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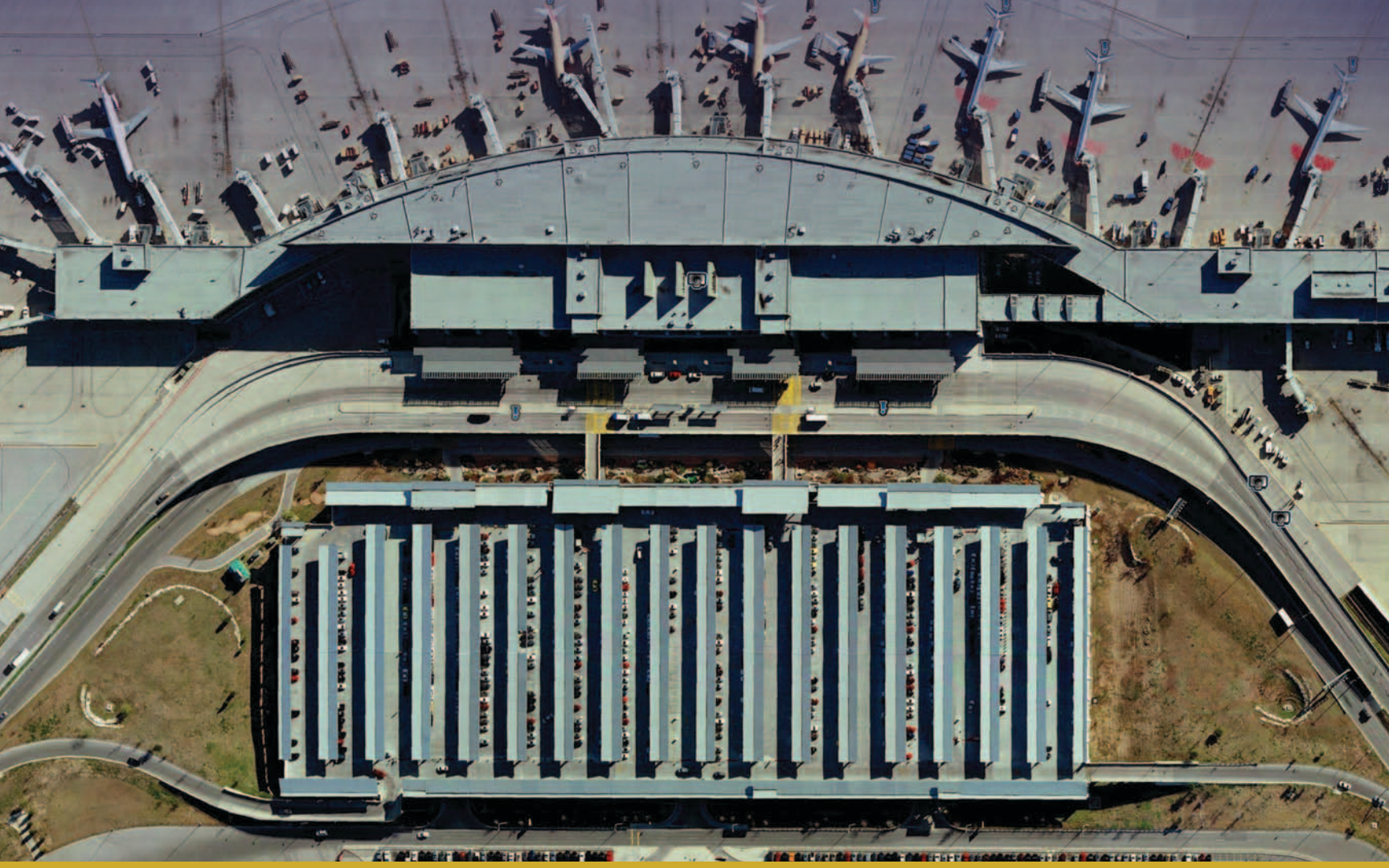
May 2011

AUSTIN-BERGSTROM INTERNATIONAL AIRPORT (ABIA) STORMWATER DRAINAGE MASTER PLAN UPDATE

FINAL REPORT

TBPE FIRM REGISTRATION NO. F-3043

CIP ID NO.: 5702.007
PROJECT NUMBER: 4910-8107-3139



IN ASSOCIATION WITH AXIOM ENGINEERS INC., CRESPO CONSULTING SERVICES INC. AND COMPUGRAPHICS

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Austin-Bergstrom International Airport (ABIA)
STORMWATER DRAINAGE MASTER PLAN (SWMP) UPDATE
Project No.: 4910-8107-3139

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SECTIONS

Section 1
Introduction

The City of Austin (COA) Department of Aviation (DOA) is seeking to improve its development process for the planning, permitting, and construction of stormwater facilities at Austin-Bergstrom International Airport (ABIA). In so doing, the DOA would like to accomplish the following:

- Improve the efficiency of the site development review process for development at ABIA;
- Manage stormwater to protect off site receptors and meet City requirements for flood control, erosion control, and water quality;
- Comply with flood control and fog-bird attractant requirements of the Federal Aviation Administration (FAA); and
- Maximize the use of developable ABIA property.

In order to assist the DOA with achieving these goals, the City of Austin, through the DOA and the Office of Contract and Land Management, hired CDM in July 2009 to perform a Stormwater Master Plan Update.

1.1 Project Goals and Objectives

The primary goals and objectives of the Stormwater Master Plan Update project were as follows:

- Create an updated plan and framework for the development of stormwater detention, conveyance, and water quality controls at ABIA.
- Evaluate and update the on-site hydrologic/hydraulic stormwater model for use as a planning, design, and permitting tool for future development at ABIA.
- Revise the site development ordinance to establish clear requirements for development and permitting of stormwater facilities at ABIA, and develop and implement process improvements to improve the efficiency of permitting ABIA facilities.
- Perform engineering analysis in support of participation in the City of Austin's Regional Stormwater Management Program (RSMP), including submission of an RSMP report and application, for the portion of the airport within the Onion Creek drainage basin.

- Fully engage the key City inter-departmental stakeholders – Watershed Protection Department (WPD), Planning and Development Review Department (PDRD), and City of Austin Legal Department (Legal) – in the development of the updated plan, ordinance changes, and process changes.

1.2 Background [1]

In 1991, the U.S. Department of Defense announced the closing of Bergstrom Air Force Base. The land for Bergstrom reverted to the City of Austin and City Council resolved to construct ABIA at this location. Construction began in 1994. Air cargo operations commenced in 1997, and commercial air service began on May 23, 1999.

The schedule for the design and construction of the conversion of the Air Force base to a civilian passenger airport was aggressive. In order to facilitate the design and permitting of the multiple projects simultaneously, DOA retained the services of a program manager that formed the framework of the New Airport Project Team (NAPT). The NAPT oversaw the development of all planning, design, and construction activities at ABIA.

Due to the schedule for completing the airport, a special arrangement was developed for the review and permitting of design projects at ABIA. An agreement was reached with the Watershed Protection and Development Review Department (WPDRD) (Note that the WPDRD was split into WPD and PDRD in 2009) to streamline the review process and to treat the airport as a single development. This agreement was subsequently formalized into an overall site development ordinance (Ordinance No. 94-1117-L) passed by City Council in 1994, which is referred to herein as the original ordinance.

The original ordinance provided a clear and effective framework for the permitting of stormwater facilities needed for ABIA's "Opening Day" facilities. However, the original ordinance did not address private development on airport property, beyond the cargo and rental car tenants. Also, it is not clear to what extent the original ordinance applied to the development of facilities after "Opening Day". Therefore, permitting of development at ABIA since "Opening Day" has been inconsistent and there remains uncertainty on the part of DOA and PDRD regarding the applicability of the original ordinance and permitting requirements for ABIA facilities.

1.3 Previous Drainage Master Plans [1]

Two previous drainage master plans have been developed for ABIA. Key aspects of these plans are summarized below.

---

[1] Portions of these subsections were paraphrased from the June 2003 Drainage Master Plan by Alan Plummer and Associates.

1995 Drainage Master Plan by Carter & Burgess

The 1995 Drainage Master Plan was developed by Carter & Burgess for the "Opening Day" conditions at ABIA. It utilized the HEC-1 Flood Hydrograph Package to complete hydrologic calculations for ABIA. Peak runoff from the drainage areas was determined using SCS dimensionless hydrographs. The 1995 plan did not include the entire airport site.

Peak runoff rates were determined for the 5-year and 25-year events using the City of Austin Standard 3-hour storm. The 1995 plan assumed that detention would not be required to offset the peak discharge from the site. Storm drain systems were identified and sized in the 1995 Master Plan to meet the design criteria of a 5-year storm in the airfield and a 25-year storm on all landside facilities.

Sedimentation and filtration ponds were identified in the 1995 plan to treat runoff from the landside areas. The original ordinance and 1995 plan were based on 0.5-inch capture volume for water quality ponds for landside facilities. Airfield areas (runways and taxiways) were not required to have water quality ponds in the 1995 plan. However, it should be noted that these areas were providing treatment through the vegetative areas adjacent to the runways and taxiways.

2003 Austin-Bergstrom International Airport Drainage Master Plan by Alan Plummer Associates, Inc.

Alan Plummer and Associates , Inc. (APA) developed a Drainage Master Plan in 2003. Under this plan, APA developed an on-site computer model for both hydrologic and hydraulic conditions at ABIA. The modeling platform was developed using DHI Software's MIKE Graphical User Interface (GUI) with the U.S. Environmental Protection Agency's (USEPA) Stormwater Management Model (SWMM) engine.

Three design storms were evaluated in the 2003 Plan. These were based on a 3-hour duration event for the 5-year, 25-year, and 100-year storms as defined at that time in the COA Drainage Criteria Manual (DCM). The MIKE SWMM model was used to identify drainage deficiencies at ABIA. The 2003 Plan indicated two primary areas of drainage deficiency associated with the old National Guard cantonment area and the cargo apron area.

Data input for the MIKE SWMM model was developed from record drawings, where such information was available. Other data was estimated using 2-foot contour information, interpolation, and other reasonable engineering assumptions. This included data input for drainage sub-areas, the storm drain network, open channels, and pond stage-storage relationships. Impervious cover was obtained from the airport base map.

The 2003 Plan also studied future development based on the Recommended Land Use Plan. Based on this plan, APA studied on-site detention options for each of the three drainage areas, as well participation in the RSMP. The plan developed Opinions of Probable Costs for the following two Alternatives:

- Alternative 1: $52, 527, 240 for on-site detention within all three drainage areas.
- Alternative 2: $48,900,040 for participation in the RSMP in the Onion Creek basin along with on-site detention within the Carson Creek and Colorado River drainage areas (this alternative included a $2,350,000 fee for RSMP participation).

The plan also studied elimination of the hydraulic control basin and provided an Opinion of Probable Cost of $6,399,000.

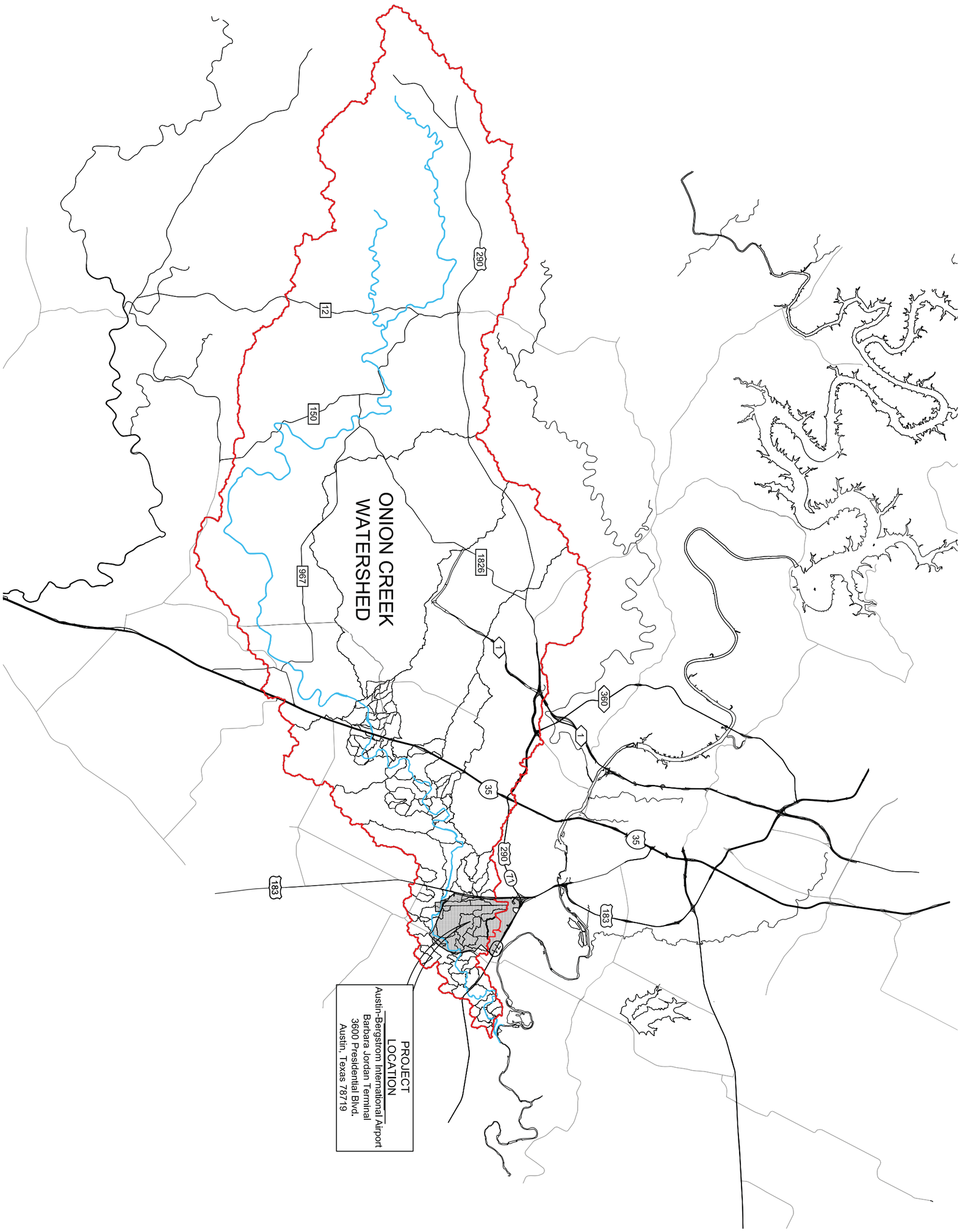
1.4 Facility Description

ABIA is a commercial aviation facility owned by the City of Austin. It is located in Southeast Austin just south of the intersection of State Highway 71 and U.S. Highway 183. The site is generally bounded by State Highway 71 on the north, U.S. Highway 183 on the west, Burleson Road on the south, and F.M. 973 on the east. The 6.5 square mile airport property is mainly located in the lower portion of the Onion Creek watershed, which encompasses a large drainage area of approximately 340 square miles. **Figure 1-1**, shows the location of the ABIA site within the watershed.

ABIA serves commercial aviation, general aviation, air cargo and the Air National Guard. Complementary uses include ground support operations, car rental facilities, parking lots and garages, a hotel, administrative facilities, and other related facilities. The airport operates with two parallel runways – the East Runway (9,000 ft) and the West Runway (12,500 ft). It includes 25 gates operating from a 600,000 square foot passenger terminal. Air cargo facilities are located in a separate terminal at the north end of the airport. General aviation facilities are located at the southern end of the airport alongside the East Runway.

The existing site plan for ABIA is shown in **Figure 1-2**. The existing site plan represents conditions at ABIA as of January 2010, and for the purposes of this report, "existing" refers to the conditions at ABIA as of January 2010.The northwestern end of the property drains to the north into the Carson Creek watershed. The northeastern portion of the property drains to the Colorado River. The majority of the property (approximately 3,400 acres) drains south to the Onion Creek, which passes through the southeast portion of the site.

The main airport site (excluding property to the north of State Highway 71) encompasses 4,163 acres with 992 acres of existing impervious cover, which equates to 23.8 percent existing impervious cover.



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LEGEND

ONION CREEK WATERSHED BOUNDARY

ONION CREEK

1" = 9,209'

N

FIGURE 1-1
WATERSHED AND SITE LOCATION MAP
Austin-Bergstrom International Airport (ABIA)
STORMWATER DRAINAGE MASTER PLAN (SWMP) UPDATE
Project No.: 4910-8107-3139

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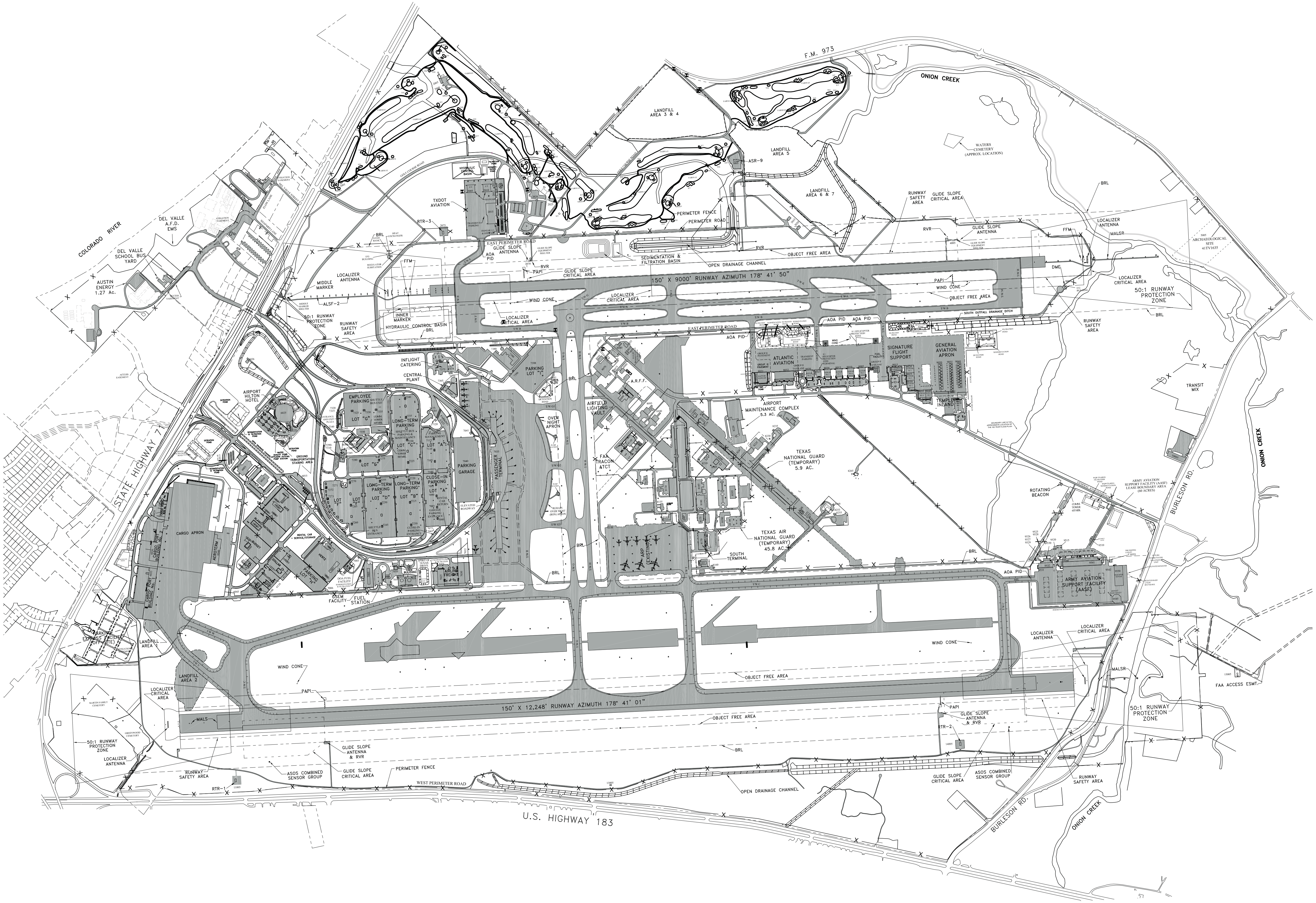

GROUND CONDITIONS AS OF JANUARY, 2010

LEGEND

EXISTING IMPERVIOUS COVER

0 350 700 1,400 2,100 2,800

FIGURE 1-2
EXISTING SITE PLAN
Austin-Bergstrom International Airport (ABIA)
STORMWATER DRAINAGE MASTER PLAN (SWMP) UPDATE
Project No.: 4910-8107-3139

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1.5 Organization

- Section 2 – Data Compilation and Evaluation: This section discusses the data compilation and evaluation necessary to prepare the stormwater models and analysis for the SWMP Update. It also provides a review of the City of Austin ordinance, codes, and regulatory requirements related to ABIA development.

- Section 3 – Impervious Cover Maps: This section discusses the creation of the existing conditions and future development impervious cover maps.

- Section 4 – Water Quality Evaluation: This section discusses the proposed water quality plan, including evaluation of existing facilities and BMPs, analysis of applicable structural and non-structural controls for ABIA, and discussion of water quality alternatives for runway/taxiway, apron, and commercial/industrial facilities.

- Section 5 – Participation in the Regional Stormwater Management Program (RSMP): This section provides a summary of the Regional Detention Study report and cost analysis for participation in the RSMP.

- Section 6 – Water Quantity Analysis: This section discusses the development of the EPA SWMM Model Version 5.0; the development of a HEC-HMS model to be used for permitting; identification of conveyance, flooding, and erosion problem areas; and the evaluation of water conveyance and detention alternatives at ABIA.

- Section 7 – Alternatives Evaluation: This section presents alternatives for three near-term project development areas at ABIA, as well as long-term detention options for the entire site.

- Section 8 – Site Development Ordinance: This section provides a summary of key provisions of the new/revised site development ordinance currently proposed for ABIA.

- Section 9 – Recommendations: This section summarizes key recommendations for the Stormwater Master Plan Update.

Section 2
Data Compilation and Evaluation

This section discusses the data compilation and evaluation necessary to prepare the models and analysis for the SWMP Update. In addition, it was necessary to review ABIA's existing ordinance and the permit requirements related to future development. The intent of this section is to identify water quantity and water quality parameters to be used in the models and evaluation methods, and to present these in one location in the document.

