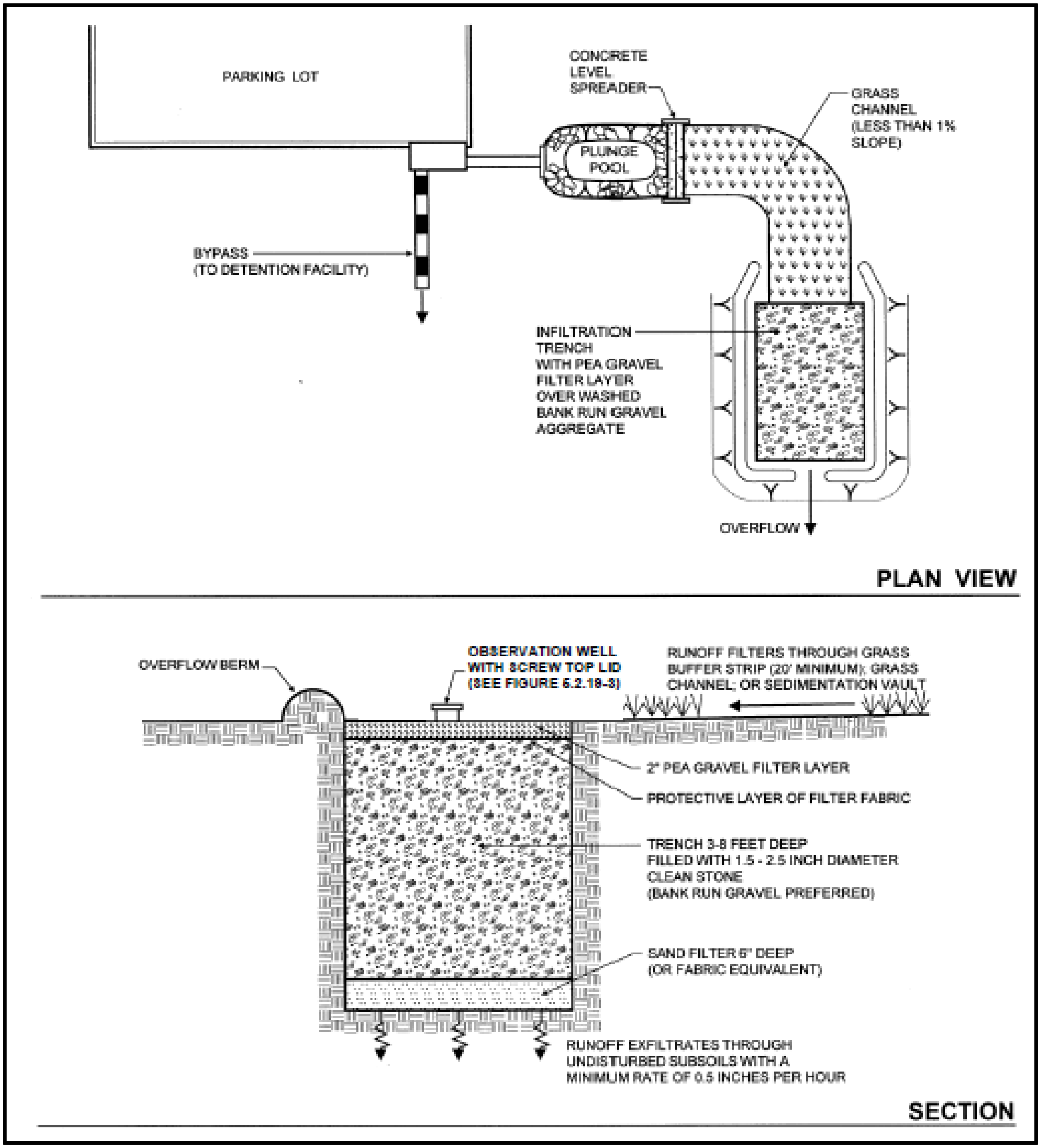


Figure 2.2.2 Design Detail for Infiltration Swale (Source: NCTCOG iSWM Manual)

2.3 INFILTRATION PLANTERS

Infiltration planters are raised structural planting beds that filter and infiltrate runoff from surrounding rooftops, parking lots, or sidewalks. They can be installed in a variety of sizes and styles, integrating an endless variety of plants, to suit any architectural style. Infiltration planters work well at the scale of individual residential, commercial, residential, or governmental parcel levels. Infiltration planters have limited capability to reduce significant amounts of runoff, with limitations based on the receiving area of runoff flowing to the planter, and the size of the planter itself. For runoff that enters the planter, removal of sediments and pollutants is high, often exceeding 80 percent.

Figure 2.3.1 Photograph of Infiltration Planter

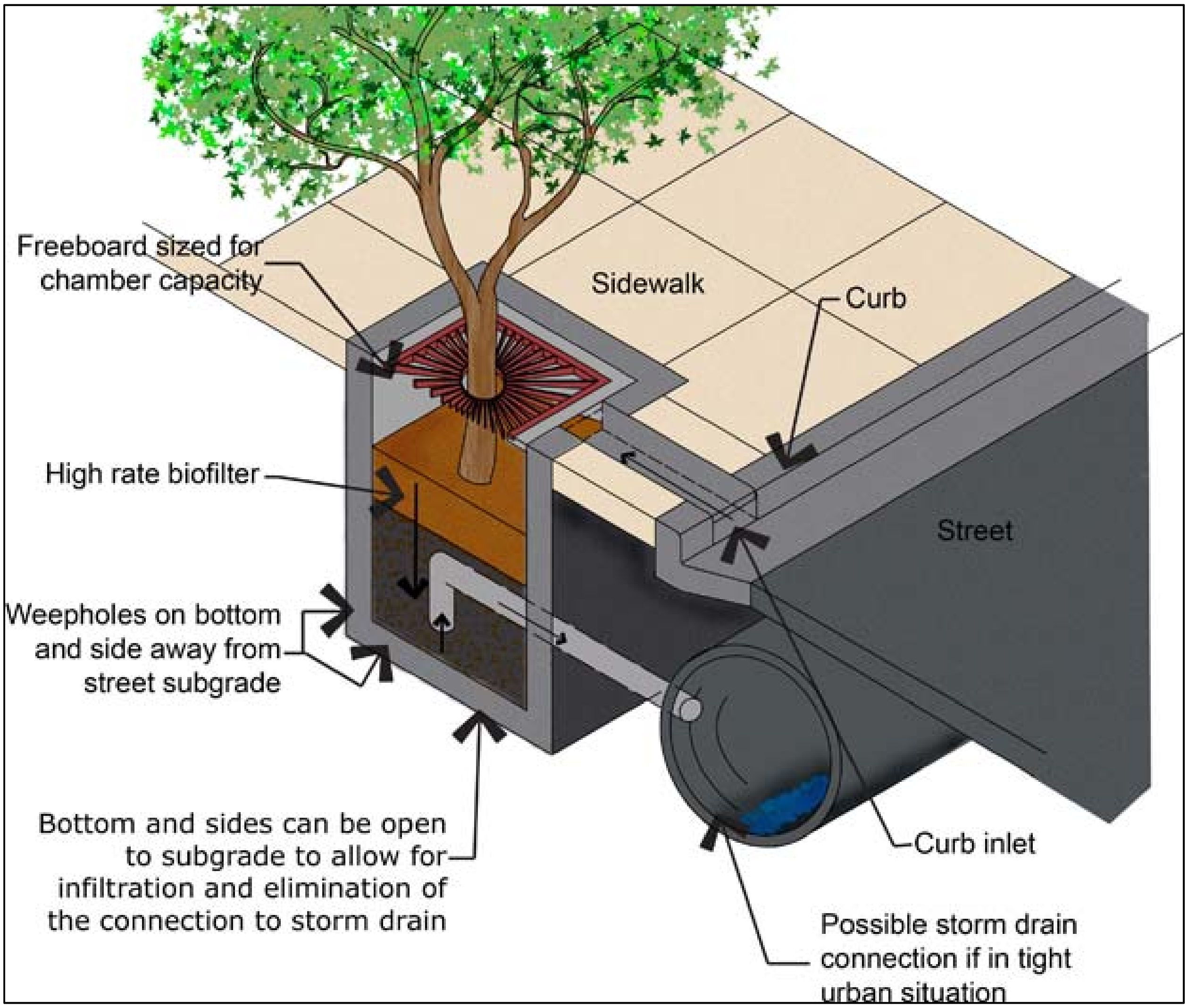


Figure 2.3.2 Design Detail for Infiltration Planter

(Source: USAF Sustainable Sites Tool Kit, http://www.wbdg.org/ccb/AF/AFSUSTTOOLKIT/Strategies/Site/Strategies_TreeWell.shtml)

2.4 POROUS AND PERMEABLE PAVEMENT

Porous pavement is a permeable pavement surface with a stone reservoir underneath. The reservoir temporarily stores surface runoff before infiltrating it into the subsoil. Runoff is thereby infiltrated directly into the soil and receives some water quality treatment. Porous pavement often appears the same as traditional asphalt or concrete but is manufactured without "fine" materials, and instead incorporates void spaces that allow for infiltration.

Figure 2.4.1 Photograph of Permeable Pavement

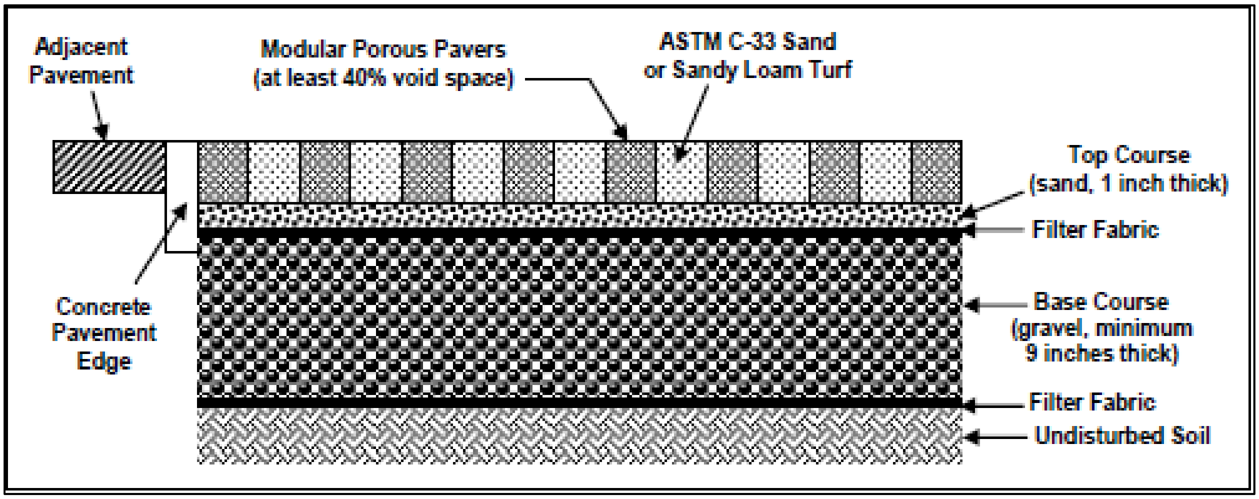


Figure 2.4.2 Design Detail for Permeable Pavement (Source: NCTCOG iSWM Manual)

2.5 VEGETATED FILTER STRIPS

Vegetated filter strips (grassed filter strips, filter strips, and grassed filters) are vegetated surfaces that are designed to treat sheet flow from adjacent surfaces. Filter strips function by slowing runoff velocities and filtering out sediment and other pollutants, and by providing some infiltration into underlying soils.

Figure 2.5.1 Photograph of Vegetated Filter Strip

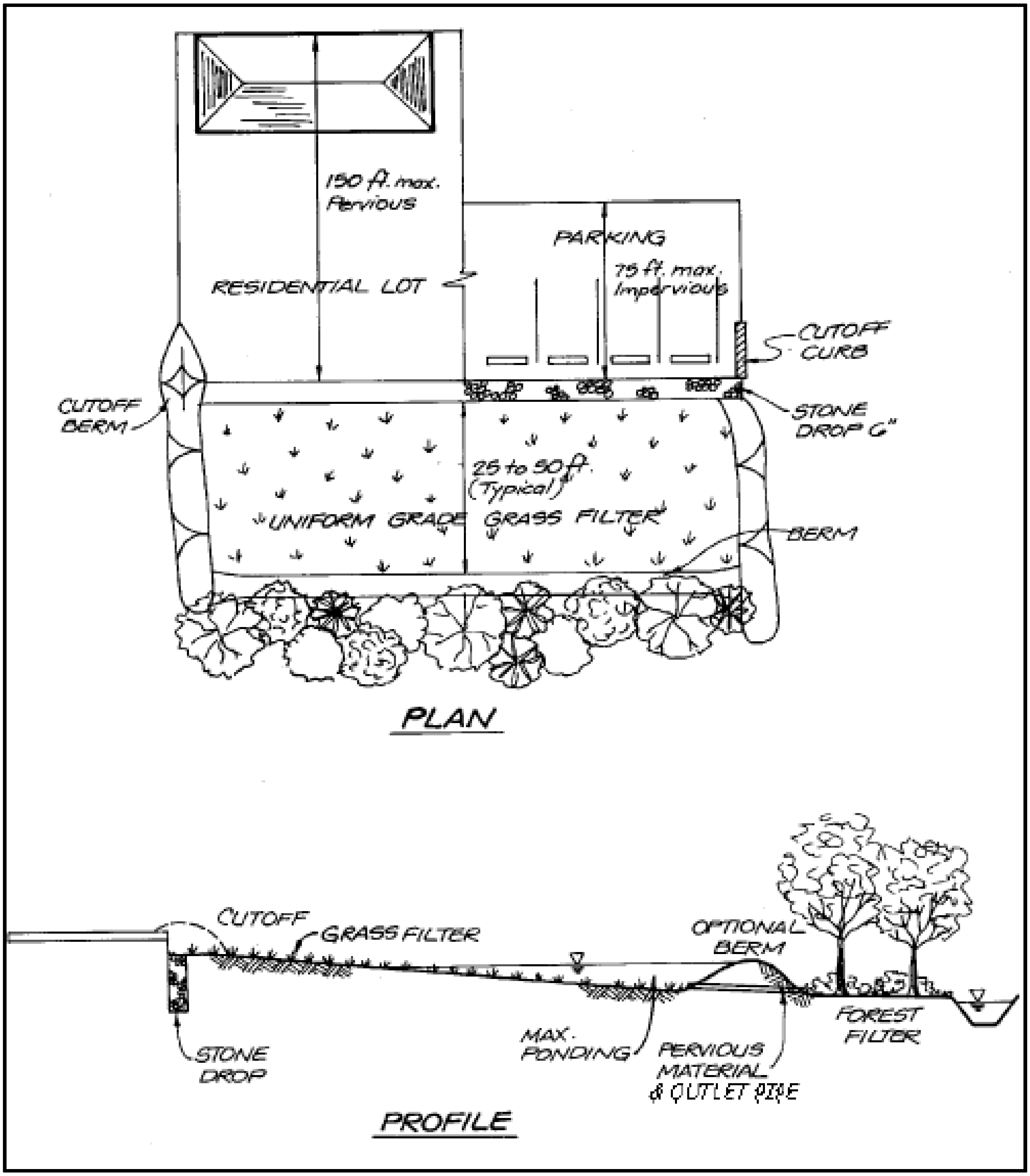


Figure 2.5.2 Design Detail for Vegetated Filter Strip (Source: NCTCOG iSWM Manual)

2.6 TREES AND TREE BOXES

Tree boxes are a green infrastructure stormwater control measure that are designed to collect the first flush of stormwater and treat it prior to discharge into the storm sewer system or to the subsoil. The structure is a pre-manufactured concrete box which is installed in-ground, filled with soil media and typically planted with native, non-invasive trees or shrubs. The tree box functions as a compact bioretention system that performs pollutant removal via filtration and adsorption.

Figure 2.6.1 Photograph of Tree Box

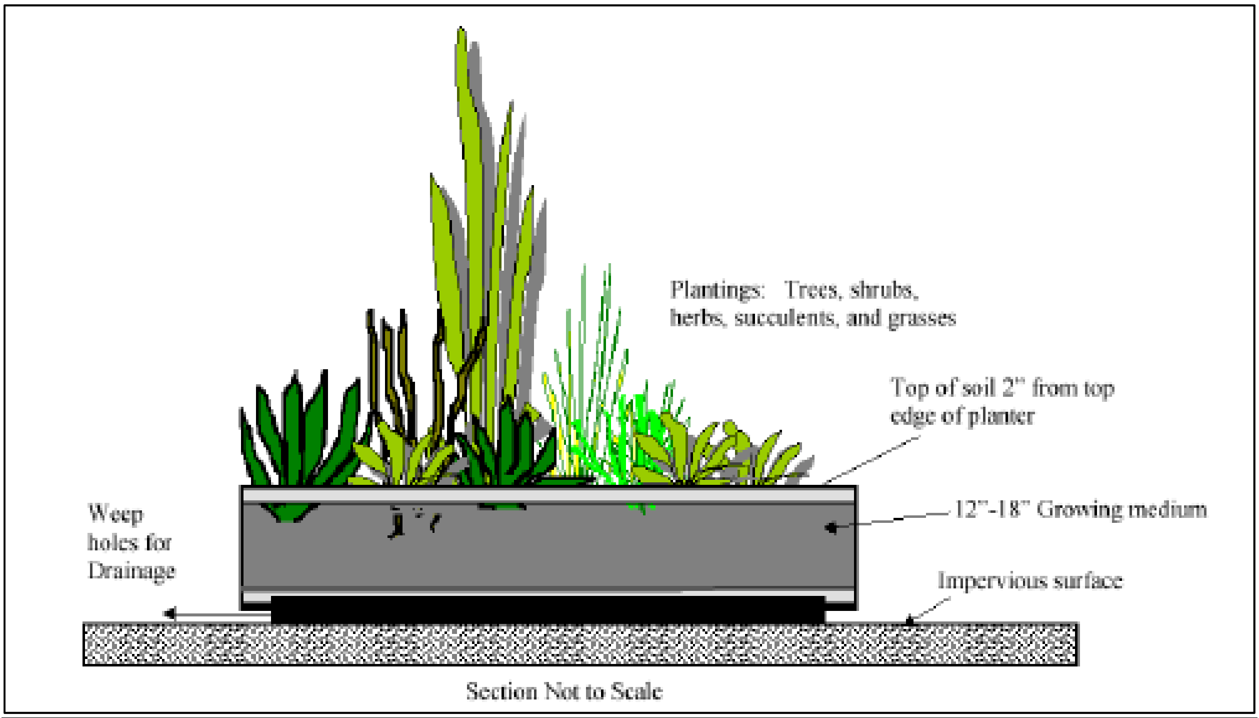


Figure 2.6.2 Design Detail for Tree Box (Source: NCTCOG iSWM Manual)

3.0 MODELING AND DESIGN TOOLS FOR GI/LID

As GI/LID development has become more common, one of the obstacles to overcome has been to find an acceptable way to model GI/LID stormwater treatment infrastructure. Not only had there been a lack of sufficient technology, there had not been a set of requirements in place for GI/LID design. A few requirements to consider are which storm events should be used for the design storm. Either a design frequency event (1-yr, 25-yr, etc.) or a specific depth (1 in., 2-in., etc.) must be chosen as the design requirement. Water quality volume should also be considered while developing guidelines. Infiltration rates and total suspended solid reduction should also be considered as a design requirement.

Since infiltration is such a key component of GI/LID strategies, design software that can model infiltration should be used in GI/LID design. The Environmental Protection Agency – Storm Water Management Model (EPA-SWMM) is a program that not only shares the components of a conventional stormwater management model, such as sub-catchments, ponds, outlet structures, and storm sewer systems, it has additional components that are used for LID modeling. These components are infiltration, infiltration storage, and infiltration recovery. Each site has unique infiltration characteristics that must be identified and accurate for the GI/LID controls to be modeled properly. The infiltration calculations in EPA-SWMM are based on Green-Ampt equations. The three variables used in those equations based on soil conditions are the capillary suction head, soil conductivity and the soil's initial deficit. Green-Ampt also uses the depth of water above the soil as a factor in infiltration. Correct soil information is essential to have in order to establish infiltration rates, storage capacity and recovery rates. Soil information can be gathered through various methods including the use of USDA / NRCS soil maps, soil borings and trench pits. Attached to this report in **Appendix 1** is a USDA soil map for the airport property which identifies the soil types within the developable areas of the airport. Soil borings typically produce the most reliable information and can also identify the water table location. Although the soil maps are valuable to identify the general soil types in the property, it is highly recommended that a comprehensive geotechnical study, including soil borings, be completed prior to any design or construction of proposed improvements. While modeling GI/LID, the soil type and conditions will have the most effect on the model, especially the saturation point of the soil. If infiltration rates of the soil do not produce favorable model results, a soil amendment could be necessary. If continuous modeling is used, the infiltration recovery rate is a key variable. This variable is not used in single storm event modeling.

Results from EPA-SWMM can be shown in various formats including, charts, graphs, tables, and profiles all of which can be color coded to highlight specific items.

EPA-SWMM is free software and can be downloaded at:
http://www.epa.gov/nrmrl/wswrd/wq/models/swmm/

4.0 GI/LID OPERATION AND MAINTENANCE

As is the case with all stormwater treatment facilities, consideration must also be given to maintenance and operation of GI/LID BMPs. Each type of BMP will have its own specific maintenance and operation schedule but for this report, the BMPs are divided into two groups, vegetated and un-vegetated. The vegetated BMPs include rain gardens, vegetated/infiltration swales, infiltration planters, vegetated filter strips and tree boxes. The un-vegetated BMPs consist of porous and permeable pavement.

Vegetated BMPs require very basic maintenance and typically the necessary maintenance equipment is readily available. Maintenance consists of a landscape maintenance crew and very light grade tools like rakes and shovels. The vegetated BMPs rely on healthy vegetation and infiltration rates to function properly. The function of the maintenance crew is to maintain the vegetation's health. Healthy vegetation has a robust root system that helps break up the soil to maintain infiltration rates. Inspections should occur on a 1-2 month basis to check the health of the plants, the soil conditions, and the mulch. After significant storm events, it is also essential to inspect the BMPs and remove any large debris that may have collected and ensure that the drainage paths are not obstructed. While establishing the BMP, it is essential that native plants be used and that they receive proper irrigation until established. Plantings should occur during the optimal planting months. Once native plants are established, they have a higher tolerance to local drought conditions and require less irrigation. If drought conditions exist and the plants appear stressed, irrigation may be required to revive the plants. Even with proper maintenance, over time the infiltration rates of the engineered soil may decrease and the vegetation could die. When this occurs the soil may need replacement or may just need to be tilled. If the soil needs to be replaced, the vegetation will need to be removed and replaced as well. Typically this is uncommon and may only be necessary every 15-20 years.

Infiltration rates can be tested by various methods. The United States Department of Agriculture uses a method that can be found at http://soils.usda.gov and uses simple procedures and equipment. Although infiltration testing can be used to determine infiltration rates, the vegetated BMPs are designed to drain and infiltrate completely within a certain period of time. If the BMP is not draining within that timeframe then the infiltration rates have deteriorated and maintenance is required. Unhealthy vegetation may be able to be saved while dead vegetation must be replaced and re-established. If invasive species take root, they should be removed.

Testing of vegetated BMPs is recommended in dry weather conditions as the plants are getting established to ensure proper function during storm events. This can be accomplished by checking the infiltration rates and plant health. The infiltration rate can be tested by the method stated above. The results from that test can be extrapolated to make sure that the facility will drain within 48 hours. As stated above, it is important that the vegetated BMPs contain healthy plant material. Unhealthy plants need to be replaced or nursed back to health. Also, since these BMPs will be designed to store storm water runoff and drain/infiltrate within a specific period of time, maximum 48 hours, vegetated swales and rain gardens can be filled manually and observed. If they do not drain within 48 hours, it is a sign that the media or underdrain, if present, is not functioning properly. If these BMPs do not drain within the allotted time, it is recommended that the infiltration media be repaired or replaced. The surface may need to be aerated or cleaned or if defective material was installed or was compacted improperly, the whole system may need to be tilled or replaced. A qualified biologist or storm water facility inspector should be able to identify the deficiency in the system and recommend a proper way to rectify the situation.

Porous and permeable pavement also requires very little maintenance and the necessary maintenance equipment is typically available onsite. The initial infiltration rates of these systems are extremely high, as high as 100 inches per hour. Even with 90% clogging, the pavement can still accommodate most major storms. If the pavement becomes too clogged, a vacuum truck can be used to clean the pores or voids within the pavement and restore the infiltration rates. If underground storage is used with the permeable pavement, the storage reservoir requires very little maintenance. If pumps are used to convey the water from the storage reservoir then the pumps will require typical pump maintenance and testing. The surface of porous pavement and permeable pavement has life spans similar to traditional asphalt and concrete. Since the infiltration rates of the surface are so high, if a small area needs replacement traditional concrete or asphalt can be used. Larger areas will need to be replaced with like material. Proper installation is essential for porous and permeable pavement as improper installation could result in an impermeable surface. An inspection schedule for the porous and permeable pavement must be established. Typically annual or biannual inspections are sufficient. Areas adjacent to landscaping must be checked to ensure soil and debris do not washout onto the surface. Construction traffic should be restricted from the pavement. All deicing activities should use a liquid deicing agent as salt and gravel could clog the pavement.

Testing the infiltration rates of porous and permeable pavement is very simple. The pavement should be able to accommodate any storm that occurs and infiltration should occur immediately. If the infiltration rates have deteriorated past that capacity then maintenance activities are required. To check the infiltration capacity of the permeable pavement, a five gallon bucket or hose should be used to apply water directly to the permeable surface. If the water does not penetrate the surface within seconds then maintenance is required. This testing should be done immediately after installation and in dry weather conditions during the annual or bi-annual inspections. The most common reason for poor infiltration rates in porous or permeable pavement in faulty installation. It is recommended that this BMP only be installed by a qualified contractor.

APPENDIX 1

USDA SOIL MAP OF AIRPORT PROPERTY

Area	Map Unit Symbol	Map Unit Name	Hydrologic Soil Group
TX113	1	Altoga silty clay, 5 to 12 percent slopes, eroded	C
TX113	2	Arents loamy, gently undulating	B
TX113	11	Axtell fine sandy loam, 1 to 3 percent slopes	D
TX113	12	Axtell fine sandy loam, 2 to 5 percent slopes, eroded	D
TX113	14	Bastsil fine sandy loam, 0 to 3 percent slopes	B
TX113	18	Burleson clay, 0 to 1 percent slopes	D
TX113	19	Burleson clay, 1 to 3 percent slopes	D
TX113	21	Crockett fine sandy loam, 1 to 3 percent slopes	D
TX113	22	Crockett fine sandy loam, 2 to 5 percent slopes, eroded	D
TX113	34	Ferris-Heiden complex, 5 to 12 percent slopes	D
TX113	35	Ferris-Urban land complex, 5 to 12 percent slopes	D
TX113	41	Heiden clay, 1 to 3 percent slopes	D
TX113	42	Heiden clay, 2 to 5 percent slopes, eroded	D
TX113	43	Houston Black clay, 0 to 1 percent slopes	D
TX113	44	Houston Black clay, 1 to 3 percent slopes	D
TX113	45	Houston Black-Urban land complex, 0 to 4 percent slopes	D
TX113	47	Lewisville silty clay, 3 to 5 percent slopes	B
TX113	53	Normangee clay loam, 1 to 3 percent slopes	D
TX113	55	Ovan clay, frequently flooded	D
TX113	61	Silawa fine sandy loam, 3 to 8 percent slopes	B
TX113	70	Sunev clay loam, 1 to 3 percent slopes	B
TX113	71	Sunev clay loam, 3 to 8 percent slopes	B
TX113	73	Trinity clay, frequently flooded	D
TX113	78	Wilson clay loam, 0 to 1 percent slopes	D
TX113	79	Wilson clay loam, 1 to 3 percent slopes	D
TX113	80	Wilson-Urban land complex, 0 to 2 percent slopes	D
TX439	5	Altoga silty clay loam, 5 to 12 percent slopes	C
TX439	7	Arents, frequently flooded	B
TX439	8	Arents, loamy	B
TX439	9	Bastsil fine sandy loam, 0 to 3 percent slopes	B
TX439	11	Birome fine sandy loam, 1 to 5 percent slopes	C
TX439	12	Birome-Aubrey-Rayex complex, 5 to 15 percent slopes	C
TX439	18	Branyon clay, 0 to 1 percent slopes	D
TX439	19	Burleson clay, 0 to 1 percent slopes	D
TX439	21	Crosstell fine sandy loam, 1 to 3 percent slopes	D
TX439	22	Crosstell fine sandy loam, 3 to 6 percent slopes	D
TX439	24	Ferris clay, 5 to 12 percent slopes, eroded	D
TX439	25	Ferris-Heiden complex, 2 to 5 percent slopes	D
TX439	27	Frio silty clay, frequently flooded	B
TX439	29	Gasil fine sandy loam, 1 to 3 percent slopes	B
TX439	30	Gasil fine sandy loam, 3 to 8 percent slopes	B
TX439	31	Gasil sandy clay loam, graded, 1 to 5 percent slopes	B
TX439	32	Gasil-Urban land complex, 1 to 8 percent slopes	B

TX113 - Dallas County
TX439 - Tarrant County

Area	Map Unit Symbol	Map Unit Name	Hydrologic Soil Group
TX439	33	Heiden clay, 1 to 3 percent slopes	D
TX439	34	Houston Black clay, 1 to 3 percent slopes	D
TX439	35	Houston Black-Urban land complex, 1 to 4 percent slopes	D
TX439	36	Justin loam, 1 to 3 percent slopes	B
TX439	37	Konsil fine sandy loam, 1 to 5 percent slopes	B
TX439	38	Leson clay, 1 to 3 percent slopes	D
TX439	41	Lott silty clay, 1 to 3 percent slopes	C
TX439	42	Lott-Urban land complex, 1 to 5 percent slopes	C
TX439	45	Mabank fine sandy loam, 0 to 1 percent slopes	D
TX439	50	Navo clay loam, 1 to 3 percent slopes	D
TX439	59	Pulexas fine sandy loam, frequently flooded	B
TX439	63	Rader fine sandy loam, 0 to 3 percent slopes	D
TX439	64	Rader-Urban land complex, 0 to 3 percent slopes	D
TX439	70	Silawa fine sandy loam, 3 to 8 percent slopes	B
TX439	71	Silstid loamy fine sand, 1 to 5 percent slopes	B
TX439	80	Trinity clay, frequently flooded	D
TX439	81	Urban land	D
TX439	83	Whitesboro loam, frequently flooded	C
TX439	84	Wilson clay loam, 0 to 2 percent slopes	D
TX439	W	Water	

DALLAS COUNTY (TX113) SOIL SUMMARIES

The soil descriptions presented here are obtained from the results of surveys conducted by the U.S. Department of Agriculture, Soil Conservation Service in Dallas County (1980). Numbers in brackets after the soil names are represented on the soil survey map for areas within DFW Airport in Dallas County (TX113).

Altoga silty clay, 5 to 12 percent slopes, eroded [1]

This is a deep, well drained, sloping to strongly sloping soil on escarpments of stream terraces. Permeability is moderate and the available water capacity is high. Runoff is medium and the hazard for erosion is severe. Included in mapping are small areas Ferris, Heiden, Lewisville and Sunev soils. This soil has medium potential for use as pasture and low potential for urban uses.

Arents, loamy, gently undulating [2]

This map area is made up of areas that have been mined for gravel and sand. Piles of discarded overburden and remaining soil material have been smoothed and most pits have been filled with soil material. Because of mixing during mining operations, these soils do not have uniform layers. Quartz pebbles are few to common throughout. The organic matter content is low and permeability is moderate. The water table is at a depth of 10 to 25 feet. The hazard of flooding is a major limitation but can be controlled with levees or other flood control structures.

Axtell fine sandy loam, 1 to 3 percent slopes [11]

This is a deep, gently sloping, moderately well drained soil on old high stream terraces. Permeability is very slow and the available water capacity is high. Runoff is medium and the hazard for erosion is moderate. Included in mapping are small areas of Crockett, Mabank, Rader and Wilson soils. This soil has a medium potential for pasture and urban uses and a low potential for cropland.

Axtell fine sandy loam, 2 to 5 percent slopes [12]

This is a deep, gently sloping, moderately well drained soil on old high stream terraces. Permeability is very slow and the available water capacity is high. Runoff is medium and the hazard for erosion is severe. Included in mapping are small areas of Crockett, Rader and Wilson soils. This soil has a medium potential for pasture and urban uses and a low potential for cropland.

Bastsil fine sandy loam, 0 to 3 percent slopes [14]

This deep, nearly level and gently sloping soil is on high terrace above the floodplains of major streams. The soil is well drained, has a moderate permeability and a high available water capacity. Runoff is medium and the hazard for erosion is moderate. Included with this soil in mapping are small areas of Smithville, Silawa and Mabank soils. This soil is well suited to most uses.

Burleson clay, 0 to 1 percent slopes [18]

This is a deep, nearly level, moderately well drained soil located on old stream terraces. Permeability is very slow and the available water capacity is high. Tilth generally is poor and the surface tends to crust. Runoff is low and the hazard of erosion is slight.

Burleson clay, 1 to 3 percent slopes [19]

This is a deep, gently sloping, moderately well drained soil on old stream terraces. Permeability is very slow, and the available water capacity is high. Runoff is medium and the hazard of erosion is moderate. Tilth is generally poor, and the surface tends to crust. This soil is used as cropland and pasture. Burleson clay has low potential for urban development. The high shrink-swell potential, low strength and corrosivity of the soil and the hazard of erosion are its main limitations.

Crockett fine sandy loam, 1 to 3 percent slopes [21]

This is a deep, gently sloping, moderately well drained soil on uplands. Permeability is very slow and the available water capacity is high. Runoff is medium and the hazard for erosion is moderate. Included in mapping are small areas of Axtell And Rader soils. This soil has high potential for pastureland and medium potential for cropland and urban uses.

Crockett fine sandy loam, 2 to 5 percent slopes, eroded [22]

This is a deep, gently sloping, moderately well drained soil on uplands. Permeability is very slow and the available water capacity is high. Runoff is medium and the hazard for erosion is severe. Included in mapping are small areas Axtell and Silawa soils. This soil has medium potential for pasture and urban uses and low potential for cropland.

Ferris-Heiden complex, 5 to 12 percent slopes [34]

This complex is made up of deep, well drained, gently rolling and rolling soils on hillsides. The Ferris soil makes up about 60 percent of this complex, the Heiden soil makes up about 20 percent, and minor soils make up the rest. The Ferris soil is on the steeper slopes, and the Heiden soil is in valleys, on the lower part of slopes, and on ridgetops. These soils are so intermingled that it was not practical to separate them in mapping at the scale used. Permeability is very slow for the Ferris soil, and the available water capacity is high. Runoff is rapid, and the hazard of erosion is severe. For the Heiden soils, permeability is also very slow, and the available water capacity is high. Runoff is rapid, and the hazard of erosion is severe. The soils in this complex are mainly used as rangeland and pasture. These soils have low potential for urban uses. Limitations to urban uses are the very high shrink-swell potential, low strength, and corrosivity of the soils, the unstable slopes, and the hazard of erosion.

Ferris-Urban land complex, 5 to 12 percent slopes [35]

This complex is made up of deep, well-drained, sloping to strongly sloping soils and areas of urban land. The Ferris soil makes up about 60 percent of this complex, urban land consisting of buildings and pavement makes up 25 percent, and minor soils make up the rest. Approximately half of the mapped area has been significantly altered by cut and fill activities. Typically, the surface layer of the Ferris soil is made up of moderately alkaline clay and is underlain by several other layers of clay to a depth of 72 inches. The soil has a very slow permeability and very high water capacity. The soil experiences rapid runoff and has a severe hazard of erosion. Small areas of Heiden and Vertel soils are included within the mapped area. The mapped soil has a low potential for urban uses. The primary limitations of the soil are the very high shrink-swell potential, low strength, unstable slopes, corrosivity of the soil and the hazard of erosion. In addition, the walls of excavations tend to cave in or slough.

Heiden clay, 1 to 3 percent slopes [41]

This is a deep, well drained, gently sloping soil on uplands. Permeability is very slow, and the available water capacity is high. Runoff is medium, and the hazard of erosion is moderate. This soil is used mainly as cropland and pasture. This soil has low potential for urban uses. The very high shrink-swell potential, corrosivity, and low strength of the soil are limitations. In addition, the walls of cuts and excavation tend to cave or slough.

Heiden clay, 2 to 5 percent slopes [42]

This is a deep, well drained, gently sloping soil on uplands. Permeability is very slow, and the available water capacity is very high. Runoff is rapid, and the hazard of erosion is severe. This soil is used mainly as pasture. This soil has low potential for urban uses. The very high shrink-swell potential, corrosivity, and low strength of the soil and the severe hazard of erosion are limitations. In addition, the walls of cuts and excavations tend to cave in or slough.

Houston Black clay, 0 to1 percent slopes [43]

This deep, nearly level soil is on broad, smooth uplands. This soil is moderately well drained, permeability is very slow and the available water capacity is high. Runoff is slow and the hazard for erosion is slight. Included with this soil in mapping are small areas of Branyon and Burleson soils. The Houston Black soil is well suite to crop and pastureland and poorly suited to urban uses.

Houston black clay, 1 to 3 percent slopes [44]

This is a deep, moderately well drained, gently sloping soil on smooth uplands. Permeability is very slow, and the available water capacity is high. Runoff is medium, and the hazard of erosion is moderate. This soil is mainly used for cropland. This soil has low potential for urban uses. The very high shrink-swell potential, corrosivity, and low strength of the soil and the hazard of erosion are limitations.

Houston Black-Urban land complex, 0 to 4 percent slopes [45]

The soil in this complex is deep and gently sloping on uplands. The complex is about 40 percent Houston Black soil, 35 percent Urban land and the rest is made up of other soils. The soil is moderately well drained, permeability is very slow and the available water capacity is high. Runoff is medium and the hazard for erosion is moderate. Included with this soil in mapping are small areas of Burleson, Dalco, Heiden and Wilson soils. This soil is poorly suited to most urban uses.

Lewisville silty clay, 3 to 5 percent slopes [47]

This is a deep, well drained, gently sloping soil on old stream terraces. Permeability is moderate, and the available water capacity is high. Runoff is medium, and the hazard of erosion is moderate. The soil is used mainly as pasture, for which it has high potential. This soil is well suited to pecan trees, which grow naturally is most pastures. The high shrink-swell potential, low strength and corrosivity are its main limitations.

Normangee clay loam, 1 to 3 percent slopes [53]

This is a deep, moderately well drained, gently sloping soil on uplands. Permeability is very slow and the available water capacity is high. Runoff is medium and the hazard for erosion is moderate. Included in mapping are small areas of Crockett and Wilson soils. This soil has high potential for pasture and medium potential for crops and urban uses.

Ovan clay, frequently flooded [55]

This deep, nearly level, clayey soil is on flood plains of major streams. This soil is moderately well drained, permeability is very slow and the available water capacity is high. Runoff is slow and the hazard for erosion is slight. Included with this soil in mapping are small areas of Trinity soils. This soil is well suited as pastureland and flooding is the main limitation for other uses.

Silawa fine sandy loam, 3 to 8 percent slopes [61]

This deep, gently sloping and sloping, loamy soil is on uplands. The soil is well drained, with moderate permeability and medium available water capacity. Surface runoff is medium and the hazard of erosion is severe. Small areas of Bastsil soils are included in this map unit. Silawa soil is well suited for urban development and recreational uses; while it is moderately suited as pasture and cropland.

Sunev clay loam, 1 to 3 percent slopes [70]

This deep, gently sloping, loamy soil is on low stream terraces and foot slopes of ridges. The soil is well drained, permeability is moderate and the available water capacity is medium. Runoff is slow and the hazard for erosion is moderate. Included with this soil in mapping are small areas of intermingled Altoga and Lewisville soils. The Sunev soil is well suited for pastureland, cropland, urban and recreational uses.

Sunev clay loam, 3 to 8 percent slopes [71]

This deep, gently sloping to sloping, loamy soil is on the foot slopes of hills and ridges. This soil is well drained, permeability is moderate and the available water capacity is medium. Runoff is medium and the hazard for erosion is severe. Included with this soil in mapping are small areas of Altoga soils. This Sunev soil is well suited to pastureland and most urban and recreational uses and moderately suited for cropland.

Trinity clay, frequently flooded [73]

This is a deep, somewhat poorly drained, nearly level soil on floodplains. This soil is flooded two to three times in most years. Typically, the area is dark clay with a very slow permeability and a high water carrying capacity. Runoff on this soil is slow with only a slight hazard for erosion. Soil inclusions consist of small areas of Ovan and Seagoville soils. This soil has very low potential for urban uses. The hazard of flooding and wetness, corrosivity, and very high shrink-swell potential of the soil are limitations. In addition, the walls of cuts and excavations tend to cave in or slough. This soil is listed in clayey bottomland range and is listed as hydric by the USDA Soil Conservation Service.

Wilson clay loam, 0 to 1 percent slopes [78]

This is a deep, nearly level to gently sloping soil located on uplands. The soil is somewhat poorly drained with very slow permeability and high water capacity. Runoff for this soil is slow and the hazard of erosion is slight. The soil has low potential for urban uses and moderately suited as cropland and pasture. Soil inclusions within the mapped area include small areas of Burleson, Crockett, Houston Black and Mabank soils.

Wilson clay loam, 1 to 3 percent slopes [79]

This is a deep, gently undulating soil located on uplands. The soil is somewhat poorly drained with very slow permeability and high water capacity. Runoff for this soil is medium and the hazard of erosion is moderate. The soil has low potential for urban uses and moderately suited as cropland and pasture. Soil inclusions within the mapped area include small areas of Burleson, Crockett, Houston Black and Mabank soils.

Wilson-Urban land complex, 0 to 2 percent slopes [80]

This complex is made up of nearly level to gently sloping, deep, somewhat poorly drained soils and areas of urban land. Permeability is very slow and the available water capacity is high. Runoff is slow and the hazard for erosion is slight. Included within this soil in mapping are small areas of Burleson, Crockett, Houston Black and Mabank soils. The Wilson soil has medium potential for urban uses. Wetness and very slow permeability are the main limitations to recreation uses.

TARRANT COUNTY (TX439) SOIL SUMMARIES

The soil descriptions presented here are obtained from the results of surveys conducted by the U.S. Department of Agriculture, Soil Conservation Service in Tarrant County (1981). Numbers in brackets after the soil names are represented on the soil survey map of DFW Airport for areas within Tarrant County (TX439).

Altoga silty clay loam, 5 to 12 percent slopes [5]

This is moderately deep to deep, sloping and strongly sloping soil is on side slopes above flood plains. The soil is well drained, permeability of the soil is moderate and the available water capacity is high. Runoff is medium and the hazard of erosion is severe. The root zone is easily penetrated by plant roots, although the high content of lime causes chlorosis in some sensitive plants. This Altoga soil is poorly suited to cropland and pastureland primarily because of slope and the potential for erosion. The soil is moderately suited to most urban and recreation uses. Small areas of Ferris soils are included in this map unit.

Arents, frequently flooded [7]

These deep, loamy soil materials are the overburden from excavated areas of gravel and sand mining operations on nearly level flood plains of large streams. These soil materials are poorly suited to most uses because of flooding and accessibility.

Arents, loamy [8]

Arents are gently undulating, loamy soils that have been smoothed and reclaimed after sand and gravel mining operations had been suspended. These soils are found mainly along terraces of major streams. The dominant soil texture is sandy clay loam, but varies to consist of fine sand, loamy fine sand and fine sandy loam. The root zone is deep. The soils are well suited for use as pasture, recreation and urban development. The soils are moderately well suited as cropland, with the primary limitations being low soil fertility, wet depressed areas and soil blowing.

Bastsil fine sandy loam, 0 to 3 percent slopes [9]

This deep, nearly level and gently sloping soil is on high terrace above the floodplains of major streams. The soil is well drained, has a moderate permeability and a high available water capacity. Runoff is medium and the hazard for erosion is slight. Included with this soil in mapping are small areas of Rader, Silawa and Mabank soils. This soil is well suited to most uses.

Birome fine sandy loam, 1 to 5 percent slopes [11]

This moderately deep, gently sloping, loamy soil is on convex ridges and side slopes of ridges. The soil is well drained, has a slow permeability and a low water capacity. Runoff is medium and the hazard for erosion is moderate. Included with this soil in mapping are small areas of Crosstell and Konsil soils on foot slopes and Rayex soils on narrow ridgetops. This soil is well suite to recreation and pasture and urban land and moderately suited to crop land.

Birome-Aubrey-Rayex complex, 5 to 15 percent slopes [12]

The soils in this complex are shallow to moderately deep, sloping to moderately steep and loamy. They are located on narrow ridges and slopes along drainageways on uplands. Sandstone outcrops, slabs and fragments are common on some slopes. The complex is approximately 35 percent Birome soil, 30 percent Aubrey soil, 15 percent Rayex soil and 20 percent other soils and rock outcrops. Soils within the complex are well drained, with moderate to rapid surface runoff, which creates a severe hazard of erosion. The bedrock restricts root penetration and natural fertility is low. The soils are poorly suited as pastureland and cropland because of slopes, stones and severe erosion. Birome and Rayex soils are moderately suited to most urban and recreational uses, while Aubrey soils are poorly suited for these uses. The abundance of wooded areas located on the soils provides excellent food and cover for deer quail and doves.

Branyon clay, 0 to 1 percent slopes [18]

This deep, nearly level, clayey soil is on broad, smooth valley fills and ancient stream terraces. This soil is moderately well drained, permeability is very slow and the available water capacity is high. Runoff is slow and the hazard for erosion is slight. Included in mapping within this soil are small areas of Houston Black soils. The Branyon soil is well suite to pasture and crop land and poorly suited to most urban and recreational uses.

Burleson clay, 0 to 1 percent slopes [19]

This deep, nearly level soil is on ancient upland terraces. The soil is moderately well drained, has a very slow permeability and a high available water capacity. Runoff is slow and the hazard for erosion is slight. Included with this soil in mapping are small areas of Branyon and Wilson soils. This Burleson soil is well suited to crop and pasture land and poorly suited to most urban and recreational uses.

Crosstell fine sandy loam, 1 to 8 percent slopes [21]

This is a deep, gently sloping, loamy soil on convex ridges and side slopes. The soil is moderately well drained, with very slow permeability and medium water capacity. Surface runoff and the hazard of erosion are moderate. Plant roots have difficulty penetration the clayey lower layers. Small areas of Birome, Gasil and eroded Crosstell soils are included within the map unit. This soil is moderately suited as cropland, pastureland, urban development and recreation uses.

Crosstell fine sandy loam, 3 to 6 percent slopes [22]

This deep soil is located on convex ridges and side slopes of ridges. The soil is moderately well drained with a very slow permeability. The available water capacity for this soil is medium. Surface runoff is rapid and the hazard of erosion is severe. Small areas of Birome and Gasil soils are included within the mapping area. This Crosstell soil is poorly suited as cropland, while it is moderately suited for pastureland and urban uses. Some of the limitations for varying uses include the hazard of erosion, fertility of the soil, shrink and swell changes in the soil and corrosivity to uncoated steel and concrete.

Ferris clay, 5 to 12 percent slopes, eroded [24]

This deep, sloping and strongly sloping, clayey soil is on side slopes of ridges and slopes above drainageways. The soil is well drained, with very slow permeability and high available water capacity. When the soil is dry and cracked, water enters rapidly; however when the soil is moist, water enters very slowly. Surface runoff is rapid and the hazard of water erosion is severe. Small areas of Altoga and Heiden soils are included within this map unit. The soil is moderately suited as pastureland, while it is poorly suited for use as cropland, urban development and recreation uses. Limitations of the soil are due to slope, gullies, water erosion, shrink/swell changes and corrosivity to uncoated steel.

Ferris-Heiden complex, 2 to 5 percent slopes [25]

The soils in this complex are deep, gently sloping and clayey. They are on convex ridges and side slopes above drainageways. This complex is about 50 percent Ferris soils, about 45 percent Heiden soils and about 5 percent other soils that are similar. The soils in this complex are well drained, have very slow permeability and a high available water capacity. Surface runoff is rapid and the hazard for erosion is high. The root zone is deep, but penetration is slow. Included with this complex in mapping are small areas of Frio, Houston Black, Lott and Navo soils. These soils are well suited to pastureland and moderately suited to cropland and urban uses.

Frio silty clay, frequently flooded [27]

This deep nearly level soil is on floodplains of major streams, with flooding occurring from one to three times per year. Floods are brief and last from a few hours to a day. The soil is well drained, with moderately slow permeability and high available water capacity. Surface runoff is slow and the hazard of erosion is slight. The root zone is deep and easily penetrated by plant roots. Small areas of Ovan and Trinity soils are included in this map unit. Trinity soils are listed as a hydric soil of Tarrant County. The Frio soil is well suited as pastureland. The main limitation for cropland, urban and recreational uses is flooding.

Gasil fine sandy loam, 1 to 3 percent slopes [29]

This deep, gently sloping soil is on convex ridges and side slopes. This soil is well drained, permeability is moderate and the available water capacity is medium. Runoff is slow and the hazard for erosion is moderate. The root zone is deep and easily penetrated by roots. Included with this soil in mapping are small areas of Konsil and Rader soils. This soil is well suited to most uses

Gasil fine sandy loam, 3 to 8 percent slopes [30]

This deep, gently sloping soil is on convex ridges and side slopes. This soil is well drained, permeability is moderate and the available water capacity is medium. Runoff is medium and the hazard for erosion is moderate. Included with this soil in mapping are small areas of Birome and Konsil soils. This soil is moderately suited as cropland and well suited to use as pastureland and urban and recreation uses.

Gasil sandy clay loam, graded, 1 to 5 percent slopes [31]

This deep, gently sloping soil is on desurfaced upland areas. The soil is well drained, permeability is moderate and the available water capacity is medium. Runoff is rapid and the hazard for erosion is severe. The root zone is deep and natural fertility is very low. The Gasil soil is moderately suited to recreation uses and pastureland, poorly suited as cropland and well suited to urban uses.

Gasil-Urban land complex [32]

The soil in this complex is deep and gently sloping on convex uplands. The complex is about 40 to 70 percent Gasil soil, 15 to 50 percent Urban land and as much as 20 percent other soils. The soil is well drained, permeability is moderate and the available water capacity is high. Runoff is slow and the hazard for erosion is moderate. The root zone is deep and easily penetrated. Included with this complex in mapping are small areas of Crosstell, Konsil, Rader and Silstid soils. The Gasil soil is well suited to most urban and recreation uses.

Heiden clay, 1 to 3 percent slopes [33]

This deep, gently sloping, clayey soil is on uplands. This soil is well drained, permeability is very slow and the available water capacity is high. Runoff is rapid and the hazard for erosion is moderate. The root zone is deep, but plant roots penetrate slowly. Included with this soil in mapping are small areas of Houston Black soil. The Heiden soil is well suited to use as crop and pasture land, moderately suited to urban uses and poorly suited to recreation uses.

Houston Black clay, 1 to 3 percent slopes [34]

This deep, gently sloping soil is on broad, smooth uplands. This soil is moderately well drained, permeability is very slow and the available water capacity is high. Runoff is medium and the hazard for erosion is moderate. The root zone is deep, but plant roots penetrate slowly. Included with this soil in mapping are small areas of Heiden and Leson soils. The Houston Black soil is well suite to crop and pastureland, moderately suited to urban uses and poorly suited to recreation uses.

Houston Black-Urban land complex [35]

The soil in this complex is deep and gently sloping on uplands. The complex is about 45 to 65 percent Houston Black soil, 15 to 50 percent Urban land and less than 25 percent other soils. The soil is moderately well drained, permeability is very slow and the available water capacity is high. Runoff is medium and the hazard for erosion is moderate. The root zone is deep, but plant roots penetrate slowly. Included with this soil in mapping are small areas of Heiden and Leson soils. This soil is moderately suited to most urban uses and poorly suited to recreation uses.

Justin loam, 1 to 3 percent slopes [36]

This deep, gently sloping soil is on convex ridges on uplands. This soil is well drained, permeability is moderately slow and the available water capacity is high. Runoff is medium and the hazard of erosion is moderate. The root zone is deep, but plant roots easily penetrate the lower layers. This soil is well suited to use as crop and pastureland and most urban and recreational uses.

Konsil fine sandy loam, 1 to 5 percent slopes [37]

This deep, gently sloping soil is on convex ridges and their side slopes. This soil is well drained, permeability is moderate and the available water capacity is high. Runoff is slow and the hazard for erosion is moderate. The root zone is deep and easily penetrated by plant roots. Included with this soil in mapping are small areas of Birome, Gasil, Silawa and Konsil soils. The Konsil soil is well suited to pastureland and most urban and recreation uses and moderately suited to cropland.

Leson clay, 1 to 3 percent slopes [38]

This deep, gently sloping soil is located on uplands. This soil is moderately well drained. Permeability is very slow and available water capacity is high. When the soil is dry and cracked, water enters rapidly. Once the soil is wet and the cracks are sealed, water enters very slowly. Runoff is medium and the hazard of erosion is moderate. The soil is difficult to work during extremes in moisture conditions and surface crusting is common. This Leson soil is mainly used as cropland and is well suited to this use. Main management objectives include controlling erosion and maintaining tilth. This soil is also well suited to pastureland and moderately suited to most urban areas. Shrinking and swelling with changes in moisture, corrosivity to uncoated steel and very slow permeability is the major limitations. These limitations can be partly overcome by good design and careful installation.

Lott silty clay, 1 to 3 percent slopes [41]

This deep, gently sloping, clayey soil is on low convex ridges. This soil is well-drained, permeability is moderately slow and available water capacity is medium. The amount of runoff is medium and the hazard of erosion is moderate. This Lott soil is mainly used as cropland and is well suited to pastureland and urban uses. Shrinking and swelling with changes in moisture, corrosivity and permeability are its main limitations.

Lott-Urban land complex, 1 to 5 percent slopes [42]

The soil in this complex is gently sloping on convex uplands. The complex is 45 to 70 percent Lott soil, 15 to 40 percent Urban land and as much as 20 percent other soils. This soil is well drained, permeability is moderately slow and the available water capacity is high. Runoff is medium and the hazard for erosion is moderate. The root zone is deep, but plants easily penetrate the lower layers. Included with this complex in mapping are small areas of Heiden and Sanger soils. The Lott soil is well suite to most urban uses and moderately suited to most recreation uses.