This section is segregated into two general subsections. The first part, Section 2.1, pertains to the evaluation of the regulatory and legal enforcement environment relative to the stormwater management system. The second part, Section 2.2, provides an inventory of the data obtained and its evaluation.

2.1 Review of Stormwater Ordinances, Operations and Regulations

2.1.1 Existing ABIA City of Austin (COA) Ordinance (94-1117-L)

In order to facilitate construction of ABIA, an overall site development ordinance – Ordinance No. 94-1117-L – was passed by City Council in 1994. This original ordinance contained specific provisions that governed the original construction of ABIA and some of the subsequent development that occurred after "Opening Day".

Some of the key provisions included in the original ordinance are summarized herein.

The ordinance provided environmental variances related to the construction of the east runway and related facilities, including variances from the following Land Development Code (LDC) provisions:

- Section 13-6-3 (a) (6) related to construction without requiring that the natural and traditional character of the land be preserved.
- Section 13-7-21 to allow construction within 150 feet of a critical environmental feature.
- Section 13-7-23 (e) to allow construction in the critical water quality zone.

Other key provisions included:

- Variance to Section 13-7-16 of the LDC allowing fill up to a maximum depth of 15 feet, and cut on the land up to a maximum of 25 feet.

- Requirement of 0.5-inch rainfall capture for water quality treatment for the following areas: passenger terminal and parking areas, commercial aircraft parking aprons, cargo apron, general aviation aircraft parking apron, the rental car facility, and the TxDOT Aviation facility.

Concurrent with the development of this SWMP update, the DOA is seeking to revise the site development ordinance for ABIA. Key provisions of the proposed new/revised ordinance are presented in Section 8.

2.1.2 FAA Requirements and Regulations

With respect to stormwater management, the FAA has prepared Advisory Circulars (AC) that direct stormwater drainage design as well as fog and bird attractant land uses within 10,000 ft of the air-side facilities under AC Series 150. The FAA sets minimum criteria and each facility may design to a higher standard as required by local and/or State regulations.

Applicable ACs include: 150/5320-5C Drainage Design, 150/5200-33B Hazardous Wildlife Attractants, 150/5370-2E Operational Safety During Construction, and 150/5300-13 Airport Design.

For Department of Defense (DOD) facilities, a minimum 2-year design storm is required with a maximum of 4-inches of ponding around inlets. For commercial airports, FAA recommends a minimum 5-year design storm with no runoff encroachment on runways or taxiways. The recommended maximum ponding limit is 4-inches around inlets. Additionally, FAA recommends that the center 50 percent of runways-taxiways and helipad surfaces along the centerline should be free from ponding for the 10-year design storm. Areas other than airfields (landside) are recommended to have a minimum 10-year design storm requirement. Storm durations for all cases are recommended to be 24 hours unless local requirements are greater. In addition, stormwater detention ponds should be designed, engineered, constructed and maintained for a maximum 48-hour detention period after the design storm and remain completely dry between storms as described in AC 150/5200-33B.

For this SWMP Update, the project team has simulated the 2-, 10-, 25-, and 100-year 24-hour storm events, and the team has followed the stormwater requirements of AC 150/5320-5C and the COA for all facilities siting and sizing. The 10-year storm has been used as a higher level of service to provide no runoff encroachment on runways and taxiways (in lieu of the 5-year storm as described above).

Additional controls and measures may be required for wildlife control in all parts of the stormwater and drainage systems, including ponds, basins, filter strips, ditches, canals, and natural conveyances. Measures could include vegetation management, modified maintenance practices, modifications to stormwater facility operations to reduce attractants, shape and configuration modifications, covers and flight-disruption

devices (i.e. wires and netting), and other population reduction measures. These additional controls would be identified in a wildlife hazard assessment and management plan.

2.1.3 ABIA Stormwater Pollution and Prevention Plan (SWPPP)

ABIA and many of its tenants are subject to the Texas Pollutant Discharge Elimination System (TPDES) Stormwater Industrial Permit, which is a general permit (TXR0500000). ABIA uses a shared Stormwater Pollution Prevention Plan (SWPPP) to comply with TPDES regulations. The plan includes identification of pollutant sources, development of pollution prevention measures (spill response measures, training, inspections, etc.), maintenance and water quality monitoring. The goal of the SWPPP is to protect stormwater runoff from potential pollutant sources.

2.1.4 COA Land Development Code

The COA has passed a number of ordinances related to stormwater quality and quantity control. These are compiled as the City's Land Development Code (LDC). Drainage provisions are in Section 25-7 and water quality provisions are described in Section 25-8 of the LDC. Detailed rules have been developed related to these provisions as described in the COA Drainage Criteria Manual (DCM) and the COA Environmental Criteria Manual (ECM).

2.2 Data Acquisition and Review

This section gives an overview of the data obtained for use in the stormwater evaluation. The initial analysis was based on previous stormwater studies and entailed the syntheses of Geographic Information System (GIS) maps.

2.2.1 Airport Background Maps – AutoCAD Drawings

The Department of Aviation (DOA) supplied a draft AutoCAD background map as the initial step in the development of the impervious cover (IC) maps for existing, near-term future, and ultimate future land use conditions. This background map was used to produce Existing Condition, Near-Term and Ultimate Future maps of the ABIA property. Each map represents the anticipated level of development intensity for a particular point in time. The Near-Term and Ultimate Future maps were developed through an iterative process discussed in more detail in Section 3. The impervious cover reflected on the Ultimate Future Impervious Cover map (Refer to Figure 3-3) was used as the basis for the hydrologic, hydraulic and water quality studies conducted for this master plan. Existing background conditions were calculated using the Existing Condition Impervious Cover map (Refer to Figure 3-1) as a basis that represents the site conditions as of January 2010.

The DOA also provided the June 2009 drawing "M20n1466 Figure 4-1 Individual Drainage Areas and Outfall Designations.pdf", which was used as a reference

document to confirm information such as outfall locations, stormwater system design, and drainage areas.

2.2.2 Topography

A digital elevation model (DEM) and map of the topography surrounding ABIA has been developed using high resolution Light Detection and Ranging (LiDAR) data. The LiDAR data was supplied by the COA, in the form of 2-ft elevation contours.

Topographic data has been used to confirm stage-area relationships in the water quality ponds, as well as other selected storage junctions in the models. The DEM may also be used to develop overland flow profiles for instances where stormwater surcharges from the primary stormwater management system (PSMS), augment surveyed stream cross-sections to accommodate very high peak flows, and to develop flood maps for various scenarios and alternatives.

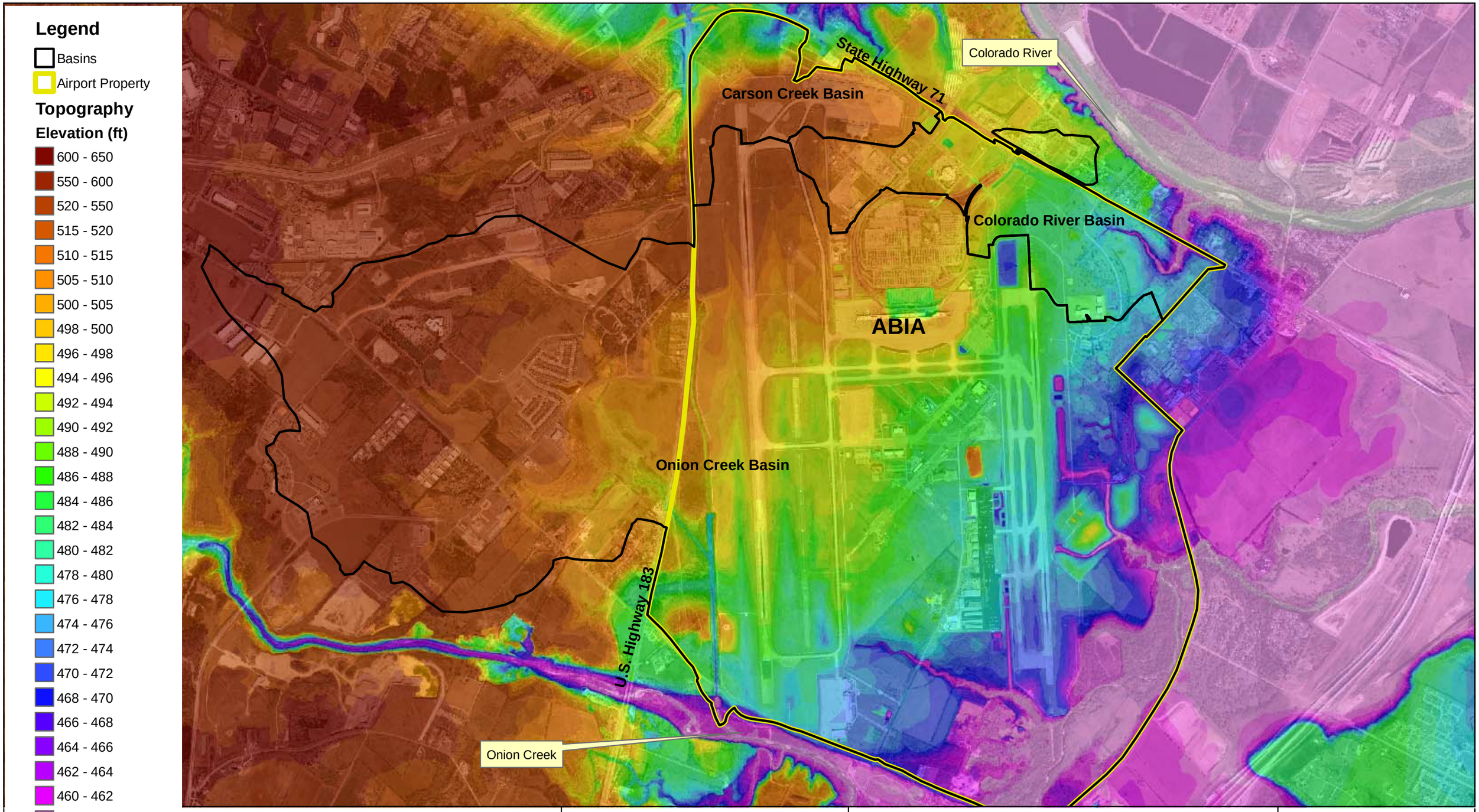
Airborne LiDAR systems obtain measurements for the horizontal coordinates (x, y) and elevation (z) of the reflective objects scanned by the laser beneath the flight path. The LiDAR data was collected for the COA in 2003. The laser-scanned objects include buildings, vehicles, vegetation, and bare ground. The data supplied by the COA was polylines (2-ft contour) in (filtered) bare earth format with a vertical datum in NAVD.

In **Figure 2-1**, a 20-ft resolution DEM of the airport is shown, representing the LiDAR data collected for the project. This figure also shows the watershed delineation within the airport property as runoff flows to outfalls on Carson Creek, the Colorado River, and Onion Creek. A large section of land west of Highway 183 flows onto airport property and eventually outfalls to Onion Creek. The basin boundaries shown in this figure were developed from the hydrologic and hydraulic models, i.e. the boundaries are based on the ABIA stormwater management system and do not necessarily follow topography.

2.2.3 Soils

Information on soil types, lateral and vertical extents, and soil characteristics were obtained in digital format from the National Resources Conservation Services (NRCS) website. The NRCS soil data is based on the Soil Survey of Travis County and was used to create the Soil Survey Geographic (SSURGO) database. SSURGO soil maps are compiled at scales from 1:12,000 to 1:63,360. Digital versions of SSURGO are available from the NRCS Soil Data Mart (SoilDataMart.nrcs.usda.gov). SSURGO data include soil polygons and extensive attribute data that define soil characteristics, properties, and potential uses. Soils are classified by hydrologic soil group (HSG), which may be used to determine infiltration characteristics.

The Travis County Soil Survey (paper copy) was also used in this project. Where this soil survey varied from the digital download, the survey data was substituted for the digital data.



N
W E
S

0 625 1,250 2,500 3,750 5,000
Feet

Figure 2-1
Area Topography
Austin-Bergstrom International Airport (ABIA)
Stormwater Drainage Master Plan (SWMP) Update
Project No.: 4910-8107-3139

CDM

Figure 2-2 shows the soil distribution based on their HSG classification. Approximately 89 percent of the project area is Type 'C' soils, which have moderately high runoff potential when thoroughly wet. The remaining 11 percent of the project area is divided between Type 'D' soils (9 percent) and Type 'B' soils (2 percent). There are no Type 'A' soils in the project area.

The most common soils in order of predominance are: Lewisville silty clay (80 percent), Altoga silty clay (9 percent) and Houston Black clay (7 percent). Lewisville and Altoga soils are both Type 'C' soils and are relatively permeable (0.63 to 2.00 inches/hour).

Information from the following report was used to determine groundwater depths at ABIA:

Final Report Base Realignment and Closure Program (BRAC) Round II Remedial Investigation (RI) for Soil and Groundwater at 12 Sites to Determine Background Levels of Naturally Occurring Constituents at Bergstrom Air Force Base (Haliburton NUS Corp, April 1994)

2.2.4 Aerial Photography

Two digital aerial photos were used for this project.

DEC 2007.tif

This file was the result of a flyover by Aerotech in 2007 and was commissioned by the DOA. This file was used in conjunction with the AutoCAD files discussed in Section 2.2.1 to aid in the development of the impervious cover maps.

MONTOPOLIS_NE.sid

This file is one of four quadrangles (others include _NW, _SE, and _SW) aerial photographs that are used as the background image in many of the figures in the report. These older photos (2003) were downloaded from the COA website and were used in the images (for reference only) because they are geo-referenced and compacted.

2.2.5 Rainfall

2.2.5.1 Design Storms

Rainfall time series for the 2-, 10-, 25-, and 100-year, 24-hour storm events were developed for the stormwater modeling using SCS Type III distributions. The SCS Type III distribution ordinates at 5-minute intervals were obtained from Table 2-7 in the Austin Drainage Criteria Manual (DCM). **Table 2-1** shows the precipitation totals used in the models, which were obtained from Table 2-4 in the DCM. Note that in this update, the 24-hour SCS distribution is used as opposed to the 3-hour storm used in the 1995 and 2003 Drainage Master Plans (see Section 6 for further explanation).

Table 2-1. Precipitation Totals for Design Storm Events

Recurrence Interval (Years)	Duration (Hours)	Depth (Inches)
2-year	24.00	3.44
10-year	24.00	6.11
25-year	24.00	7.63
100-year	24.00	10.20

Source: Table 2-4. Depth-Duration-Frequency Table for Austin and Travis County, Austin Drainage Criteria Manual

2.2.5.2 Validation Storm

The storm chosen to validate the ABIA models was the November 15, 2001 storm, which had a total precipitation depth of 6.8-inches in 24 hours at the selected gauge; however, it was very intense for a two-hour period. Within portions of the Austin area, this storm approached the 100-year storm in depth and intensity. This data was downloaded as hourly depths from the National Climatic Data Center (NCDC) in Asheville, NC. The rain gauge was located at ABIA (Bergstrom AP (AUS)).

Hourly precipitation data are not refined enough for hydrologic calculations in subbasins as small as those used in the hydrologic and hydraulic models discussed in Section 6. However, since data in smaller intervals were not available, these hourly data needed to be converted into smaller time intervals. The hourly volumes could be evenly divided over twelve 5-minute intervals, but there are better approximations than this. For this project, the storm data were disaggregated into 5-minute intervals using NetSTORM (public domain program developed by CDM for the U.S. Army Corps of Engineers). This algorithm uses preceding and following rainfall volumes to estimate the interval volumes. For example, if the preceding hour has zero rainfall and the following hour has 2-inches, the given hour's volume would be disaggregated into a pattern that increases in intensity.

2.2.5.3 Regional Areal Extent

For the ABIA Regional Detention Study described in Section 5, adjustments to the total precipitation volumes for the design storms were made based on areal extent. The Onion Creek watershed is approximately 340 square miles. The U.S. Army Corps of Engineers (USACE) Hydrologic Engineering Center (HEC) Hydrologic Modeling system (HMS) models used for this analysis were based on storm extents of approximately 30 square miles because it is unlikely that the 100-year, 24-hour storm event of 10.2-inches would cover the entire 340 square mile basin evenly. Test scenarios were run with lower precipitation amounts to examine the effect of areal storm extent on the results.

This adjustment was not necessary for the local ABIA models.

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LEGEND

SOIL CLASSIFICATION BOUNDARY
HYDROLOGIC SOIL GROUP A
HYDROLOGIC SOIL GROUP B
HYDROLOGIC SOIL GROUP C
HYDROLOGIC SOIL GROUP D

N

0 350 700 1,400 2,100 2,800

FIGURE 2-2
SOILS MAP
Austin-Bergstrom International Airport (ABIA)
STORMWATER DRAINAGE MASTER PLAN (SWMP) UPDATE
Project No.: 4910-8107-3139

CDM
Texas P.E. Firm No. F-3043

2.2.6 Boundary Condition Data

For the ABIA hydrologic and hydraulic models, free outfall conditions were used unless otherwise specified below. See Section 6 for further details on the use of boundary conditions.

2.2.6.1 Onion Creek

The Travis County USACE HEC– River Analysis System (HEC-RAS) Model was used to develop the 100-year floodplain (Refer to Section 6). The model was run as provided by the COA and the simulation results were used to provide fixed stage boundary conditions at Onion Creek outfalls.

2.2.6.2 Colorado River

The HEC-RAS model that was provided did not include the Colorado River north of ABIA. For the outfall in the northeast corner of ABIA that is close to this river, a fixed peak stage was conservatively estimated from the nearby HEC-RAS results and engineering judgment.

2.2.7 Existing Models

This subsection describes the models from outside sources that were collected and used to develop this SWMP update. These models were converted and/or upgraded to existing ABIA conditions in Sections 5 and 6.

2.2.7.1 2003 ABIA MIKE SWMM

The DOA supplied the 2003 MIKE Stormwater Management Model (SWMM) Drainage Master Plan Model. MIKE SWMM is a proprietary graphical user interface (GUI) developed by DHI using the U.S. Environmental Protection Agency's (USEPA's) SWMM hydrologic and hydraulic engine. This model was developed for the DOA by Alan Plummer Associates, Inc. (APAI). This model was converted to the newest public domain version of USEPA SWMM version 5.0 as described in Section 6.

2.2.7.2 Onion Creek HEC-HMS

The COA Watershed Engineering Department supplied a regional USACE HEC-HMS of the Onion Creek watershed. This HEC-HMS model (updated in 2009) is considered to be the most accurate model of the overall Onion Creek watershed currently available. This model was the base model for the Regional HMS models as described in Section 5.

2.2.8 Stormwater Infrastructure Data (Plans)

Table 2-2 lists "as-built" and design plans that were used in both the water quality analysis and the update of the hydrologic and hydraulic models. The plans were

analyzed to determine water quality basin volumes as described in Section 4, and to update stage-volume relationships for the hydraulic models in Section 6. Additional information related to these plans and water quality features is provided in Appendix A.

Table 2-2. Stormwater Infrastructure Plans

Site Plan No.	Project Name	Sheet No.	Drawing Status	Date	Source
SP-02-0236C	Texas Air National Guard	20	Released	03/05/04	WPD
SP-03-0059C	ABIA Propane Facility	C301	WPD Released ABIA As Built	WPD 05/14/03 ABIA 05/14/03	WPD/ABIA
ABIA: SP-94-0438C.0913(B) WPD SP-98-0384D	Rental Car Companies-GSEM	C302 C304	ABIA As Built WPD Released	ABIA 05/13/97 WPD 01/14/99	ABIA
SP-99-0151	ABIA Hotel	06	Released	07/12/99	WPD
SP-94-0482(C-912(b)	Cargo Landside	--	--	--	WPD
SP-94-0482(C-912(b)	Cargo Ramp	C0311	Released	--	WPD
SP-94-0004C	Northwest Landside Cargo Area	C0306	Released	01/09/96	WPD
SP-98-0265	GSEM	C0301 C0502	Released	11/30/98	WPD
SP-98-0266C	Belly Freight/Fuel Farm	C0301 C0502	Released	11/24/01	WPD
SP-94-0438C-912(d)	Terminal Building, Roadways, Parking Areas	C0336	Released	08/14/95	WPD
SP-98-0218C	South FBO Ramp	C0310	Released	09/08/98	WPD
WP: SP-98-0320 ABIA: SP-94-0438C-0-12K	North FBO Ramp	C0311	Released	11/12/01	WPD
SP-00-2256C	T-Hangar Ramp, South Corporate Hangars	C311	Released	09/19/00	WPD
SP-01-0293C	North FBO Ramp	C0313 C0314	Released	10/31/01	WPD
SP-94-0438C.0910	Terminal Apron	--	Released	02/05/98	WPD email
SP-94-0438C.0912(H)	TxDOT Flight Services	C0320 C0321	--	12/19/00	WPD

2.2.9 Water Quality Data

Water quality data was obtained from ABIA on-site monitoring programs. The data was compared to available airport data from a COA watershed study that included data from the old Robert Mueller airport, and data presented in studies of other airports.

2.2.9.1 TPDES Water Quality Monitoring

ABIA monitors on-site water quality to meet TPDES requirements. To fulfill the monitoring requirements, ABIA must monitor outfalls where discharges from upstream industrial operations may contribute to stormwater degradation.

The ABIA TPDES permit requires the monitoring of the 12 constituents shown in **Table 2-3**. The permit requires sampling of these constituents once per year. Grab samples are taken at six locations as described in Section 4. Samples are required to be taken during the first flush of a rainfall event. TPDES sampling typically takes place at outfalls, however, the physical construction of several BMPs and the adjacent outfall makes this impractical. As a result, some samples are taken at outfalls (treated runoff) and some samples are taken at BMP inlets (untreated runoff), or at intermediate points in the BMP, such as between the sedimentation and filtration basins (partially treated).