Mabank fine sandy loam, 0 to 1 percent slopes [45]

This deep, nearly level, loamy soil is in concave areas in uplands. This soil is somewhat poorly drained, permeability is very slow and the available water capacity is medium. Runoff is slow and the hazard for erosion is slight. The root zone is deep, but roots slowly penetrate the lower clayey layers. Included with this soil in mapping are small areas of Wilson and Rader soils. The Mabank soil is well suited to pastureland, moderately suited to cropland and poorly suited to most urban and recreational uses.

Navo clay loam, 1 to 3 percent slopes [50]

This deep, gently sloping, loamy soil is on side slopes and low ridges along drainageways. The soil is moderately well drained with very slow permeability and high available water capacity. Surface runoff and the hazard of erosion are moderate. The root zone is deep although plants have difficulty penetrating the clayey lower layers. Navo clay loam is well suited as pasture; and moderately suited to cropland, urban development and recreational uses. Small areas of Wilson soil are included in this map unit. Good vegetative cover provides habitat for small to medium wildlife and birds.

Pulexas fine sandy loam, frequently flooded [59]

This deep, nearly level soil is on narrow flood plains of streams that are within and that drain sandy and loamy areas. This soil is well drained, permeability is moderately rapid and the available water capacity is medium. Runoff is slow and the hazard for erosion is slight. The root zone is deep and easily penetrated. Included with the soil in mapping are small areas of Whitesboro soils. This Pulexas soil is well suited to pastureland and poorly suited for cropland.

Rader fine sandy loam, 0 to 3 percent slopes [63]

This deep and nearly level gently sloping, loamy soil is on low terraces and in valleys. This soil is moderately well drained, permeability is very slow and the available water capacity is medium. Runoff is slow and the hazard for erosion is slight. The root zone is deep, but plants have difficulty penetrating the clayey lower layers. Included with this soil in mapping are small areas of Mabank soils and soils closely similar to Rader soils. The Rader soil is well suited to pasture and cropland and moderately suited to urban and recreation uses.

Rader-Urban land complex, 0 to 3 percent slopes [64]

The soil in this complex is deep and nearly level and gently sloping on high stream terraces and in valleys. The complex is about 40 to 65 percent Rader soils, 15 to 40 percent Urban land and less than 25 percent other soils. This soil is well drained, permeability is very slow and the available water capacity is medium. Runoff is slow and the hazard for erosion is slight. The root zone is deep but plants have difficulty penetrating the clayey lower layers. Included with this complex in mapping are smaller areas of Crosstell, Gasil and Mabank soils. This complex is moderately suited to urban and recreational uses.

Silawa fine sandy loam, 3 to 8 percent slopes [70]

This deep, gently sloping and sloping, loamy soil is on high terraces above floodplains of major streams. The soil is well drained, with moderate permeability and medium available water capacity. Surface runoff and the hazard of erosion are moderate. This soil can be worked throughout a wide range of moisture conditions. Small areas of Gasil and Konsil soils are included in this map unit. Silawa soil is well suited for pastureland, urban development and recreational uses; while it is moderately suited as cropland. Abundant herbaceous and woody cover provides habitat for deer, quail and doves.

Silstid loamy fine sand, 1 to 5 percent slopes [71]

This deep, gently sloping, sandy soil is on high stream terraces and side slopes of ridges. This soil is well drained, permeability is moderate and the available water capacity is medium. Runoff is slow and the hazard for erosion is slight. The root zone is deep and easily penetrated. Included with this soil in mapping are small areas of Bastsil, Gasil and Konsil soils. The Silstid soil is well suited as pastureland and for most urban uses and moderately suited for cropland and most recreational uses.

Trinity clay, frequently flooded [80]

This complex is made up of nearly level to gently sloping, deep, somewhat poorly drained soils and areas of urban land. Permeability is very slow and the available water capacity is high. Runoff is slow and the hazard for erosion is slight. Included within this soil in mapping are small areas of Burleson, Crockett, Houston Black and Mabank soils. The Wilson soil has medium potential for urban uses. Wetness and very slow permeability are the main limitations to recreation uses.

Urban land [81]

This unit consists of areas that are 85 to 100 percent works and structures. Included in mapping are some built up areas on which building and structures cover less than 85 percent of the surface. Also included are small areas of soils that have been covered by fill material.

Whitesboro loam, frequently flooded [83]

This deep, nearly level, loamy soil is on flood plains of major streams. It floods once to three times in most years for periods of several hours to two days. Slopes range from 0-1 percent. The soil is moderately well drained, permeability is moderate and available water capacity is high. Surface runoff is slow and the risk of erosion is slight. This soil is mainly used as pastureland. Areas within this soil unit are excellent for deer, dove and quail.

Wilson clay loam, 0 to 2 percent slopes [84]

This is a deep, nearly level to gently sloping soil located on upland ridges and in slightly depressed areas above drainage ways. The soil is somewhat poorly drained with very slow permeability and high water capacity. Runoff for this soil is slow and the hazard of erosion is slight. In depressed areas, water is ponded on the surface for a few hours following rains. This soil is difficult to work because the soils crusts and dense plow pans that form in cultivated areas. The soil is well suited as pastureland, moderately suited as cropland and poorly suited for urban development. The main limitations are shrinking and swelling during extremes in moisture, corrosivity and seasonal wetness. Soil inclusions within the mapped area include small areas of Burleson, Navo and Ponder soils.

Soil Map
DFW Airport
Tarrant and Dallas County, Texas

JACOBS

W:\JOBI\FBY88394 - DFW Trigg Lake Dam Study\600 DISCIPLINE\606 GIS\606.1 MXD\DFW_Soils.mxd

Appendix B

DFWIA Standard Operating Procedures

This page intentionally left blank

Title: Storm Water Drainage System Management		Code Number: ETAM.014.002
Functional Category: Systems Performance	Issuing Department: ETAM	Effective Date: 09/30/2016

1.0 PURPOSE

1.1 The purpose of this procedure is to provide guidelines on managing the Airport Board Storm Water Channel/System in accordance with Storm Water Pollution Prevention Plan and Storm Water Management Plan.

1.2 Energy Transportation Asset Management is committed to leading the industry and to the continual improvement of its environmental practices to ensure compliance with state and federal rules and regulations.

2.0 DEPARTMENTS / PERSONS AFFECTED

2.1 Energy Transport & Asset Management (ETAM)

3.0 POLICY

Per the Airport Boards Storm Water Pollution Prevention Plan (SWPPP) and Storm Water Management Plan the storm water channels on DFW Airport will be inspected and maintained on an established frequency to ensure compliance with state and federal rules, and maintain water quality standards.

4.0 PROCEDURE

4.1 General Requirements

- 4.1.1 All structures and visible units of the improved storm water system should be inspected periodically and the deficiencies corrected as soon as practical.
- 4.1.2 Personnel assigned to perform the required inspections shall be knowledgeable in identifying system deficiencies.
- 4.1.3 Periodic inspections should be made, including a patrol of the system during or after a storm, if conditions do not seem normal and it is safe to do so.
- 4.1.4 Inspections are to be conducted in either dry or wet weather conditions.
- 4.1.5 Report any suspect spills or releases to the AOC at (972) 973-3112.

4.2 Inspection Criteria:

- 4.2.1 Open Channel Drainage Systems
  - 4.2.1.1 Check for evidence of slope instability, such as landslides or sloughing.
  - 4.2.1.2 Verify dense turf has developed to stabilize open ditches.
  - 4.2.1.3 Check for erosion and undermining around structures in watercourse or embankments.
  - 4.2.1.4 Check for cracking or heaving of hydraulic structures.
  - 4.2.1.5 Check for accumulation of weeds, brush, logs, silt, beaver dams, and other debris that might divert or restrict the flow at any time.
  - 4.2.1.6 Check for un-permitted wastes (e.g., hydrocarbons, glycol, food wastes, or sheen).
- 4.2.2 Piped Conveyance System
  - 4.2.2.1 Check inlet grates for clogging by grass cuttings, sticks, and debris.
  - 4.2.2.2 Check pipelines for stoppage by sediment, waste or debris.
  - 4.2.2.3 Check for soil settlement around pipes and structures from infiltration.
  - 4.2.2.4 Check for un-permitted wastes (e.g., hydrocarbons, glycol, food wastes, or sheen).
  - 4.2.2.5 Perform periodic walkthrough (where possible) and televised inspections to locate deficiencies and defects such as concrete pipe cracks, pipe joint separations, infiltrations, corrugated pipe deformations, obstructions, etc.

4.3 Inspection Reports

4.3.1 Report system component condition and or individual discrepancies on Storm Water Inspection Checklist:

4.3.2 Give location based on current DFW Watercourse Map.

4.3.2.1 Local description should include what local features (roads, buildings, boundaries, outfalls, etc.) are necessary. Description for the inspection extents should also be included.

4.3.2.2 Sub--watershed.

4.3.2.3 Watercourse most directly affected (e.g., MS – A1).

4.3.2.4 Geo-spatial location (i.e. Emergency Grid Number, GPS coordinates).

4.3.3 Record recent weather data if relevant (e.g. – days since recent rain event).

4.3.4 Record type and description (size, severity) of discrepancy.

4.3.5 Record Date and Time.

5.0 RESPONSIBILITIES

5.1 **Airport Infrastructure Manager:**

5.1.1 Will review the inspection reports on an annual basis.

5.1.2 In the event that the repair of a deficiency is beyond the capability of the in-house resources to correct, the Airport Infrastructure Manager is responsible for developing a plan of action to address the deficiency.

5.2 **Supervisor:**

5.2.1 Ensure that employees responsible for inspections have:

5.2.1.1 A fundamental understanding of the function and operation of the system.

5.2.1.2 Read and understand the procedures to follow for inspection of the system.

5.2.2 Compile and review inspections with assistance of Infrastructure Manager to determine what supplemental effort is needed to complete the system evaluation.

5.3 **Employees:**

5.3.1 Employees designated to perform the inspections shall follow these procedures.

6.0 DEFINITIONS

6.1 Natural Watercourses

6.1.1 Rill - drainage path smaller than a gully, created by confluence of sheet flows and usually the first sign of significant on-site erosion.

6.1.2 Gully – drainage path created by reoccurring washout (1’ – 5’ local depth).

6.1.3 Ravine – drainage path or washout larger than a gully.

6.1.4 Creek - watercourse corresponding to the DFW watersheds. In some cases these paths have been channelized.

6.2 Constructed Watercourses, may be grass or paved

6.2.1 Flume – drainage path usually smaller and steeper than a ditch having a site-specific purpose.

6.2.2 Ditch - small constructed watercourse (1’ – 5’ local depth) tributary to a channel or creek.

6.2.3 Barditch - roadside ditch created by construction borrow excavation.

6.2.4 Channel - large watercourse usually tributary to DFW creeks.

6.3 Other

6.3.1 Swale – depression or low lying area that concentrates water flows, may be constructed or naturally occurring.

6.3.2 Washout – hydraulic removal of soil from around embankments, any significant slope (top, toe, or face), or hydraulic structures.

6.3.3 Sloughing – slope failures due to loss of soil strength from saturation and/or excessive grades.

6.3.4 Outfall – end of pipe or outlet location for confluence of minor watersheds.

6.3.5 Subwatershed – one of the nine major watersheds that in sum account for DFW property.

6.3.6 Improved storm water system – the permitted or designed and constructed surface drainage systems built to convey storm water flows to the natural drainage systems.

6.3.7 Control structures – dissipaters, detention basins, and similar structures.

6.4 Notes

6.4.1 Definitions are DFW specific.

6.4.2 Storm water Inspection Checklist (sample attached) – To be used in compiling semi-annual system evaluation; and to report any severe isolated discrepancies (comprised of any items noted on the checklist form). This form may be in electronic format.

6.5 DFW Watercourse Map (attached) – Identifies all major drainage paths and watersheds.

7.0 APPROVAL / REVISION HISTORY

7.1 04/05/2004 – AM.014 Original document

7.2 08/01/2009 – AM.014.001First Revision

7.3 09/30/2016 – ETAM.014.002 Second Revision. Formatting and organization update.

Title: Outfall Characterization/Monitoring Program		Code Number: SWMS4-001.04
Functional Category: Stormwater – MS4	Issuing Department: Environmental Affairs	Effective Date: 06/01/2016

1.0 PURPOSE

1.1 To satisfy the Illicit Detection and Elimination minimum control measure required by the DFW Airport Storm Water Management Plan (SWMP) pursuant to the Texas Pollutant Discharge Elimination System (TPDES) Municipal Separate Storm Sewer System permit (MS4 Permit TXR04000).

2.0 DEPARTMENTS / PERSONS AFFECTED

2.1 Environmental Affairs Department (EAD)

3.0 EQUIPMENT LIST

3.1 Camera
3.2 Sampling bottles
3.3 LaMotte Smart 3 Colorimeter (field tests)
3.4 Water quality meter (YSI Pro)
3.5 Measuring tape (if not characterized previously)

4.0 PROCEDURE

4.1 EAD must implement the following Outfall Characterization/Monitoring Program to eliminate illicit discharges in the DFW Airport MS4 pursuant to the TPDES MS4 Permit and the DFW Airport SWMP:

4.1.1 Prior to conducting field activities, a representative from EAD shall make all reasonable attempts to collect background information regarding the drainage area for the outfall to be inspected. Examples include reviewing:
4.1.1.1 Micro-station storm sewer maps,
4.1.1.2 As-built drawings,
4.1.1.3 And similar resources referencing facilities and upstream areas the outfall supports

4.1.2 Following the initial background search, a field survey will be conducted at the outfall (end of pipe) and at all upstream areas discharging to the outfall.

4.1.3 The inspector shall document the following on the Outfall Characterization Table:
4.1.3.1 Date outfall inspected,
4.1.3.2 Outfall name/number,
4.1.3.3 Outfall size or diameter,
4.1.3.4 Outfall description (concrete, corrugated metal, round, square, etc.),
4.1.3.5 Outfall Coordinates (Latitude/Longitude),
4.1.3.6 Weather Conditions (Clear, Cloudy/Overcast, Drizzle/Sleet, Rainy/Stormy),
4.1.3.7 Condition of the outfall (good condition, interior/exterior cracks)

4.1.3.8 Presence of any non-storm water flows discharging from the end of pipe,

4.1.3.9 All storm water drains present,

4.1.3.10 Potential non-storm water flows (sprinkler systems, condensate lines, illicit discharges) that may discharge to the outfall,

4.1.3.11 Suspect illicit discharges or connections (sanitary sewer, process waters, illegal dumping of chemicals or waste, and/or spilled material),

4.1.3.12 Indicators of possible pollutants (staining on pavement, discolored water, stressed vegetation),

4.1.3.13 List of all facilities with storm water connections or surface water flows discharging to the outfall,

4.1.3.14 Water Quality (for outfalls with sufficient amount of water present).

4.1.3.15 Any additional comments relating to possible illicit connections associated with the outfall.

4.1.4 Digital photographs shall be taken to document the condition of each outfall at the end of pipe, and any illicit connections or unusual flows observed during the upstream inspection.

4.1.5 For those outfalls with a sufficient amount of flow present, samples will be collected. The following documentation shall be included on the inspection form:

4.1.5.1 Outfall number, date, time, analyst initials, water, water temperature, pH, dissolved oxygen, conductivity, salinity, sheen, odor, wildlife, foam discharge, samples collected, and any additional comments that may be needed.

4.1.6 If at any time during the survey, a "non-storm water" flow is present, water sampling must be conducted for laboratory analysis to assist in determining if the discharge is natural (or allowable) or illicit, and to record analytical results for dry weather flows.

4.1.6.1 Parameters include:

4.1.6.1.1 <u>COD</u> (1 sample collected in plastic container preserved with Sulfuric Acid),

4.1.6.1.2 <u>E. Coli</u> (2 samples collected in Whirl Pak container preserved with Sodium Thiosulfate),

4.1.6.1.3 <u>Glycol -only during deicing season-</u> (1 sample collected in 40 ml clear, glass volatile organic analyte container preserved on ice),

4.1.6.1.4 <u>Individual Permit Metals (Al, Cu, Zn)</u> (1 sample collected in 250 ml plastic container preserved with Nitric Acid),

4.1.6.1.5 <u>Ammonia</u> (1 sample collected in 250 ml plastic container preserved with Sulfuric Acid),

4.1.6.1.6 <u>Oil and Grease</u> (2 samples collected in 1 liter wide mouth glass container preserved with Sulfuric Acid); and,

4.1.6.1.7 <u>TPH</u> (2 samples collected in 40 ml, glass volatile organic analyte container preserved with Hydrochloric Acid)

4.1.7 All information shall be recorded on the Outfall Characterization Table (attached), or IDDE Outfall Inspection Form (attached).

5.0 RESPONSIBILITIES

5.1 Environmental Affairs Department will be responsible for

5.1.1 Conducting all background research, outfall characterization field surveys, sample collection, and documentation associated with the outfall characterization program.

5.1.2 Completing Outfall Characterization Table (initial investigation), Investigation of Non-Storm Water Discharges form, or IDDE Outfall Inspection Form.

6.0 DEFINITIONS

6.1 **ALLOWABLE NON-STORM WATER DISCHARGES.** Liquids other than precipitation that mix with storm water and/or is directly discharged to a storm water conveyance system (i.e. a storm drain, catch basin, etc.) that are considered allowable. Examples include:

- Discharges from firefighting activities and fire hydrant flushing (excluding discharges of hyper-chlorinated water, unless the water is first de-chlorinated and discharges are not expected to adversely affect aquatic life).
- Water line flushing (excluding discharges of hyper-chlorinated water, unless the water is first de-chlorinated and discharges are not expected to adversely affect aquatic life), potable water sources (excluding discharges of hyper-chlorinated water, unless the water is first de-chlorinated and discharges are not expected to adversely affect aquatic life),
- Runoff or return flow from landscape irrigation, lawn irrigation, and other irrigation utilizing potable water, groundwater, or surface water sources,
- Water from routine external washing of buildings, conducted without the use of detergents or other chemicals,
- Water from the routine washing of pavement conducted without the use of detergents or other chemicals and where spills or leaks of toxic or hazardous materials have not occurred (unless all the spilled material has been removed),Air conditioner condensate, compressor condensate, and condensate that externally forms on steam lines,
- Water from foundation or footing drains where flows are not contaminated with pollutants (e.g. process materials, solvents, and other pollutants),
- Springs and other uncontaminated groundwater, and other non-storm water discharges not reasonably expected to be significant sources of pollution, may be established as an allowable discharge, pending approval by DFW Environmental Affairs and the Texas Commission on Environmental Quality.

6.2 **ILLICIT DISCHARGE.** Any discharge to an MS4 that is not entirely composed of storm water, except discharges pursuant to this general permit or a separate authorization and discharges resulting from emergency fire fighting activities.

7.0 FORMS AND REFERENCES

7.1 ***Outfall Characterization Table.*** Attached and on the S: Drive in S:\Forms\SWMS4

7.2 ***IDDE Inspection Form.*** Attached and on the S: Drive in S:\Forms\SWMS4

8.0 REVISION HISTORY

8.1	06/12/2009	Original Document
8.2	07/30/2010	Revised Format
8.3	01/08/2015	Permit Renewal Revisions
8.4	06/01/2016	Revised Format

APPROVAL FOR STANDARD OPERATIONAL PROCEDURE:

06/29/2016

Vice President, Environmental Affairs Date

OUTFALL CHARACTERIZATION TABLE

DFW

Inspected By: Site Name: Date:

Outfall Name or Number: Associated Watershed:

Outfall size or diameter (approximate):

Outfall Description and Condition (example, cracked concrete pipe in poor condition with visible rust stains discharging to unlined ditch):

Insert Outfall Photo:

Outfall No	Lat/Log	Description

Weather Conditions (circle one): Clear Cloudy/Overcast Light Drizzle/Sleet Rainy/Stormy

note: inspections should only be conducted during dry conditions

Results/Observations (circle one): Dry (or no discharge) Discharge present Cannot Determine (explain)

(Can not determine could be selected if a pipe is submerged in a creek or water body, or if the end of pipe is not physically visible)

Comments:

OUTFALL CHARACTERIZATION TABLE

DFW

Describe the drainage area the outfall supports (circle one) Developed Undeveloped

If Developed, conduct an upstream exterior survey of all upstream facilities. List all facilities with storm sewer connections or surface flows discharging to the outfall. Identify all potential non-storm water flows associated with each facility (i.e. irrigation systems, condensate lines).

Facility Name/Type	Address	Potential Non-Storm Water Discharges
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		

If the area is undeveloped and a discharge is observed from the outfall, an upstream survey must be conducted to identify the source of the discharge. Describe observations in comments section below. If no visible sources are identified, flows may be attributed to groundwater if water samples are collected and analyzed for common pollutants.

Comments:

List any potential illicit connections or non-allowable non-storm water discharges:

IDDE OUTFALL INSPECTION FORM

DFW

SECTION 1: BACKGROUND DATA

Inspected By:	Time:	Date:
Outfall Number:	Associated Watershed:	
Air Temperature(˚F):	Latitude:	Longitude:

Weather Conditions (select one): ☐ Clear ☐ Cloudy/Overcast ☐ Light Drizzle/ Sleet ☐ Rainy/Stormy

LAND USE IN DRAINAGE AREA (Check all that apply)

☐ Industrial ☐ Open Space

☐ Commercial ☐ Municipal

SECTION 2: OUTFALL DESCRIPTION

LOCATION:

☐ Closed Pipe ☐ Open Drainage ☐ Other

DIMENSIONS (feet or inches):

MATERIAL:

☐ RCP ☐ PVC ☐ Steel ☐ Other

SHAPE:

☐ Round ☐ Square ☐ Other

☐ Single ☐ Double ☐ Triple ☐ Other

SUBMERGED:

In Water: ☐ No ☐ Partially ☐ Fully

With Sediment: ☐ No ☐ Partially ☐ Fully

COMMENTS: (Can not determine could be selected if a pipe is submerged in a creek or water body, or if the end of pipe is not physically visible)

FLOW:

☐ Dry (or no discharge) ☐ Discharge present ☐ Cannot Determine (explain)

FLOW DESCRIPTION:

☐ Trickle ☐ Moderate ☐ Substantial

IDDE OUTFALL INSPECTION FORM

DFW

SECTION 3: FLOW RELATED PHYSICAL INDICATORS

INDICATOR	DESCRIPTION					RELATIVE SEVERITY INDEX (1-3)		
□ ODOR	□ None	□ Sewage	□ Fuel/ gas	□ Rancid/sour	□ Other:	□ Faint	□ Easily Detected	□ Noticible from a distance
□ COLOR	□ None	□ Clear	□ Brown	□ Gray	□ Other:	□ Faint	□ Easily Detected	□ Noticible from a distance
□ TURBIDITY	□ None		□ Slight Cloudiness	□ Cloudy	□ Opaque	□ Faint	□ Easily Detected	□ Noticible from a distance
□ FLOATABLES	□ None	□ Suds	□ Petroleum (Oil Sheen)	□ Sewage (Toilet Paper, etc)	□ Trash/Debris	□ Slight	□ Moderate	□ Excessive

SECTION 4: OUTFALL CONDITION (BIOLOGICAL INDICATORS)

CONDITION	DESCRIPTIONS			
STRUCTURE	□ Good Condition	□ Spalling, Cracking or Chipping	□ Corrosion	□ Peeling Paint
VEGETATION	□ None	□ Minimal Amount	□ Excessive	□ Inhibited

ALGAE	□ Yes	□ No	AQUATIC LIFE	□ Yes	□ No	Fish Kills?	□ Yes	□ No
			If yes, name:					

SECTION 5: ANALYTICAL DATA

FIELD TEST

	Meter ID#	Time Sample Collected:
PH:		
TEMP (C):		
DO (mg/L):		
CONDUCTIVITY (mS/cm) :		
CHLORINE (ppm):		
AMMONIA-NITROGEN (ppm):		
SURFACTANTS (ppm):		
GLYCOL (during deicing season if applicable):		

LAB ANALYSIS (IF SUFFICIENT FLOW)

□ TPH	□ COD	□ E. COLI	□ OIL & GREASE	□ AL, CU, ZN	□ OTHER		

Comments:

SECTION 6: OVERALL OUTFALL CHARACTERIZATION (NCTCOG IDDE MANUAL CLASSIFICATIONS)

■ Unlikely □ Potential (presence of two or more indicators) □ Suspect(one or more indicators) □ Obvious

Title: YSI Professional Plus (Pro Plus) Conductivity Calibration		Code Number: DQ-001.18
Functional Program Category: Data Quality	Issuing Department: Environmental Affairs Department	Effective Date: 12/11/2014

1.0 PURPOSE/SCOPE

1.1 The purpose of this Standard Operational Procedure (SOP) is to provide instruction for correctly performing conductivity calibration on a YSI Professional Plus (Pro Plus) meter.

2.0 DEPARTMENTS / PERSONS AFFECTED

2.1 Environmental Affairs Department

3.0 EQUIPMENT LIST

3.1 YSI Pro Plus meter with cable and probe module and sensors attached
3.2 Transport/calibration cup
3.3 Conductivity standard solution
3.4 Nitrile gloves
3.5 Tap water
3.6 Paper Towels
3.7 Computer
  3.7.1 Microsoft Office Access
3.8 *YSI Professional Plus User Manual*

4.0 PROCEDURE

4.1 Press the green **power** key to display the run screen.
4.2 Press the **Calibration** key to display the calibration menu screen.
4.3 Use the arrow keys to highlight the **Conductivity** selection and press ENTER. The Conductivity Calibration selection screen is displayed.
4.4 Use the arrow keys to highlight the **Specific Conductance** selection and press ENTER.
  4.4.1 Rinse the conductivity/temperature sensor with a small amount of conductivity standard that can be discarded.
  4.4.2 Pour approximately 55mL of conductivity standard (enough to fully immerse the conductivity/temperature probe) into a clean, dry or pre-rinsed (with conductivity standard) transport/calibration cup.
  4.4.3 Carefully immerse the sensor end of the probe module into the solution in the calibration cup, making sure the probe is completely immersed past the vent hole.
  4.4.4 Gently rotate and/or move the probe module up and down to remove any air bubbles from the conductivity cell.
  4.4.5 Screw the transport/calibration cup on the threaded end of the probe module and securely tighten. Do not over-tighten as this could cause damage to the treaded portions.
4.5 Use the arrow keys to choose the **SPC-mS/cm** units and press ENTER.

4.6 Highlight **Calibration value** and press ENTER

4.7 Use the keypad to enter the calibration value of the conductivity standard being used. Be sure to enter the value in mS/cm at 25°C.

4.8 Allow at least one minute for temperature equilibration before proceeding. The current values of all enabled sensors will appear on the screen and will change with time as they stabilize.

4.9 Observe the reading under Specific Conductance. When the reading shows no significant change for approximately 30 seconds, use the arrow keys to highlight **Accept Calibration** and press ENTER.

4.10 Press the **Calibration** key to complete the calibration.

4.11 Enter the calibration in the "Service Log" of the *Equipment Maintenance and Calibration Log* database.

4.12 Unscrew transport/calibration cup from probe module.

4.12.1 Rinse the transport/calibration cup with tap water.

4.12.2 Rinse the probe module with tap water and gently pat dry.

4.13 Pour approximately 1/4 to 1/2 inch of tap water into transport/calibration cup and gently tighten on the probe module for transportation and/or short term storage.

4.14 Refer to the *YSI Professional Plus User Manual* if additional instruction is needed.

5.0 RESPONSIBILITIES

5.1 **Environmental Affairs Personnel.** It is the responsibility of Environmental Affairs personnel to calibrate environmental equipment prior to monitoring, following proper calibration procedures to ensure accuracy in water quality readings and data integrity.

6.0 DEFINITIONS

6.1 **CONDUCTIVITY (SPECIFIC CONDUCTANCE).** A measure of the electrical current-carrying capacity, in micromhos/cm, of 1cm^3 of water at 25°C. Dissolved substances in water dissociate into ions with the ability to conduct electrical current. Specific conductance is a measure of salinity in water. Salty water has high specific conductance.

6.2 ***EQUIPMENT MAINTENANCEAND CALIBRATION LOG.*** Microsoft Office Access database for recording environmental sampling and monitoring equipment inventory, calibration, maintenance and repair records.

7.0 FORMS AND REFERENCES

7.1 ***Equipment Maintenance and Calibration Log (Microsoft Office Access database).*** Located in the S: Drive at S:\Access\Equipment Maintenance and Calibration Log.mdb

7.2 ***YSI Professional Pro User Manual.*** Electronic version located in the S: drive at ..\..\..\Equipment Operating Manuals\YSI-ProPlus-User-Manual-RevD.pdf

8.0 REVISION HISTORY

8.1 06/12/13 Original Document

8.2 12/11/14 Revised

APPROVAL FOR STANDARD OPERATIONAL PROCEDURE:

____
Vice President, Environmental Affairs

Title: YSI Professional Plus (Pro Plus) Dissolved Oxygen Calibration		Code Number: DQ-001.19
Functional Program Category: Data Quality	Issuing Department: Environmental Affairs Department	Effective Date: 12/11/2014

1.0 PURPOSE/SCOPE

1.1 The purpose of this Standard Operational Procedure (SOP) is to provide instruction for correctly performing dissolved oxygen (DO) calibration on a YSI Professional Plus (Pro Plus) meter. This procedure calibrates DO in percent (%) water saturated air. Calibrating DO in % automatically calibrates DO in mg/L as well.

2.0 DEPARTMENTS / PERSONS AFFECTED

2.1 Environmental Affairs Department (EAD)

3.0 EQUIPMENT LIST

3.1 YSI Pro Plus meter with cable and probe module and sensors attached
3.2 Transport/calibration cup
3.3 Tap water
3.4 Computer
  3.4.1 Microsoft Office Access
3.5 *YSI Professional Plus User Manual*

4.0 PROCEDURE

4.1 Press the green **power** key to display the run screen.
4.2 Place approximately 1/8 inch of tap water in the bottom of the transport/calibration cup.
4.3 Carefully place the probe module into the transport/calibration cup. Make sure that the DO and temperature sensors are NOT immersed in the water, and that there are no water droplets on the DO membrane or temperature sensor.
4.4 Screw the transport/calibration cup onto the probe module, then disengage one or two threads to ensure the DO sensor is vented to the atmosphere.
4.5 Allow approximately ten minutes for the air in the transportation/calibration cup to become water saturated and for the temperature to equilibrate before proceeding. The current values of all enabled sensors will appear on the screen and will change with time as they stabilize.
  4.5.1 From the computer, open the Microsoft Access Database located in the S: Drive, then open the *Equipment Maintenance and Calibration Log* database file located in the Access folder.
  4.5.2 Click on the "Service Log" button to open the calibration form. Record Name, Date, Time, Equipment I.D., and the Type of Service in the Main Form section of the "Service Log". (Refer to *SOP DQ-001.15, Equipment Calibration and Maintenance Log* for complete instructions on entering calibration data.)
  4.5.3 Obtain the true (uncorrected) barometric pressure reading in inches from the barometer located in the EAD laboratory.

4.5.4 In the "DO Calibration for Water Saturated Air" Sub Form, record the true barometric pressure reading in the "Barometric Pressure Uncorrected in Inches" field and press "Enter".

4.5.5 The "Barometric Pressure Uncorrected in millimeters" field will automatically be replaced by the true barometric pressure reading converted to mm Hg.

4.5.6 Record the temperature displayed on the screen of the YSI Pro Plus meter in the "Temperature of Standard" field and press "Enter". The "Value of Standard" field will automatically be filled with the corrected DO value.

4.5.7 Record the current DO reading in mg/L from the YSI Pro Plus meter in the "Initial Reading" field of the Sub Form.

4.6 On the YSI Pro Plus meter, proceed with the following:

4.6.1 Press the **Calibration** key to display the calibration menu screen.

4.6.2 Use the arrow keys to highlight the **DO** selection. Press the ENTER key.

4.6.3 Use the arrow keys to highlight the **DO%** selection. Press the ENTER key.

4.6.4 The "Calibrate DO" screen is displayed, with the internal **Barometer** reading displayed in brackets at the top of the display.

4.6.5 If the **Barometer** reading displayed on the meter matches the reading in the "Barometric Pressure Uncorrected in millimeters" field of the DO Calibration Sub Form, proceed to 4.6.6. If the **Barometer** reading is incorrect (does not match the calculated reading in the "Barometric Pressure Uncorrected in millimeters" field of the DO Calibration Sub Form, from section 4.6.4 above, the meter's barometer can be calibrated by proceeding with the following:

4.6.5.1 Use the arrow keys on the YSI Pro Plus meter to highlight the **Barometer** reading displayed in brackets. Press the ENTER key.

4.6.5.2 Use the alpha/numeric keypad and the arrow keys to enter the correct barometer reading (from step 4.5.5), then highlight **<<<<ENTER>>>>** on the display, and press the ENTER key to return to the "Calibrate DO" screen.

4.6.6 Wait for the Temperature and DO% values under "Actual Readings" to stabilize, then use the arrow keys to highlight "Accept Calibration", and press the ENTER key (or press the **ESC** key to cancel the calibration).

4.6.7 Record the DO reading in mg/L from the YSI Pro Plus meter in the "Calibrated To" field of the DO Calibration Sub Form.

4.7 Rinse the probe module with tap water and gently pat dry.

4.8 Keep approximately 1/4 to 1/2 inch of tap water in the transport/calibration cup and gently tighten on the probe module for transportation and/or short term storage.

4.9 Refer to the *YSI Professional Plus User Manual* if additional instruction is needed.

5.0 RESPONSIBILITIES

5.1 **Environmental Affairs Personnel.** It is the responsibility of each Environmental Affairs personnel member to:

5.1.1 Calibrate the environmental equipment they will be using prior to monitoring;

5.1.2 Document all calibration activities in the *Equipment Maintenance and Calibration Log* database;

5.1.3 Follow proper procedures for calibrations and documentation of calibration activities to ensure accuracy in water quality readings, data integrity, and that required maintenance for environmental equipment is conducted.

6.0 DEFINITIONS

6.1 **DISSOLVED OXYGEN (DO).** The oxygen freely available in water. Dissolved oxygen is vital to fish and other aquatic life, and for the prevention of odors. Traditionally, the level of dissolved oxygen has been accepted as the single most important indicator of a water body's ability to support desirable aquatic life.

6.2 ***EQUIPMENT MAINTENANCEAND CALIBRATION LOG.*** Microsoft Office Access database for recording environmental sampling and monitoring equipment inventory, calibration, maintenance and repair records.

6.3 **DO CALIBRATION SUB FORM.** The "DO Calibration for Water Saturated Air" Sub Form located underneath the Main Form of Service Log in the *Equipment Maintenance and Calibration Log* database.

6.4 **mm Hg.** Millimeters of mercury; a unit of pressure.

7.0 FORMS AND REFERENCES

7.1 ***Equipment Maintenance and Calibration Log (Microsoft Office Access database).*** Located in the S: Drive at S:\Access\Equipment Maintenance and Calibration Log.mdb

7.2 ***YSI Professional Pro User Manual.*** Electronic version located in the S: drive at ..\..\..\Equipment Operating Manuals\YSI-ProPlus-User-Manual-RevD.pdf

8.0 REVISION HISTORY

8.1	06/13/13	Original Document
8.2	12/11/14	Revised

APPROVAL FOR STANDARD OPERATIONAL PROCEDURE:

____

Vice President, Environmental Affairs

Title: YSI Professional Plus (Pro Plus) pH Calibration		Code Number: DQ-001.20
Functional Program Category: Data Quality	Issuing Department: Environmental Affairs Department	Effective Date: 12/11/2014

1.0 PURPOSE/SCOPE

1.1 The purpose of this Standard Operational Procedure (SOP) is to provide instruction for correctly performing pH calibrations on the YSI Professional Plus (Pro Plus) meter. This procedure provides instruction for a **2-point** calibration using pH 7.00 and pH 10.00 buffer standards. The procedure can be used for a **1-point** calibration by omitting sections 4.7 through 4.12. A **1-point** calibration should only be conducted if adjusting a **2-point** calibration that had been performed within the same week.

2.0 DEPARTMENTS / PERSONS AFFECTED

2.1 Environmental Affairs Department (EAD)

3.0 EQUIPMENT LIST

3.1 YSI Pro Plus meter with cable and probe module and sensors attached
3.2 Transport/calibration cup
3.3 pH Buffer Standards (pH 7.00 and pH 10.00)
3.4 Nitrile gloves
3.5 Tap water
3.6 Paper Towels
3.7 Computer
3.7.1 Microsoft Office Access
3.8 *YSI Professional Plus User Manual*

4.0 PROCEDURE

4.1 Press the green **power** key on the YSI Pro Plus meter to display the run screen.
4.2 Press the **Calibration** key to display the calibration menu screen.
4.3 Use the arrow keys to highlight the **ISE1 (pH)** selection. Press the ENTER key.
4.4 Pour approximately 30mL of pH 7.00 buffer standard into a transport/calibration cup that is clean and dry, or pre-rinsed with pH 7.00 buffer standard,.
4.5 Place the probe module in the pH 7.00 buffer standard, ensuring that the pH sensor is fully immersed. The meter should automatically recognize the buffer value and display it at the top of the calibration screen.
4.5.1 From the computer, open the Microsoft Access Database located in the S: Drive, then open the *Equipment Maintenance and Calibration Log* database file located in the Access folder.
4.5.2 Click on the "Service Log" button to open the calibration form. Record Name, Date, Time, Equipment I.D., and the Type of Service in the Main Form section of the "Service Log". (Refer to *SOP DQ-001.15, Equipment*

Calibration and Maintenance Log for complete instructions on entering calibration data.)

4.5.3 In the pH Calibration SUB FORM, select the value of the pH buffer solution being used for the point 1 calibration (7.00) or the point 2 calibration (10.00) from the "pH Standard" drop-down menu box.

4.5.4 In the "Temperature of Standard" field of the SUB FORM, record the temperature that is displayed on the YSI Pro Plus meter **Calibrate ISE1 (pH)** screen. Press the computer's "Enter" key, and the correct calibration value of standard will then be displayed in the "Value of Standard" field.

4.5.4.1 If the **Calibration Value** displayed on the YSI Pro Plus meter is incorrect (doesn't match the "Value of Standard" on the SUB FORM), highlight the **Calibration Value** on the meter and press ENTER to input the correct value

4.5.4.2 Use the alpha/numeric keypad and the arrow keys to enter the correct calibration value, then highlight **<<<<ENTER>>>>** on the display and press the ENTER key to return to the **Calibrate ISE1 (pH)** screen.

4.6 Wait for the Temperature and pH values under "Actual Readings" to stabilize, then use the arrow keys to highlight "Accept Calibration", and press the ENTER key (or press the **ESC** key to cancel the calibration).

4.6.1 If not continuing with a 2nd calibration point, press the **Calibration** key to complete the calibration and record it in the YSI Pro Plus meter. Then skip to steps 4.13 through 4.16.

4.7 Continue with the 2nd calibration point by rinsing the probe module, sensors and transport/calibration cup in tap water. Shake off excess water, then rinse with a small amount of pH 10 buffer standard.

4.8 Pour approximately 30mL of pH 10.00 buffer standard into the transport/calibration cup.

4.9 Place the probe module in the 10.00 buffer standard. The meter should automatically recognize the buffer value and display it at the top of the calibration screen.

4.10 On the computer in the pH Calibration SUB FORM (*Equipment Maintenance and Calibration Log* database), click on the "Next Standard" button.

4.11 Follow steps 4.5.3 through 4.6 to complete the point 2 calibration.

4.12 Be sure to complete and record the entire calibration by pressing the **Calibration** key on the YSI Pro Plus meter when finished calibrating.

4.13 On the computer, click on the "Close and Save" button on the *Equipment Maintenance and Calibration Log* database Service Log to save calibration record.

4.14 Thoroughly rinse the probe module, sensors, and transport/calibration cup in tap water.

4.15 Pour approximately 1/4 to 1/2 inch of tap water into transport/calibration cup and gently tighten on the probe module for transportation and/or storage.

4.16 Refer to the *YSI Professional Plus User Manual* if additional calibration instruction is needed.

5.0 RESPONSIBILITIES

5.1 **Environmental Affairs Personnel.** It is the responsibility of each Environmental Affairs personnel member to:

5.1.1 Calibrate the environmental equipment they will be using prior to monitoring;

5.1.2 Document all calibration activities in the *Equipment Maintenance and Calibration Log* database;

5.1.3 Follow proper procedures for calibrations and documentation of calibration activities to ensure accuracy in water quality readings, data integrity, and that required maintenance for environmental equipment is satisfied.

6.0 DEFINITIONS

6.1 **pH.** The hydrogen-ion activity of water caused by the breakdown of water molecules and presence of dissolved acids and bases.

6.2 ***EQUIPMENT MAINTENANCE AND CALIBRATION LOG.*** Microsoft Office Access database for recording environmental sampling and monitoring equipment inventory, calibration, maintenance and repair records.

7.0 FORMS AND REFERENCES

7.1 ***Equipment Maintenance and Calibration Log (Microsoft Office Access database).*** Located in the S: Drive at S:\Access\Equipment Maintenance and Calibration Log.mdb

7.2 ***YSI Professional Pro User Manual.*** Electronic version located in the S: drive at ..\..\..\Equipment Operating Manuals\YSI-ProPlus-User-Manual-RevD.pdf

8.0 REVISION HISTORY

8.1 06/13/09 Original Document

8.2 12/11/14 Revised

APPROVAL FOR STANDARD OPERATIONAL PROCEDURE:

____
Vice President, Environmental Affairs

DFW INTERNATIONAL AIRPORT
Environmental Affairs Department
Standard Operational Procedure

Title: Watershed Management Monthly Sampling Events		Code Number: WSM-001.01
Functional Program Category: Watershed Management	Issuing Department: Environmental Affairs Department	Effective Date: 06/27/2016

1.0 PURPOSE/SCOPE

1.1 The purpose of this procedure is to provide detailed descriptions for Watershed Management monthly sampling events. Monthly sampling events are performed for the Watershed Management program to document and assess surface water conditions at DFW Airport,, contribute data for statewide water assessment, and to measure the effectiveness of EAD's Best Management Practices (BMP).

2.0 DEPARTMENTS / PERSONS AFFECTED

2.1 Environmental Affairs Department

3.0 EQUIPMENT LIST

3.1 YSI Professional Plus Meter
3.2 Watershed Field Sheet
3.3 Nitrile Gloves
3.4 Cooler with ice
3.5 Sample containers (proper type, size and preservative)
3.6 Sample container labels
3.7 Sharpies/pens
3.8 Watch/Clock
3.9 Chain of Custody

4.0 PROCEDURE

4.1 <u>Sampling locations and sampling frequencies</u>

4.1.1 There are six fixed monitoring stations established for the Watershed Management program. These monitoring stations are located on surface waters located on Airport property, including:

- Two stations on the main stem of Bear Creek (BC-1 and BC-2)
- One station on Grapevine Creek (GV-2)
- One station on Cottonwood Creek (CW-2)
- One station on Mud Springs Creek after the confluence of Hackberry Creek (MS-1)
- One station on South Fork Hackberry Creek (SFH-1)

4.1.2 All locations for monitoring stations can be referenced with the 2014 *Watershed Sites Map* attached to this document and located at S:\Watershed Mgmt\Maps\Watershed Sites-PDF.pdf

4.1.3 All fixed monitoring stations are sampled on a monthly basis when applicable.

4.1.4 A sampling event should be scheduled approximately the same time every month. Flexibility has been incorporated into scheduling watershed sampling events to address emergency or regulatory based incidents, which may take precedence.

4.2 Water Quality Monitoring

4.2.1 YSI meter should be calibrated in the lab prior to field use. Refer to the YSI Professional Plus Water Quality Meter (YSI meter) *Equipment Instruction* documents for calibration procedures (*EQUIP.06-09*) or consult the instruction manual for calibration instructions.

4.2.2 Parameters that will be documented and/or measured include:
- Date and time
- dissolved oxygen
- pH
- water temperature
- specific conductance

4.2.3 Upon site arrival, the meter should be powered on and submerged with sensor guard for at least fifteen minutes before any data measurements are taken. Water quality data can be hand written on the field form at the site or stored on the meter and transferred later.

4.2.4 Along with meter data, note the depth of the meter sensor, local weather conditions, habitat information, and any information requested on the field form at the time of site visit.

4.3 Sampling Techniques

4.3.1 Sampling practices should adhere to the guidelines set forth in TCEQ's *Surface Water Quality Monitoring Procedures, Volume 1.*

4.3.2 Sample kits arrive upon request from ALS Environmental Laboratories with all sampling containers and preservatives.

4.3.3 Unpreserved sampling containers should be lowered several inches below the surface of the water when collecting a sample to avoid collecting any surface film. A triple rinsed non-preserved stainless steel bucket/cup can be used to collect water and pour it into containers that contain preservatives. The containers should not be filled to the top to avoid the loss of preservative.

4.3.4 Containers (40 milliliter VOAs) used to collect samples for volatile organic compounds should be filled to the top leaving zero head space.

4.3.5 Sampling containers should be labeled appropriately with the following information included:
- Sampling Identification
- Sample Project
- Sampler's Name
- Date & Time
- Preservative
- Analysis

4.3.6 Properly complete the appropriate Chain of Custody and custody seals to accompany the samples.

4.3.7 The water samples should be stored in an ice chest filled with ice and kept at a standard temperature of 4° Celsius, per EPA protocol.

4.4 Sampling Parameters

4.4.1 Sampling parameters were selected to screen pollutants associated with Airport activities and model parameters sampled for State and Federal surface water quality classification.

4.4.2 Current sampling parameters, preservatives, and testing methods are listed below:

Parameter	Preservative	Method
Total Petroleum Hydrocarbons	HCL	Texas1005
8 RCRA Metals by total digestion	HNO3	EPA 200.8
Mercury	HNO3	EPA 245.1
Zinc	HNO3	EPA 200.8
Copper	HNO3	EPA 200.8
Nickel	HNO3	EPA 200.8
Biochemical Oxygen Demand	ICE	SM 5210B
Chemical Oxygen Demand	H2S04	EPA 410.4
Total Kjeldahl Nitrogen	H2SO4	SM 4500
Nitrate	H2SO4	EPA 300
Nitrite	ICE	EPA 300
Orthophosphate	H2SO4	EPA365.3
Total Phosphate	H2SO4	EPA365.3
Chlorophyll A	ICE	Chrophyll A
E.Coli	ICE	IDEXX Quanti-Tray/2000
Chloride	ICE	SM 300.3
Sulfate	ICE	EPA 300.3
Ammonia	H2SO4	SM 4500
Ethylene and Propylene Glycol	ICE	EPA 8015M

4.5 Discharge/Profile

4.5.1 Discharge measurements should be taken on a quarterly basis to fulfill Clean Rivers Program requirements.

4.5.2 See *SOP WSM-001.03 Surface Water Discharge Measurements* for discharge measurement and calculation.

5.0 RESPONSIBILITIES

5.1 **Environmental Operations Analyst.** It is the responsibility of the Environmental Operations Analyst to coordinate regular sampling/monitoring events, and perform equipment maintenance and set-up.

5.2 **Environmental Affairs Project Manager.** It is the responsibility of the Environmental Project Manager overseeing the Watershed Management Program to review and edit field reports, analytical reports, and special study reports.

6.0 DEFINITIONS

6.1 **VOLATILE ORGANIC COMPOUNDS.** Organic compounds that can evaporate at normal temperature and pressure

6.2 **INTERSEASONAL.** Representation from all four seasons with a range of temperatures and varying stages of stream flow.

6.3 **EDDY CURRENT (EDDIES).** A circular water movement formed beside a main current or when the current passes an obstruction such as a log or rock. An eddy current moves upstream.

7.0 FORMS AND REFERENCES

7.1 ***Watershed Sites Map.*** Located on the S: Drive at S:\Watershed Mgmt\Maps\Watershed Sites-PDF.pdf

7.2 ***EQUIP.06-09.*** Located in the S: Drive at S:\Equipment Operating Manuals\Equipment Instruction Documents

7.3 ***WSM-001.03 Surface Water Discharge Measurements.*** Located on the S: Drive in the "Current Departmental Procedures" folder

7.4 ***Watershed Management Field Data Form.*** Located in the S: Drive at S:\Watershed Management\WS Field Data Sheet.pdf

7.5 ***Surface Water Quality Monitoring Procedures, Volume 1.*** Located in the S: Drive at S:\Watershed Mgmt\CRP\SWQM\swqmp_V1.pdf

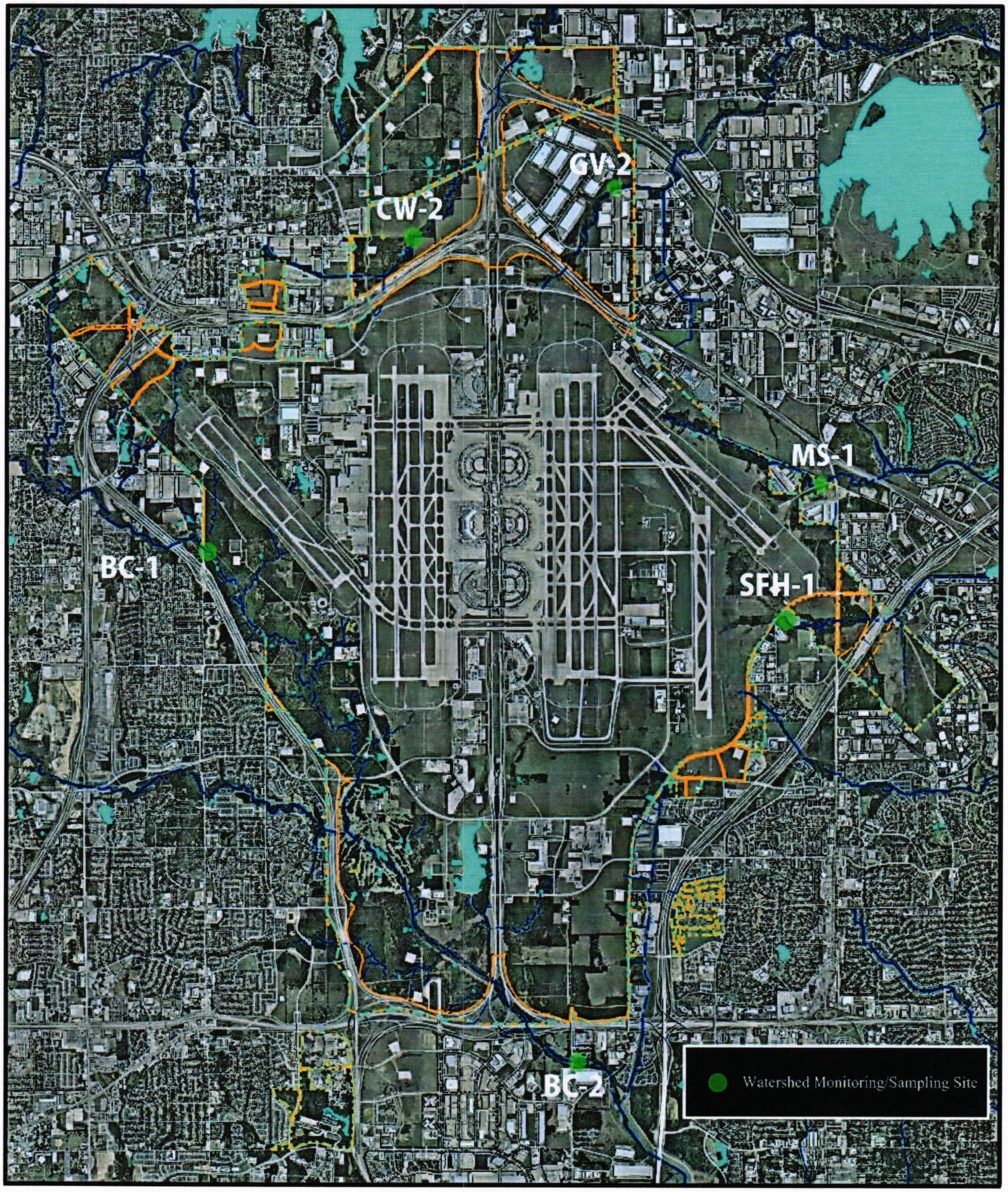
8.0 REVISION HISTORY

8.1	07/15/09	Original Document
8.2	09/09/10	Revision
8.3	01/08/15	Revision
8.4	06/27/16	Updated Methods Table, Forms and References, and branding format

APPROVAL FOR STANDARD OPERATIONAL PROCEDURE:

Rhett Hunt 06/29/2016

Vice President, Environmental Affairs Date



Watershed Management Site Location Map DFW International Airport Environmental Affairs Department	DFW

Title: Surface Water Discharge Measurements		Code Number: WSM-001.03
Functional Program Category: Watershed Management	Issuing Department: Environmental Affairs Department	Effective Date: 06/28/2016

1.0 PURPOSE/SCOPE

1.1 The purpose of this procedure is to provide detailed instructions/guidelines for performing flow and/or discharge measurements at the designated monitoring sites associated with the Watershed Management program. Discharge measurements are used to calculate the volume of water that passes through a cross section of a stream or river within a certain time frame. Flow measurements for Watershed Management are performed to measure the speed and quantity of water flowing in a stream which has direct effects on the pollutant loading and overall water quality.

2.0 DEPARTMENTS / PERSONS AFFECTED

2.1 Environmental Affairs Department

3.0 EQUIPMENT LIST

3.1 Rubber boots/hip waders/chest waders
3.2 Top-setting wading rod
3.3 Ott MF Pro Flow Meter and Sensor
3.4 Stop watch
3.5 Floatable objects (wood chips)
3.6 Engineer 100 foot reel tape measure (with gradations every tenth of a foot)
3.7 Large Screwdriver/Stake

4.0 PROCEDURE

4.1 <u>Discharge Measurements with the Ott MF Pro</u>

4.1.1 The Ott MF Pro (updated version of the Marsh/McBirney flow mate) is a piece of equipment consisting of two parts: the handheld meter, and the electromagnetic sensor . The electromagnetic probe uses electrical impulses created by opposing magnets in the probe to measure velocity. Full depth and 60% depth of the stream can be achieved by either reading the wading rod, or, as will be described here, by using the MF Pro's built-in depth sensor (consult the *Surface Water Quality Monitoring Procedures Vol. 1* for usage of the wading rod).