Table 2-3. Pollutants Monitored for TPDES Permit

Constituent (Total)	Monthly* Average (mg/L)	Daily Composite (mg/L)	Daily Maximum (mg/L)	Monitoring Frequency
Arsenic	0.1	0.2	0.3	1/Year
Barium	1.0	2.0	4.0	1/Year
Cadmium	0.05	0.1	0.2	1/Year
Chromium	0.5	1.0	5.0	1/Year
Copper	0.5	1.0	2.0	1/Year
Lead	0.5	1.0	1.5	1/Year
Manganese	1.0	2.0	3.0	1/Year
Mercury	0.005	0.005	0.01	1/Year
Nickel	1.0	2.0	3.0	1/Year
Selenium	0.05	0.1	0.2	1/Year
Silver	0.05	0.1	0.2	1/Year
Zinc	1.0	2.0	6.0	1/Year

**Grab samples required*

A single event for each year was sampled at the six outfalls designated in the SWPPP, resulting in 32 samples. The samples are analyzed at an approved laboratory. Table 2-3 shows the pollutants monitored as part of the TPDES monitoring program. Only two of the pollutants in the TPDES monitoring – Lead and Zinc – are included the COA ECM list of pollutants concentrations and removal efficiencies.

2.2.9.2 Austin Water Utility Monitoring

ABIA monitors the runoff from ramp and aircraft parking areas where de-icing occurs. The monitoring occurs only during "de-icing" season, or generally only the winter months. Runoff from de-icing areas is captured and held in a holding basin until the monitoring results have been obtained. If the results indicate de-icing chemicals exceed a trigger level, the runoff is pumped to the Austin Water Utility for treatment. Chemical Oxygen Demand (COD) is the constituent used to determine the presence of de-icing fluids. Otherwise, the runoff is treated as standard stormwater runoff. WQP-E captures runoff from de-icing areas near the main terminal. WQP-N captures runoff from the air cargo deicing areas.

ABIA monitors a wide range of constituents at the de-icing ponds. The constituents monitored vary across the sample data set. Of the monitored parameters, Pb, Zn, TSS, COD, and BOD are also included in the COA ECM list of pollutants concentrations and removal efficiencies. A total of 73 de-icing basin events were monitored between 2002 and 2009. The following are the number of de-icing events where parameters from COA ECM list were monitored.

Constituent	COD	BOD	TSS	Pb	Zn
Number	64	38	45	36	36

2.2.9.3 Robert Muller Municipal Airport Data

The Stormwater Runoff Quality and Quantity from Small Watersheds in Austin, TX report written by the COA Watershed Protection Department contains a set of monitoring data from a watershed that includes the east side of Robert Mueller Municipal Airport. It consists of a 99.1-acre drainage area with 46 percent impervious cover containing runways, a portion of the terminal, and passenger parking areas. In the sample period of 1994 to 1999 (the airport was operational), 259 events were monitored (Refer to **Figure 2-3** below).

2.2.9.4 Florida Airport Study

The Florida Department of Transportation published a study titled Application Assessment for Florida Airports Stormwater Study dated June 29, 2007. The study looks at field information describing water quality of runways, taxiways, and airport parking areas. The parameters Pb, TN, TP, TSS, and ZN were evaluated as part of the report. These pollutants are also listed as key parameters in the COA ECM.

2.2.9.5 Seattle-Tacoma Airport Study

The Seattle-Tacoma International Airport (STIA) AKART Analysis prepared by R. W. Beck looked at the existing stormwater BMPs at STIA and proposed methods to add or improve stormwater treatment. The parameters Pb, TSS, and Zn were evaluated as part of the report. These pollutants are also listed as key parameters in the COA ECM. Sweeping operations were also studied in this report.

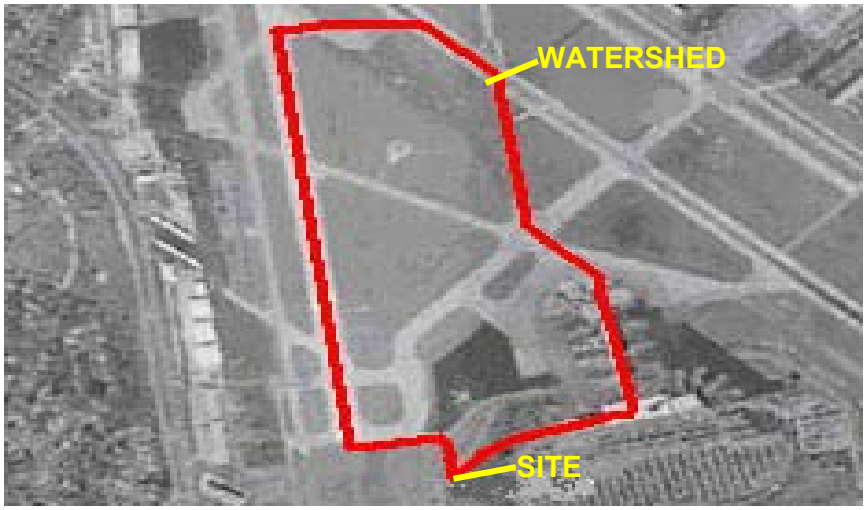


Figure 2-3. Robert Mueller Municipal Airport Monitoring Watershed

2.2.9.6 Analysis of Off-Site Data

Off-site data was compared to the ECM pollutant concentrations and to the ABIA monitoring data. **Table 2-4** provides a comparison of the off-site and on-site data. The table compares the COA ECM concentrations, the Mueller data, the Florida data, and the STIA data with the selected ABIA data.

The Florida and STIA studies provide points of comparison with similar facilities in other parts of the country. In general, concentrations are lower in the Florida and STIA studies than data for the same parameters listed in the ECM (Pb, TN, TP, TSS, and Zn for Florida, Pb, TSS, and Zn for STIA).

Table 2-4. Comparison of Constituents

Constituent	COA ECM Commercial >15% IC c (mg/L)	Small Watershed ERA (Mueller) c (mg/L)	ABIA TPDES 2006 - 2009 c (mg/L)	ABIA Untreated c (mg/L)	Florida c (mg/L)	STIA c (mg/L)
BOD	8.0	7.4	-	4.5	-	
COD	79.00	62.96	-	45.4	-	
Pb	0.030	0.021	< 0.01	0.017	0.006	0.015
TN	1.82	1.80	-		0.46	
TOC	19.0	9.03	-		-	
TP	0.16	0.79	-		0.074	
TSS	110	57.6	-	9.5	12.75	35.7
Zn	0.050	0.141	0.021	0.036	0.042	0.021

The Robert Mueller data provides a comparison to an airport in the same geographic area as ABIA. Mueller airport data has lower concentrations compared to the values listed in the ECM for BOD, COD, Pb, TN, TOC, and TSS, while TP and Zn are higher.

2.2.9.7 Analysis of On-Site Data

As previously mentioned, ABIA data includes treated, untreated, and partially treated runoff. In order to provide a comparison of like data, untreated ABIA data was sorted from the full set of ABIA monitoring data (Untreated column in Table 2-4). This further reduces the number of data available for analysis. The ABIA concentrations for untreated stormwater for parameters BOD, COD, Pb, TSS, and Zn are all lower than the COA ECM levels as shown in Table 2-4.

Additional analysis was performed on ABIA Pb and Zn data. Monitoring results were sorted by time and both Pb and Zn show trends toward lower concentrations over the 2002 to 2009 time period. The Pb trend has been nationally noted due to the regulation against lead additives in gasoline.

2.2.9.8 Conclusions

A review of the available data indicates that stormwater runoff at ABIA likely has lower pollutant concentrations than runoff from "typical" sites in Austin. This is expected due to the airport's sweeping and scrubbing operations to manage foreign object and debris (FOD). This conclusion cannot be fully supported by the available data, however, due to the small number of events sampled in the ABIA monitoring, the low frequency of sampling, the type of runoff sampled (treated, untreated), the lack of consistent data from a similar site, and the specific constituents tested. The Florida and STIA data suggest that ABIA runoff is similar in pollutant concentrations to other airports in the United States.

Mueller airport data suggests the potential for relatively high levels of TN, TP and Zn. Available information indicates that the use of urea as a de-icing agent and lack of structural controls may explain some of the higher concentrations at Mueller, particularly of TN. No specific sources of TN, TP and Zn have been identified that would suggest high concentration levels at ABIA. Downward trends of lower Pb and Zn concentration at ABIA are indications that neither parameter is a significant concern at ABIA.

If site-specific ABIA water quality data is desired for future planning and design purposes, a stormwater monitoring program could be developed to further statistically validate results.

2.2.10 Water Quality Best Management Practices (BMPs)

Water quality data sources were reviewed relative to potential BMPs. These include:

- Highland Lakes Watershed Ordinance
- Water Quality Management Technical Manual: LCRA
- Surface Water Design Manual, King County, Washington
- City of Austin, Environmental Criteria Manual
- Stormwater Best Management Practices in an Ultra-Urban Setting: Selection and Monitoring, US DOT, Federal Highway Administration
- Controlling Urban Runoff: A practical method for planning and designing Urban BMPs, Thomas Schueler, Department of Environmental Programs, Metropolitan Washington Council of Governments
- TCEQ, Edwards Aquifer Technical Guidance Manual, June 2005
- International Stormwater BMP Database (www.bmpdatabase.org)

Section 3
Impervious Cover Maps

3.1 Existing Condition

As detailed in Section 2, the Department of Aviation (DOA) supplied an AutoCAD file of the ABIA site for use in compiling impervious cover maps. This background map was reviewed against aerial photographs of the ABIA property and record site plan information from individual projects and updated to reflect on-the-ground improvements not included in the initial drawing. The aerial photograph used was a 2007 photograph titled "Dec2007.tif" provided by DOA staff. The boundary of ABIA property east of State Highway 71 was also clarified and refined. A working copy of the updated background map was supplied to DOA personnel for review and comment. DOA comments were consolidated by Joseph Medici and returned to CDM. Additional existing improvements, including remnant Air Force roadways, abandoned golf course cart paths, etc. were identified and added to the background map to produce the Existing Conditions Impervious Cover map included as **Figure 3-1**. This figure represents actual on-the-ground conditions of the ABIA site as of January 2010 and contains approximately 992 acres of impervious cover.

3.2 Near-Term Development Condition

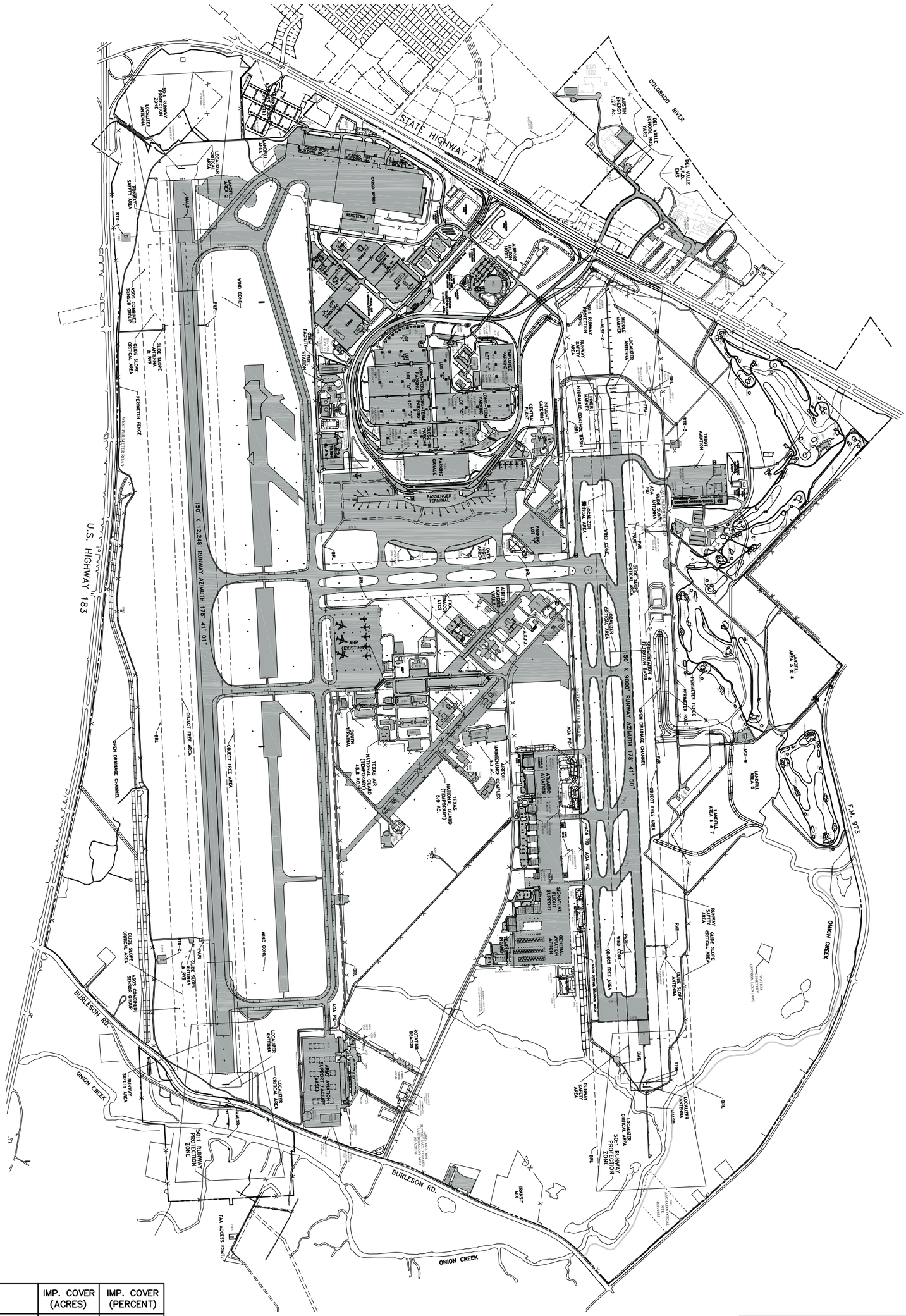
Future ABIA development was initially identified in a work session attended by CDM, Axiom and DOA team members. Using the most recent (but dated) ABIA Master Plan and other documents, the approximate location, size and development intensity of anticipated future developments were located on the background map. Future developments were classified as Near-Term (generally in a 15-year planning horizon) and Long-Term (50-year planning horizon). Twenty-one separate near-term projects were identified and are shown on the Near-Term Future Impervious Cover map. Each was added to the existing condition map to produce a working copy of the Near-Term Future Impervious Cover map. This map was subsequently provided to DOA staff for additional review and comment. The near-term development will occupy approximately 231 acres of land and will include approximately 193 acres of impervious cover. A small portion of the land proposed for near-term development currently contains impervious cover that will be replaced by future projects. The net impervious cover increase associated with near-term development is therefore approximately 177 acres. The Near-Term Future Impervious Cover map is shown in **Figure 3-2**.

3.3 Ultimate Development Condition

An Ultimate Future Impervious Cover map was generated using the same process as that which produced the Near-Term Future Impervious Cover map. Thirteen separate long-term development projects were identified and are shown on the Ultimate Future

Impervious Cover map. These generally represent larger areas of land including development of the abandoned golf course, redevelopment of the property between State Highway 71 and the Colorado River and reconstruction of a significant portion of the west runway system.

These projects will occupy approximately 1,184 acres of land and will encompass approximately 1,125 acres of total impervious cover assuming the development intensities indicated on the map are achieved. The Ultimate Future Impervious Cover map is shown in **Figure 3-3**. Some development areas contain existing impervious cover which will be removed and replaced with future development. As a result, the net increase shown in the Impervious Cover Summary Table in Figure 3-3 is less than the 1,125 acre total. The total impervious cover of the original ABIA property (excluding areas north of State Highway 71) at full buildout is anticipated to be approximately 1,995 acres.



	IMP. COVER (ACRES)	IMP. COVER (PERCENT)
EXISTING	992	23.8%

NOTE: EXCLUDES AREAS NORTH OF S.H. 71

GROUND CONDITIONS AS OF JANUARY, 2010

LEGEND

EXISTING IMPERVIOUS COVER

0 350 700 1,400 2,100 2,800

N

FIGURE 3-1
EXISTING CONDITIONS IMPERVIOUS COVER
Austin-Bergstrom International Airport (ABIA)
STORMWATER DRAINAGE MASTER PLAN (SWMP) UPDATE
Project No.: 4910-8107-3139

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CDM
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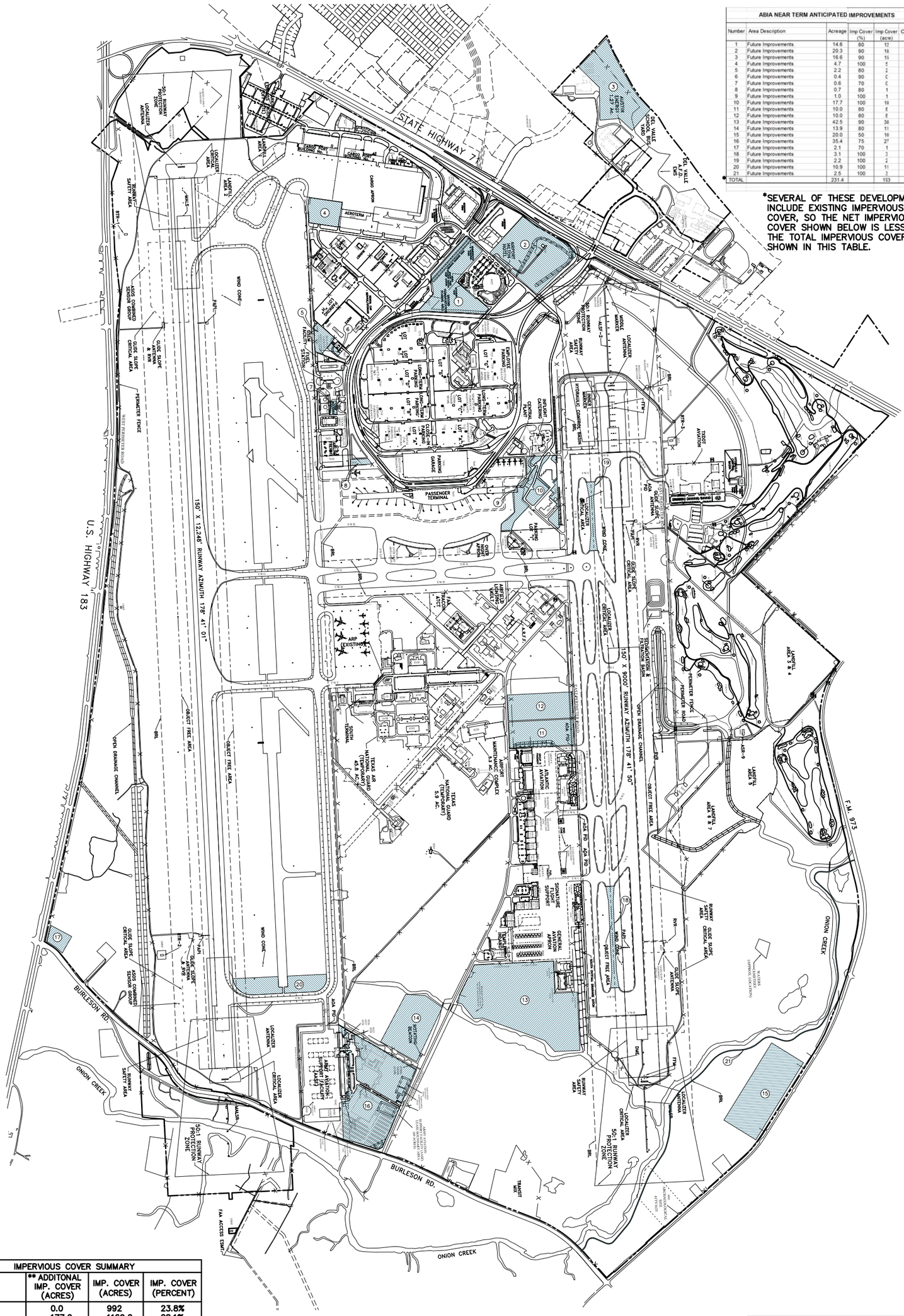
ABIA NEAR TERM ANTICIPATED IMPROVEMENTS					
Number	Area Description	Acreage	Imp Cover (%)	Imp Cover (acre)	Completion
1	Future Improvements	14.6	80	12	2015
2	Future Improvements	20.3	90	18	2015
3	Future Improvements	16.6	90	15	2020
4	Future Improvements	4.7	100	5	2020
5	Future Improvements	2.2	80	2	2018
6	Future Improvements	0.4	90	0	2011
7	Future Improvements	0.6	70	0	2025
8	Future Improvements	0.7	80	1	2011
9	Future Improvements	1.0	100	1	2020
10	Future Improvements	17.7	100	18	2012
11	Future Improvements	10.0	80	8	2015
12	Future Improvements	10.0	80	8	2020
13	Future Improvements	42.5	90	38	2015
14	Future Improvements	13.9	80	11	2020
15	Future Improvements	20.0	50	10	2020
16	Future Improvements	35.4	75	27	2012
17	Future Improvements	2.1	70	1	2015
18	Future Improvements	3.1	100	3	2015
19	Future Improvements	2.2	100	2	2015
20	Future Improvements	10.9	100	11	2015
21	Future Improvements	2.5	100	3	2013
TOTAL		231.4		163	

*SEVERAL OF THESE DEVELOPMENTS INCLUDE EXISTING IMPERVIOUS COVER, SO THE NET IMPERVIOUS COVER SHOWN BELOW IS LESS THAN THE TOTAL IMPERVIOUS COVER SHOWN IN THIS TABLE.



IMPERVIOUS COVER SUMMARY			
	** ADDITONAL IMP. COVER (ACRES)	IMP. COVER (ACRES)	IMP. COVER (PERCENT)
EXISTING	0.0	992	23.8%
NEAR TERM	177.0	1169.0	28.1%

**NET IMPERVIOUS COVER ADDED

NOTE: EXCLUDES AREAS NORTH OF S.H. 71

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LEGEND

NEAR FUTURE IMPROVEMENTS

0 350 700 1,400 2,100 2,800

N

FIGURE 3-2
NEAR-TERM FUTURE IMPERVIOUS COVER
Austin-Bergstrom International Airport (ABIA)
STORMWATER DRAINAGE MASTER PLAN (SWMP) UPDATE
Project No.: 4910-8107-3139

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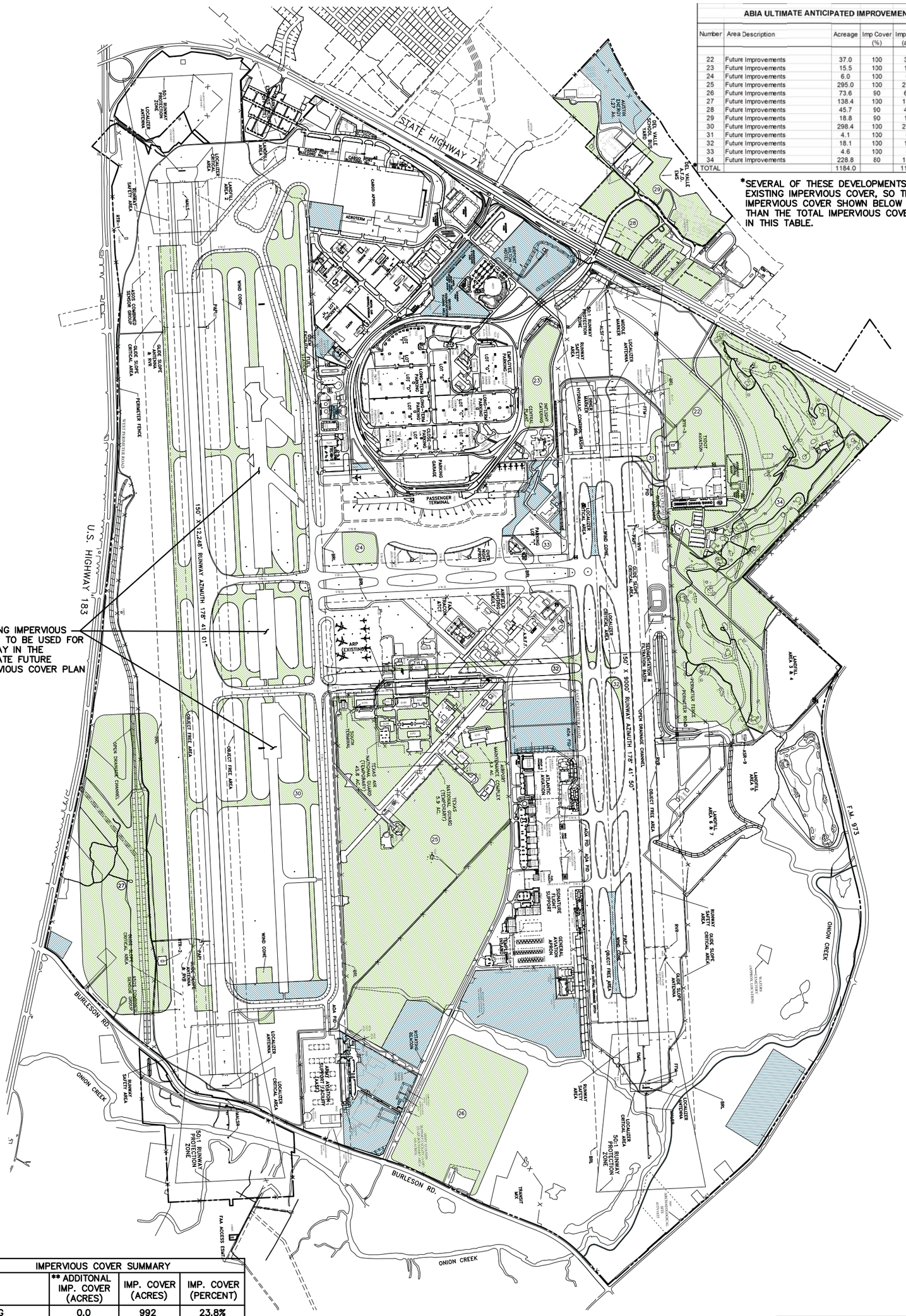
ABIA ULTIMATE ANTICIPATED IMPROVEMENTS					
Number	Area Description	Acreage	Imp Cover (%)	Imp Cover (acre)	Completion
22	Future Improvements	37.0	100	37.0	2035
23	Future Improvements	15.5	100	15.5	2035
24	Future Improvements	6.0	100	6.0	2035
25	Future Improvements	295.0	100	295.0	2035
26	Future Improvements	73.6	90	66.2	2035
27	Future Improvements	138.4	100	138.4	2035
28	Future Improvements	45.7	90	41.1	2035
29	Future Improvements	18.8	90	16.9	2035
30	Future Improvements	298.4	100	298.4	2035
31	Future Improvements	4.1	100	4.1	2035
32	Future Improvements	18.1	100	18.1	2035
33	Future Improvements	4.6	100	4.6	2035
34	Future Improvements	228.8	80	183.0	2035
TOTAL		1184.0		1124.5	

*SEVERAL OF THESE DEVELOPMENTS INCLUDE EXISTING IMPERVIOUS COVER, SO THE NET IMPERVIOUS COVER SHOWN BELOW IS LESS THAN THE TOTAL IMPERVIOUS COVER SHOWN IN THIS TABLE.



IMPERVIOUS COVER SUMMARY			
	** ADDITONAL IMP. COVER (ACRES)	IMP. COVER (ACRES)	IMP. COVER (PERCENT)
EXISTING	0.0	992	23.8%
NEAR TERM	177.0	1169.0	28.1%
ULTIMATE FUTURE	825.7	1994.7	47.9%

**NET IMPERVIOUS COVER ADDED
NOTE: EXCLUDES AREAS NORTH OF S.H. 71

LEGEND

NEAR TERM IMPROVEMENTS

ULTIMATE IMPROVEMENTS

N

0 350 700 1,400 2,100 2,800

FIGURE 3-3
ULTIMATE FUTURE IMPERVIOUS COVER
Austin-Bergstrom International Airport (ABIA)
STORMWATER DRAINAGE MASTER PLAN (SWMP) UPDATE
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Section 4
Water Quality Evaluation

This section reviews the existing water quality controls in place at ABIA and their significant design features. This is followed by a discussion of the approach used to select BMPs for future use at ABIA, and concludes with a set of recommendations for water quality controls at ABIA.

4.1 Description of Existing Water Quality Features

This section describes the existing water quality controls in place at ABIA.

4.1.1 Introduction

Existing water quality controls at ABIA consist of sedimentation/filtration systems and runway/taxiway vegetative filter strips. Both partial and full sedimentation systems, as defined in the City of Austin Environmental Criteria Manual (ECM), are used. Runway/taxiway vegetative filter strips are the result of standard runway and taxiway embankment construction. Some of the vegetative filter strips pre-date the conversion from Bergstrom Air Force Base to ABIA and others were constructed along with the new runway and taxiway system. Many of the sedimentation/filtration systems were developed to capture 1/2-inch of runoff as allowed by the original site development ordinance. Other sedimentation/filtration systems treat areas that were not specifically designated for 1/2-inch capture by the original ordinance and were designed to the more recent "1/2-inch plus" criteria requiring up to 1/2-inch capture plus 0.1 inches of additional capture volume for every 10 percent of impervious cover in excess of 20 percent impervious cover (up to 1.3-inches) as described in the ECM. Some of the existing water quality systems require pumps due to the flat terrain. **Figure 4-1** shows the existing water quality system locations. Details of the water quality systems are summarized in **Table 4-1**. Additional water quality pond information can be found in Appendix A-1.

All of the systems have been observed under dry-weather and storm conditions and no problems have been observed in their performance. Additionally, DOA has indicated that they have not experienced high maintenance costs with the existing sedimentation/filtration systems at ABIA, as the sand does not clog as frequently as typically occurs with other local sand filters.

For consistency with previous reports and City rules, it should be noted that ABIA documentation refers to both water quality and detention basins as "Water Quality Ponds". Water quality and detention basins that service a specific drainage area are referred with a single reference designator such as 'WQP A'. The ECM uses the term "Sedimentation/filtration system" to refer to a water quality control that consists of a sedimentation basin and a sand filter basin.

Table 4-1. ABIA Existing Water Quality Systems

Designation	Airside/ Landside	Sed/Fill Type [4]	Provided Capture Depth [1] (in)	Calculated Capture Depth [3] (in)	Required Capture Depth	Contributing Drainage Area [1] (ac)	Provided WQ Volume [1] (cf)
WQP TANG	Landside	Partial	1.128	1.89	1.1	31.31	214,918
WQP F	Landside	Partial	1.09	1.35	1.1	0.71	3,489
WQP L	Landside	Partial	NA [2]	1.09	1.1	123.0	488,240
WQP M	Landside	Partial	0.92 (req) 3.8 (prov)	3.79	0.9	10.0	137,500
WQP N [6]	Landside	Full	0.50	0.70	0.5 [5]	27.93	70,656
WQP N [6]	Airside	Full	0.50	0.50	0.5 [5]	42.97	78,614
WQP P	Landside	Full	NA [2]	0.66	NA [2]	18.51	44,060
WQP R	Landside	Partial	1.18	1.25	1.2	1.55	7023.0
WQP-T	Landside	Partial	1.09	1.02	1.1	4.48	16,594
WQP G	Landside	Full	0.50	0.56	0.5 [5]	169.89	345,463
WQP A	Airside	Full	0.50	0.54	0.5 [5]	26.60	52,425
WQP B	Airside	Full	0.50	0.51	0.5 [5]	25.00	46,141
WQP C	Airside	Full	1.112	1.197	1.1	24.87	108,086
WQP D	Airside	Full	1.07	1.37	1.1	22.18	110,591
WQP E	Airside	Partial	0.50	0.51	0.5 [5]	37.85	70,000
WQP J	Landside	Full	0.50	0.51	0.5 [5]	13.88	25,872

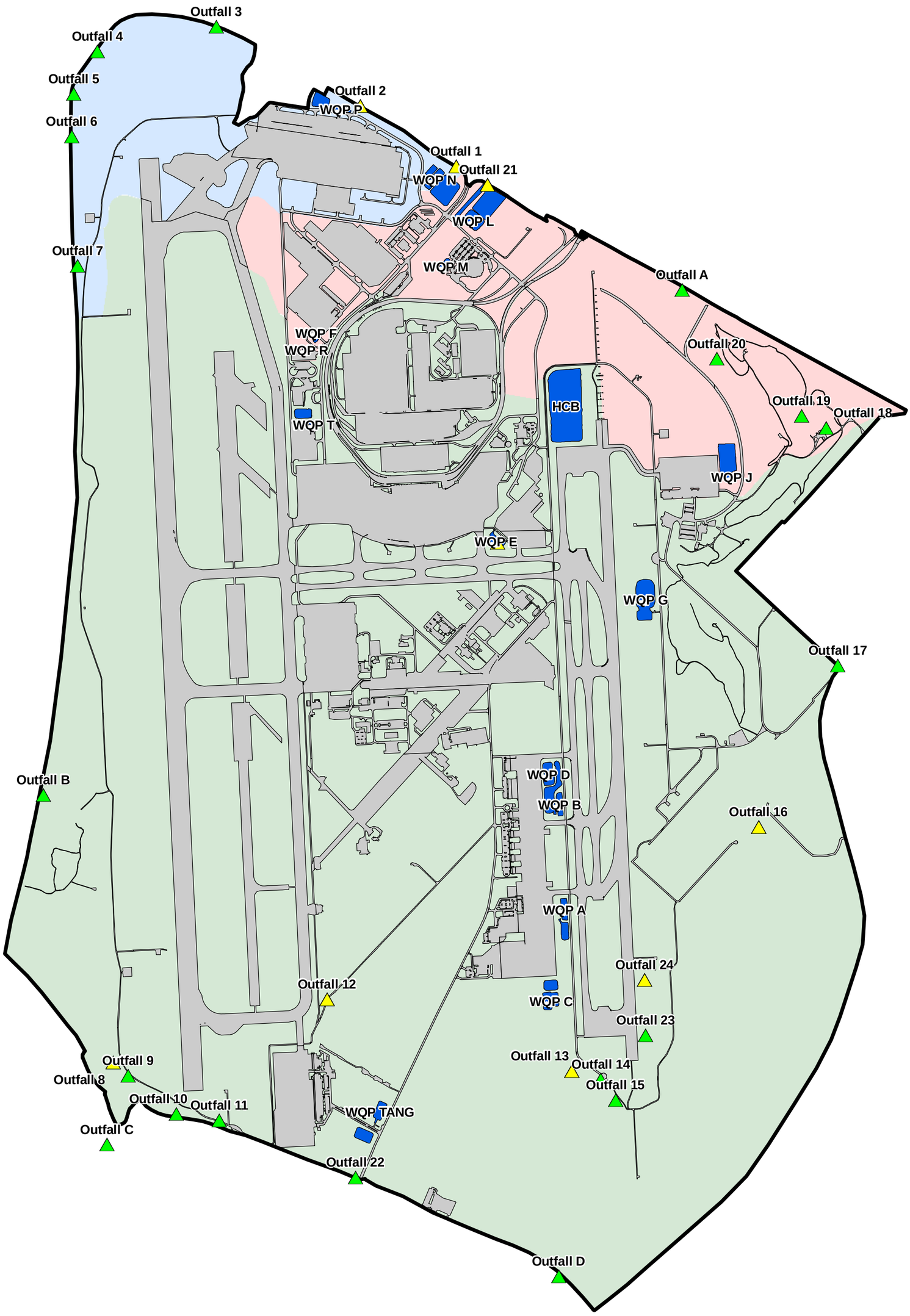
[1] Data obtained from record drawings supplied by ABIA or Watershed Protection
[2] Not available from record drawings
[3] Calculated from Drainage Area and WQ Volume from record drawings
[4] Full and Partial refer to Sedimentation/Filtration System details as defined in the ECM
[5] 1/2–inch per the original ordinance
[6] WQP N consists of two basins – airside and landside – refer to Section 4.1.1 for additional description

Note: The systems referred to as Water Quality Ponds (WQP) at ABIA typically consist of both water quality and detention systems. ‘ WQP N’ is unique in that it consists of a holding pond, a sedimentation/filtration system and a detention system. The holding pond, or “WQP N Airside” captures de-icing runoff during storm events when de-icing occurs and is used as additional water quality volume in all over runoff events. The sedimentation/filtration system or “WQP N Landside” captures runoff from other portions of the drainage area.

These controls are sometimes also referred to as “sand filters”.

Table 4-1 is a summary of the existing ABIA water quality controls gathered from record drawings provided by ABIA and the COA Watershed Protection Department. Additional water quality pond information can be found in Appendix A-1.

Water quality volume is determined by multiplying the capture depth times the contributing drainage area. Typically, the provided water quality volume is slightly larger than the required water quality volume due to construction considerations. The original ordinance included an agreement that limited the 1/2-inch capture of runoff to four areas: passenger terminal automobile parking areas, commercial aircraft parking apron, cargo apron, and general aviation aircraft parking. The water quality systems servicing these areas are ‘WQP G’ (passenger terminal parking); ‘WQP E’ (commercial



Legend

- Outfalls
- Outfall/Monitoring Point
- Existing Impervious Cover
- Existing Ponds

COA Watersheds

- Carson
- Colorado
- Onion

0 0.25 0.5 Miles

N W E S

Figure 4-1
Existing Water Quality Systems
Austin - Bergstrom International Airport (ABIA)
STORMWATER DRAINAGE MASTER PLAN (SWMP) UPDATE
Project No.: 4910-8107-3139

aircraft parking); 'WQP N' (cargo apron); and 'WQP A', 'B', 'C', and 'D' (general aviation apron). The systems referred to as Water Quality Ponds (WQP) at ABIA typically consist of both water quality and detention systems. 'WQP N' is unique in that it consists of a holding pond, a sedimentation/filtration system, and a detention system. The holding pond, or 'WQP N Airside', captures de-icing runoff during storm events when de-icing occurs and is used as additional water quality volume in all over runoff events. The sedimentation/filtration system or 'WQP N Landside' captures runoff from other portions of the drainage area.

Appendix A-1 contains detailed information on the existing ABIA water quality systems gathered from construction drawings provided by ABIA and the COA Watershed Protection Department.

Although not specifically enumerated by previous studies or plans, the runways and taxiways are treated by vegetative filter strips, and structural controls such as sedimentation/filtration systems have not been required. Some structures and paved areas at ABIA were part of the original Bergstrom Air Force Base. These facilities pre-date the common practice of installing water quality features and do not have specifically designed controls. Some of these areas drain to grassy areas that function as swales and vegetated filters.

The "Provided Capture Depth" column in Table 4-1 is the capture depth as taken from available record drawings. The "Required Capture Depth" is 0.5 inches if the capture depth is 1/2-inch as called out in the original ordinance. Otherwise, it is determined using the "1/2-inch plus rule". The following water quality systems have significant differences between the provided and calculated capture depths:

- WQP TANG. The contributing drainage area for Texas Air National Guard water quality facility includes existing development and adjacent undeveloped areas. At the time of this report, the TANG facility is being expanded and the water quality system is being redesigned.
- 'WQP N Landside'. The sedimentation/filtration system (not including the adjacent holding basin) of WQP N captures approximately 0.7-inches due to some of its original drainage areas being routed to WQP P. It was originally sized at 0.5 inches.
- 'WQP D'. This water quality system has additional capacity based on information in the record drawings.
- 'WQP L'. 'WQP L' was sized under the 1/2-inch plus rule for a build out of its contributing drainage area that was never completed. The water quality system appears to be oversized for the current level of impervious cover in its contributing drainage area. Some of the typical record drawing information, including the

captured volume, was not available and was estimated for this study. The water quality basin and the drainage area including impervious cover may need to be verified.

4.1.2 Airside Controls

Airside water quality controls consist primarily of vegetative filter strips located adjacent to the runways, taxiways, and fringes of the apron areas. Good quality vegetative filter strips have been observed throughout ABIA airside, with good soils, vegetation, slopes and flow-distribution. The design of the filter strips is constrained by FAA safety regulations limiting potential hazards to aircraft in the runway and taxiway clear zones. The FAA regulations specify permissible embankment slopes and restrict the types of drainage structures such as inlets, concrete channels, and constructed flow spreaders.

In some airside areas, specifically around aprons, structural water quality controls have been constructed. These controls consist of holding ponds designed to capture runoff containing de-icing fluids or hazardous materials, typically fuel spills. Hazardous material handling is typically restricted to certain areas such as the ramps or Remain Overnight Parking (RON) areas. Runoff from these areas is routed to the holding ponds. Sedimentation/filtration systems are used for standard treatment for all other runoff events. Both full and partial sedimentation/filtration systems are used in the airside areas.

Existing airside sedimentation/filtration systems that have unique design features are described below:

- 'WQP N' provides treatment for airside runoff from the air cargo facilities located in the north part of the airport. It consists of a holding pond and a sedimentation/filtration system. Runoff from the non-ramp areas of the air cargo apron are routed to the sedimentation basin of the sedimentation/filtration system. Runoff from the air cargo ramp is routed to the holding pond. If hazardous materials, such as a fuel spill, are captured, the fluid is contained and pumped out for disposal. If de-icing fluids are captured and concentrations detected are above target levels, the holding pond is discharged to the Austin Water Utility for treatment. If de-icing fluids are below the target levels, the holding pond water is discharged to the sand filter in the sedimentation/filtration basin.

- 'WQP E' provides treatment for portions of the main terminal apron. It treats the portions of the apron where fueling and de-icing take place. These areas include the ramp and the south RON area. Runoff from the south RON area is collected in two 50,000 gallon tanks located south of the apron and pumped to WQP E. WQP E is configured as two sand filters that can be operated to treat runoff from two runoff

events, or operated in tandem to treat a single event. As with WQP N, runoff with hazardous materials or de-icing fluids are captured and properly disposed. Runoff with de-icing concentrations below the target levels are discharged through the sand filter.

- 'WQP A' is a sedimentation/filtration system that treats runoff from both airside and landside of the Signature Flight Support operation area. A manually operated spill control valve is located at the headworks of the water quality system. The valve can be used to route runoff to a 2,300 gallon spill control tank.

- 'WQP B' is a sedimentation/filtration system that treats runoff from both airside and landside of the Austin Atlantic Aviation Operations area. A manually operated spill control valve is located at the headworks of the water quality system. The valve can be used to route runoff to a 2,000 gallon (approximate) spill control tank.

- 'WQP C' is a sedimentation/filtration system that treats runoff from both airside and landside of the T-Hangar area near the Signature Flight Operations. A manually operated spill control valve is located at the headworks of the water quality system. The valve can be used to route runoff to a 5,000 gallon spill control tank.

- 'WQP D' is a sedimentation/filtration system that treats runoff from the North Apron expansion from both airside and landside of the Austin Atlantic Aviation Operations area. A manually operated spill control valve is located at the headworks of the water quality system. The valve can be used to route runoff to a 2,000 gallon (approximate) spill control tank.

4.1.3 Landside Controls

Existing landside water quality controls consist primarily of sedimentation/filtration systems. Hazard material traps are located in some areas where fueling occurs or the potential for hazardous material spills is present. Both full and partial sedimentation/filtration systems as defined in the ECM are used in the landside areas.

Landside sedimentation/filtration systems that have unique design features are described below:

- 'WQP G' is a sedimentation/filtration system that treats runoff from the terminal parking area. Runoff collected in the sedimentation basin is pumped up to the adjacent filtration basin.

- 'WQP M' is a sedimentation/filtration system that treats the runoff from the Hilton Hotel site. It is a partial sedimentation/filtration system that captures the entire 100-year runoff volume. After filtration, the water quality volume is pumped from the system and discharged to the nearby outfall.

- 'WQP L' treats runoff from the rental car maintenance area to the northwest of the main terminal. It is a partial sand filter that uses a pump to drawdown the water quality volume.

4.1.4 Good Housekeeping Practices

Good housekeeping practices with a potential impact on water quality are described in the ABIA Storm Water Pollution Prevention Plan (SWPPP). Additional practices are documented in the ABIA Integrated Pest Management Tactics document (refer to Appendix A-2) which includes general guidelines for cultural practices, site sanitation, biological control, plant material, and herbicide/pesticide use.

The ABIA SWPPP was prepared pursuant to requirements of the Texas Pollutant Discharge Elimination System (TPDES) administered by the Texas Commission on Environmental Quality (TCEQ). It provides guidance for Department of Aviation (DOA) and ABIA tenants to identify possible sources of pollution, and for the implementation of practices to prevent or control the degradation of storm water runoff. A summary of the Best Management Practices (BMPs) in the SWPPP is shown in **Table 4-2**.