4.1.2 The MF Pro flow meter is used to perform stream/channel measurements in areas where the stream or river has enough depth to completely submerge the flow sensor, approximately 1.0 inch.

4.1.3 This SOP details use of the MF Pro; refer to the *Surface Water Quality Monitoring Procedures, Volume 1* for site selection criteria and number of cross-sections (usu. 0.5' increments).

4.1.4 Follow these steps using the MF Pro to collect profile/discharge measurements:

The MF Pro can be used to store data per station, per site; no field form is required for data collection during discharge measurements.

1. Power on the unit and select OK when the self-check is complete.
2. From the main menu, select 'Profiler' and enter operator name. Select OK and select 'Stream', select OK again.
3. Enter a name for the stream profile, select OK.
4. Enter '560' (local elevation) for stage reference, select OK.
5. Enter the stream width value as the tape reads, without compensation for dry land (no 'burned' distance), select OK.
6. Enter the tagline offset value of the tape ('burned' distance) to compensate for dry land included in the original reading for stream width from step 5, select OK.
7. Estimate the number of desired stations from above, enter number of stations, select OK.
8. The next screen will be the menu for station 1, which will be the left edge of water (LEW); select 'edge/obstruction and select 'left'. This will set the distance, depth, and velocity at zero. Select 'next'.
   *This will also apply to the final station with the right edge of water.
9. For all remaining stations (except for the final station), select 'edge/obstruction' and 'open water'.
10. Select 'Dist. to vertical'. Position the flow sensor at the prompted distance, as it reads on the tape. Select OK.
11. Select 'Set Depth' and lower the wading rod/sensor to the lowest position, i.e. the maximum depth. Select OK.
12. Select 'Measure Velocity'>'One point'>0.6. Raise the wading rod to the prompted value using the on-screen graphic. This will set the depth of the sensor to 60% of the total depth. Hold the sensor still and Select OK. Wait for the sensor to collect a flow measurement. If a misrepresentative value is given, select 'Repeat', otherwise, select OK. Select 'Main'.
13. Select 'Next' and repeat steps 9-12 until the final station. For the final station, repeat step 8; instead of selecting left under the 'edge/obstruction' menu, select 'right' edge of water.
14. When all stations are complete, select 'Save Data and Exit', and follow the on-screen menus for saving the file.

4.1.5 The information stored in the MF Pro during the discharge measurement is saved in a tab separated file (.tsv) that can be later entered into a spreadsheet or database. (Discharge information can be calculated in the field by multiplying width and depth to get the area. Then multiply area with the velocity reading to get the discharge. Q(discharge)=V(velocity) x A(area). Q=VA

4.2 <u>Averaged Time Discharge Measurements – Low Flow Measurements</u>

4.2.1 Averaged time measurements are performed in areas where the water is less than 1.0" in depth, less than 5' in width, or any other conditions that would limit an effective measurement with the Ott MF Pro flow meter.

4.2.2 The materials needed for an average time measurement include three floatable objects of the same size and shape (wood chips), a stopwatch, an engineering measuring tape, and a field form.

4.2.3 Follow these steps for performing an average time measurement:

1. Measure the length, width, and depth of a stream reach so the area can be calculated. Look for laminar flow in the reach to measure flow

readings. The length should be at least 20.0', when possible. This same area will be used to perform all three timed measurements.

2. Float the object down the middle of the stream for the entire length of the measured area and record the time to 0.01 of a second. Repeat this process twice for a total of three measurements.
3. Discharge information can be calculated by dividing the length by the three recorded times to get three velocity reading. Each of the velocity readings are then multiplied by the area to get discharge. The three discharge values are averaged to get the final discharge value. $Q_{ave}=[(V_1*A)+(V_2*A)+(V_3*A)]/3$

4.3 High Flow and No Flow Conditions

4.3.1 Do not attempt flow measurements during high flow conditions or adverse weather due to safety concerns. For purposes of the Watershed Management Program, high flow is considered a stream depth which, in the center of the channel, is greater than the hips of the field technician. Swift moving water only a few feet deep can present hazards.

4.3.2 An average time measurement can be performed during high flow conditions if the depth can be measured from the middle of the channel. In some circumstances, a depth measurement can be made from a bridge.

4.3.3 During no flow scenarios, field technicians are still required to fill out the field form appropriately, indicating flow severity value, weather conditions, and stream characteristics.

5.0 RESPONSIBILITIES

5.1 **Environmental Operations Analyst.** It is the responsibility of the Watershed Management program analyst to manage and coordinate monthly monitoring and sampling events, which include conducting discharge measurements at monitoring sites. The Environmental Operations Analyst is also responsible for equipment maintenance and calibration, assembling sample equipment, and completing laboratory analytical and field form data entry.

5.2 **Environmental Project Manager:** It is the responsibility of the Environmental Project Manager to review and edit water quality reports, special study reports and laboratory analytical data. In addition, the Environmental Project Manager oversees budgets and budget contracts for contract services, including Environmental Laboratory contracts and contracts for special studies.

6.0 DEFINITIONS

6.1 **EDDY CURRENT (EDDIES).** A circular water movement formed beside a main current or when the current passes an obstruction such as a log or rock. An eddy current moves upstream

6.2 **WETTED PERIMETER.** Portion of the stream channel that consists of the left edge of water to the right edge of water

6.3 **STREAM REACH.** Length of stream to be evaluated

6.4 **PERENNIAL POOL.** An intermittent stream may have deep pools that remain after the channel is dry. These pools known as perennial pools can be significant to aquatic life.

7.0 FORMS AND REFERENCES

7.1 ***Watershed Management Field Data Form.*** Located in the S: Drive at S:\Watershed Mgmt\Forms\xXxField Data SheetxXx.xlsx

7.2 ***Watershed Sites Map.*** Located on the S: Drive at S:\Watershed Mgmt\Maps\Watershed Sites-PDF 2016.pdf

8.0 REVISION HISTORY

8.1	07/15/09	Original Document
8.2	08/18/10	Revision
8.3	01/08/15	Revision
8.4	06/28/16	Updated hyperlinks and branding format

APPROVAL FOR STANDARD OPERATIONAL PROCEDURE:

______________________________ 06/29/2016

Vice President, Environmental Affairs Date

Appendix C

DFWIA SWMP Model Methodology

This page intentionally left blank

STORMWATER MODELING METHODOLOGY REPORT

DFW DALLAS FORT WORTH INTERNATIONAL AIRPORT

October 2018

CDM Smith

Table of Contents

List of Figures

List of Tables

Appendices

Section 1

Introduction and Background

1.1 Introduction

The Dallas Fort Worth Internal Airport (DFWIA) is located in north-central Texas, between Dallas and Fort Worth, as shown in **Figure 1-1**. Since opening in 1974, the DFWIA has developed both aviation and commercial properties without a formalized stormwater drainage master plan (SDMP) and has adapted its planning, capital improvements, and operations process in an ad hoc manner. As a consequence, chronic issues have arisen such as channel/streambank erosion, sedimentation, outfall/culvert structure failures, and flooding. In particular, FEMA has not established flood insurance rate maps (FIRMs) for the majority of airport property. Until approximately 2010, new airport developments have not been required to adhere to stormwater sustainable guidelines to manage the impact of new impervious surfaces on the existing watersheds. Stormwater quality is being addressed under the Stormwater Management Program as required by Federal/State regulations, but no other aspects of watershed management, such as flood mitigation, streambank and riparian area protection and conveyance were dealt with on a strategic basis.

In order to more effectively manage current and forecasted stormwater volumes throughout the airport property, DFWIA has determined that a comprehensive Stormwater Drainage Master Plan (SDMP) for the airport is needed for cost-effective solutions to existing problems and planning and guidance for development and redevelopment of stormwater infrastructure, and how to best maintain and rehabilitate (where needed) existing infrastructure. The intent is for the SDMP to integrate with the Airport's Sustainability Master Plan developed in 2014. A companion document, in the form of a Stormwater Maintenance Management Program (Program) document will act as a guide for implementation and maintenance of the SDMP.

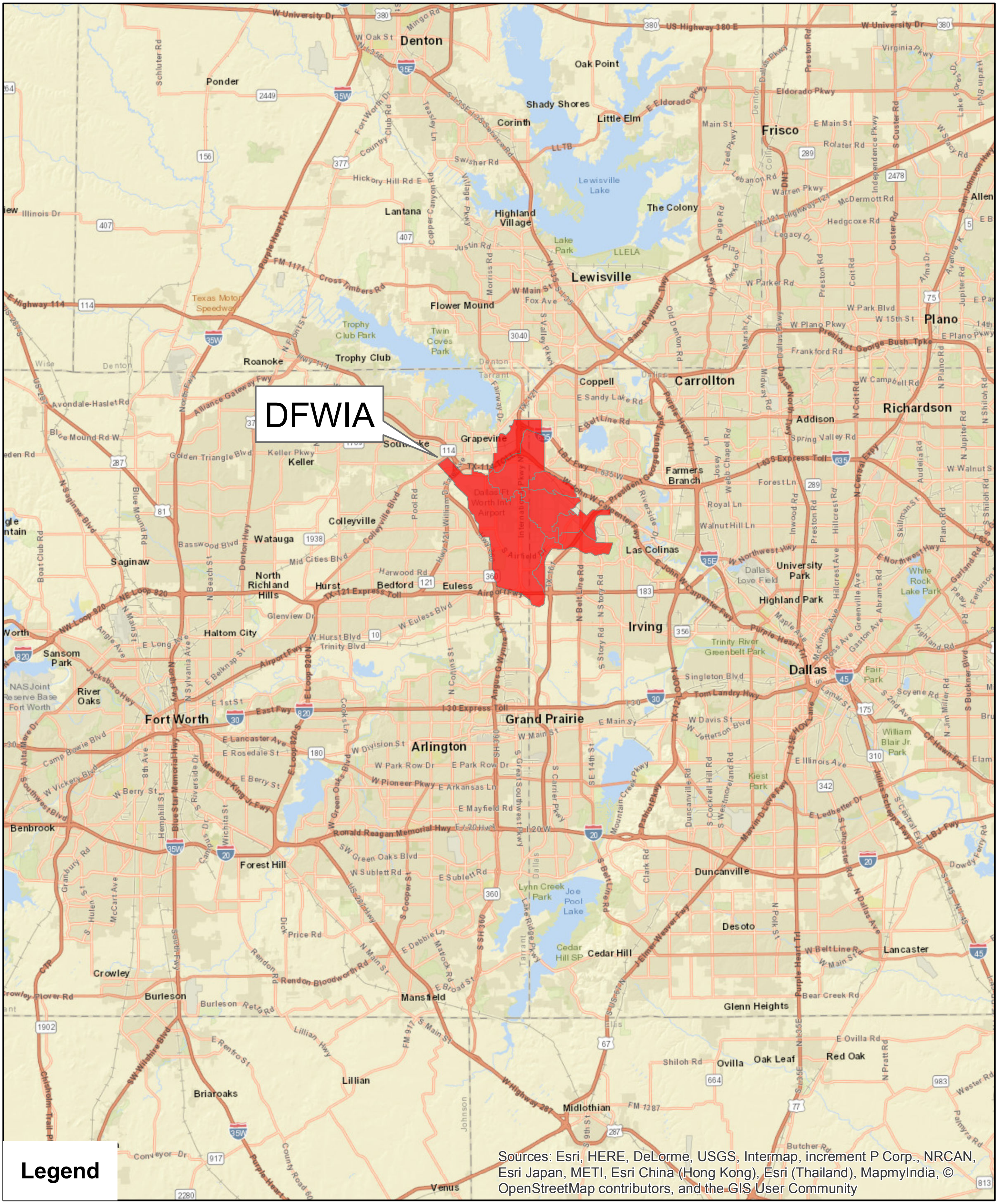
The objectives of the DFWIA SDMP are to:

1. Develop comprehensive stormwater models for the entire DFWIA property using consistent modeling software to increase level of detail, digital access and accuracy.

2. Identify stormwater management alternatives that DFWIA can implement to resolve current flooding and erosion problems and equitably manage new development.

3. Create guidance documents to regulate future development at DFWIA to manage both water quantity and the complex water quality issues of non-point source (urban runoff) pollutant loading to the area waterways.

4. Address Texas Pollutant Discharge Elimination System (TPDES) water quality requirements.



N
W
E
S

Miles
0 1 2 4 6 8

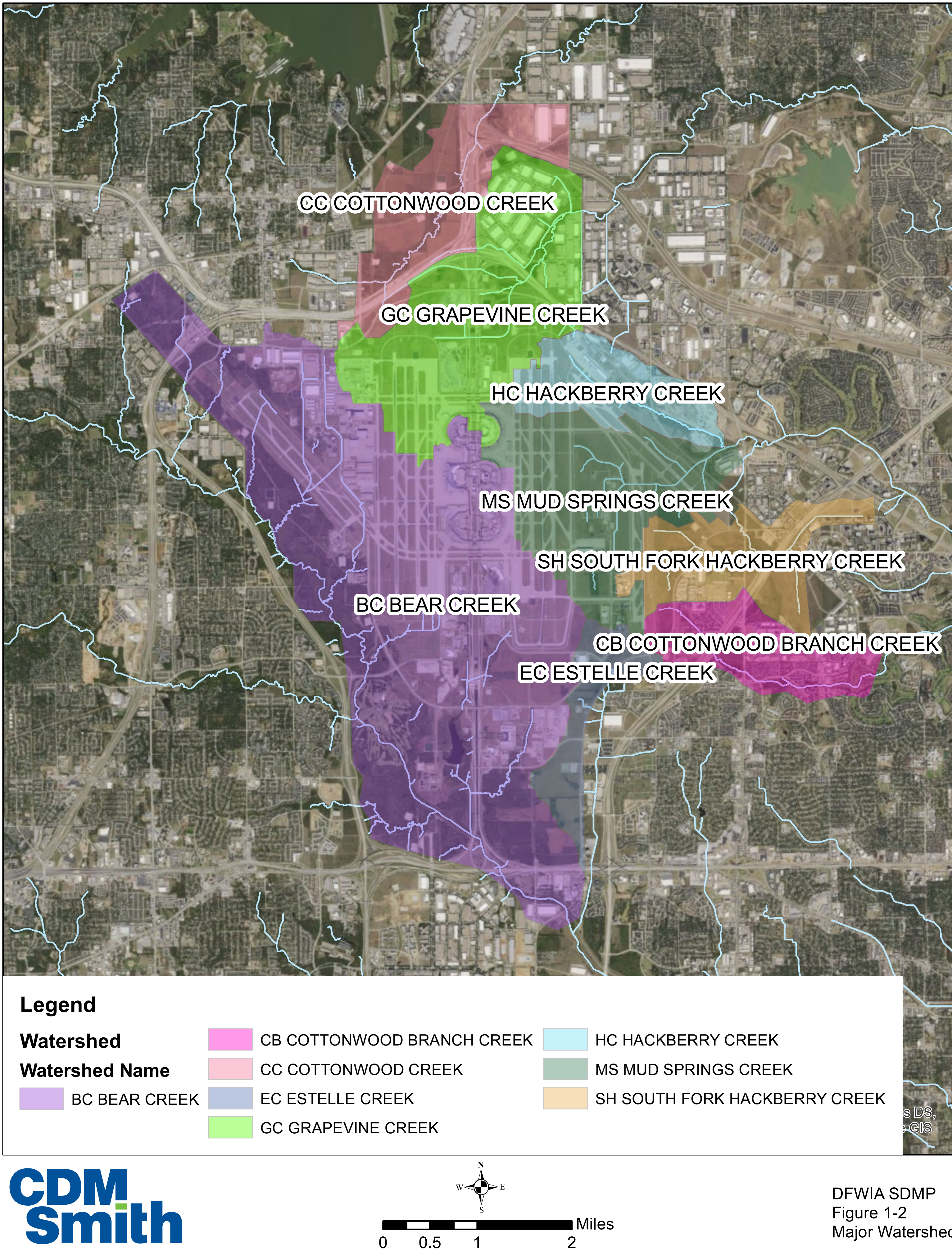
DFWIA SDMP
Figure 1-1
Project Location

The project study area encompasses the DFWIA property as well as interactions with the following municipalities:

- City of Irving;
- City of Coppell;
- City of Grapevine;
- City of Euless, and
- City of Fort Worth.

A total of 8 major watershed have been identified and are shown on **Figure 1-2**.

This Methodology Volume provides background and supplemental information on the various methodologies applied for the respective basin plans.



CDM Smith

DFWIA SDMP
Figure 1-2
Major Watersheds

1.2 Project Background

This section outlines the information to be provided in each of the watershed reports and provides references to other pertinent information that should be considered in conjunction with the information contained in the individual report sections.

1.2.1 Watershed Information

Each watershed report includes a description of the hydrologic and hydraulic parameters used to model the area. The methodology for establishing specific model input parameters such as Manning's roughness coefficients, soil types and characteristics, and impervious area percentage by land use are explained in detail in Section 3.0 of this report.

1.2.2 Existing Conditions

This section of the watershed report includes a description of current conditions within the watershed. This section is intended to provide a brief summary of existing land use and major CIP projects included in the basin.

1.2.3 Supplementary Information

In addition to the information explicitly detailed in the watershed reports, there are supplementary materials which, when used in conjunction with the SDMP report, provide additional information on flooding and water quality issues within each watershed. The following supplementary information will be referenced as applicable within each watershed report:

- Previously compiled reports
- FEMA Flood Insurance Study (FIS)
- FEMA Digital Flood Insurance Rate Maps (DFIRM)

Coincident with the development of the SDMP, CDM Smith will conduct a review of the available FIS and FIRM.

1.2.3.1 FIS

The FEMA FIS includes a description of the modeling effort used to update the special flood hazard areas within DFWIA. More importantly, the FIS includes floodway data tables, discharge tables, and flood profiles for each flooding source defined for DFWIA.

1.2.3.2 Discharge Tables

The FIS contains a Summary of Discharges table which outlines the peak discharges for each modeled flooding source within DFWIA at major cross roads. The discharge tables include peak discharges for the 10-. 50-, 100-, and 500-year storm events. Locations of discharges are noted in the tables and can be cross referenced with the DFIRM panels.

1.2.3.3 Floodway Data Tables

The FIS contains a Floodway Data Table (FDT) for each flood source identified. The FDT includes the floodway width, Base peak flow, and base peak velocity at each model node where floodway is established. Additionally, the FDT includes information on the water surface elevation both with and without floodway. Locations of nodes are can be cross referenced with the DFIRM panels.

1.2.3.4 Stream Profiles

The FIS contains a stream profile for each flood source identified. Each profile documents the water surface elevation along the length of the stream for the 10-. 50-, 100-, and 500-year storm events. Major road crossings and relevant model nodes are noted on each profile. Locations of nodes are can be cross referenced with the DFIRM panels.

1.2.4 Level of Service

Each watershed report details the exceedances of Level of Service (LOS) for water quantity, water quality, and operations and maintenance. The ability of a project to improve the LOS in a basin is the basis for project selection. The desired LOS defined for each category as well as the methodology for determining exceedances of LOS is detailed in Section 6.0 of this report. The LOS will be evaluated using the United States Environmental Protection Agency (USEPA) StormWater Management Model (SWMM), which is a public domain hydrologic, hydraulic and water quality model.

1.2.5 Alternative Evaluation

This section of the watershed report describes each alternative developed to address LOS exceedances within the watershed. Alternatives may address multiple LOS exceedances (e.g. water quantity and water quality) or may focus on a single LOS violation (e.g. water quality only) depending on the needs of the watershed and the specific alternative characteristics. Each alternative description will include a figure depicting project location, a brief description of the alternative, and a summary of the alternative's expected benefits.

In some cases, there may be multiple options available at a single project site. For example, an empty parcel may be used for dry detention or biofiltration accompanied by conveyance improvements. To evaluate which of these options best addresses LOS exceedances in the watershed, the CDM Smith team will evaluate each of the options as a separate alternative for comparison.

1.4.6 Recommended Plan

Each watershed report concludes with a description of the recommended plan for the watershed. This description includes a list of all the individual components of the recommended plan as well as a summary of its expected benefits. This information should be used during project design to ensure that detailed design results in the expected project benefits (e.g., flood stage and velocity reductions, treatment by BMPs).

Section 2

Project Nomenclature

2.1 Watersheds

For purposes of consistency and understanding, the SDMP established a specific project nomenclature to create meaning to the model IDs and project files. The SDMP project includes 8 basins, each identified by a 2-digit code as shown on **Figure 1-2**.

2.2 Hydrologic Units

Hydrologic Units (HUs) are used by SWMM to evaluate areas that directly load to the stormwater management system. To provide for consistency in naming each HU will be assigned a unique ID number and to help understand the location of the HUs, the 2-letter watershed code was added in front of each HU ID as well as the letters HU to identify the entity as a HU. Refer to hydrologic units nomenclature guidelines on **Figure 2-1**.

2.3 Nodes and Conduits

Similar to HUs, the 2-letter subbasin code was added to the front of a five digit ID for the nodes (also sometimes called junctions) and conduits. Additionally, suffixes were added when necessary to identify structures, overflows, or approximated conduits as shown in the nodes and conduits nomenclature guidelines in **Figure 2-1**. Nodes are named starting with the smallest number at the outfall and increasing in value as the nodes move upstream. Each branch within the subbasin is given its own 1000 series and conduits are named with the ID of the upstream node. More than one conduit may be needed through a structure. **Figure 2-1** displays a figure of structure overflow where one conduit goes under the roadway and a second conduit overtops the roadway. These two conduits are given suffix of S and O for the structure and overflow, respectively. Approximated conduits are given a suffix of A. These conventions as well as model input filename conventions are shown on **Figure 2-2**.

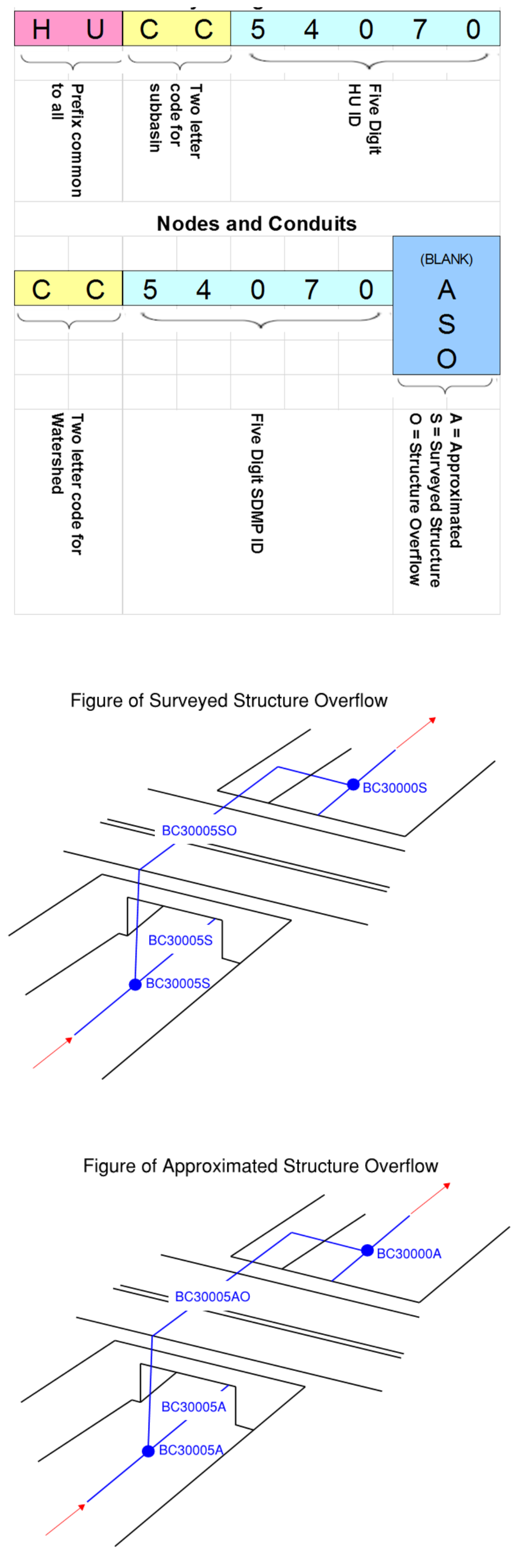


Figure 2-1 DFWIA Stormwater Drainage Master Plan Nomenclature for Model Elements

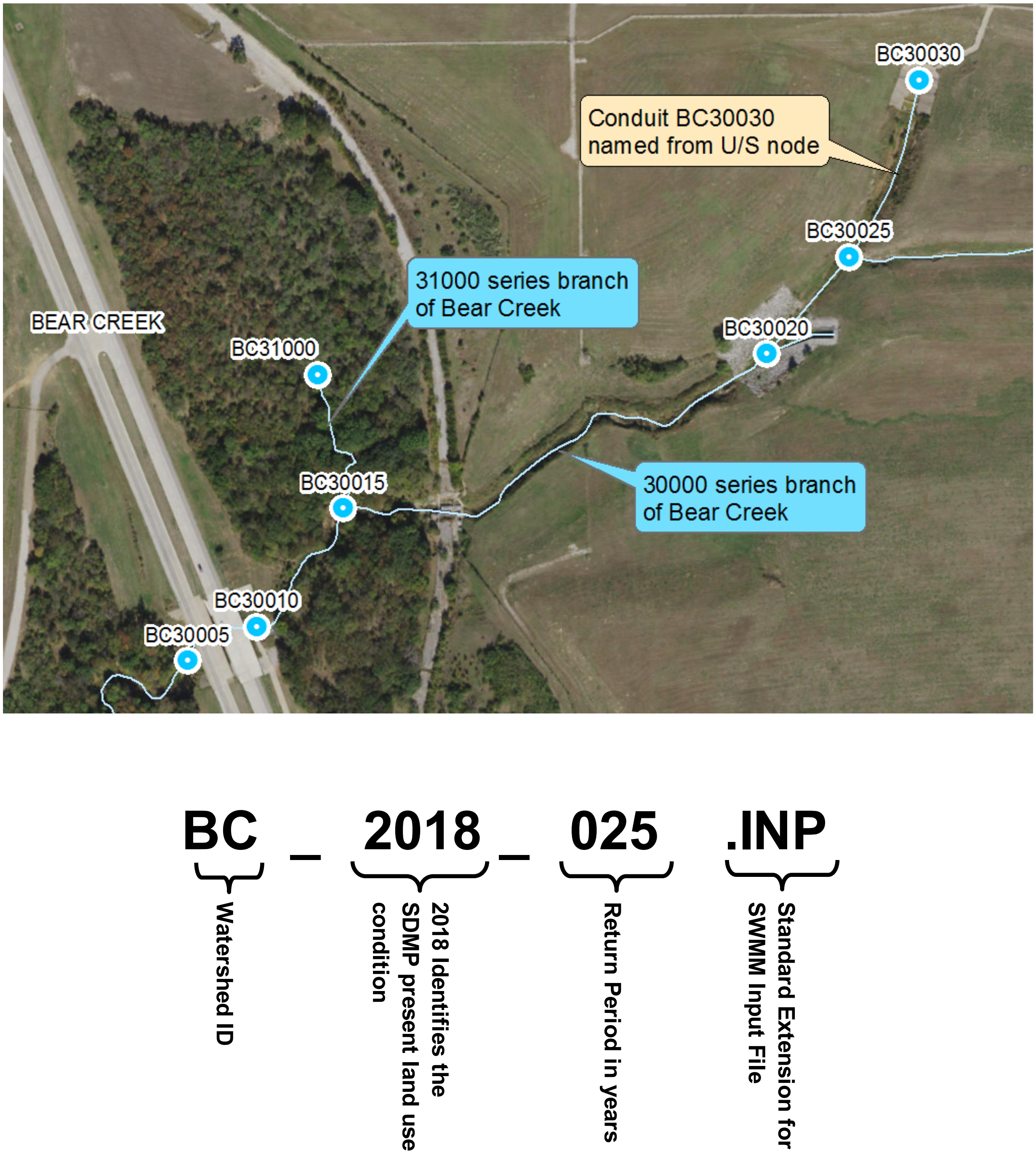


Figure 2-2 DFWIA SDMP Nomenclature for Nodes, Conduits, and model Input File Names

This page intentionally left blank.