Table 4-2. Best Management Practices and DOA Policies and Procedures (SWPPP)

Baseline BMPs		
SC1	General – Baseline Best Management Practices	Training, maintenance, inspections, spill protection response
Activity Specific BMPs and DOA Policies and Procedures		
SC2	Prevention of Illicit Non-Visible Non-Storm Water Discharges	Cross connections between sanitary sewer & storm sewer
SC3	Aircraft, Ground Service Equipment, and/or Vehicle Maintenance	Maintenance locations, procedures to control/dispose of contaminants
SC4	Aircraft, Ground Service Equipment, &/or Vehicle Fueling/Defueling	Procedures for fueling/defueling
SC5	Aircraft, Ground Service Equipment, and/or Vehicle Washing and/or Degreasing	Locations, times and procedures for washing aircraft, GSE & vehicles
SC6	Aircraft, Ground Service Equipment, &/or Vehicle Staging and Storage	Locations and procedures for storing aircraft, GSE & vehicles
SC7	Aircraft and Airfield De/Anti-icing, Deicing Recovery and Fluids Storage	Procedures for aircraft deicing
SC8	Material Handling	Handling of potential contaminant material (other than fuel)
SC9	Storage of Significant Materials	Storage of potential contaminant material (includes fuel)
SC10	Waste Handling and Disposal	Procedures for disposing materials that could contaminate storm water

Table 4-2. Best Management Practices and DOA Policies and Procedures (SWPPP)

SC11	Building and Grounds Maintenance	Pesticide/fertilizers, erosion/sedimentation controls. Building washing
SC12	Lavatory Service Operations	Aircraft lavatory services and disposing of associated waste fluids.
SC13	Pavement Washdown	Pavement washing (routine/spill). Pavement sweeping
SC14	Painting	Procedures for painting aircraft & ground support equipment
SC15	Airfield Pavement De-rubberizing	Describes airfield pavement de-rubberizing procedures. As needed.
SC16	Fire Fighting Equipment Testing &/or Training	Handling discharges from firefighting equipment tests & training
Treatment Control BMPs and DOA Policies and Procedures		
TC1	TC1 Oil/Water Separators	Annual inspection of oil/water separators, sludge removal
TC2	TC2 Water Quality Ponds	Maintenance of water quality ponds to comply with COA policies.

The BMPs in the SWPPP consist of:

- **Baseline BMPs**. Baseline BMPs identify practices pertaining to fundamentals such as general housekeeping, employee training and inspection.
- **Activity Specific BMPs**. Activity Specific BMPs are engineering and operational practices that have been developed for specific types of industrial operations.
- **Treatment Control BMPs.** Treatment Control BMPs are specific structural controls in place at ABIA.

Stormwater treatment takes place through a combination of BMPs in series, as illustrated by the BMP stormwater treatment train shown in **Figure 4-2**. Some of the BMPs are preventative in nature, such as those that involve the handling and storing of hazardous materials for example. Other BMPs have a direct affect on the pollutant loading such as pavement scrubbing and airfield de-rubberizing.

The Integrated Pest Management Tactics document (refer to Appendix A-2) encourages a low use of pesticides and herbicides. The specific herbicides recommended in the Tactics document for weed control are Roundup® Pro and Fusilade®.

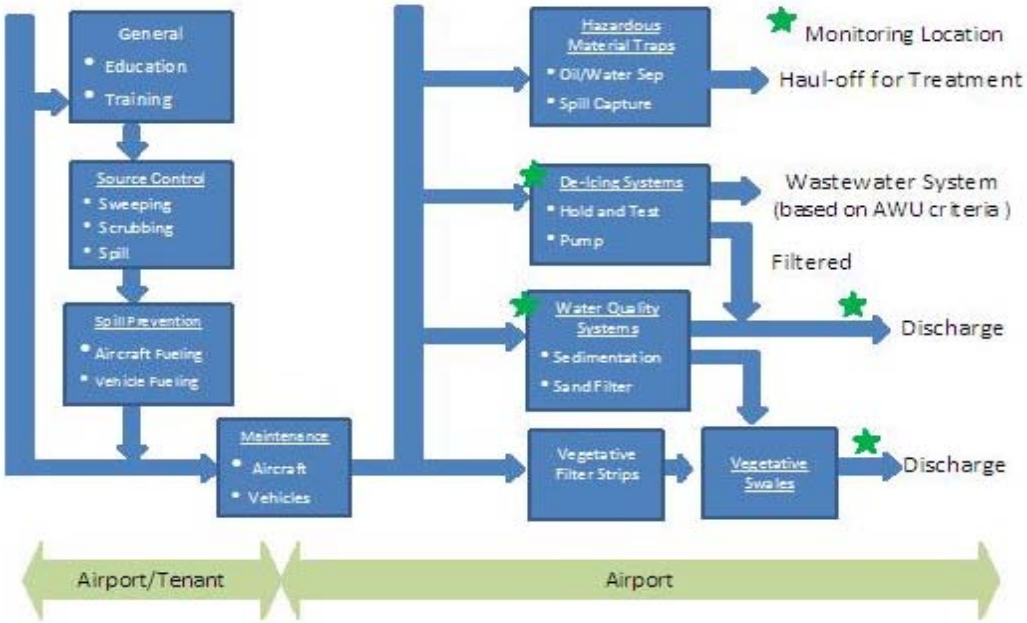


Figure 4-2. ABIA BMP Treatment Train

Pavement sweeping is a significant BMP at ABIA. ABIA currently uses Tymco Model 600 Regenerative Air Sweeper, which is considered a high-efficiency sweeper. Removal efficiencies of 35 to 54 percent have been estimated for a range of pollutant parameters (STIA, 1998). Both airside and landside pavement sweeping are performed on a regular basis. Sweeping occurs on the airside on an as-needed basis based on observations from daily inspections. Landside sweeping takes place approximately 3-times a week. Sweeping is not required by the SWPPP. Data on the quantity or quality of material removed by sweeping has not been collected. An ABIA high efficiency sweeper is shown in **Figure 4-3**.

Figure 4-3. ABIA High Efficiency Sweeper (ABIA)

Pavement washdown removes solids and chemical constituents that accumulate on paved surfaces such as aprons, parking lots and garages, paved surfaces where aircraft or ground support equipment is parked, or where spills have occurred. Dry techniques are used when possible. Waste water from washdown activities is reclaimed for proper disposal. Runoff from pavement washdown is reclaimed for offsite treatment.

4.1.5 Pollutant Load Removal

Determining the size and type of water quality controls required for a development site can follow one of two approaches. A loading analysis can be used to develop a water quality treatment plan for an overall site such as ABIA or for individual development sites. Alternatively, technical BMP selection and sizing guidance found in the ECM can be used to select and design BMPs.

Development of a loading analysis must account for all existing development (existing impervious cover), existing water quality controls, and all proposed future development (ultimate impervious cover) in order to develop proposed water quality controls. For ABIA, the loading analysis is complicated by the large amount of existing Air Force Base impervious cover, which is considered to be exempt from water quality requirements (although many areas are served by various grassed swales and vegetative filter strips). Also complicating a site-wide loading analysis is the uncertainty in the actual future land use, specifics of the design for a development area and phasing of future development.

The preferred method for water quality BMP selection and analysis for ABIA is to utilize the BMP technical guidance found in the ECM augmented with ABIA site specific BMPs. These BMPs are described in Section 4.2. Use of standardized BMP techniques has been the primary method utilized by the City for 25 years, and provides an overall consistency in future stormwater design. Although the loading methodology is also used in Austin, the uncertainty of the type and timing of future development makes it more difficult to implement over a long build-out period. In some cases, a loading analysis may still be useful. A loading analysis may prove useful in a particular development area where water quality controls are being combined, or when compensatory credit is being considered. A representative loading analysis is shown in the following sections.

4.1.5.1 Load Generated Based on ECM Data

The COA ECM lists 10 pollutants that are of interest in the performance of water quality BMPs. The City has developed a set of standard pollutant concentrations and loadings for these pollutants for both developed and undeveloped sites. The ECM pollutant concentrations for undeveloped and for developed commercial sites has been reproduced in **Table 4-3**.

Table 4-3. ECM Pollutant Concentrations (COA)

Pollutant	Concentration* (Undeveloped Sites)	Concentration * Commercial >15% IC (Developed Sites)
Total Suspended Solids (TSS)	55	110
Total Phosphate (TP)	0.04	0.16
Total Nitrogen (TN)	0.54	1.82
Chemical Oxygen Demand (COD)	22	79
Biochemical Oxygen Demand (BOD)	8	8
Total Lead (Pb)	0.003	0.03
Fecal Coliform (FC)	4000	39,000
Fecal Streptococci (FS)	3000	46,000
Total Organic Carbon (TC)	6	19
Zinc (Zn)	0.008	0.05

*Concentrations in mg/l, except FC and FS which are in colonies/100 ml

A loading analysis can be performed using the pollutant concentration data shown in Table 4-3 and runoff estimates to calculate a baseline load and a load generated for a given land use, and removal efficiencies for a particular BMP.

4.1.5.2 Load Removed by BMPs

Pollutant loads removed by a BMP can be calculated using data and methods described in the ECM. Appendix A-3 shows a loading calculation for an example 10-ac drainage area with 80 percent impervious cover using the 1/2-inch runoff capture rule.

This chart uses the sedimentation/filtration removal efficiencies found in the ECM for the listed constituents as shown in **Table 4-4**. Appendix A-4 shows the same loading analysis using the 1/2-inch plus rule for the same example 10-ac area and 80 percent impervious cover.

Table 4-4 Sedimentation/Filtration Pollutant Removal Efficiency (COA)

Efficiency Ratio	TSS	TP	TN	COD	BOD	Pb	FC	FS	TOC	ZN
%	87	61	31	67	51	80	36	65	61	80

Appendix A-5 shows a similar loading analysis for the airfield vegetative filter strips described in 4.2.3.1. The vegetative filter strip example is based on a 75 percent impervious cover ratio (based on the ratio of impervious cover to filter strip size developed in Section 4.2.3.1). As an infiltration BMP, the removal rate of a vegetative filter strip is 100 percent.

The loading analysis for the three examples is summarized in **Table 4-5**:

Table 4-5. Summary Loading Analysis for TSS

	½-inch	½-inch plus	Vegetative Filter Strip
Total Load (lbs)	200.2	200.2	186.6
Load Captured (lbs)	146.1	182.1	173.6
Load removed (lbs)	127.1	158.5	173.6
% Load Removed	63%	79%	93%

4.2 Discussion of Best Management Practices

4.2.1 Introduction

A wide range of BMPs were considered as candidates for water quality treatment facilities at ABIA. BMPs were selected for use based on safety criteria and applicability for use in the Austin area. FAA safety regulations restrict the use of BMPs within 10,000-ft of airside areas that could act as a source of fog and/or as wildlife habitat preventing the use of a number of BMPs that use a permanent water volume or dense vegetation. Specifically, wet ponds and wetland treatment ponds were not included as candidates for ABIA. Structural BMPs that present safety hazards to aircraft are not permitted in runway and taxiway areas. Emphasis was given to BMPs that are currently recommended in the ECM or where specific design guidance is provided in the ECM.

BMPs are designed to treat a specific water quality volume. In the case of ABIA, the water quality volume is determined by either the original ordinance or the ECM. The original ordinance allowed the airport to use a 1/2-inch capture for certain areas. The 1/2-inch capture means that a volume equal to a 1/2-inch rainfall depth over the contributing drainage area to a water quality control is required. For example, a sedimentation/filtration system with a 10-ac contributing area would require a water quality volume of 1/2-inch times 10 ac or 0.4 ac-ft.

For developments where the 1/2-inch capture described in the original ordinance is not in effect, the COA ECM "1/2-inch plus" formula is used (sometimes referred to as the 10 percent rule). Under this rule, the first 1/2-inch of runoff plus an additional 0.1 inch for each ten percent increase of impervious cover over twenty percent must be captured.

4.2.2 Recommended BMPs

4.2.2.1 Sedimentation/Filtration

Sedimentation/filtration systems as defined in the ECM consist of basins that capture stormwater runoff to provide sedimentation and treatment through a sand filter. This BMP can be configured in one of two ways. One is called "Full Sedimentation/Filtration" since the entire water quality volume is captured in the sedimentation basin, then discharge slowly to the filtration basin. A "Partial Sedimentation/Filtration" configuration has the water quality volume stored in both the sedimentation and filtration basins which are typically divided by a gabion wall. These

BMPs are designed to drawdown in 48-hours. Sedimentation/filtration systems provide a high rate of TSS and particulate removal, but are less effective at removing dissolved pollutants and nutrients. Removal efficiencies for sedimentation/filtration systems are shown in Table 4-4. Construction and maintenance costs are considered high compared to other BMPs. Sedimentation/filtration is the standard treatment method used in the City of Austin. Full and partial sedimentation/filtration systems are the only structural controls currently installed at ABIA.

For planning purposes, a 10-ac area requiring a 1/2-inch capture would result in a water quality volume of 18,150 cubic feet. Depending on the site characteristics and construction techniques, this size volume would generally require about 6,000 square feet of area (assuming a 4-ft basin depth). A 10-ac area with 80 percent impervious cover would require a 1.1-inch capture under the "1/2-inch plus rule" would result in a water quality volume of 39,930 cubic feet, which would generally require about 13,000 square feet of area (assuming a 4-ft basin depth).

Partial sedimentation/filtration systems are recommended for use at ABIA. The footprint of partial systems is smaller than that of full systems, and ABIA reports low maintenance costs for the existing partial systems. These BMPs are not appropriate for use in runway/taxiway areas. Design of sedimentation/filtration systems should follow the guidance found in the 2010 COA ECM. **Figure 4-4** illustrates a full sedimentation/filtration system. A representative sedimentation/filtration system at ABIA is shown in **Figure 4-5**.

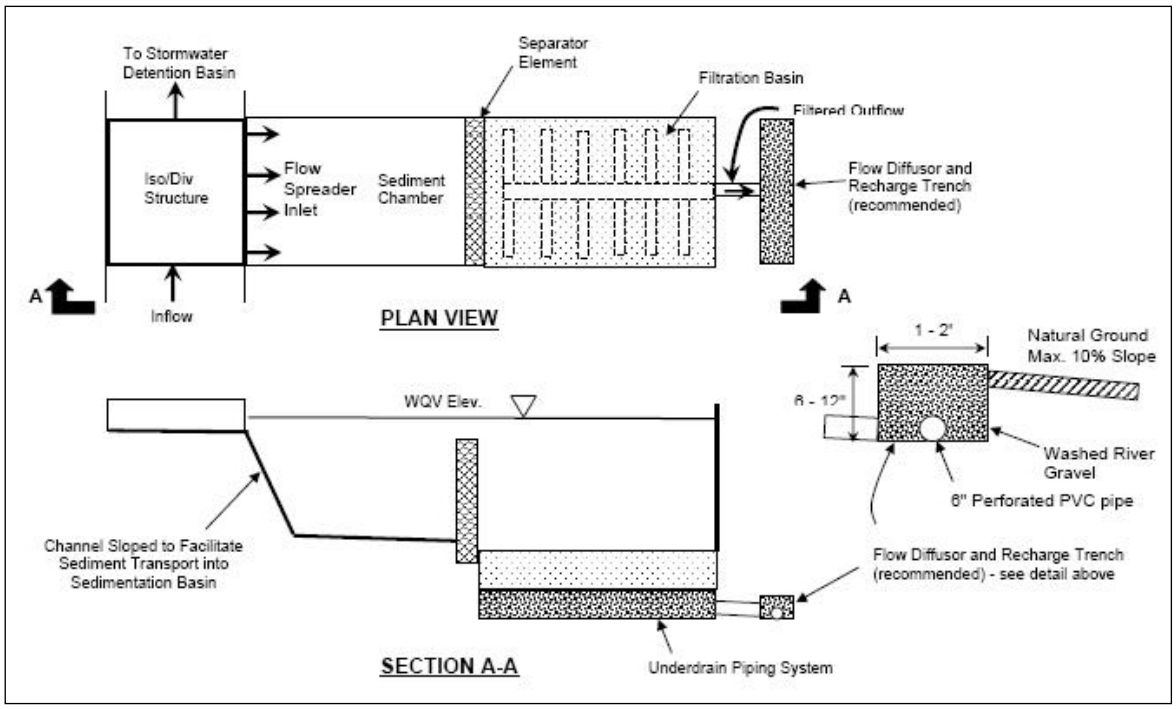


Figure 4-4. Full Sedimentation/Filtration System (COA)

Figure 4-5. Representative ABIA Sedimentation/Filtration System

4.2.2.2 Biofiltration Ponds

Biofiltration ponds (as defined in the ECM) are constructed in a similar manner as sedimentation/filtration systems with the sand media replaced by a biofiltration media. The COA has specified a biofiltration media that is specially formulated for the Austin climate. It uses chemical, biological, and physical properties of plants, microbes, and soils to remove pollutants. As with sedimentation/filtration systems, biofiltration ponds can be constructed as full or partial systems.

Biofiltration ponds have the same hydraulic head requirements as sedimentation/filtration systems. At the time of this report, the COA credits biofiltration ponds with the same pollutant removals as sedimentation/filtration systems. Recent research conducted by the COA indicates that biofiltration ponds are likely to have somewhat better removal rates than sedimentation/filtration systems. Both of these BMPs are designed to drawdown in 48-hours.

Obvious wildlife attractant BMPs were screened and removed from the list of recommended BMPs at ABIA. During the course of this study, various participants expressed concern that Biofiltration Ponds might be a wildlife attractant. It is recommended that the DOA have proposed biofiltration pond concepts or designs reviewed by an FAA wildlife specialist. These BMPs are not appropriate for use in runway/taxiway areas. Design of biofiltration ponds should follow the guidance found in the 2010 COA ECM. **Figure 4-6** illustrates a partial biofiltration pond. A photo of a representative biofiltration pond is shown in **Figure 4-7**.

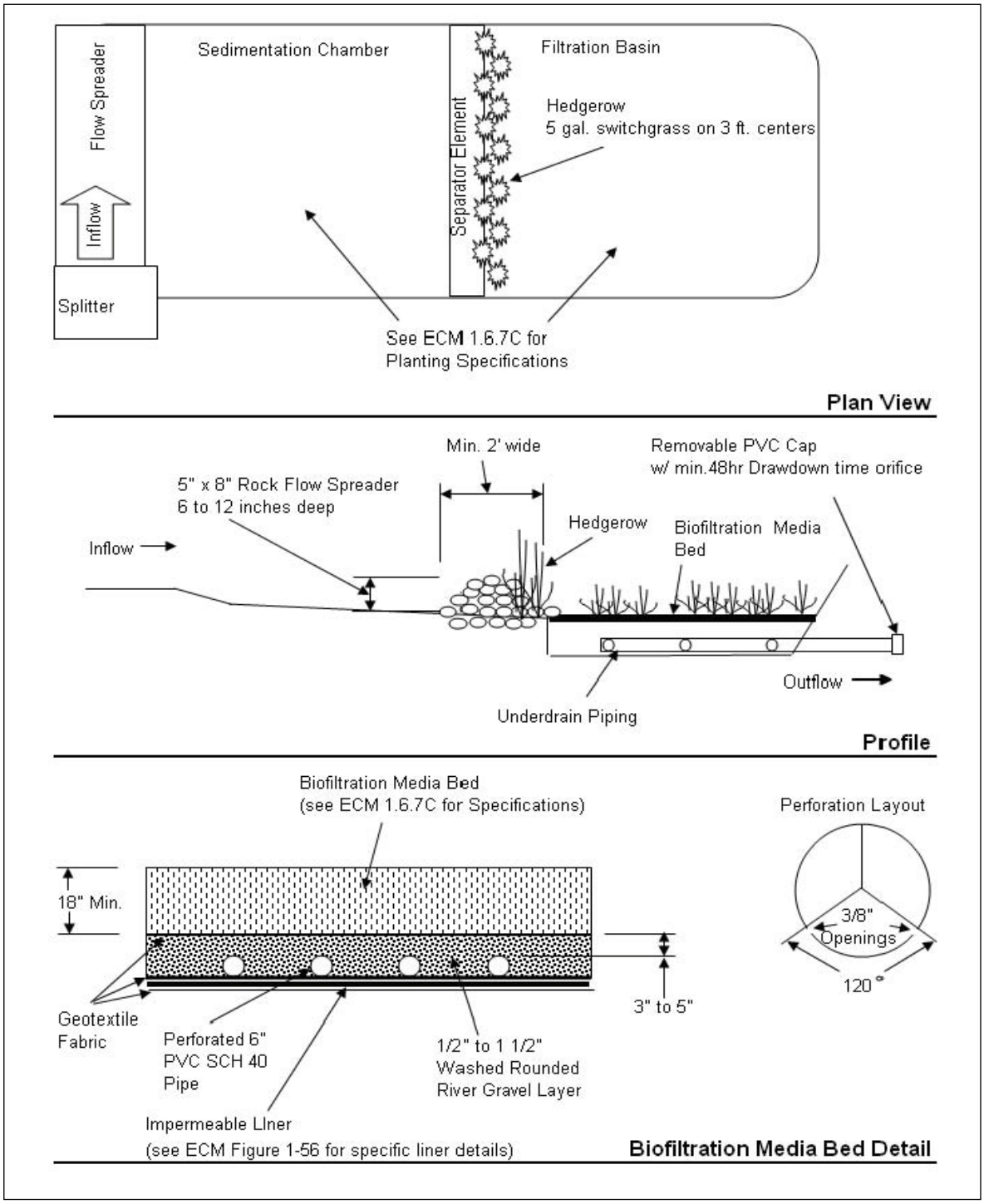


Figure 4-6. Partial Biofiltration System (COA)

Figure 4-7. Representative Biofiltration System

4.2.2.3 Retention/Irrigation

A retention irrigation system, as defined in the ECM, consists of a basin that captures and isolates stormwater runoff and a distribution system that distributes the captured water to a vegetated area, typically using pumps, piping, and irrigation heads.

Retention/irrigation systems are designed to roughly simulate the natural hydrologic regime of evapotranspiration and infiltration. Because there is no discharge of the WQV to receiving water, they sequester 100 percent of the pollutants from the captured water quality volume and the COA credits the system with 100 percent removal. These systems require sufficient land area for dispersion/irrigation. Floodplains or other restricted areas are often used for dispersion/irrigation areas. Maintenance for retention irrigation systems is similar to maintenance for sedimentation/filtration systems with the addition of maintenance for the pump and irrigation system and subtraction of the sand media refurbishment and replacement.