Section 3

Model Hydrologic and hydraulic Parameters

To provide for consistency between stormwater models of the 8 watersheds the following guidance is provided with respect to hydrologic and hydraulic parameters. An overall model checklist is included in Appendix A.

3.1 Stormwater Modeling

Proper evaluation of existing stormwater facilities (conveyance and storage) is critical in order for DFWIA to effectively manage flood and erosion risk, capital improvements, water quality issues, and future development. For this evaluation, the CDM Smith Team will use USEPA SWMM version 5+ to simulate the surface water hydrology and hydraulics. This model was chosen because it has been verified through use in Stormwater Drainage Master Plans at airports throughout the United States. SWMM is also approved by FEMA for floodplain mapping and accepted as an industry standard modeling platform for urban systems with systems of combined open channels and piped networks.

SWMM is a dynamic hydrologic and hydraulic model capable of performing continuous or event simulations of surface runoff, and subsequent hydraulic conveyance in open channel and pipe systems.

The hydrologic system operates by applying precipitation across HUs and through hydrologic calculations, determining surface runoff to loading points on the user-defined Primary Stormwater Management System (PSMS). Runoff hydrographs for these loading points provide input for hydraulic routing the PSMS to the outlet.

The hydraulic flow routing routine of SWMM 5 uses a link-node representation of the stormwater management system to dynamically route flows by continuously solving the complete one-dimensional Saint-Venant flow equations. The dynamic flow routing allows for representation of channel storage, branched or looped networks, backwater effects, free surface flow, pressure flow, entrance and exit losses, weirs, orifices, pumping facilities, rating curves, and other special structures/links. Control rules may be used to operate the structures based on timing and/or stage and flow conditions within the model.

Earlier versions of SWMM (versions 3 and 4) used separate models for hydrology (RUNOFF Model) and Hydraulics (EXTRAN Model), which were linked by an interface file. SWMM 5 uses similar architecture; however, the hydrologic and hydraulic engines are modules within the same model and run simultaneously.

3.2 Hydrologic Parameters

Hydrologic model parameters used for the model simulations are described in this section.

3.2.1 Topographic Data

Topographic data will be used to define hydrologic boundaries, overland flow slopes, channel floodplains, critical flood elevations, and stage-storage area relationships. Topographic data are available from four major sources:

1. Existing survey data (creek cross section and roadway crossings) requested by CDM Smith and provided by DFWIA;
2. Light Detection and Ranging (LiDAR) survey obtained in 2015 and 2017 by the North Central Texas Council of Governments (NCTCOG);
3. As-built plans for upgraded roadway crossings and improvements to the PSWMS; and
4. Site specific topographic survey to be obtained as part of this SDMP.

The CDM Smith team will use the data to delineate hydrologic divides, define stage-area-storage relationships, define channel geometries with survey, and define bridge/culvert/control structure characteristics.

All models will be referenced to the North American Vertical Datum of 1988 (NAVD88).

3.2.2 Hydrologic Units (HUs)

Natural physical features or constructed stormwater management systems that control and direct stormwater runoff to a common outfall generally define HUs. The following general criteria were used to determine HU boundaries:

- Topographic highs;
- Large-scale physical features such as railroad grades, airport runways, and roads;
- Where structures of topographic features could appreciably impound water for the 100-year event; and
- Existing reports and studies and field verification, to define ambiguous boundaries.

For the SDMP, the previously developed watershed boundaries will be analyzed and modified as appropriate based upon the refined topography provided by the LiDAR survey. GIS software will be used to digitize the HUs, calculate properties, and to extract land use and soil properties for use in calculation of HU hydrologic parameters.

3.2.3 Rainfall Intensities and Quantities

NOAA Atlas 14, Volume 11, Version 2 was used to determine rainfall depths for six recurrence intervals of 24-hour duration design storms as shown in **Table 3-1** and **Appendix B**. The rainfall depths will be applied in the models using the SCS Type II rainfall distributions, according to methodologies developed by the North Central Texas Council of Governments (NCTCOG) and published in the integrated Stormwater Management (iSWM) Hydrology guidance documents. A sensitivity analysis revealed minimal variation in rainfall depths across DFWIA, therefore consistent values shall be applied to all watersheds.

Table 3-1 NOAA Atlas 14 Rainfall Depths.

24-hour Storm (in)	1-yr	5-yr	10-yr	25-yr	100-yr	500-yr
	3.3	5.0	5.9	7.1	9.2	12.0

3.2.4 Hydrologic Parameters

The hydrologic module of SWMM uses overland flow data in the form of width, slope, and Manning's roughness coefficient to create a physically based overland flow runoff plane to route runoff to the PSMS for hydraulic routing. The overland flow hydraulic length is the weighted-average travel length to the PSMS.

Overland flow slope is the average slope across the overland flow hydraulic length. Length and slope information will be estimated from topographic map data and field inspection data. Manning's equation is used for the overland flow routing. **Table 3-2** lists typical Manning's roughness coefficient (n) values for overland flow. Note that pervious land use coverages appear rough because the depth of overland flow (a few inches) is equal to or less than the height of the roughness feature.

Table 3-2 Published Values of Manning's Roughness Coefficients for Overland Flow

Source	Ground Cover	Manning's n	Range
Crawford and Linsley (1966)[a]	Smooth asphalt	0.012	
	Asphalt of concrete paving	0.014	
	Packed clay	0.03	
	Light turf	0.20	
	Dense turf	0.35	
	Dense shrubbery and forest litter	0.4	
Engman (1986)[b]	Concrete or asphalt	.011	0.01-0.013
	Bare sand	.01	0.01-0.16
	Graveled Surface	.02	0.012-0.03
	Bare clay-loam (eroded)	0.02	0.012-0.033
	Range (natural)	0.13	0.01-0.32
	Bluegrass sod	0.45	0.39-0.63
	Short grass prairie	0.15	0.10-0.20
	Bermuda grass	0.41	0.30-0.48

Notes: [a]Obtained by calibration of Stanford Watershed Model

[b]Computed by Engman (1986) by kinematic wave and storage analysis of measured rainfall-runoff data.

Examination of the Land Use GIS shapefile provided by DFWIA reveals 16 different land uses. These land uses have been aggregated into 10 land use classes for hydrologic modeling as described in Section 3.2.6. Land use based Manning's roughness coefficient values used in the SWMMs are shown in **Table 3-3**.

Table 3-3 Land Use Based Manning's Roughness Coefficients used in SWMM.

	Forest, Open & Park	Pasture	Agricultural & Golf Courses	Low Density Residential	Medium Density Residential	High Density Residential	Light Industrial, Commercial & Institutional	Heavy Industrial	Wetlands	Watercourses & Waterbodies
Impervious Manning's n	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.100	0.024
Pervious Manning's n	0.400	0.300	0.300	0.250	0.250	0.250	0.250	0.250	0.400	0.060

3.2.5 Soils Types and Characteristics

Soils within the site were obtained from NCTCOG, and the data originate from the U.S. Department of Agriculture, Natural Resources Conservation Service, published January, 2007 as the Soil Survey Geographic (SSURGO) database. The data table available with the NCTCOG file must be linked to data available from https://sdmdataaccess.nrcs.usda.gov/ to obtain descriptions of soil types appropriate to your application.

The hydrologic model within SWMM uses both soil storage and infiltration rates to determine the volume of surface water runoff and infiltration in pervious land areas. Soil capacity (or soil storage) is a measure of the amount of storage (in inches) available in the soil type for a given antecedent moisture condition. The average antecedent moisture condition (AMC II) was used for all design storm analyses. Soil capacities were estimated based on the NCTCOG iSWM Hydrology manual*.*

The Horton soil infiltration equation was used within SWMM to simulate infiltration into the soil. For design storm modeling, the Horton method presumes that the infiltration rate varies exponentially from an initial maximum infiltration rate to a minimum infiltration rate during the event. Model input includes maximum and minimum infiltration rates, and a decay constant that determines how fast the infiltration rate is moving toward the minimum rate during the event. Additionally, a total maximum infiltration depth can be specified based on the moisture capacity of the soil. SWMM will not allow the infiltration volume during the event to exceed this volume.

Each of the soil types described above has been assigned to one of the four Hydrologic Soil Groups (A, B, C, or D) established by the SCS. Hydrologic Soil Group A is comprised of soils with a very high infiltration potential and a low runoff potential. Hydrologic Soil Group D is comprised of soils with very low infiltration potential and a high runoff potential. The other two categories fall between A and D soil groups. Dual class soils (e.g., A/D) mean that a hard pan or impermeable layer limits vertical infiltration, but the surficial soils are highly permeable and could infiltrate as a Class A soil if the confining layer was cut with a ditch or swale.

Global parameters were established for each Hydrologic Soil Group and were used to determine area-weighted parameter values based on the percent of each Hydrologic Soil Group within each HU. Detailed information on the use of the Horton infiltration equation is described in the *SWMM 5 Users Manual.* **Table 3-4** lists the global infiltration parameters used to calculate the hydrologic input data used in this study.

Table 3-4 Global Horton Infiltration Parameters

Hydrologic Soil Group	Maximum Infiltration Rate (in/hr)	Minimum Infiltration Rate (in/hr)	Decay Rate (1/hr)	Drying Time (days)	Maximum Soil Storage (in)
A	9.0	0.50	2.0016	2.1	5.00
B	6.0	0.25	2.0016	2.1	3.80
C	4.0	0.10	2.0016	2.1	1.40
D	2.0	0.05	2.0016	2.1	1.0

3.2.6 Land Use and Impervious Areas

For this study, existing land use is defined as year 2017, and derived from DFWIA land use data collected on 5-31-2017 and provided as part of the airport geodatabase for that year. Examination of the Land Use GIS shapefile provided by DFWIA reveals 16 different land uses. The land use codes within DFWIA were aggregated into 10 land use classes used in the hydrologic modeling as shown below with the 10 classes in *italics*:

1. AIRPORT SUPPORT FACILITIES: *Heavy Industrial*
2. BEAR CREEK GOLF CLUB: *Agricultural & Golf Courses*
3. COMMERCIAL RETAIL – NEW: *Light Industrial, Commercial, & Institutional*
4. CONSOLIDATED RENTAL CAR COMPLEX: *Light Industrial, Commercial, & Institutional*
5. DIRECT AVIATION USES AND SUPPORT: *Light Industrial, Commercial, & Institutional*
6. FLOOD PLAIN: *Forest, Open & Park*
7. FLOOD PLAIN - OPEN SPACE: *Forest, Open & Park*
8. INDUSTRIAL/FLEX*: Heavy Industrial*
9. MIXED USE COMMERCIAL: *Light Industrial, Commercial, & Institutional*
10. NOISE LAND: *Forest, Open & Park*
11. OFFICE/CORPORATE/FLEX: *Light Industrial, Commercial, & Institutional*
12. PLANNED RAIL: *Forest, Open & Park*
13. RIGHT OF WAYS – NEW: *Forest, Open & Park*
14. SURFACE WATER*: Watercourses & Waterbodies*
15. UNCLASSIFIED*: to be examined on a case by case basis and assigned*
16. WETLANDS: *Wetlands*

And the NCTCOG Land Use GIS shapefile contains 22 land uses for areas within the airport as follows:

1. AIRPORT
2. CEMETERIES
3. COMMERCIAL
4. COMMUNICATION
5. EDUCATION
6. HOTEL/MOTEL
7. INDUSTRIAL
8. INSTITUTIONAL/SEMI-PUBLIC
9. MOBILE HOME
10. MULTI-FAMILY
11. OFFICE
12. PARKING
13. PARKS/RECREATION
14. RAILROAD
15. RANCH LAND
16. RETAIL
17. RUNWAY
18. SINGLE FAMILY
19. SMALL WATER BODIES
20. UTILITIES
21. VACANT
22. WATER

These NCTCOG land uses will be used as needed to classify areas outside the limits of the airport land use coverage, and will be aggregated into the 10 land use classes as shown.

Each land use class has unique parameters for percent impervious, percents of directly and non—directly connected impervious areas (DCIA and NDCIA, respectively), and pervious and impervious cover roughness factors. The land use distribution for the airport is presented in **Table 3-5**. For airside areas the actual percent imperviousness will be measured, with the remaining portion classified as "Forest, Open & Park".

Table 3-5 DFWIA Land Use Distribution

Land Use Class	Area (Acres)	Percent
Forest, Open & Park	1,811.8	10.6
Pasture	0.0	0.0
Agricultural & Golf Courses	201.6	1.2
Low Density Residential	0.0	0.0
Medium Density Residential	0.0	0.0
High Density Residential	0.0	0.0
Light Industrial, Commercial & Institutional	2,498.7	14.5
Heavy Industrial	4,452.5	25.9
Wetlands	0.0	0.0
Watercourses & Waterbodies	41.2	0.2
Unclassified	8,177.4	47.6
Total	17,183.3	100.0

The DCIA represents all the impervious surfaces that are directly connected to the stormwater system. The NDCIA represents the impervious surfaces that have a pervious buffer prior to discharge into the stormwater system. Using the spatial distribution of the ten land use classes, an area-weighted average percent imperviousness for each hydrologic unit can be obtained.

After rainfall and area, the percent imperviousness of each hydrologic unit is the most sensitive parameter defined in the SWMM hydrologic model which determines the volume and rate of surface water runoff. As discussed above, the imperviousness is based on land use percentages. A summary of model input parameters per land use is presented in **Table 3-6**.

Table 3-6 Impervious by Land Use Category

Land Use Category	Percent Impervious(1)	Percent DCIA	Percent NDCIA	Percent Pervious
Forest, Open & Park	5	1	4	95
Pasture	5	1	4	95
Agricultural & Golf Courses	5	1	4	95
Low Density Residential	15	8	8	85
Medium Density Residential	35	23	12	65
High Density Residential	83	65	18	18
Light Industrial, Commercial & Institutional	90	81	9	10
Airport/Heavy Industrial	90	81	9	10
Wetlands	100	100	0	0
Watercourses & Waterbodies	100	100	0	0

Note: (1) Total Impervious Area

3.2.7 Depression Storage

Land use specific depression storage values are used in the model to account for initial abstractions of rainfall totals for the design storm events. The parameter accounts for small depressions in the landscape that form puddles, as well as rainfall that is caught in tree canopies and the foliage of vegetation. These initial abstractions are withheld from the hydrologic routing and effectively removed from the system. At the beginning of a rainfall event and for each land use, rainfall is intercepted up to the depth reported in **Table 3-7**, after which the rainfall bypasses the initial abstraction and is used for hydrologic routing.

Table 3-7. Land Use Based Initial Abstractions Used in SWMM.

	Forest, Open & Park	Pasture	Agricultural & Golf Courses	Low Density Residential	Medium Density Residential	High Density Residential	Light Industrial, Commercial & Institutional	Heavy Industrial	Wetlands	Watercourses & Waterbodies
Impervious Ia (inches)	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.50	0.10
Pervious Ia (inches)	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.50	0.10

3.3 Hydraulic Parameters

This section presents the development of the hydraulic parameters for SWMM.

3.3.1 Field Investigations, As-Built Data, and Additional Survey

The DFWIA PSMS consists of streams, culverts, bridges, control structures, underground pipe networks, vaults, a first flush system, and detention ponds. The CDM Smith team conducted field investigations to assist in updating the definition of the hydraulic network.

As part of the development of the SDMP, additional field surveys will be required for cross sections and structures to augment the previous work. Survey will be taken in the NAVD88 datum and in accordance with FEMA Data Capture Standards.

3.3.2 Model Schematic

The SWMM hydrologic and hydraulic model uses a node/link representation of the PSMS as shown previously in **Figure 2-2**. Nodes are located at:

- The ends of culverts;
- At points along a pipe system where there is a change in material, size, or a significant inflow;
- Upstream and downstream of bridge structures;
- Points along the streams where the geometry, direction, and/or slope of the channel varies significantly;
- Stream intersections;
- Structures along the streams (weirs, but in general may include pump stations, orifices, etc.);
- Problem areas;
- Gage locations;
- Potential future development connections; and
- Points representing the HU low elevations.

3.3.3 Stage-Area Relationships

Stage area relationships will be computed for low lying areas in some HUs using the LiDAR data. The plan area for storage at 0.5 and 1.0 ft intervals will be calculated from the topographic surface as appropriate. The models will be used to evaluate large storm events, up to the 500-yr storm, therefore the channel reaches will need to extend sufficiently to increase the floodplain. In SWMM, the stage-area data can be assigned to a "storage node." SWMM uses the data to calculate the relationship between stage and storage volume.

To avoid "double counting" of storage in the model, storage associated with the floodplain of a stream reach must be kept separate from the stage-area storage nodes outside of the stream reach floodplain. Therefore, stage-area relationships will only be provided to storage junctions at the furthest upstream node on a tributary, upstream of a structure, in roadway swales, to represent inline ponds, and to represent inline or offline storage where reaches do not include floodplains. Stage -area relationships are necessary in relatively flat models where flood waters may overflow the channel banks and fill low-lying areas. An accounting of the volume of these areas is needed for both accurate flood elevation predictions as well as peak flow estimates.

3.3.4 Conduits

The following data was incorporated in SWMM to characterize conduits (channel, pipes, and bridges): local losses, Manning's n value, length, height, and width.

3.3.4.1 Culverts

For circular and elliptical pipes, as well as rectangular box culverts, model input data includes surveyed depth, width (if non-circular), length and upstream and downstream inverts. Local loss coefficients are listed in **Tables 3-8** and **3-9**. Additionally, losses can be evaluated via commonly accepted methods, such as those published by Vennard and Street.

3.3.4.2 Natural Channels

Most of the natural channel (or irregular conduit) cross-sections to be modeled do not have topographic survey data, and these will be represented using LiDAR data where possible and augmented and confirmed as necessary with survey. In some locations survey will be required, as LiDAR does not penetrate the water surface. Due to the requirement of modeling the 500-yr storm, it is necessary to augment the surveyed cross-sections (where available) with floodplain elevations from the LiDAR topography. As the top of bank is reached during extreme events, SWMM treats irregular cross-sections as a closed conduit and the cross-sectional area becomes limited at this elevation. For the more intense storms, flood water is simulated to the top of the bank for many of the cross-sections and flows over floodplains. These floodplains will be added to the stream reaches in the model by augmenting the measured survey, while the significant storage that then was represented in each reach must be removed from the stage-area relationship in the adjacent storage junctions, where applicable.

3.3.4.3 Bridges and Roadway Overflows

Bridges are irregular cross-sections that are unique in that if flood stages rise high enough, the cross-section is cut off by the bottom of the roadway (at the lower chord elevation) and the flow regime changes from an open channel with free water surface to a pressurized flow regime. In order to model bridges, the custom shape type conduit will be used in SWMM 5. A custom shape may be any closed conduit shape that can be characterized by depth versus width at multiple depths in the section. From this data a shape curve is used to represent the bridge in SWMM. To validate the use of shape curves for use in simulation of bridge hydraulics, testing and comparison of the SWMM shape curve methodology to the United States Army Corps of Engineers model HEC-RAS was performed.

Due to the high intensity of the design storms, many of the roads within DFWIA are expected to be flooded, especially for the 25, 100 and 500-yr storms. For the SDMP, the surveyed road crown elevations, where applicable, will be merged with the LiDAR data to provide a wider, deeper cross-section for flow, in the same manner as channel cross-sections.

Table 3-8 Entrance Loss Coefficients

Type of Structure and Design of Entrance	Coefficient K_{ent}
Pipe, Concrete	
Projecting from fill, socket end (groove-end)	0.2
Projecting from fill, sq. Cut end	0.5
Headwall or headwall and wingwalls	
◊ Socket end of pipe (groove-end)	0.2
◊ Square-edge........	0.5
◊ Rounded (radius - 1/12 D)	0.2
Mitered to conform to fill slope	0.7
End-Section conforming to fill slope........	0.5
Beveled edges, 33.7 or 45 bevels........	0.2
Side- or slope-tapered inlet	0.2
Pipe, or Pipe-Arch, Corrugated Metal	
Projecting from fill (no headwall)	0.9
Headwall or headwall and wingwalls square-edge........	0.5
Mitered to conform to fill slope, paved or unpaved slope	0.7
End-Section conforming to fill slope........	0.5
Beveled edges, 33.7 or 45 bevels	0.2
Side- or slope-tapered inlet	0.2
Box, Reinforced Concrete	
Headwall parallel to embankment (no wingwalls)	
◊ Square-edged on 3 edges........	0.5
◊ Rounded on 3 edges to radius of 1/12 barrel dimension, or beveled edges on 3 sides	0.2
Wingwalls at 30 to 75 to barrel	
◊ Square-edged at crown	0.4
◊ Crown edge rounded to radius of 1/12 barrel dimension, or beveled top edge	0.2
Wingwall at 10E to 25 to barrel square edge at crown	0.5
Wingwalls parallel (extension of sides)	
Square-edged at crown........	0.7
Side- or slope-tapered inlet	0.2

Table 3-9 Exit and In-Pipe Loss Coefficients.

Description	K
Inlet to manhole	0.25
Manhole in straight section of closed conduit	0.10
Manhole at a 45 degree bend	0.25
Manhole at a 90 degree bend	0.50
Exit closed conduit to lake	1.00
Exit closed conduit to open channel	0.3-0.7

3.3.5 Boundary Conditions

Hydraulic boundary conditions are needed in order to accurately simulate peak stages and flows throughout the system. Existing FEMA models will be used to determine boundary conditions where available. In locations where FEMA information does not exist local stream gages will be used, and in cases where neither exist engineering judgement will be used to establish model boundary conditions.

This page intentionally left blank.

Section 4

Water Quality Evaluations

4.1 Introduction

The DFWIA SWMM hydrologic and hydraulic models can be used to evaluate water quality. This includes consideration of the following:

- Evaluation of existing surface runoff loadings from various land cover categories, focusing on total nitrogen (TN), total phosphorus (TP) and total suspended solids (TSS), although other parameters may be added as needed;
- Evaluation of existing watershed groundwater inflows and associated loads of TN, TP and TSS; and
- Evaluation of existing and proposed Best Management Practices (BMPs)/Stormwater Control Measures (SCMs).

4.2 Green Stormwater Infrastructure Runoff Volume Control Load Reduction

SWMM can explicitly model the effects of Green Stormwater Infrastructure (GSI) features including bioretention, porous pavement, infiltration trench, rain barrel and vegetative swale. The hydrologic processes associated with a GSI feature in SWMM are presented in **Figure 4-1**.

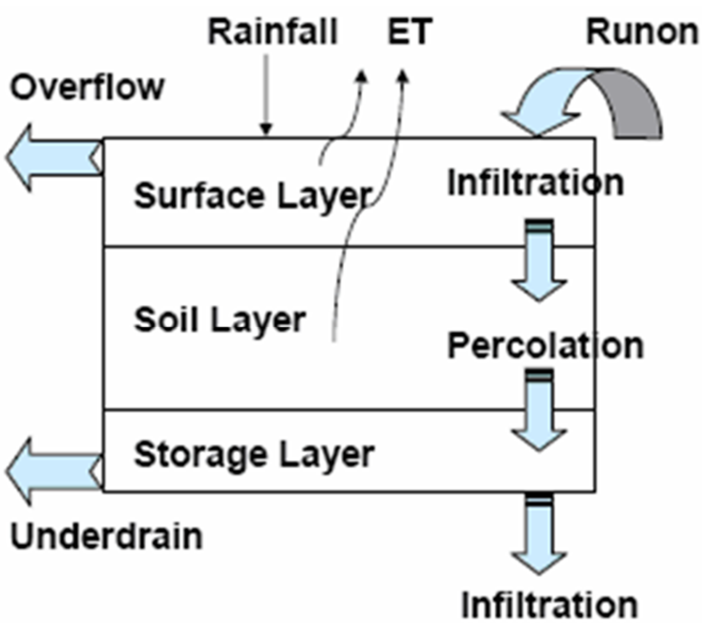


Figure 4-1 SWMM Representation of Green Stormwater Infrastructure Features

The SWMM program refers to these controls as Low Impact Development (LID) controls, for consistency in nomenclature this document will use the term GSI. Not all of the GSI features require all of the generic layers shown in the figure (e.g., pervious pavement would not have a soil layer; GSI feature may or may not have an underdrain). Using this explicit GSI modeling, runoff and associated pollutant load from adjacent impervious areas accumulate on the surface layer of the GSI feature, and the model will explicitly determine the fraction of water that is lost via infiltration and ET and what fraction will overflow to the subcatchment outlet. Use of these GSI features is recommended for the BMPs that are reducing pollution loads primarily through runoff capture and infiltration.

As an example, a conceptual bioretention facility can be defined in SWMM that includes a surface ponding layer of 6 inches, soil layer of 12 inches, and a stone storage layer of 6 inches. If the soil and storage layers are assumed to have 30% of the layers on average available to accept stormwater, then the overall storage in the conceptual bioretention facility is 6 + 30% * 18 inches = 11.4 inches. If the bioretention facility is designed to capture 0.5 inches of runoff from the impervious tributary area, then the area of the conceptual bioretention facility would be 0.5 / 11.4 * 100% = 4.4% of the impervious tributary area.

To apply the conceptual bioretention facility to a particular model subcatchment, the percent of the subcatchment impervious area that is treated by bioretention BMPs needs to be entered as a model input, and the subcatchment input needs to include the conceptual bioretention BMP with a surface area in this example that is 4.4% of the treated impervious area. SWMM will route the appropriate impervious area runoff to the conceptual bioretention facility, and the remaining impervious runoff will be routed as before (to the subcatchment outlet and/or to adjacent pervious area).

In other subcatchments with bioretention facilities, the same conceptual bioretention facility can be assigned. What would vary between subcatchments is the percentage of impervious area that is treated by bioretention, and the associated footprint of the conceptual bioretention facility (again 4.4% of the treated impervious area).

Pollutant reduction associated with the GSI feature is generally associated with the reduction in runoff volume from the subcatchment. Overflow from the GSI feature would have essentially the same concentration as the incoming runoff or water that has ponded in the feature. Previous experience with SWMM also indicates that, when an underdrain is simulated, the concentration of water passing through the underdrain may be zero or may be equal to the concentration of water in the GSI feature, depending upon whether or not there is inflow to the feature at the time. Water that infiltrates from the GSI feature will be added to the subsurface groundwater budget.