Retention/Irrigation provides two advantages over a standard sedimentation/filtration system. One is the 100 percent removal of retention/irrigation could be used to offset other areas where limited or no removal can be attained due to physical or space constraints. Also, the pump system required for the irrigation system can allow the pond

bottom to be below the natural outlet level of a gravity-drained pond, thus allowing more storage in the same space. However, the required irrigation area can be significant. For the predominant soils on the ABIA site, 0.1 ac of irrigation area is required for every one acre developed at 80 percent impervious cover. This assumes a shorter total dewatering time of 48 hours (12 hour hold and 36 hours of irrigation) than the basic guidance. The availability of irrigation areas may not be a factor if they can be located in areas that would not normally be developed. Design of retention/irrigation systems should follow the guidance found in the 2010 COA ECM. These BMPs are not appropriate for use in runway/taxiway areas.

Type C soils are suitable for infiltration based BMPs and are the predominant soil type at ABIA. Consult the soil map in Figure 2-2 when designing infiltration based systems.

4.2.2.4 Infiltration

Stormwater infiltration devices capture and temporarily store stormwater runoff as flow through systems while allowing infiltration into the soil. Infiltration devices can also capture runoff in a variety of ways including exfiltration trenches and retention basins. Swales and filter strips are specialized forms of infiltration devices. Infiltration devices can be easily implemented at ABIA with minimal staging time due to the relatively high hydraulic conductivity of the soils found at ABIA. The predominant soils on the site have infiltration rates listed as 0.63 to 2.00 inches per hour.

Because there is no discharge of the WQV to a receiving water, infiltration sequesters 100 percent pollutant from the captured water quality volume, the COA credits the system with 100 percent removal. Construction and maintenance costs for infiltration devices vary depending on the capture devices used.

Infiltration devices are not explicitly described in the ECM. However, many approved BMPs in the ECM (including retention irrigation and vegetative filter strips) use infiltration as the treatment mechanism. The 2010 COA ECMs contain a number of examples that provide guidance for designing infiltration devices (e.g., 1.6.7.H Example Case Study 2 and Example Case Study 3). One type of infiltration system is illustrated in **Figure 4-8**.

Onsite soils at ABIA are typically sufficient as the infiltration material. Potential locations for use of infiltration basins/swales may include areas between taxiways or in parking lot medians. These locations will likely warrant short drawdown times and shallow ponding depths. Assuming a drawdown time of 24 hours and a shallow ponding depth (maximum of 8 inches), approximately 0.06 ac of infiltration bed would be needed for every acre of impervious cover to meet the equivalent requirements from the ECM. The overall infiltration area would depend on the side slope and other drainage features, but for planning purposes, the area will likely be approximately 0.08 to 0.10 ac per acre of impervious cover. For parking lot medians, longer drawdown times (48 hours) and deeper ponding depths (1 foot) would result in significantly smaller infiltration areas (approximately 1/2 the size listed above).

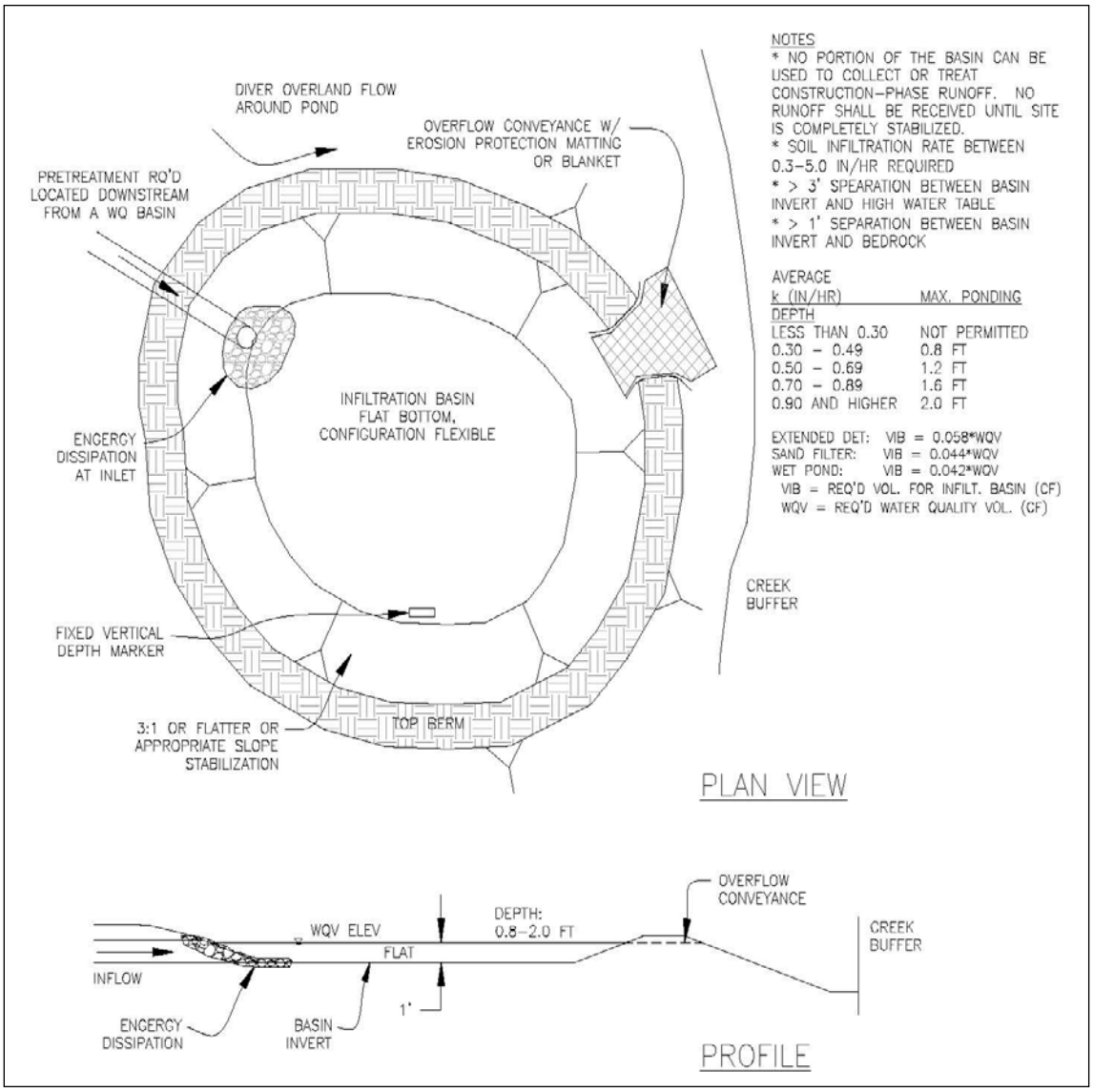


Figure 4-8. Representative Infiltration System (LCRA)

Although this BMP is generally considered a structural control, due to the pond-like features, the implementation at ABIA will likely be more comparable to vegetative controls like vegetative filter strips or vegetative swales.

Type C soils are suitable for infiltration based BMPs and are the predominant soil type at ABIA. Consult the soil map in Figure 2-2 when designing infiltration based systems. FAA safety regulations should be considered for infiltration BMPs located in runway/taxiway areas.

4.2.2.5 Rain Gardens

A rain garden is an infiltration/filtration system suitable for small (under 1 ac) drainage areas. Rain gardens are decentralized water quality controls that can be distributed across a development and provide aesthetic as well as ecological benefits. Design of rain gardens can vary; however, they generally consist of an optional vegetative filter strip for pretreatment and an infiltration basin covered with a biofiltration media. A bypass structure ensures that high flows bypass the rain garden.

Rain gardens are suited for small drainage areas such as portions of parking lots and in commercial developments. If rain gardens are over irrigated or receive significant quantities of herbicides and pesticides, they can become sources of pollution. An approved Integrated Pest Management Plan is required for rain gardens.

Design of rain garden systems should follow the guidance found in the 2010 COA ECM. A typical rain garden design is illustrated in **Figure 4-9**.

Type C soils are suitable for infiltration based BMPs and are the predominant soil type at ABIA. Consult the soil map in Figure 2-2 when designing infiltration based systems. Rain gardens are not appropriate for use in runway/taxiway areas.

4.2.2.6 Batch Reactors

A batch reactor consists of a basin designed to capture the water quality volume and hold it for a minimum of 12 hours and then release it. Sedimentation is the primary treatment mechanism in batch reactors. The removal efficiency of TSS is equivalent to sedimentation/filtration systems.

Batch reactors require less hydraulic head than sedimentation/filtration systems and provide similar TSS removal. They require less surface area than full sedimentation/filtration systems. Maintenance costs are higher due to the valve/controller assembly at the outlet. Batch reactors can also function as hazardous material traps. Batch reactors are well suited to some of the low flat areas of the airport where BMPs require pumping to operate.

Batch reactors are not currently approved in the ECM and need to be approved by WPD prior to being used. A formal study of batch reactors has been published, and the batch reactor is an approved BMP in the TCEQ's Edwards Aquifer Technical Guidance Manual. **Figure 4-10** shows the main components of a batch reactor (TCEQ). Batch reactors are not suitable in runway/taxiway areas.

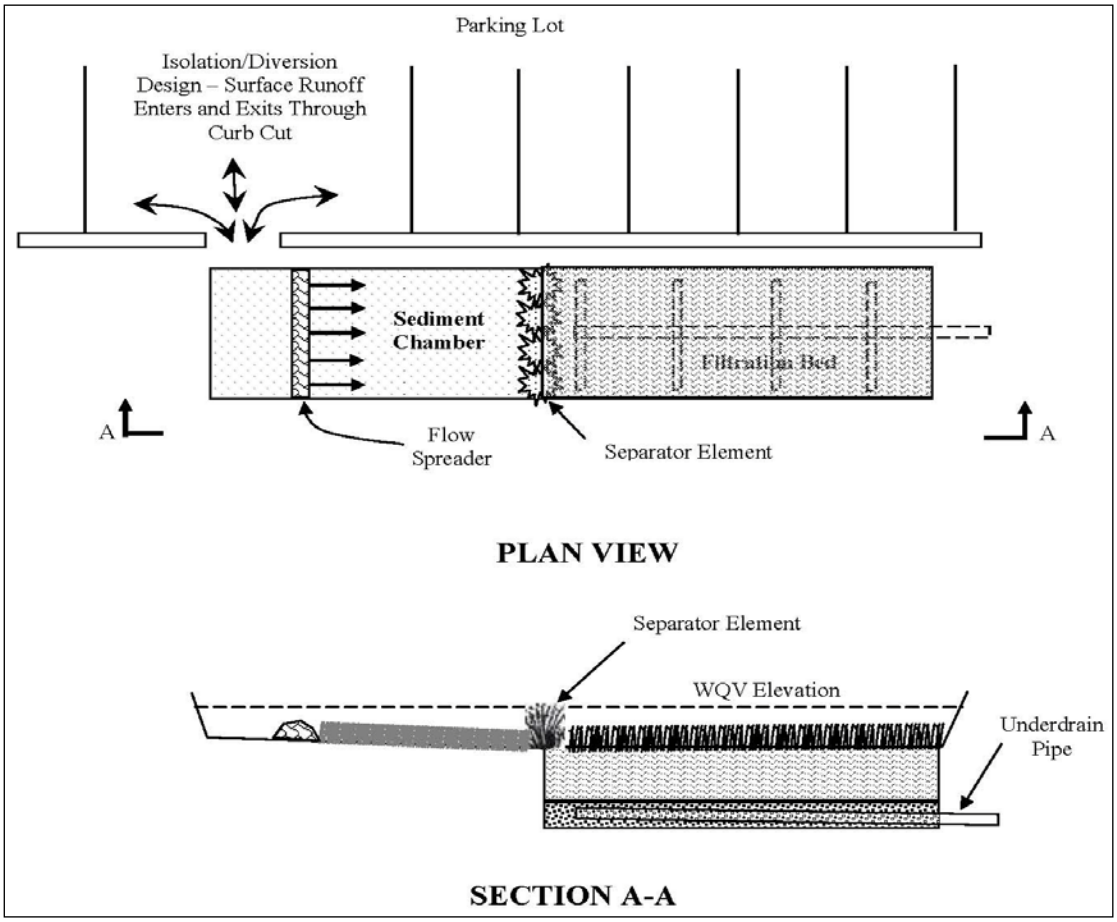


Figure 4-9. Rain Garden Design (COA)

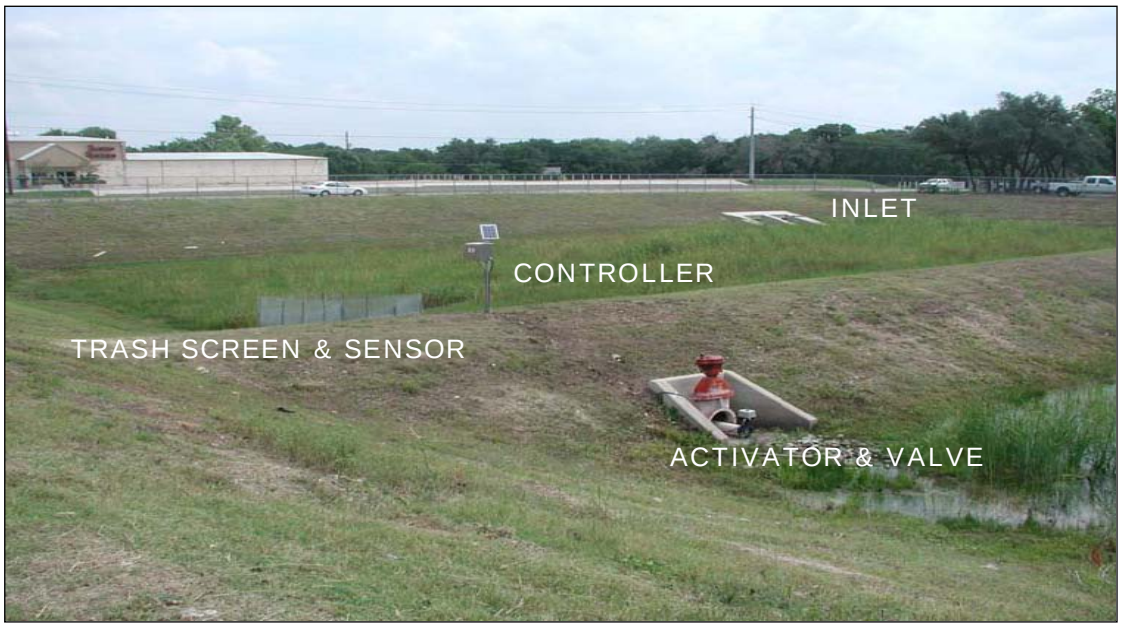


Figure 4-10. Batch Reactor BMP (TCEQ)

4.2.2.7 Vegetative Filter Strips

Vegetative filter strips are vegetated areas/swales that receive runoff in a uniform, sheet-flow manner in order to provide pollutant removal. Proper functioning requires good vegetative cover, permeable soils, and flat and uniform slopes (to prevent concentration). Maintaining shallow unconcentrated flow at the upper edge of the filter strip and throughout the strip is the key to successful performance. The drainage area to the filter strip generally should be relatively flat with a uniform slope in both directions. The contributing area should be of uniform length and width relative to the filter strip length and width. Some applications have used complicated flow spreader devices.

Although vegetative filter strips have been reported to remove pollutants by settling or capture within the vegetation, for purposes of this plan, pollutant removal is considered to be through infiltration only. The removal of pollutants is considered to be 100 percent for the runoff that infiltrates. Design criteria for vegetative filter strips are provided in the ECM. For this project, a site-specific evaluation was performed for the ABIA based on the on-site soils, rainfall patterns and existing filter strips and airport facilities (refer to Appendix A-6). The evaluation is based on the criteria and methods for determining infiltration that is provided in a number of sections in the ECM.

The key results of this evaluation are:

- The vegetative filter strip length (in the direction of flow) must be at least 33 percent of the length of the contributing area, also in the direction of flow (e.g. 33 square feet of filter strip is required for every 100 square feet of pavement).

- Sheet flow is achieved along the runways, taxiways and taxilanes; therefore, no additional flow spreader devices are needed in these areas. FAA safety regulations would limit the use of flow spreader devices in the vicinity of these facilities.

Key requirements from the ECM for implementation of vegetative strips are:

- Minimum 25-ft vegetative filter length

- Maximum 100-ft vegetative filter length (maximum sheet flow length)

- Maximum slope of 10 percent

At the intersections of runways, taxiways and taxilanes, vegetative filter strips can still be effectively utilized. The typical radius for the airside pavement is about 125-ft with a typical range from about 50-ft to 150-ft. With this large a radius, the runoff will still flow onto and through the vegetative filter strip as sheet flow. There is more pavement area at intersections along with more limited vegetative filter strip area. In general, the ratio of 0.33 square feet of vegetative filter strip for every square foot of pavement will still be

effective. Vegetative filter strips will still function adequately for a radius as small as 75 ft, with gradual transitions to match the vegetative filter strips for the straight pavement sections of about 50-ft. For less than a 75-ft radius, specific grading would need to be designed to achieve the 0.33 to 1 ratio or other methods should be considered.

Vegetative filter strips do provide enhanced treatment over the standard sedimentation/filtration system design, especially for removal of nutrients. For the intersections with less than a 75-ft radius, providing 25-ft minimum vegetative filter strip along the radius of the intersections would still provide enhanced treatment overall for the airside facilities considering the effectiveness of the filters for the straight sections.

Type C soils are suitable for infiltration based BMPs and are the predominant soil type at ABIA. Consult the soil map in Figure 2-2 when designing infiltration based systems. Runway and taxiway embankments should be constructed using Type C soils or soils amended to have a hydraulic conductivity equivalent to Type C soils.

4.2.2.8 Vegetative Swales

Vegetative swales are grass lined channels that remove pollutants primarily by infiltration (retention and/or detention with proper residence times). They require shallow slopes and soils with medium to high hydraulic conductivity. They are often used as pre-treatment measures for other downstream BMPs. They generally service drainage areas of less than 10 ac, although they can serve larger areas at airports and are consistent with FAA requirements.

Vegetative swales provide moderate to high removal of TSS and other pollutants. They are among the least expensive stormwater controls to construct and maintain. This BMP has the potential to provide conveyance for larger storm flows (if properly designed to maintain low velocities). As with other vegetative controls, channelization should be avoided in vegetative swales.

Vegetative swales are not specifically described in the ECM; however, based on the infiltration procedures provided in the manual, effective removal based on infiltration alone can be determined. Also, the TCEQ's Edwards Aquifer Technical Guidance Manual has general criteria and design procedures to supplement the ECM guidance.

Since the primary pollutant removal measure is infiltration, then the infiltration procedures used for the vegetative filter strips would apply in the same basic manner.

If the side slopes are steeper than the maximum allowed by a vegetative filter strip (10 percent or 10:1), the infiltration must occur on the bottom. This would require the bottom area of the swale to be 33 percent of the area of the contributing pavement. For the swale to function properly, the arrangement of the pavement would need to be

constructed in a uniform manner around the swale (similar to the vegetative filter requirements) and not have concentrated flows coming in through pipes or down the side slopes. If the side slopes are 10 percent or flatter, then the side area could be added to bottom area to meet the requirement (this would be a combination vegetative filter strip and swale).

Other general criteria should include:

- Maximum width: 16 ft (10 ft if pavement is contributing from only one side)
- Bottom gradient: 0.5 percent to 2.5 percent
- Side slope: 5:1 maximum
- Vegetation requirements: same as vegetative filter strip from ECM
- Shape: trapezoidal
- Velocity: maximum 1 fps for the 2-year, 24-hour storm and maximum of 3 fps for the 100-year 24-hour storm
- Maximum contributing area (including the swale and side slopes): 10 ac

Refer to Appendix A-6 for a technical memo to the City of Austin detailing the design of vegetative filter strips at ABIA. Type C soils are suitable for infiltration based BMPs and are the predominant soil type at ABIA. Consult the soil map in Figure 2-2 when designing infiltration based systems.

4.2.2.9 Pavement/Street Sweeping and Pavement Washdown

Pavement/street sweeping is currently performed on both the landside and airside at ABIA. Sweeping occurs on the airside on an as-needed basis based on a daily inspection schedule. Landside sweeping takes place approximately 3-times a week. Sweeping operations, while frequent, are not listed as a specific BMP such as those found in the SWPPP. In addition, ABIA does not have data on the amount of material removed during sweeping operations.

Pavement washdown removes solids and chemical constituents that accumulate on paved surfaces such as aprons, parking lots and garages, paved surfaces where aircraft or ground support equipment is parked, or where spills have occurred. Dry techniques are used when possible. Waste water from washdown activities is reclaimed for proper disposal. Runoff from pavement washdown is reclaimed for offsite treatment.

There is relatively little data in the literature to support the effectiveness of airport sweeping and washdown operations in removing pollutants that contribute to pollutant loading of stormwater runoff. The Seattle Tacoma Report estimates 35 percent removal for lead, zinc, and copper and 54 percent removal for TSS for sweeping operations.

There appears to be a measureable water quality benefit from the airport sweeping and washdown operations. In order to establish the effectiveness of sweeping operations at ABIA, additional data is required to quantify the amount of pollutants removed and the effect on pollutant loading of stormwater runoff quality. Refer to Section 4.4 for recommendations for developing a monitoring program to assess the effectiveness of sweeping and washdown operations.

4.2.2.10 Rainwater Harvesting

Rainwater harvesting systems, as described in the ECM, capture runoff from rooftops. The captured water is used for beneficial purposes such as landscape irrigation or cooling water. The State of Texas offers financial incentives for some rainwater harvesting systems.

It is assumed that rainwater harvesting systems capture runoff from rooftops that are 100 percent impervious cover. Typical uses for the captured water are to irrigate vegetated areas or to drain to a vegetated filter strip for infiltration. The ECM specifies a drawdown time of 72 hours. Refer to the ECM for additional design details and example rainwater harvesting designs. A typical rainwater harvesting system is shown in **Figure 4-11**.

4.2.2.11 Inlet Control Devices

Standard BMPs may be difficult to incorporate in areas with existing stormwater facilities and a high percentage of impervious cover. In these areas, inlet control devices or in-line devices may be candidates for stormwater quality treatment. Although the COA is considering the use of proprietary devices in some ultra-urban areas, inlet control and/or in-pipe systems are not currently approved in the ECM.

Some examples of inlet and in-pipe systems are:

- Filterra
- Comtech/Stormwater Management StormFilter ®
- Storm Water Continuous Deflective Separation units
- Suntree

Numerous other devices exist and are in use around the country. For most of these, including those listed above, additional testing and demonstration would be required. Some limited use may be allowed for demonstration purposes in areas with major space and hydraulic constraints.

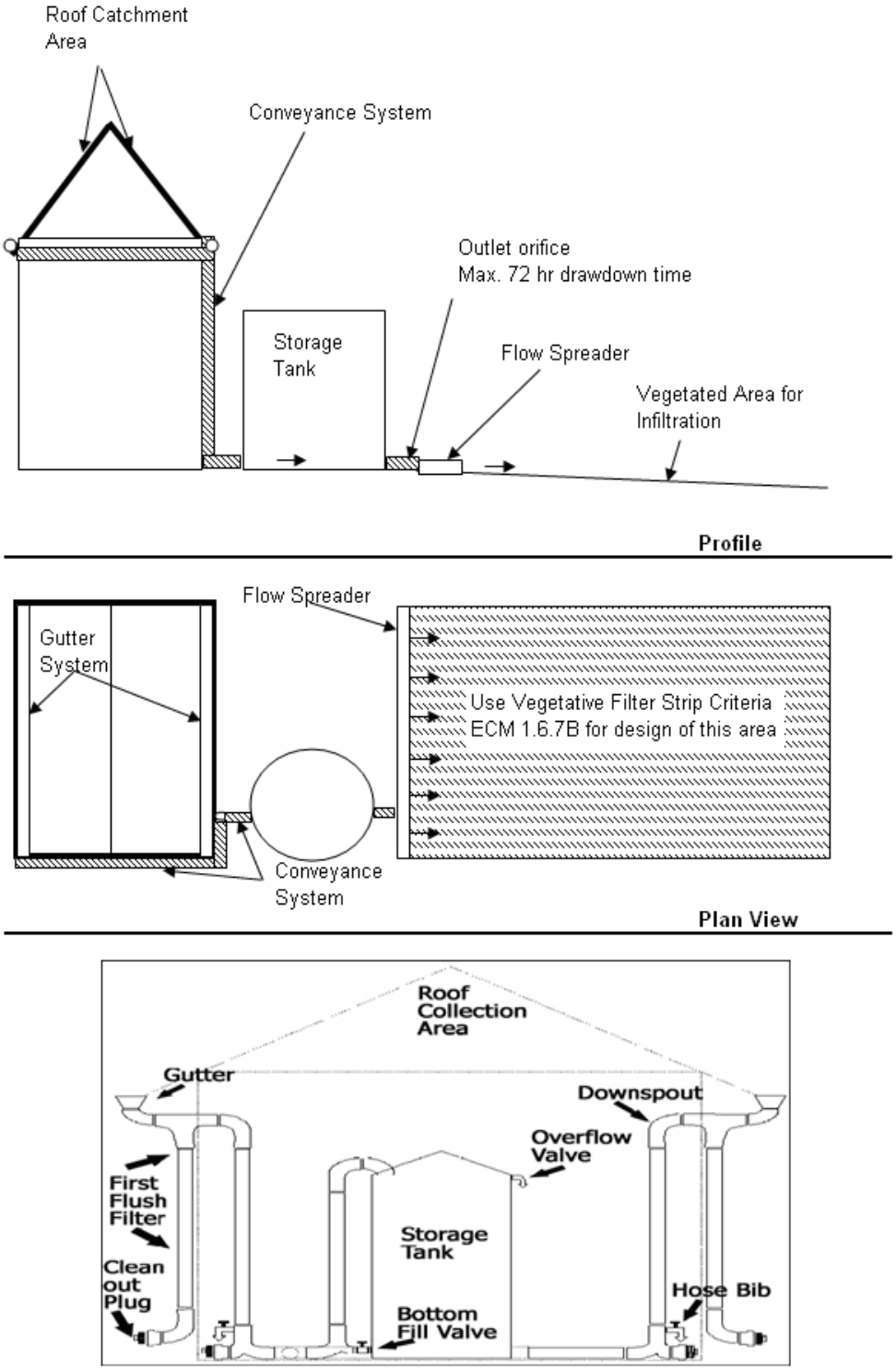


Figure 4-11. Typical Rainwater Harvesting System (COA)

4.3 Water Quality Facilities Alternatives

4.3.1 Introduction

A basis for water quality planning is maintaining and improving the numerous current water quality practices at ABIA. These are effective and efficient measures that should be continued. These general recommendations include:

1. Continue implementing the BMPs listed in the ABIA SWPPP.
2. Continue airside and landside pavement sweeping and pavement washdown operations. Maintain system logs and a database of the frequency of sweeping, areas swept, weight of material removed, and the concentrations of key parameters removed (such as the 10 ECM constituents in Table 4-3).
3. Update and enhance the Integrated Pest Management plan - especially as it pertains to BMP maintenance.

For water quality facilities planning, the airport was divided into Development Zones. These zones are aligned with watershed boundaries and SWMM drainage areas. Future development at ABIA was also considered in delineating the Development Zones. The three types of Development Zones are:

- Airside - Runways/Taxiways
- Airside - Aprons
- Landside - Commercial/Industrial (including automobile and truck parking)

Runways/Taxiways and Aprons are airside facilities, while commercial/industrial areas are landside. Development Zones and proposed near-term and ultimate future improvements are shown in **Figure 4-12** (the larger number in Italics are Development Zones).

Table 4-6 contains data for the Development Zones. **Table 4-7** contains information for the ABIA future improvements.

Table 4-6. Development Zone Data

Development Zone Number	Area (Acres)	Type	Watershed	Existing IC (acres)	Future IC (acres)
1	162.5	Commercial	Onion	2.51	140.41
2a	910.4	Runway/Taxiway	Onion	234.87	286.08
2b	18.9	Runway/Taxiway	Colorado	2.65	12.13
2c	190.0	Runway/Taxiway	Carson	25.77	19.05
3	442.7	Commercial	Onion	48.02	384.34
4a	194.5	Commercial	Onion	129.70	133.40
4b	172.2	Commercial	Colorado	61.30	103.20
4c	61.2	Commercial	Carson	24.43	28.88
5a	363.3	Runway/Taxiway	Onion	100.65	112.10
5b	20.7	Runway/Taxiway	Colorado	1.44	3.39
6	127.3	Apron	Onion	1.91	82.57
7	95.5	Apron	Onion	45.13	88.07
8a	601.9	Commercial	Onion	79.04	10.23
8b	21.6	Commercial	Onion	10.21	10.00
9	47.0	Apron	Onion	0.27	46.84
10	40.8	Apron	Carson	38.11	38.46
11	52.0	Apron	Onion	14.85	50.25
12	215.0	Runway/Taxiway	Onion	101.37	101.77
13	184.6	Commercial	Colorado	7.34	74.72
14	64.4	Apron	Onion	30.41	62.09
15	144.1	Commercial	Onion	11.68	113.26
16	25.1	Apron	Onion	20.30	20.30
Totals	**4155.8**			**992.0**	**1921.5**

Table 4-7. ABIA Future Development Data

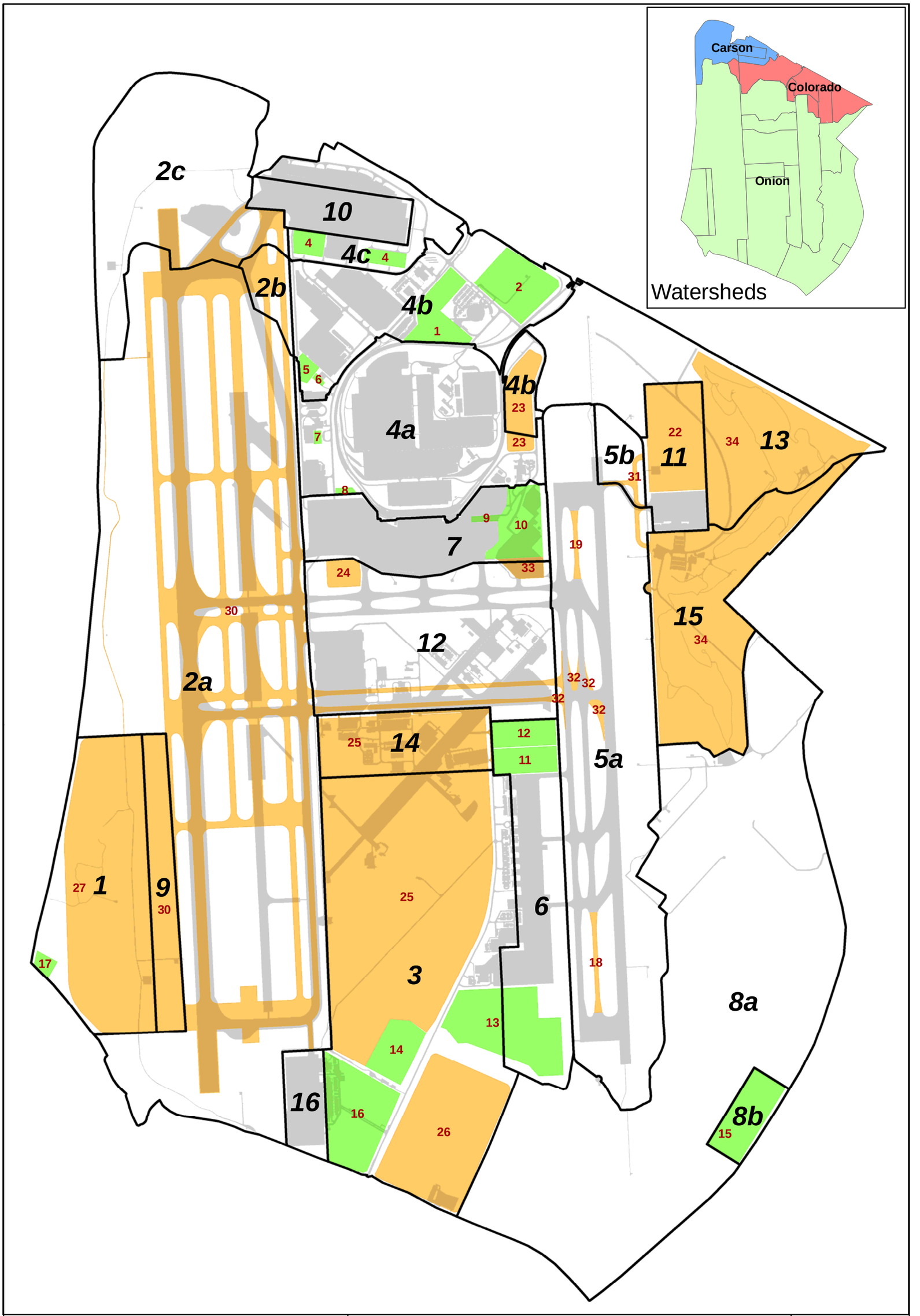
2	4b	Future Improvements	2020	20.35
4	4c	Future Improvements	2020	4.45
	4c	Future Improvements	2020	3.64
5	4b	Future Improvements	2018	2.24
6	4b	Future Improvements	2011	0.45
7	4a	Future Improvements	2025	0.61
8	4a	Future Improvements	2011	0.66
9	7	Future Improvements	2020	1.09
10	7	Future Improvements	2012	17.97
11	6	Future Improvements	2015	9.80
12	6	Future Improvements	2020	9.80
13	6	Future Improvements	2020	42.49
14	3	Future Improvements	2020	13.72
15	8b	Future Improvements	2020	20.00
16	3	Future Improvements	2012	35.38
17	1	Future Improvements	2015	2.11
18	5a	Future Improvements	2015	3.14
19	5a	Future Improvements	2015	2.22
22	11	Airline Maintenance	2035	36.72
23	4a	Building Maintenance	2035	12.69
23	4a	Building Maintenance	2035	2.76
24	12	RON 6 Spaces (SP)	2035	5.47
25	3	Passenger Terminal and 21 Gates	2035	236.21
25	14	Passenger Terminal and 21 Gates	2035	62.08
26	3	Employeee Parking	2035	73.61
27	1	Air Cargo	2035	138.73
30	9	Runway and Taxiway Additions	2035	46.84
30	2a	Runway and Taxiway Additions	2035	324.17
31	5a	Taxiway E Improvements	2035	4.14
32	5a	Taxiway Addition/Improvements	2035	2.81
32	12	Taxiway Addition/Improvements	2035	15.54
33	12	R.O.N. Apron Additional Expansion	2035	4.59
34	13	Misc Improvements	2035	89.31
34	15	Misc Improvements	2035	141.58
			Total	**1,402.1**

Note 1: Descriptions are for planning purposes only.

Guidelines in the following sections have been designed specifically for future development at ABIA. Following these guidelines for water quality controls will ensure that the COA water quality requirements have been met or exceeded based on guidelines provided by the ECM. Following the guidelines will streamline the review and permitting process with the COA Planning and Development Review Department. Water quality BMPs documented in the ECM that are not part of this plan can be used where applicable. Deviations from the recommendation in this plan or from the ECM could result in longer review process and require additional engineering and design effort. Recommendations have been developed for each of the Development Zone types described above.

In addition to the three types of Development Zones described above, ABIA has designated the central-north area of the airport as a Constrained Development Area (CDA), due to physical and economic constraints associated with airport viability (shown in **Figure 4-13**). The general basis for the Constrained Development Area includes:

- This area surrounds the key existing elements of the current facility (the main terminal and the existing cargo area). Much of the future development will be necessarily constrained to be within close proximity to these key elements.
- Much of this area was originally developed based on 1/2-inch capture volume. These 1/2-inch systems were built between 1994 and 2000 and appear to be functioning properly.
- Existing and future vegetative/infiltration controls, primarily on the airside, provide enhanced water quality treatment.
- Regular pavement sweeping and washdowns of the parking lots/garages and aprons provides some additional pollutant removal.
- Most of the area was included in the original development of the airport, and much of the future development will be re-development over existing impervious cover
- Some of the existing impervious cover in this area pre-exists ABIA from the Bergstrom Air Force Base.
- Existing drainage infrastructure, including pipes and culverts under roadways, highways and runways limit the location, size and types of controls.



Legend

22 Development Zones

Existing Impervious Cover

Future Development

17 Near Term

18 Ultimate

0 0.25 0.5 Miles

N W E S

Figure 4-12
Future Development
Austin - Bergstrom International Airport (ABIA)
STORMWATER DRAINAGE MASTER PLAN (SWMP) UPDATE
Project No.: 4910-8107-3139

Legend

Constrained Development Area

Airport Property

0 0.25 0.5 Miles

N W E S

Figure 4-13
Airport Boundary and Constrained Development Area
Austin - Bergstrom International Airport (ABIA)
STORMWATER DRAINAGE MASTER PLAN (SWMP) UPDATE
Project No.: 4910-8107-3139

A detailed analysis of the water quality treatment for the proposed development in the CDA and the water quality treatment in the runway/taxiway areas is presented in Appendix A-7. The analysis shows that the treatment provided by vegetative filter strips in the runway/taxiway areas exceeds the difference between the required treatment for 1/2-inch versus 1/2-inch plus capture volume for development within the CDA and can be used as compensatory treatment to support the 1/2-inch capture for proposed development in the CDA.

4.3.2 Runway/Taxiway Treatment Facilities

Runways and taxiways are located in Development Zones 2a, 2b, 2c, 5a, 5b, and 12 (Refer to Figure 4-12).

Primary Treatment BMP

- Vegetative Filter Strips – Filter strips are an efficient and proven treatment method and are the preferred treatment method for runways and taxiways. They meet the requirements of the COA regulations and comply with FAA regulations. Follow the guidelines in Section 4.2.2.7 for designing vegetative filter strips in the runway/taxiway areas. FAA safety regulations must be observed. If the full filter strip length is not possible because of runway/taxiway configuration or other constraints, one of the additional treatment BMPs listed below should be used.

Additional Treatment BMPs

- Infiltration. Follow the guidelines in Section 4.2.2.4 for designing infiltration systems in the runway/taxiway area. Ponding depth and other FAA safety regulations must be observed.

- Vegetative Swales. Follow the guidelines in Section 4.2.2.8 for designing vegetative swales in the runway/taxiway area. FAA safety regulations must be observed. This BMP should be used only where vegetative filter strips or infiltration cannot be implemented due to unavoidable space constraints. Vegetative swales are not currently approved in the ECM and need to be approved by WPD prior to being used.

4.3.3 Apron Treatment Facilities

Aprons are located in Development Zones 6, 7, 9, 10, 11, 14, and 16 as shown in Figure 4-12. Apron water quality treatment facilities are divided into two sections: 1) taxilanes and 2) all other apron areas. Taxilanes are designated lanes on the apron where aircraft taxi between the terminal and the taxiways. Aircraft maintenance, fueling, and de-icing do not take place in taxilanes.

Primary Treatment BMP (Apron)

- **Sedimentation/Filtration**. Follow the ECM guidelines for sedimentation/filtration systems with water quality volume sizing as described above (1/2-inch for the

Constrained Development Area and 1/2 plus in all other areas). Partial sedimentation/filtration systems are recommended due to their smaller footprint compared to full sedimentation filtration systems.

- **Hazardous Material Traps (Apron)**. For spill containment in some apron areas, traps are required based on potential spill size. Although a sedimentation/filtration system can function as a spill trap, they are not practicable to maintain as such. A spill trap should be built into the headworks of a sedimentation/filtration system or separate spill tank should be installed for each of the potential spill areas upstream of the system.

De-Icing Operations (Apron)

- **De-Icing Operations**. Specific areas are designated for de-icing activities, with the preferred arrangement of new facilities to be with the containment only receiving runoff from the deicing area, thus isolating the de-icing fluid for proper disposal. As with the existing systems, de-icing fluid would be pumped to the wastewater system. The containment and pumping system could be developed separately (upstream of) or as part of the sedimentation/filtration system.

Additional Treatment BMPs (Apron)

- **Pavement Sweeping and Pavement Washdown**. Pavement sweeping and pavement washdown is a valuable BMP for the apron and should be continued.

- **Batch Reactor**. The batch reactor is the most suitable alternative to the sedimentation/filtration system, since the nature of the batch system (retaining the runoff for 12 hours before the valve opens or pump starts) is very compatible with the function of hazardous materials traps or de-icing containment. Batch reactors are not currently approved in the ECM and need to be approved by WPD prior to being used.

Other BMPs (Apron)

- **Other BMPs**. Other BMPs such as biofiltration, swales and infiltration are typically not desirable for applications associated with trapping hazardous materials or spill containment and are not suitable for apron areas. Vegetative filter strips may be suitable for some apron areas.

Primary Treatment BMP (Taxilanes)

- **Vegetative Filter Strips**. Follow the guidelines in Section 4.2.2.7 for designing vegetative filter strips in the taxilane areas. FAA safety regulations must be observed. Runoff from the taxilane should sheet flow directly to the filter strip and not mix with runoff from other apron areas. If the full filter strip length is not possible because of apron and taxiway configuration or other constraints, one of the additional treatment BMPs listed below should be used.

Additional Treatment BMPs (Taxilanes)

- **Sedimentation/Filtration**. Sedimentation/filtration systems could be combined with other apron or facility water quality controls. Partial sedimentation/filtration systems are recommended due to their smaller footprint compared to full sedimentation filtration systems.

- **Batch Reactor**. The valve or pump operation may be particularly suitable for taxilanes when segregating and treating the storm runoff. Batch reactors are not currently approved in the ECM and need to be approved by WPD prior to being used.

4.3.4 Commercial/Industrial Treatment Facilities

Commercial/Industrial development areas are located in Development Zones 1, 3, 4a, 4b, 4c, 8a, 8b, 13, and 15 as shown in Figure 4-12.

Primary Treatment BMP

- **Sedimentation/Filtration** – Follow the ECM guidelines for sedimentation/filtration systems with water quality volume sizing as described above (1/2-inch for the Constrained Development Area and 1/2 plus in all other areas).

Hazardous Materials Traps

- **Hazardous Material Traps** – For spill containment for fueling and some maintenance areas, traps are required based on potential spill size. Although a sedimentation/filtration system can function as a spill trap, they are not practicable to maintain as such. A spill trap should be built into the headworks of a sedimentation/filtration system or separate spill tank should be installed for each of the potential spill areas upstream of the system.

Additional Treatment BMPs

Virtually all BMPs discussed above can be applicable for the commercial and industrial type areas. For the purposes of this plan, the additional BMPs for these areas are listed below in general order of priority, although this will vary on site-specific conditions. Guidance is provided with respect to the suitability of the BMP for some conditions.

- **Pavement Sweeping and Pavement Washdown**. Pavement sweeping and pavement washdown is a valuable BMP for the apron and should be continued.

- **Vegetative Swales.** Follow the guidelines in Section 4.2.2.8 for designing vegetative swales. This BMP should be used only where other BMPs cannot be implemented due to unavoidable space constraints. This BMP was included primarily for limited airside use in areas with severe space constraints or some site specific landside uses where space and drainage system constraint prevent the practical implementation of other controls. Infiltration type BMPs may not be suitable in areas with low soil

permeability. The Travis County Soil Survey should be consulted to verify soil permeability. Vegetative swales are not currently approved in the ECM and need to be approved by WPD prior to being used.

- **Batch Reactor**. The batch reactor is a suitable alternative to the sedimentation/filtration system, since the nature of the batch system (retaining the runoff for 12 hours before the valve opens or pump starts) is very compatible with the function of hazardous materials traps. Batch reactors are not currently approved in the ECM and need to be approved by WPD prior to being used.

- **Retention/Irrigation**. Retention/irrigation is an excellent alternative to sedimentation/filtration because of the better overall removal rates and flexibility provided by the pumping system. The 100 percent removal rates could be used to provide an offset for areas with lower treatment or where there is not a practical treatment alternative. This alternative could be used as a site-specific alternative where land is available for irrigation. These areas could include open space adjacent to floodplains or water quality zones. Infiltration type BMPs may not be suitable in areas with low soil permeability. The Travis County Soil Survey should be consulted to verify soil permeability. Retention/irrigation is well suited to the southern and eastern portions of ABIA where large areas contained in the Onion Creek 100-year floodplain are present.

- **Vegetative Filter Strips**. Follow the guidelines in Section 4.2.2.7 for designing vegetative filter strips. If the full filter strip length is not possible because of pavement configuration, infiltration areas combined with vegetative swales should be considered. Infiltration type BMPs may not be suitable in areas with low soil permeability. The Travis County Soil Survey should be consulted to verify soil permeability. Unlike the runway/taxiway areas and taxilane areas, flow spreaders may be required in vegetative filter strips in commercial/industrial areas.