The performance of the modeled BMPs can be compared to literature values presented in sources such as the Texas Commission on Environmental Quality (TCEQ) surface water quality standards and the Virginia Runoff Reduction Method (VRRM) spreadsheet which evaluates compliance with State water quality criteria. Values included for some BMP types are presented in **Table 4-1**. The values for each BMP type include runoff reduction, treatment removal efficiency, and overall removal (accounting for both runoff reduction and treatment).

Table 4-1 Typical BMP Pollutant Removal Efficiencies for TP and TN

BMP Type	Runoff Reduction (%)	Treatment Efficiency (%)		Overall Reduction (%)	
		TP	TN	TP	TN
Vegetated Roof	45 - 60	0	0	45 - 60	45 – 60
Rooftop Disconnection	25 – 90	0 - 50	0 – 60	25 - 95	25 - 96
Permeable Pavement	45 - 75	25	25	59 - 81	59 – 81
Grass Channel	10 - 20	15	20	24 – 32	28 – 36
Dry Swale	40 - 60	20 - 40	25 – 35	52 - 76	55 – 74
Bioretention	40 - 80	25 - 50	40 – 60	55 - 90	64 – 92
Infiltration	50 - 90	25	15	63 - 93	58 – 92
Extended Detention Pond	0 - 15	15	10	15 - 28	10 - 24
Sheetflow to Filter/Open Space	50 - 75	0	0	50 - 75	50 – 75
Wet Swale	0	20 - 40	25 – 35	20 - 40	25 - 35
Filtering Practices	0	60 - 65	30 – 45	60 - 65	30 - 45
Constructed Wetlands	0	50 - 75	25 – 55	50 - 75	25 - 55
Wet Ponds	0	50 - 75	20 – 40	50 - 75	20 – 40
Manufactured Treatment Device	0	20	0	20	0

Notes:

1. Overall Reduction = Runoff Reduction + Treatment Efficiency * (100 – Runoff Reduction)/100
2. Source: Virginia Runoff Reduction Method spreadsheet.

For washoff treatment BMPs that are not explicitly modeled as part of the watershed hydraulic system, the removal efficiency values in **Table 4-2** are more applicable. As noted in the table, the load reduction for GSI will be proportional to the runoff reduction calculated by SWMM.

These features within SWMM will be applied as applicable to create developer guidance and evaluate the efficiency of BMPs throughout the airport.

Table 4-2 BMPs and Associated Removal Efficiencies for SWMM

BMP Type	Classification	Washoff Treatment Efficiency (%)			
		DP	PP	TSS	TN
Vegetated Roof	LID - Runoff Reduction	Load reduction proportional to simulated runoff reduction			
Rooftop Disconnection	LID - Runoff Reduction	Load reduction proportional to simulated runoff reduction			
Permeable Pavement	LID - Runoff Reduction	Load reduction proportional to simulated runoff reduction			
Bioretention	LID - Runoff Reduction	Load reduction proportional to simulated runoff reduction			
Infiltration	LID - Runoff Reduction	Load reduction proportional to simulated runoff reduction			
Dry Swale	LID - Runoff Reduction	Load reduction proportional to simulated runoff reduction			
Sheetflow to Filter/Open Space	LID - Runoff Reduction	Load reduction proportional to simulated runoff reduction			
Grass Channel	Washoff Treatment	20	35	25 [3]	30
Extended Detention Pond	Washoff Treatment	10	35	60 [2]	15
Wet Swale	Washoff Treatment	15	45	25 [3]	30
Filtering Practices	Washoff Treatment	55	70	85 [2]	40
Constructed Wetlands	Washoff Treatment	40	80	80 [2]	40
Wet Ponds	Washoff Treatment	40	80	80 [2]	30
Manufactured Treatment Device	Washoff Treatment	10	35	50 [4]	0

Notes:

1. Selected values for DP, PP and TN selected for consistency with Table 4.
2. Source: Chesapeake Bay Program, *Best Management Practices for Sediment Control and Water Clarity Enhancement*, October 2006.
3. Source: Geosyntec Consultants Inc. and Wright Water Engineers Inc., *International Stormwater Best Management Practices (BMP) Database Pollutant Category Statistical Summary Report: Solids, Nutrients, and Metals*, December 2014.
4. Source: Virginia DEQ, *Stormwater Management Plan Review Course.*

Section 5

FEMA Floodplain Models

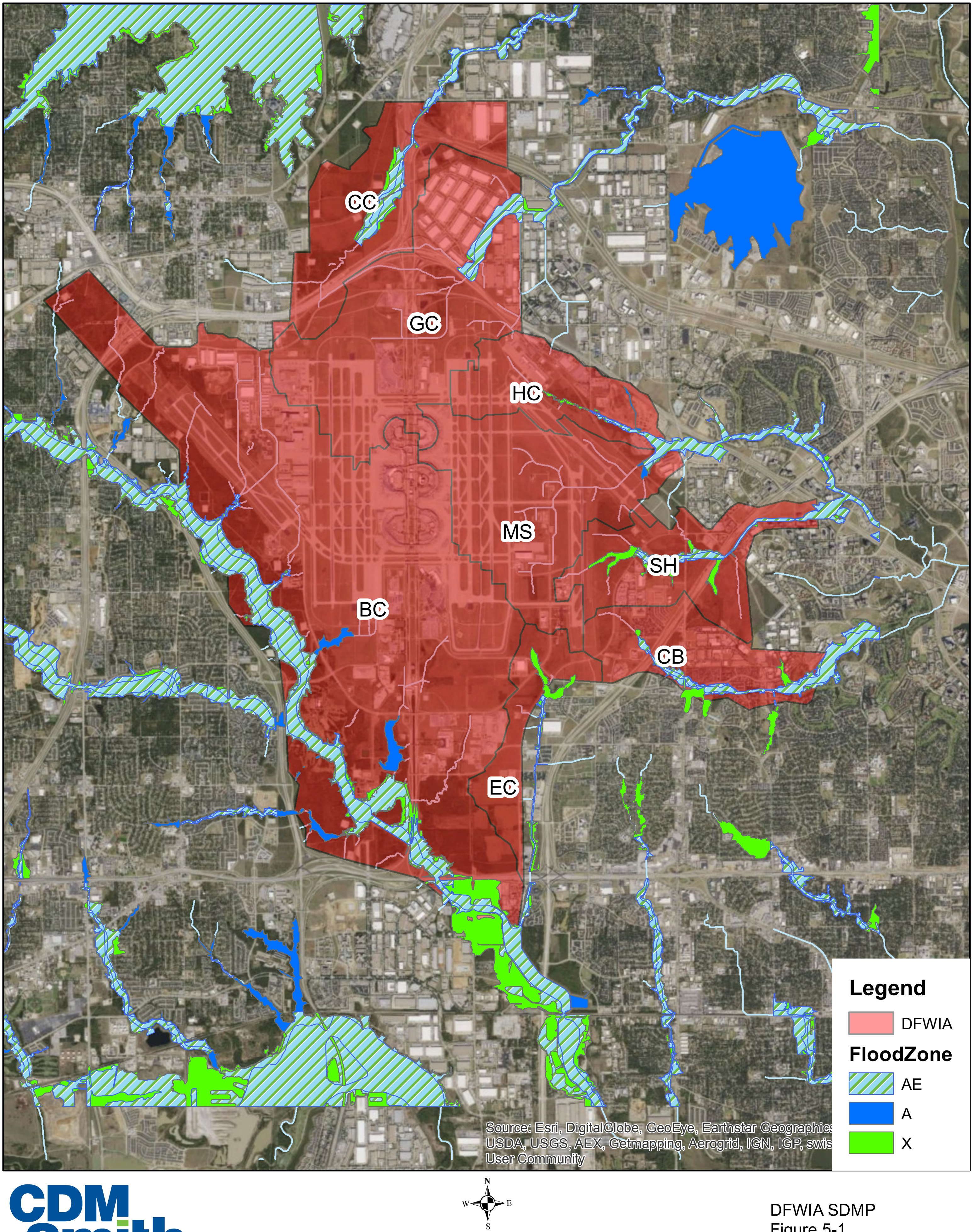
A number of the waterways within DFWIA have been modeled, and FEMA regulated floodplains have been developed as shown in **Figure 5-1**.

5.1 Use of Existing FEMA Models

Prior to initiating modeling of any watersheds the area should be checked to confirm the presence or absence of existing FEMA models. When FEMA models are present the modeler should review the model(s) and use relevant information to inform the development of the SWMM models of the area. After development of the SWMM model, results should be compared with the FEMA model(s). Discrepancies should be noted with respect to location and deviation, the validity of the discrepancies should be confirmed, and the differences documented.

5.2 Use of SWMM Models to Support FEMA Mapping

The EPA SWMM model is a FEMA approved platform for flood modeling and mapping. While the current SDMP effort does not include FEMA map development or modifications, the models will be developed to a level of detail where they can be used in the future to support FEMA related activities such as mapping, and the development of LOMRs/LOMAs/CLOMRs.



CDM Smith

DFWIA SDMP
Figure 5-1
FEMA Regulated Floodplain

Section 6

Stormwater Criteria and Level of Service

This report section summarizes the various stormwater quantity Level of Service (LOS) design criteria which may be applicable to DFWIA and presents recommended LOS criteria for the development of the DFWIA Stormwater Drainage Master Plan.

6.1 Stormwater Flood Control and Quantity Criteria

Multiple agencies and jurisdictions have developed criteria for flood control which may apply to DFWIA. These various criteria are summarized in the following sections. Section 2.1.4 presents the CDM Smith recommended criteria for the DFWIA SDMP, which is based on a comprehensive review of the various applicable criteria.

6.1.1 Federal Requirements and Regulations

This section presents a summary of the Federal water quantity criteria that apply to stormwater management at DFWIA.

6.1.1.1 Federal Aviation Administration (FAA)

The United States Department of Transportation Federal Aviation Administration (FAA) has developed an Advisory Circular, *AC 150/5320-5D, Airport Drainage Design, August 2013*, for the design and maintenance of airport surface drainage systems. This Advisory Circular combines existing surface drainage topics covered in different agency manuals into one Unified Facilities Criteria Surface Drainage Design document. The Advisory Circular establishes general concepts and procedures for the hydrologic design of surface structures. In the Circular FAA sets minimum standards; however, each facility may be designed to a higher standard as required by local and/or state regulations.

Surface Drainage Design

AC-150/5320-5D recommends different design storm frequencies for different airport facilities. For public-use airports like Love Field, the FAA recommends:

- A 5-year design storm with no encroachment of runoff on taxiway and runway pavement (including paved shoulders).
- For the 5-year storm a ponding limit of 4 inches around apron inlets.
- Areas other than airfields (landside) will normally be based on a 10-year design storm.
- The center 50% of runways, taxiways and helipad surfaces along the centerline should be free from ponding for the 10-year design storm.
- The design frequency for depressed pavement sections and underpasses is a 50-year storm.

- Storm durations for all cases are recommended to be 24-hour events unless local requirements are greater.
- Surface runoff from the selected design storm will be disposed of without damage to facilities, undue saturation of the subsoil, or significant interruption of normal traffic.
- The use of a lesser frequency event, commonly the 100-year storm, to assess hazards at critical locations where water can pond to appreciable depths is referred to as a check storm.

Table 6.1 Summarizes the design storm requirements of FAA.

Table 6.1 FAA Minimum Surface Drainage Standards

Facility Type	Design Storm Return Period	Design Storm Duration (hr)	Notes
Taxiway & Runway Pavement	5	24	No ponding encroaching on edge of pavement A ponding limit of 4-inches around apron inlets
Runway, Taxiway, & Helipad Centerlines	10	24	Center 50% free from ponding
Landside Areas	10	24	
Depressed pavement sections and underpasses	50	24	

For areas other than airfields and heliports, check the appropriate local regulatory agency for guidance on design storm requirements.

Other Design Criteria

- AC 150/5320-5D, also requires that conduits or channels greater than 96 square inches passing through or beneath security fences have security barriers.
- Traverse grade within the runway or taxiway safety area outside of the shoulders will be between 1.5 and 3 percent as required by *AC 150/5300-13 Airport Design.* Drainage ditched may not be located within the safety area. The first 200 feet of the runway safety area beyond the end of the runway the longitudinal grade will be between 0 and 3 percent, with a maximum of -5 percent thereafter.

Fog and Wildlife Attractant Land Uses

Aviation facilities have restrictions on surface storage of water due to the potential development of fog and attraction of wildlife, especially waterfowl. The FAA recommends a separation distance of 10,000 feet from wildlife attractants. The FAA circular, *AC 150/52000-33B, Hazardous Wildlife Attractants On or Near Airports, August 2007*, contains the land-use practices that potentially attract wildlife. The FAA also recommends a distance of 5 statute miles between the furthest edge of the airport operating area (AOA) and the wildlife attractant, if the attractant could cause hazardous wildlife movement into or across the approach, departure, or circling airspace.

6.1.1.2 Federal Emergency Management Agency (FEMA)

FEMA determines floodplain boundaries on the basis of hydrologic and hydraulic modeling. The US Army Corps of Engineers (USACE) and local communities support FEMA in the production of the Flood Insurance Rate Maps (FIRMs). The floodplain boundaries are presented on the FIRMs, and the area within the DFWIA boundaries is identified on the current FEMA issued Flood Insurance Rate Maps (FIRMs). The DFWIA is covered by multiple FIRMs, which can be accessed at the following website https://msc.fema.gov/portal/search#searchresultsanchor. As shown in **Figure 5-1** there are numerous areas within the DFWIA that are within the FEMA regulated floodplain, and are hence subject to FEMA regulations.

6.1.2 State Requirements and Regulations

6.1.2.1 Stormwater Discharges

Permitting of storm water discharges under the National Pollutant Discharge Elimination System (NPDES) has been delegated to the State of Texas since September 1998. A final version of the Texas Pollutant Discharge Elimination System (TPDES) Storm Water Multi-Sector General Permit TX R05000 was published on August 14, 2016. Air Transportation Facilities are included as part of Sector S under Activity Code 4581. Accordingly, the airport must comply with the Texas Commission on Environmental Quality (TCEQ) issued Texas Pollution Discharge Elimination System (TPDES) Municipal Storm Separate Sewer System (MS4) regulations and requirements of the TX R050000 Multi-Sector General Permit. This requires DFWIA to develop a stormwater management program that includes stormwater pollution prevention plans (SWPPPs), treatment or pollutant removal techniques, stormwater monitoring, and other stormwater quality controls.

6.1.3 Municipal Requirements and Regulations

DFWIA is surrounded by a number of cities that will be directly involved in stormwater management via either contributing to, or receiving flows from, the DFWIA stormwater management system. Cities directly affected include:

- City of Irving;
- City of Coppell;
- City of Grapevine;
- City of Euless, and
- City of Fort Worth.

Each of these municipalities has their own stormwater rules and regulations which should be consulted when establishing LOS in areas that are coincident to the municipality and DFWIA.

6.1.4 NCTCOG Regional Stormwater Regional Strategy

The North Central Texas Council of Governments (NCTCOG) has developed a regional program which provides guidance and a framework to develop and implement regional strategy to address water quality issues affecting the region. The goals of this regional program are to:

- Protect the health and welfare of citizens and the environment,
- Effectively address state and federal regulations,
- Share professional knowledge and experience, and
- Provide training to governmental staff and the development community.

The overall program, titled “Integrated Stormwater Management (iSWM)” provides four types of documentation, criteria, technical, tools and program guidance.

NCTCOG has developed iSWM to help cities implement more environmentally friendly approaches to storm water management. The program is intended to provide guidance for all development and redevelopment related to storm water activities. iSWM provides comprehensive guidelines for each project phase from planning through design, construction and maintenance. The City of Dallas has adopted the iSWM Criteria Manual for Site Development and Construction, as amended with local provisions on June 2010, for voluntary use in conjunction with the City of Dallas Drainage Design Manual (1993). iSWM stormwater quantity criteria highlights are summarized in this section.

The City of Dallas amended iSWM Criteria Manual recommends that a stormwater management system be designed for four storm events (listed in **Table 6.2** below).

Table 6.2 Dallas iSWM Storm Events

Storm Event Name	Storm Even Focus	Storm Event Description
Water Quality	Remove pollutants in stormwater runoff to protect water quality	Criteria based on a volume of 1.5-inches of rainfall, not storm frequency
Streambank Protection	Regulate discharge from site to minimize downstream bank and channel erosion	1-year, 24-hour storm event
Conveyance	Control runoff within and from the site to minimize flood risk to people and properties for the conveyance as well as the 100-year storm	5-year, 24-hour storm event
Flood Mitigation		100-year, 24-hour storm event

A downstream assessment for 1-year, 5-year, and 100-year events is required to protect downstream properties, determine the extent of necessary improvements for streambank protection and flood mitigation. The downstream impacts have two focus areas, Streambank Protection and Flood Mitigation.

Once the analysis is complete, the following questions at each determined junction downstream must be answered to determine the necessity, type, and size of non-structural and structural controls to be placed on- site or downstream of the proposed development:

- Are the post-development discharges greater than the pre-development discharges?
- Are the post-development velocities greater than the pre-development velocities?

- Are the post-development velocities greater than the velocities allowed by the receiving systems?
- Are the post-development flood heights greater than the pre-development flood heights?

Should undesirable downstream impacts be found, iSWM states the general options available for the two Focus Areas. These are shown in **Table 6.3**.

Table 6.3 Dallas iSWM Storm Events

Design Focus Area	Design Options
Streambank Protection	Option 1: Reinforce/stabilize downstream conditions
	Option 2: Install stormwater controls to maintain or improve existing downstream protection
	Option 3: Provide on-site controlled release of the 1-year, 24-hour storm event over a period of 24 hours
Flood Mitigation and Conveyance	Flood Mitigation
	Option 1: Provide adequate downstream conveyance systems
	Option 2: Install stormwater controls on-site to maintain or improve existing downstream conditions
	Option 3: In lieu of a downstream assessment, maintain existing on-site runoff conditions
	Conveyance
	Minimize localized site flooding of streets, sidewalks, and properties by a combination of on-site stormwater controls and conveyance systems

Additional guidance, options and design criteria are also contained in iSWM which are intended to be used in tandem with local Drainage Design Manuals.

6.1.5 Recommended Stormwater Quantity Criteria

As noted in this section, DFWIA is subject to both federal and local requirements, as well as, existing and future conditions which must be considered in development criteria. The recommended Stormwater Quantity Criteria takes into consideration these variations. This section summarizes the recommended Stormwater Quantity Criteria which will be used in the foundation of alternatives for the DFWIA SDMP.

The water quantity (flooding and erosion) criteria standards presented in the preceding sections may be summarized by separating the property into airside and landside areas. Note that for all design storms, the NRCS (formerly SCS) Type II 24-hour hyetographs shall be used with storm frequency volumes as shown in Section 3.

General

The stormwater drainage system should safely collect, store, and convey the flow from the 100-year frequency flow. Various methods should be considered to accommodate these flows.

- Only dry detention or underground systems may be applied for the airport and the surrounding neighborhoods up to 10,000 feet from the airport boundary. No BMPs that may be considered wildlife or fog attractants are allowed within this range. The dry detention areas must be designed according to the iSWM parameters discussed in the previous sections.

- Future building construction or major renovations should be checked against and protected against the 100-year storm event.

For airside areas:

- Taxiways, runways, and shoulders should not be encroached at all for the 5-year storm, while maintaining 50% from centerline clear from ponding for the 10-year storm.
- The 100 year 24 hour design storm will be checked versus runway and taxiway elevations to determine stages at runway-taxiway crown elevations.
- The maximum ponding at apron inlets should be 4 inches for the 5 year storm.
- Temporary storage of stormwater between runways, taxiways, and aprons should be considered.
- Traverse grade outside of runway-taxiway shoulders, not to exceed three (3) percent.

Landside Areas:

- Hydraulic design should follow criteria and guidelines as presented in the iSWM Manual as edited.
- Future development/re-development should be required to evaluate and implement onsite measures that will be established as part of this SDMP and published in the developer guidance manual to reduce peak discharges to the DAL system.
- For the major roads (principal arterials), one lane of traffic in each direction should remain open for the 100-year storm, and the peak flood stage should be below the top of curb.
- For all other roads within the airport boundary, or immediately adjacent to it, peak flooding for the 100-year storm may not exceed 6-inches or the top of the curb, whichever is greater.

Offsite Areas

For all offsite areas, the criteria are established so as to “do no harm” downstream. Runoff at the airport must be collected, and attenuated so that peak stages do not increase for the neighboring areas, velocities do not create erosion problems, and water quality is maintained.

Summary

This section is not inclusive of all criteria that must be met, but is meant to be a summary guide for allowable flood levels versus design storms. The criteria that cover airside areas apply for existing as well as future conditions. Alternative designs will be presented as part of this SDMP to mitigate problem areas for which the criteria are not being met. The designs may apply to landside building flooding and road flooding as well, where applicable. The offsite area criteria cover future airport development, including the alternative designs for onsite mitigation.

Appendix A

Hydrologic and Hydraulic Model QM Checklist

This spreadsheet includes a check list for the hydrologic and hydraulic (H/H) model applications for the DFWIA Stormwater Master Plan (SWMP). Add initials, dates and comments as completed.

Created: **03/15/88** MFS (CDM Smith)
Edited: **04/15/18** **MFS (CDM Smith) - Draft**

Step By Step Process and QM Checklist
Hydrologic and Hydraulic Models

Watershed: Example

Step	Item	Completed By	Date	Checked By	Date	Notes	Comments
1	Define H/H Model Levels of Detail	MFS	04/15/18	Someone Else	Enter	Define extent of PSMS based on problem areas, causes, floodplains, and growth areas where development/redevelopment criteria are needed.	The SWMM hydraulic model was extended to address a problem area that also affects the primary system.
2	Define Catchments	MFS	04/15/18	Someone Else	Enter	Delineate based on appropriate detail for problem and development/redevelopment areas; average 150 acres in District Service Area (into 300 acre LSSs in Service Area) and average 1,000 acres in upstream tributary areas	Average of X acres is generally met
3	Asset and Catchment Identification	MFS	04/15/18	Someone Else	Enter	DFWIA asset management codes, geodatabase	Alphanumeric codes are consistent with DFWIA standards
4	Rainfall Hyetographs and Evaporation	MFS	04/15/18	Someone Else	Enter	Historic storms and time periods for calibration, validation, and continuous simulation. Historic gage and radar rainfall data as appropriate for historic events. SCS Type II uniform distribution for design storms (1, 2, 5, 10, 25, 50, 100 and 500 yr 24 hr). Monthly evaporation for continuous simulation periods.	Three events were considered in the time period from 2002 through 2012. The _____ rain storm was used because it was a design magnitude events (ranged from a x to a y storm) for comparable land use and hydraulic conditions in the subwatershed. Rainfall data appear to be correctly entered into the model. Radar rainfall data were also used and were corrected =/- 5% based on nearest gage verification and refinement.
5	Define Hydrograph Load Points	MFS	04/15/18	Someone Else	Enter	Load points based on actual delivery of pipes and channels to model (inlets, sumps, channels, streams, wetlands, lakes and reservoirs). Discretize catchments and distribute load points as necessary to avoid artificial mounding and flow reversals.	Hydrograph loading appears appropriate to the X acre scales respectively. No artificial mounding observed.
6	Soils and Groundwater	MFS	04/15/18	Someone Else	Enter	Green-Ampt and Horton parameters (soil suction, soil storage, max and min infiltration rates, decay rate, regeneration rate for continuous simulation) for soil types (A, B, C, D) and a range of antecedent moisture conditions (AMCs). Use AMC II for design storms. As necessary, estimate depths to seasonal water table and baseflow by reach from NRCS (SCS) Soils Reports, District geotechnical data, and stakeholder data. Use at least 1 month start-up (spin-up) period for continuous simulation to bring soils into equilibrium with actual conditions. Use AMC I at the beginning of the start-up period to allow the soil parameters to achieve AMC I during dry periods.	AMC II was used
7	Land Uses & DCIAs	MFS	04/15/18	Someone Else	Enter	Aerial photogrammetry, impervious test areas to refine estimates, future land use development/redevelopment build-out from ALP	Impervious area values and DCIA from _____.
8	Overland Flow Paths and Parameters	MFS	04/15/18	Someone Else	Enter	Use 3 to 5 paths to develop average area-weighted path and parameters for length, slope, Manning n roughness, and fraction of catchment each path represents; spreadsheet of parameters	Three paths averaged based on estimate of representative fraction of catchment. Manning n roughness will not be an area-weighted value by catchment but may be area-weighted by land use distribution
9	Time of Concentration (Tc)	MFS	04/15/18	Someone Else	Enter	For models that use Tc, it should be varied by design storm using the NRCS kinematic wave equation and varying rainfall accordingly.	Not used for this SWMM application
10	Model Schematic	MFS	04/15/18	Someone Else	Enter	To-scale on aerial or other planimetric base map, show watershed, subwatershed, catchments, conduits and junctions/nodes with identification numbers. Problem areas and floodplains should also be layers that can be added or removed as added.	Appropriate levels of detail for problems and development/redevelopment/ordinance guidance. Consistent with Mapping standards.
11	Define Time Steps	MFS	04/15/18	Someone Else	Enter	Generally will be less than 1 to 5 minutes for hydrologic model and 1 second or less for hydraulic model. A wet-dry time step may be used for the water quality continuous simulations	Hydrology at 1 minute, hydraulics at 0.1 seconds due to deep, short conduit at problem area location
12	Hydrologic Model/Layer (SWMM RUNOFF, HEC-HMS) Conduits	MFS	04/15/18	Someone Else	Enter	For SWMM, conduits will be in the hydraulic layer (EXTRAN) at whatever level of data is available for sections, shapes, lengths and inverts). Existing SWMM RUNOFF models from the RIDE program or from FEMA (e.g., HEC HMS) or other entity, hydrologic routing conduits may have used for delivery of water to the hydraulic model (HEC-RAS or EXTRAN network) in uniform flow reaches where the slope of the hydraulic grade line is relatively uniform. This model data may be used to extract information for the hydraulic network.	None in this model
13	Hydrologic Model Stage-Area	MFS	04/15/18	Someone Else	Enter	Stage-area-storage relationships in SWMM will be represented in the hydraulic layer (formerly called EXTRAN). This may be used to calculate initial abstractions in the hydrologic layer for conceptual representations of smaller scale and/or LSS SCMs. Use GIS to define from 2 ft contour DEM.	None in this model
14	Hydrologic Model WSELs	MFS	04/15/18	Someone Else	Enter	These may have been used in RIDE SWMM RUNOFF OR FEMA HEC HMS models for conceptual representations of smaller scale and/or LSS SCMs. This model data may be used to extract information for the hydraulic network.	None in this model
15	Hydrologic Model Boundary Conditions	MFS	04/15/18	Someone Else	Enter	May be used for conceptual representations of smaller scale and/or LSS SCMs	None in this model
16	Hydrologic Model Connectivity	MFS	04/15/18	Someone Else	Enter	Define and confirm connections for load points to the hydraulic model and hydrologic model conduits	Each load point matches a hydraulic model node
17	Hydrologic Model Results	MFS	04/15/18	Someone Else	Enter	Continuous simulation period of 1 to 3 years; 1, 2, 5, 10, 25, 50, 100 and 500 yr 24 hr design storms under existing and future land use conditions as appropriate); and the calibration and validation storms.	Checked and confirmed continuity (less than 0.1% error for all events) and generated hydrographs for continuous simulation and design storm conditions.
18	Hydraulic Model/Layer (SWMM EXTRAN, HEC-RAS) Channels	MFS	04/15/18	Someone Else	Enter	Irregular cross-sections from LiDAR, associated DEM, and survey (every ____ section on average). Check for absolute floodplain storage (check that the minimum section point, called GR values, in SWMM is between the elevations/inverts of the upstream and downstream junction points). Overbank n values should be based on field recon/photos and/or Chow Open Channel Hydraulics (1959). Road overflows should be represented as parallel surface flow channels with a raised invert for the road overflow elevation.	Confirmed splicing of survey for every fourth section into the 2 ft contour and (from LiDAR). Noted variations as appropriate for spot elevation confirmation survey
19	Hydraulic Model Pipes	MFS	04/15/18	Someone Else	Enter	Transportation Crossings (culverts and bridges), Culverted Streams; Model as realistic as possible (actual vs. equivalent shapes, sizes and lengths). The pipe representation should reflect appropriate roughness coefficient, entrance and exit losses, and internal local losses if necessary	Combined survey and stakeholder data (ODOT, County A, City B)
20	Hydraulic Model Junctions/Nodes	MFS	04/15/18	Someone Else	Enter	Connecting conduit and explicit storage for floodplain storage beyond stream channel representations, detention basins, SCMs/BMPs. The modeler should check the maximum and minimum values for connected conduits to confirm that flood stages are maintained within the model network.	Use____ database
21	Hydraulic Model Inverts	MFS	04/15/18	Someone Else	Enter	Inverts in North American Vertical Datum (NAVD) 1988 or invert offsets (ZPs in EXTRAN)	Confirmed or modified all datum to NAVD 1988
22	Hydraulic Model Stage-Area	MFS	04/15/18	Someone Else	Enter	Separate storage from channel and pipe storage. Explicit representation of major detention basin SCMs/BMPs, dams-reservoirs, and other floodplain storage not included in channel cross-sections from LiDAR, associated DEM, and survey. Check vs. FEMA DFIRMs for changes/differences.	Confirmed absolute floodplain storage (appropriate depth of floodplain to incised channel - not biased by a minimum cross-section survey point at a relative channel "hump" or "hole"). Two small tributaries were added as stage-area at nodes x and Y
23	Hydraulic Model Initial Water Surface Elevations (WSELs)	MFS	04/15/18	Someone Else	Enter	Base flows and lake NWLs from USGS records, reservoir operations records and other surveys. The modeler can use a "hot start" file for start-up periods or to establish initial flows for a given storm.	AMC III conditions
24	Hydraulic Model Boundary Conditions	MFS	04/15/18	Someone Else	Enter	FEMA FIS, sensitivity analyses, USGS gages, consider time-variability; As appropriate use existing FEMA HEC-RAS models in dynamic mode to estimate stage-time and identify relative differences in peak flows and stages.	Used USGS data and FEMA data to define a stage-time range. Tested sensitivity of the BC. Relatively insensitive after station X.
25	Indicator Road/Building Elevations	MFS	04/15/18	Someone Else	Enter	Elevations in Ft-NAVD 1988, low gutter, low road crown and low building evaluations by junction/node; Show in Flood Summary Tables for LOS comparison by design storm	Surveyed X locations to confirm numbers.
26	H/H Model Connectivity	MFS	04/15/18	Someone Else	Enter	Check versus model schematic	Connectivity is confirmed.

27	H/H Model Verification	MFS	04/15/18	Someone Else	Enter	Check input and output, continuity, connectivity, regression equation result comparisons. Note ranges of variation, potential reasons and refine to meet < +/- 1% continuity error in all models. In addition, the modeler should: - Check for and eliminate any node flooding (water loss from system) by refining node maximum depth, increasing siz of open channel section, adding roadway or land surface overflow conduits; - Check for high velocities (>10 ft/s) that may reflect model instability; - Check model peak flows/stages increasing from upstream to downstream (otherwise may indicate instability); and - Use a GUI to view of stage/flow/velocity time series and also water surface profiles that may graphically depict oscillations and instability.	Continuity is maintained within tolerances for the combined H/H results.
28	Calibration	MFS	04/15/18	Someone Else	Enter	Use at least three rain gages with radar rainfall as appropriate. USGS gage stage-velocity-flow/time, HWMs, USGS Regression, and FEMA FIS comparisons. Modify parameters to match stage, then velocity if available, and then flow and volume. Watch for potential hysteresis (looped rating curve) in the gage data. Prepare tabular summaries of flood stage and HWM comparisons. Perform statistical evaluations for goodness-of-fit for continuous simulation periods (Nash-Sutcliffe, et al)	Chose event for calibration (dates and year). This ranged form approximately w to Z inches over the subwatershed for the three day period (approximately a 5 to 10 year design storm). Peak stages at two USGS stations and Y HWM locations were within +/- 0.5 ft which is within the tolerance.
29	Validation	MFS	04/15/18	Someone Else	Enter	Independent event; Use at least three rain gages with radar rainfall as appropriate; USGS gage comparisons, Stage/Flow/Velocity-Time, HWMs. Tabular summaries of flood stage and HWM comparisons. Statistical evaluations for goodness-of-fit for continuous simulation periods (Nash-Sutcliffe, et al). Do not modify parameters to match stage, velocity, or flows/volumes. Note reasons for differences and advise on potential model refinement.	Chose the January X, 200X event. Results match within tolerance. Validation acceptable. Proceed to production simulations.
30	Model Application	MFS	04/15/18	Someone Else	Enter	Apply model for the design storms and continuous simulation period. Compare velocity peaks, frequencies and durationsto define asset condition and potential problem areas for erosion (and associated structural concerns), sedimentation, and flooding. Apply model for design storms for existing and potential future lands use conditions as appropriate.	Erosion problem areas are generally consistent with noted erosion from field investigations.
31	Hydraulic Results - Condition Assessment Tables (Flooding and Erosion)	MFS	04/15/18	Someone Else	Enter	Report stages, velocities, flows for a continuous simulation period of 1 to 3 years along with the 1, 2, 5, 10, 25, 50, 100 and 500 yr 24 hr design storms using an NRCS Type II distribution under existing and future land use conditions as appropriate. Peak flood stage summary tables by junction/node for the 1 through 500 year events (flag locations where peak stage is above indicator evaluations). Appendix tables of peak flows and velocities by conduit for each design storm (flag velocities above 3 ft/sec and above 7 ft/sec).	Problem areas are generally consistent with FEMA floodplains, previous studies, and noted erosion from field investigations.
32	Hydraulic Results - Inundation Maps	MFS	04/15/18	Someone Else	Enter	Flood inundation maps for the 100 year storm (screen results with 5 and 25 year also)	Noted large differences in inundation form the 5 to the 25 year events at nodes T and U
33	Hydraulic Results - Flood Profiles	MFS	04/15/18	Someone Else	Enter	Flood profiles for the 2, 5, 10, 25, 50, 100 and 500 yr 24 hr design storms under existing and future land use conditions as appropriate.	Identified two reaches as bottlenecks
34	Alternative 1	MFS	04/15/18	Someone Else	Enter	Define components clearly for watershed, reach and problem or group of problems. Flood summary tables for 1 through 500 year events (flag locations where peak stage is still above indicator evaluations). Appendix tables of peak flows and velocities by conduit for each design storm (flag velocities that are still above 3 ft/sec and above 7 ft/sec).	Includes O&M enhancements (sediment removal, bank and slope regrading as noted). Tested floodplain storage protection (turned off for simulation to compare increases). Evaluated 0.25 inches of onsite retention.
35	Alternative 2	MFS	04/15/18	Someone Else	Enter	Alt 2 builds upon Alt 1. Define components clearly for subwatershed, reach and problem or group of problems. Flood summary tables for 1 through 500 year events (flag locations where peak stage is still above indicator evaluations). Appendix tables of peak flows and velocities by conduit for each design storm (flag velocities that are still above 3 ft/sec and above 7 ft/sec).	Alt 1 with floodplain storage protection recommended plus streambank stabilization and restoration coordinated with floodplain storage restoration as noted.
#REF!	Costing (Construction & O/M)	MFS	04/15/18	Someone Else	Enter	Coordinate model results with life cycle cost estimates (20 year design life - confirm); Discount rate (to be determined).	Estimated costs of flood damages and reductions.
#REF!	Recommended Alternative	MFS	04/15/18	Someone Else	Enter	Finalize recommended model for details and components at a conceptual design level of detail for plan, section, and profile views	Summary tables and figures for Alt Xare consistent the model representations.
#REF!	Model Documentation	MFS	04/15/18	Someone Else	Enter	Draft report sections as tasks are completed. At completion, finalize documentation for recommended models and write copies to CDs. Include details, quantities and locations in tables and figures as appropriate for project components at a conceptual design level of detail for plan, section, and profile views. Identify potential sequencing needs for projects and potential phases of larger projects as appropriate.	Summary report tables and figures for Alt X are consistent the model representations. Digital versions of Alts 1 through 4 are saved with recent updates and refinements include. Filenames are X.X
#REF!	**Additional Comments/Notes:** Add additional discussion as needed here.						

Appendix B

NOAA Atlas 14 Precipitation

NOAA Atlas 14, Volume 11, Version 2
Location name: Dallas, Texas, USA*
Latitude: 32.8892°, Longitude: -97.0411°
Elevation: 569.55 ft**
* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Sandra Pavlovic, Michael St. Laurent, Carl Trypaluk, Dale Unruh, Orlan Wilhite

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

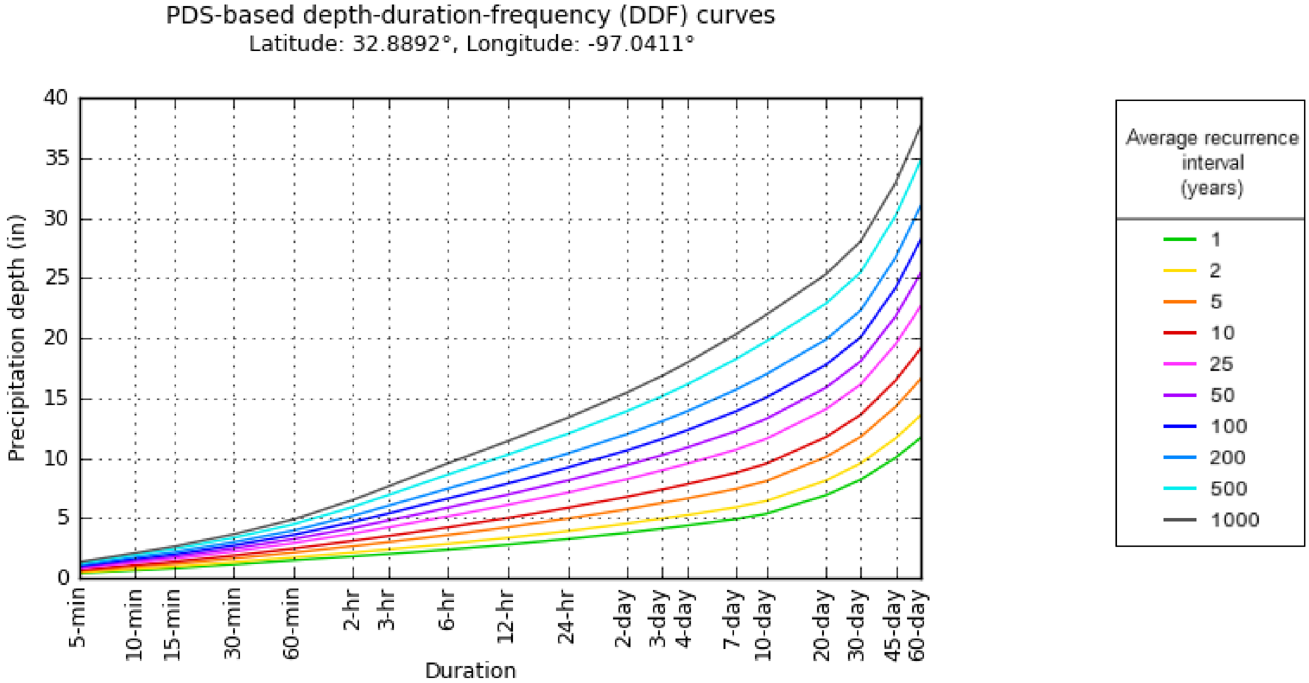
PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]

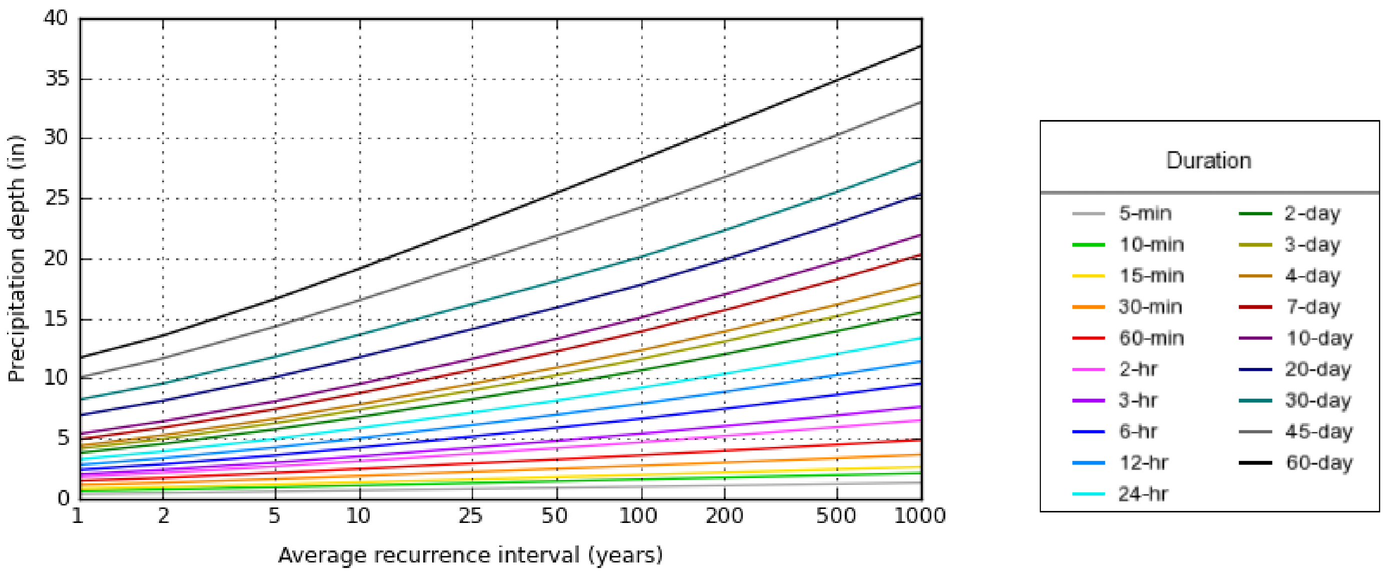
Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	**0.419** (0.317-0.553)	**0.487** (0.373-0.639)	**0.600** (0.457-0.789)	**0.692** (0.519-0.921)	**0.818** (0.594-1.12)	**0.913** (0.646-1.28)	**1.01** (0.695-1.45)	**1.11** (0.744-1.63)	**1.24** (0.806-1.88)	**1.34** (0.849-2.09)
10-min	**0.671** (0.508-0.886)	**0.781** (0.597-1.02)	**0.962** (0.733-1.26)	**1.11** (0.833-1.48)	**1.31** (0.955-1.80)	**1.47** (1.04-2.06)	**1.62** (1.12-2.33)	**1.77** (1.19-2.61)	**1.97** (1.28-3.00)	**2.12** (1.34-3.30)
15-min	**0.835** (0.632-1.10)	**0.970** (0.743-1.27)	**1.19** (0.910-1.57)	**1.38** (1.03-1.83)	**1.62** (1.18-2.22)	**1.81** (1.28-2.54)	**2.00** (1.38-2.87)	**2.19** (1.47-3.23)	**2.45** (1.59-3.73)	**2.65** (1.68-4.12)
30-min	**1.16** (0.877-1.53)	**1.34** (1.03-1.76)	**1.65** (1.26-2.17)	**1.90** (1.43-2.53)	**2.24** (1.62-3.06)	**2.49** (1.76-3.49)	**2.74** (1.89-3.95)	**3.01** (2.03-4.44)	**3.38** (2.20-5.14)	**3.67** (2.32-5.71)
60-min	**1.50** (1.14-1.99)	**1.75** (1.34-2.29)	**2.15** (1.64-2.83)	**2.48** (1.86-3.31)	**2.94** (2.13-4.01)	**3.27** (2.31-4.58)	**3.62** (2.50-5.20)	**3.99** (2.68-5.87)	**4.50** (2.92-6.84)	**4.90** (3.10-7.62)
2-hr	**1.84** (1.41-2.40)	**2.16** (1.67-2.79)	**2.68** (2.07-3.49)	**3.12** (2.37-4.11)	**3.73** (2.74-5.04)	**4.20** (3.00-5.82)	**4.69** (3.26-6.66)	**5.22** (3.53-7.58)	**5.95** (3.89-8.92)	**6.53** (4.16-10.0)
3-hr	**2.03** (1.57-2.64)	**2.41** (1.87-3.09)	**3.01** (2.33-3.89)	**3.53** (2.69-4.61)	**4.25** (3.13-5.70)	**4.81** (3.45-6.61)	**5.40** (3.77-7.61)	**6.04** (4.11-8.70)	**6.93** (4.55-10.3)	**7.65** (4.88-11.6)
6-hr	**2.40** (1.86-3.07)	**2.87** (2.24-3.62)	**3.61** (2.82-4.60)	**4.25** (3.28-5.49)	**5.16** (3.84-6.84)	**5.88** (4.26-7.99)	**6.65** (4.68-9.24)	**7.48** (5.12-10.6)	**8.64** (5.70-12.7)	**9.57** (6.15-14.3)
12-hr	**2.81** (2.21-3.56)	**3.37** (2.66-4.20)	**4.26** (3.37-5.36)	**5.02** (3.91-6.42)	**6.11** (4.60-8.00)	**6.98** (5.09-9.35)	**7.89** (5.60-10.8)	**8.88** (6.13-12.5)	**10.3** (6.84-14.9)	**11.4** (7.38-16.9)
24-hr	**3.27** (2.60-4.10)	**3.93** (3.14-4.85)	**4.97** (3.97-6.19)	**5.87** (4.62-7.40)	**7.14** (5.42-9.23)	**8.15** (6.00-10.8)	**9.21** (6.59-12.5)	**10.4** (7.21-14.4)	**12.0** (8.04-17.1)	**13.4** (8.68-19.4)
2-day	**3.80** (3.06-4.71)	**4.57** (3.68-5.56)	**5.76** (4.65-7.08)	**6.79** (5.40-8.47)	**8.26** (6.33-10.5)	**9.42** (7.00-12.3)	**10.7** (7.69-14.2)	**12.0** (8.41-16.4)	**13.9** (9.38-19.6)	**15.5** (10.1-22.2)
3-day	**4.15** (3.36-5.10)	**4.98** (4.04-6.02)	**6.28** (5.10-7.66)	**7.40** (5.92-9.15)	**8.99** (6.93-11.4)	**10.3** (7.66-13.3)	**11.6** (8.41-15.4)	**13.1** (9.20-17.7)	**15.2** (10.3-21.1)	**16.9** (11.1-23.9)
4-day	**4.40** (3.57-5.38)	**5.28** (4.30-6.34)	**6.65** (5.43-8.08)	**7.84** (6.30-9.65)	**9.54** (7.38-12.0)	**10.9** (8.16-14.0)	**12.3** (8.96-16.2)	**13.9** (9.81-18.7)	**16.1** (10.9-22.3)	**17.9** (11.8-25.3)
7-day	**4.93** (4.04-5.96)	**5.91** (4.85-7.03)	**7.44** (6.13-8.94)	**8.77** (7.12-10.7)	**10.7** (8.35-13.3)	**12.2** (9.25-15.6)	**13.9** (10.2-18.1)	**15.7** (11.1-20.8)	**18.2** (12.4-24.9)	**20.3** (13.4-28.3)
10-day	**5.38** (4.43-6.47)	**6.44** (5.33-7.61)	**8.10** (6.71-9.67)	**9.54** (7.78-11.6)	**11.6** (9.11-14.4)	**13.3** (10.1-16.8)	**15.0** (11.1-19.4)	**17.0** (12.1-22.4)	**19.7** (13.5-26.7)	**21.9** (14.5-30.3)
20-day	**6.93** (5.77-8.23)	**8.15** (6.85-9.57)	**10.1** (8.48-11.9)	**11.8** (9.69-14.1)	**14.1** (11.1-17.2)	**15.9** (12.1-19.8)	**17.8** (13.2-22.6)	**19.9** (14.3-25.8)	**22.9** (15.8-30.5)	**25.3** (16.9-34.4)
30-day	**8.23** (6.91-9.70)	**9.58** (8.13-11.2)	**11.8** (9.97-13.8)	**13.6** (11.3-16.2)	**16.2** (12.8-19.6)	**18.1** (13.9-22.3)	**20.1** (15.0-25.4)	**22.3** (16.1-28.8)	**25.5** (17.6-33.7)	**28.1** (18.8-37.8)
45-day	**10.1** (8.50-11.8)	**11.7** (9.97-13.6)	**14.3** (12.2-16.7)	**16.5** (13.8-19.4)	**19.5** (15.6-23.5)	**21.8** (16.9-26.8)	**24.2** (18.1-30.3)	**26.7** (19.4-34.2)	**30.2** (21.0-39.6)	**33.0** (22.2-44.0)
60-day	**11.7** (9.93-13.6)	**13.6** (11.6-15.7)	**16.6** (14.2-19.2)	**19.1** (16.1-22.4)	**22.7** (18.3-27.1)	**25.4** (19.8-31.0)	**28.2** (21.2-35.1)	**31.0** (22.5-39.3)	**34.8** (24.2-45.2)	**37.6** (25.4-49.9)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).
Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.
Please refer to NOAA Atlas 14 document for more information.

Back to Top

PF graphical



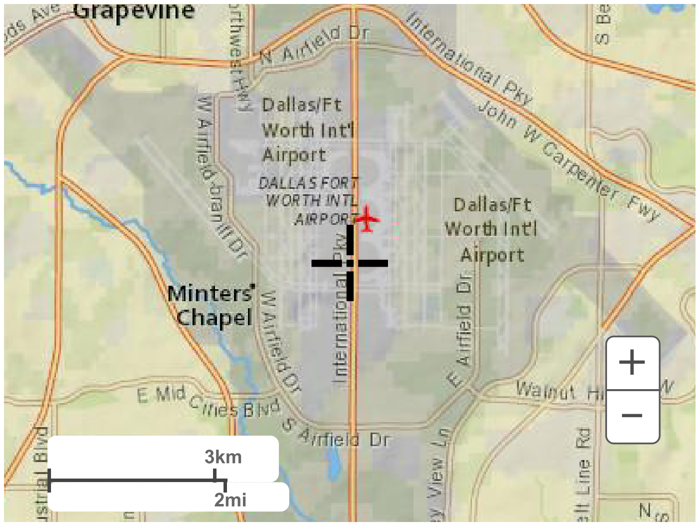


NOAA Atlas 14, Volume 11, Version 2 Created (GMT): Thu Oct 4 19:01:10 2018

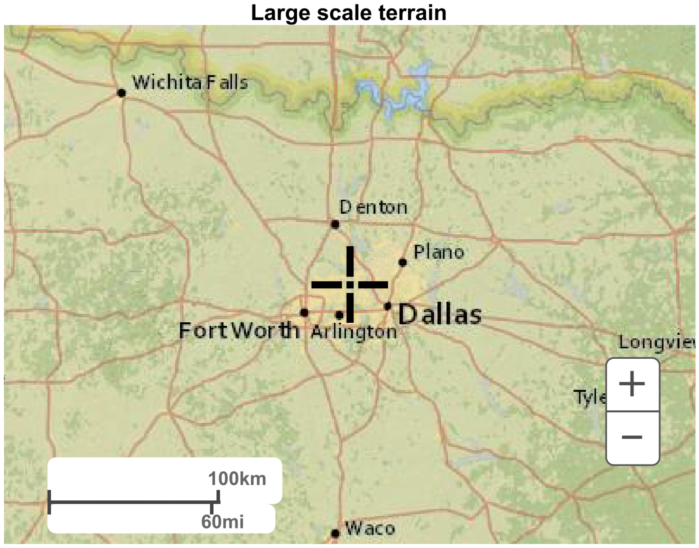
Back to Top

Maps & aerials

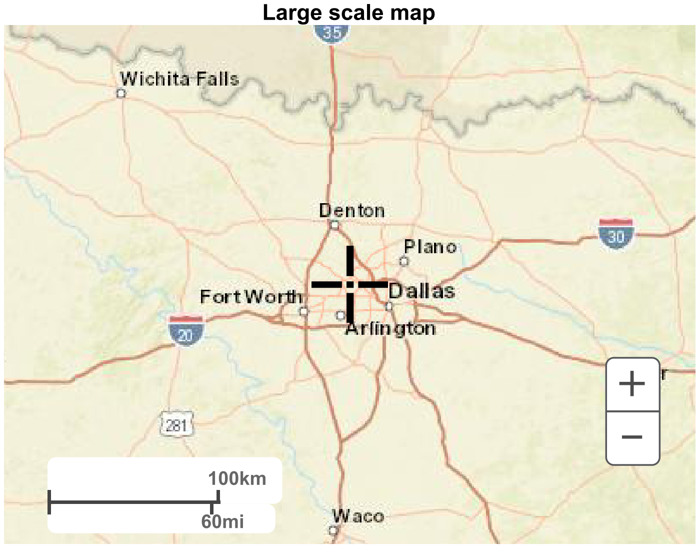
Small scale terrain



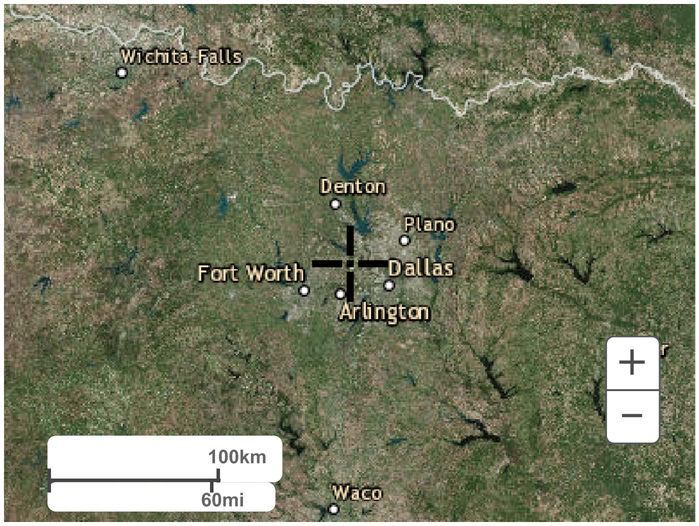
Large scale terrain



Large scale map



Large scale aerial



[Back to Top]

US Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service
National Water Center
1325 East West Highway
Silver Spring, MD 20910
Questions?: HDSC.Questions@noaa.gov


DFW
DALLAS
FORT WORTH
INTERNATIONAL
AIRPORT