- **Infiltration**. Follow the guidelines in Section 4.2.2.4 for designing infiltration areas, including parking lot medians, adjacent to small pavement areas and small isolated impervious cover. Infiltration type BMPs may not be suitable in areas with low soil permeability. The Travis County Soil Survey should be consulted to verify soil permeability.

- **Raingardens**. Raingardens may be implemented in parking lot medians, adjacent to small pavement areas and small isolated impervious cover. A combination of vegetative and infiltration techniques may be used to develop an effective raingarden that also meets the intent of conservation related parking lot landscape initiatives. Infiltration type BMPs may not be suitable in areas with low soil permeability. The Travis County Soil Survey should be consulted to verify soil permeability.

- **Biofiltration**. Biofiltration would generally be a good alternative for sedimentation/filtration due to the expected higher removal rates, especially for nutrients, and low maintenance; however, the potential for increasing wildlife hazards may make this alternative less attractive. Location and potential for wildlife attraction should be carefully considered before using this option.

- **Rainwater Harvesting**. Rainwater harvesting can be used in areas where development includes structures with roof catchment areas and nearby vegetated areas that can be used as irrigation or infiltration areas. Refer to the ECM for additional details on rainwater harvesting designs.

- **Proprietary Inlet/In-Pipe Systems.** Proprietary inlet/in-pipe systems may help achieve stormwater treatment requirements in areas where the combination of existing stormwater facilities, drainage, and a high percentage of impervious cover makes the use of standard BMPs less desirable. Inlet or in-pipe systems require approval by the COA.

4.3.5 Expansion of Existing Systems

Some of the existing sedimentation/filtration systems have a potential for expansion, with respect to treatment volume. The systems that appear to have potential for expansion are WQP C, G, L and N. Some of the methods that could increase the volume include:

- **Deepening**. This method requires the outlet flowline to be lowered, which depends on the adjacent conveyance system depths. In some cases, the volume is not substantially increased due to the side slopes of the basins.

- **Pumping**. Pumping can be used to allow the basin depth to be increased, to pump from a conveyance, or to pump from the sedimentation pond to the filter basin.

- **Vertical Walls**. The volume of an existing grass sloped basin can be increased by using vertical walls without increasing the surface area of the basin.

All of the methods of expansion are relatively expensive when compared to the small volume typically gained.

4.3.6 Proposed Water Quality Sizing

Projected impervious cover areas were developed based on proposed future development at ABIA. In all but the airfield areas, the baseline water quality control, sedimentation/filtration, was used to estimate the required water quality volume required for ultimate conditions.

Table 4-8 shows the water quality volume estimates. Estimations for the required capture volume and the required water quality volume were made using the 1/2-inch capture rule for development in the Constrained Development Area, and the 1/2-inch

plus rule for all other areas. The pond area is calculated assuming a pond depth of 4 feet and a 1.3x factor to account for embankment slopes and splitter boxes.

Table 4-8. Proposed Water Quality System Sizing

ABIA Number	Development Zone	Type	Area (acres)	IC (%)	Ultimate IC (acres)	1/2" plus Capture (inches)	Required Capture (inches)	Required WQV (acre-ft)	Pond Area (acres)
1[1]	4b	Commercial	14.65	80	11.72	1.1	0.5	0.61	0.20
2[1]	4b	Commercial	20.35	80	16.28	1.1	0.5	0.85	0.28
4[1]	4c	Commercial	4.45	100	4.45	1.3	0.5	0.19	0.06
4[1]	4c	Commercial	3.64	90	3.28	1.2	0.5	0.15	0.05
5[1]	4b	Commercial	2.24	80	1.79	1.1	0.5	0.09	0.03
6[1]	4b	Commercial	0.45	90	0.40	1.2	0.5	0.02	0.01
7[1]	4a	Commercial	0.61	70	0.43	1.0	0.5	0.03	0.01
8[1]	4a	Commercial	0.66	80	0.53	1.1	0.5	0.03	0.01
9[1]	7	Apron	1.09	100	1.09	1.3	0.5	0.05	0.01
10[1]	7	Apron	17.97	100	17.97	1.3	0.5	0.75	0.24
11	6	Apron	9.80	80	7.84	1.1	1.1	0.90	0.29
12	6	Apron	9.80	80	7.84	1.1	1.1	0.90	0.29
13	6	Apron	42.49	90	38.24	1.2	1.2	4.25	1.38
14	3	Commercial	13.72	80	10.98	1.1	1.1	1.26	0.41
15	8b	Commercial	20.00	50	10.00	0.8	0.8	1.33	0.43
16	3	Commercial	35.38	75	26.54	1.0	1.0	2.95	0.96
17	1	Commercial	2.11	70	1.47	1.0	1.0	0.18	0.06
18[2]	5a	Runway/Taxiway	3.14	100	3.14	-	-	-	-
19[2]	5a	Runway/Taxiway	2.22	100	2.22	-	-	-	-
22	11	Apron	36.72	100	36.72	1.3	1.3	3.98	1.29
23	4a	Commercial	12.69	100	12.69	1.3	1.3	1.37	0.45
23	4a	Commercial	2.76	100	2.76	1.3	1.3	0.30	0.10
24[1]	12	Apron	5.47	100	5.47	1.3	0.5	0.23	0.07
25	3	Commercial	236.21	100	236.21	1.3	1.3	25.59	8.32
25	14	Apron	62.08	100	62.08	1.3	1.3	6.73	2.19
26	3	Commercial	73.61	100	73.61	1.3	1.3	7.97	2.59
27	1	Commercial	138.73	100	138.73	1.3	1.3	15.03	4.88
30	9	Apron	46.84	100	46.84	1.3	1.3	5.07	1.65
30[2]	2a	Runway/Taxiway	324.17	100	324.17	-	-	-	-
31[2]	5a	Runway/Taxiway	4.14	100	4.14	-	-	-	-
32[2]	5a	Runway/Taxiway	2.81	100	2.81	-	-	-	-
32[2]	12	Runway/Taxiway	15.54	100	15.54	-	-	-	-
33[1]	12	Runway/Taxiway	4.59	100	4.59	1.3	0.5	0.50	0.16
34	13	Commercial	89.31	80	71.44	1.1	1.1	8.19	2.66
34	15	Commercial	141.58	80	113.26	1.1	1.1	12.98	4.22

Notes

[1]Ponds in Constrained Developent Area (1/2-inch capture)

[2]Runway/taxiway areas - treated with vegetated filter strips. WQ Ponds are not required.

Refer to **Figure 4-14** for representative locations of the proposed water quality systems. The following developments have special considerations:

- ABIA development 1, 5, and 6 (Development Zone 4b)

  According to available site plan drawings, WQP L was sized for a contributing area of 109.9 ac. The water quality volume, measured from the construction drawings, is 11.21 ac-ft. The calculated capture depth is therefore 1.2 inches, corresponding to 90 percent impervious cover. Field visits indicate that the contributing drainage area is not built out to plan. It does appear however, that WQP L has been sized to handle the ultimate build-out of the contributing drainage area and that excess capacity exists in the pond. ABIA development areas 5 and 6 along with 9-ac of ABIA development area 1 are within the contributing drainage area of WQP L. Based on the basin size and drainage area shown for WQP-L, additional water quality systems may not be required for these areas. The drainage area, impervious cover, and water quality volume of WQP L should be verified by field survey prior to development in this area.

- ABIA development 4 (Development Zone 4c)

  Runoff from the two developments in the cargo area (currently undeveloped in Development Zone 4c) is currently routed to WQP N and is located in both the original ordinance 1/2-inch capture area and in the Constrained Development Area. Additional water quality treatment is therefore not required.

- ABIA development 9 and 10 (Development Zone 7)

  Development 9 and 10 are located in the terminal apron area and are subject to the original ordinance 1/2-inch capture rule, as well as being contained in the Constrained Development Area. Runoff from these areas does not currently route to a water quality system and therefore requires water quality treatment.

In the airfield areas, a 25-ft filter strip length was used to estimate the area required for water quality treatment for ultimate conditions. The following filter strip areas (approximate) are required to meet the water quality treatment in the airfield areas:

- West runway/taxiways 83 acres
- East runway/taxiways 31 acres
- Cross taxiways 9 acres

The space needed for 50-ft wide vegetative filter strips in the airfield areas is shown for a portion of the west runway in **Figure 4-15**.

4.3.7 Consolidated Water Quality Facilities Alternatives

Consolidation of water quality BMPs with 2-year detention can potentially result in significant cost savings and reduce the land area required for stormwater controls at ABIA. Facilities to provide 2-year detention may be necessary for erosion control during conveyance to the receiving systems. Refer to Section 7.2 for a discussion of three areas where 2-year detention facilities could be combined with water quality facilities.

Large combination water quality and stormwater facilities were considered for the ABIA SWMP. Other than some smaller combined facilities, the larger facilities were not deemed to be feasible at this time based on ABIA site conditions and constraints as well as the uncertainty of the location, nature and timing of development:

- The high initial capital cost of a larger stormwater facility may not be recouped for many years.
- A preliminary review of the site topography and other site conditions did not indicate sites that were particularly suitable for this type of facility.
- Wet ponds are the only standard water quality control that is feasible for use with the larger facilities. This BMP was eliminated early in the planning process due to wildlife attractant concerns.

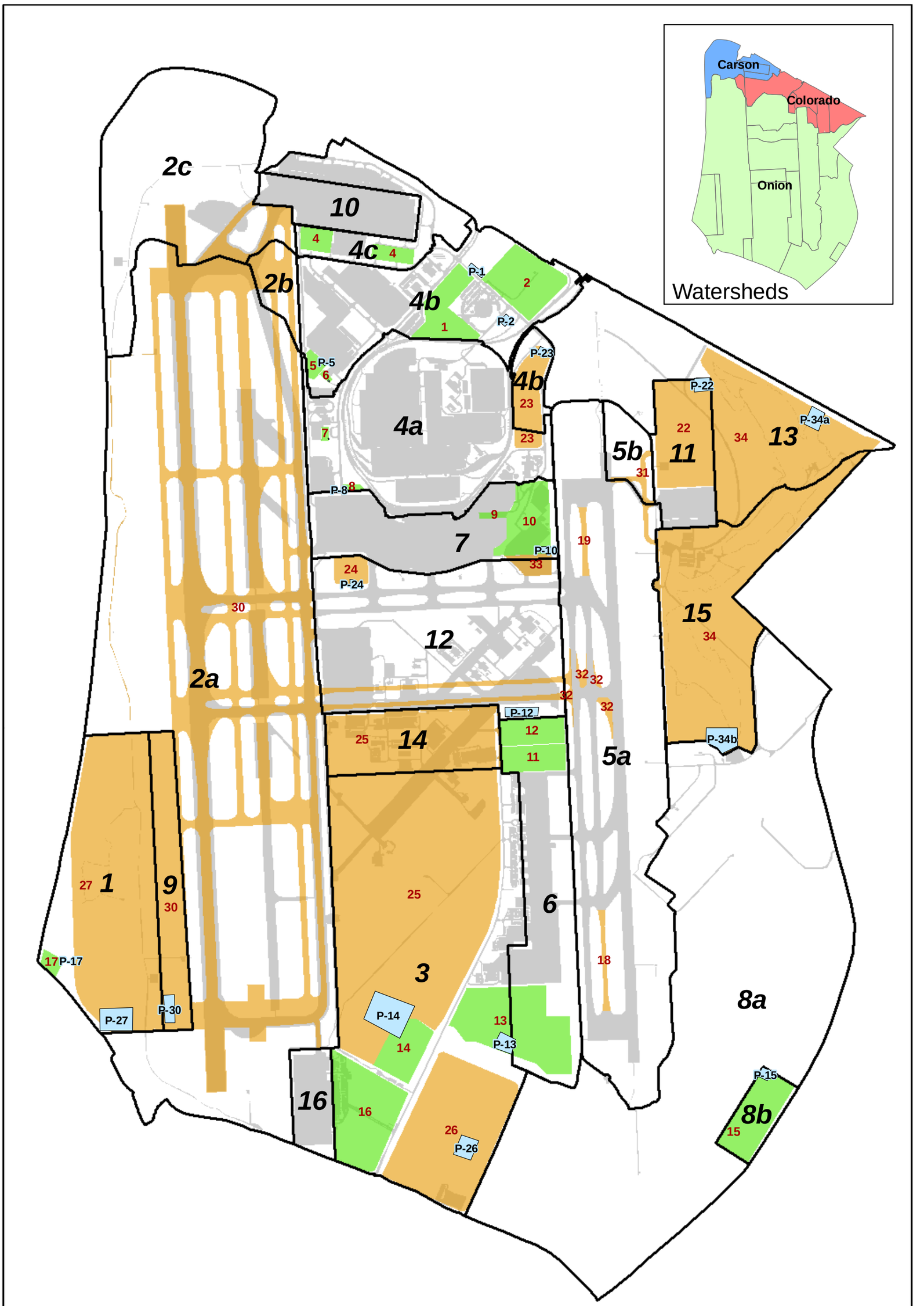
The large number of outfalls limits the potential for consolidation.

- Many outfalls are directly to Onion Creek or very close to the major receiving water (i.e. Carson Creek and the Colorado River).
- Some of the larger potential facility sites are within the floodplain or other environmental features, and near the end of the runways.
- The larger facilities would likely require a large up-front investment, with a gradual return on the investment as the airport built-out.

4.4 Runoff and Innovative BMP Monitoring

Establishment of a new baseline pollutant loading at ABIA, or the determination of the performance of innovative BMPs may be useful in validating performance of alternative BMPs and in designing water quality controls at ABIA. In order to demonstrate loadings and performance, a BMP performance study is recommended. The attributes of a study of this nature are described in the ECM Section 1.6.9.3.C (Alternative Data) and generally consist of:

- Topographic maps showing sampling locations and the contributing drainage to the sampling points.



Legend

- 22 Development Zones
- P-2 Proposed Ponds
- Existing Impervious Cover

Future Development

- 17 Near Term
- 18 Ultimate

0 0.25 0.5 Miles

N W E S

Figure 4-14
Proposed Water Quality Systems
Austin - Bergstrom International Airport (ABIA)
STORMWATER DRAINAGE MASTER PLAN (SWMP) UPDATE
Project No.: 4910-8107-3139

Legend

- Development Zones
- Existing Impervious Cover

Future Development

- Near
- Ultimate
- Vegetated Filter Strips

COA Watersheds

- Carson
- Colorado
- Onion
- 100-Yr Floodplain
- COA CWQZ
- COA WQTZ

500 250 0 500 Feet

(Inset Map Scale)

N W E S

Figure 4-15
Representative Vegetated Filter Strips
Austin - Bergstrom International Airport (ABIA)
STORMWATER DRAINAGE MASTER PLAN (SWMP) UPDATE
Project No.: 4910-8107-3139

- Detailed description of conditions including drainage plan, ponding areas, soil classification, level of development, type of development and vegetative cover.
- Sampling plan including number of samples studied, protocol to determine what storms are sampled, when during a storm samples were taken, and method of collection.
- A quality assurance plan indicating the laboratory that performed the analysis, method of handling, and name of person taking samples.
- Rainfall data and flow data at each sampling point, as well as methods of calibration and flow rating equations.

Typically in studies of this nature, 25 to 30 storm events are sampled. Samples are collected using automated sampling equipment and flow meters/data loggers. In the case of BMP monitoring, both inflow and outflow must be monitored over the period of the event and drawdown. Costs for monitoring a BMP, including equipment, laboratory fees, and analysis, are estimated to be approximately $45,000.

Section 5
Participation in the Regional Stormwater Management Program (RSMP)

5.1 RSMP Overview

The City of Austin operates a Regional Stormwater Management Program (RSMP) intended to increase the efficiency and effectiveness of stormwater practices throughout the City. The program allows certain qualifying projects to forego the construction of on-site detention ponds (for flood control) in exchange for paying a participation fee in the RSMP. Regional detention programs in general provide for much more effective regional flood control as compared to a large number of smaller detention ponds. Individual ponds are generally designed to mitigate the direct runoff impact of a single development but are not always designed to completely complement other flood control measures in any given watershed. Regional programs provide an opportunity to combine the flood control budget for numerous projects into a single fund, allowing flood control measures to be implemented on a regional scale, thus allowing more cost-effective improvements.

To qualify for participation in the City's RSMP program, a project must be able to demonstrate that stormwater runoff increases can be safely conveyed to a receiving stream of sufficient size where the change in peak flow and velocity due to the development are insignificant. Due to the fact that State Highway 71 provides primary access to the airport site at Presidential Boulevard (near the north end of the site), a large share of the existing airport development is concentrated along the northern ABIA boundary. As a result, a majority of the anticipated future development is likely to occur further south, in the Onion Creek drainage basin. ABIA is located very low in the overall Onion Creek drainage basin, which encompasses approximately 340 square miles and extends through Travis County into both Hays and Blanco Counties. The relative location in the watershed will allow the ABIA property to drain to Onion Creek and subsequently to the Colorado River prior to the arrival of peak flows from the upper Onion Creek basin. This early release of water prevents the peak discharge (for any given storm) from ABIA from occurring coincident with the peak discharge in the watershed as a whole. Because of the airport's location and the fact that the main stem of the creek passes through ABIA property (making conveyance to the main channel possible) the site is an excellent candidate for participation in the City of Austin Regional Detention Program.

5.2 RSMP Report and Determination

The ABIA regional detention study was performed in general accordance with the requirements of the City of Austin Drainage Criteria Manual. The scope of the regional detention study included the following actions:

- Preparation of existing condition and ultimate future build-out impervious cover development maps of the ABIA facility.
- Determination of the hydrologic characteristics for ABIA property for both existing and ultimate future conditions.
- Modeling the Onion Creek watershed to determine the impact of future ABIA development on peak flows and velocities at various points of interest.
- Analysis of the study results and preparation of a report.

An existing HEC-HMS model of the Onion Creek watershed was used to estimate the impact of future development of ABIA. The model was obtained from the City of Austin Watershed Engineering Department and is considered to be the most accurate model of the overall watershed currently available. The model contains 26 individual drainage basins that contain at least some portion of ABIA property. The impervious cover of each of these basins was updated to reflect the current layout of the airport as depicted in the Existing Conditions Impervious Cover map (Figure 3-1). The model was also updated to reflect an adjustment to the Onion Creek – Carson Creek drainage boundary made during the construction of the primary parking lots for the passenger terminal. The results of the model were subsequently used as the existing, or background, condition against which model results for future conditions were compared.

The City of Austin Watershed Engineering Department also provided a HEC-RAS hydraulic model of Onion Creek. Because hydraulic modeling indicated the changes in peak flow in the main stem of Onion Creek due to future development of ABIA to be insignificant (generally less than 0.03 percent), HEC-RAS modeling of the creek was deemed unnecessary by Watershed Engineering staff.

The hydrologic characteristics of each of the Onion Creek basins was updated to reflect the ultimate buildout condition of the airport as depicted in Ultimate Future Impervious Cover map (Figure 3-3). The results of the future condition model were compared to the background models to assess the impact of future ABIA development on peak flow rates in Onion Creek. The results of the regional detention support the following study conclusions.

- Ultimate development of the ABIA is unlikely to result in measurable changes in the peak storm flows or peak water surface elevations in Onion Creek. Numerous modeling scenarios were investigated. For the modeling scenario most applicable to the ABIA site, the projected 100-year flow increased 2 cfs over a background flow of about 120,000 cfs. The worst case increase was 35 cfs against a background flow of approximately 140,000 cfs. Results for the 25-year storm event modeling indicated the same trends as the 100-year modeling.

- The construction of on-site detention is unlikely to result in measurable changes in the peak storm flows or peak water surface elevations in Onion Creek. For the modeling scenario most applicable to the ABIA site, the projected 100-year flow with on-site detention increased 6 cfs over a background flow of about 120,000 cfs.

- The configuration of the ABIA property is such that direct conveyance of storm flows to the main stem of Onion Creek is possible for almost 95 percent of the proposed future development within the Onion Creek drainage basin. Some outfalls will require erosion control improvements as discussed in Section 6.5.3.2

The ABIA site is an excellent candidate for participation in the City of Austin Regional Detention Program. The Regional Detention Study Report is provided in electronic format in Appendix B.

5.3 Permitting Requirements

The ABIA regional detention study was submitted to the City of Austin Watershed Protection Department with a regional detention application and other associated documentation. The submittal represents a formal request for participation in the RSMP program. The report and application have been approved by Watershed Engineering staff. The approval letter is included in Appendix B and the fee was paid on April 7, 2011 for 300 acres of participation. This fee will allow the future development of a fixed amount of additional impervious cover without the need to construct 10, 25 and 100-year flood control measures on the ABIA site. The future development will be required to comply with the general assumptions outlined in the regional detention report.

5.4 Cost Analysis and Pricing Plan

The cost of participation in the RSMP program is based on the amount of impervious cover proposed for participation and the market value of the land on which the development will occur. The impervious cover portion for the fee is calculated according to the following table obtained from the City of Austin Regional Detention application packet:

Table 5.1. Impervious Cover Fee

Acres From	Acres To	Cost per Impervious Acre
0.00	1.00	$60,000
1.01	2.00	$18,000
2.01	5.00	$8,000
5.01	10.00	$6,000
10.01	20.00	$5,000
20.01	50.00	$4,000
50.01	Infinity	$2,500

This impervious cover fee is adjusted for inflation based on the construction cost index published by *Engineering News Record*. The inflation adjustment as of March, 2011 is 1.3559. Because the cost per acre drops significantly with size, the unit cost for large projects (on the order of hundreds of acres) will be far lower than that for a small project of a few acres. The fee also contains a land value component which is simply five percent of the value of the land being proposed for participation. For example, the regional participation fee for a project containing 300 acres of impervious cover on 584.9 acres of land valued at $8,112.32 per acre could be calculated as follows:

Impervious Cover Fee:

1x $60,000 + 1 x $18,000 + 3 x $8,000 + 5 x $6,000 + 10 x $5,000 + 30 x $4,000 + 250 x $2,500

Impervious Cover Fee = $927,000

Land Cost Fee:

Land Cost = 584.9 x 0.05 x $8,112.32 = $237,244.80

Total RSMP Fee:

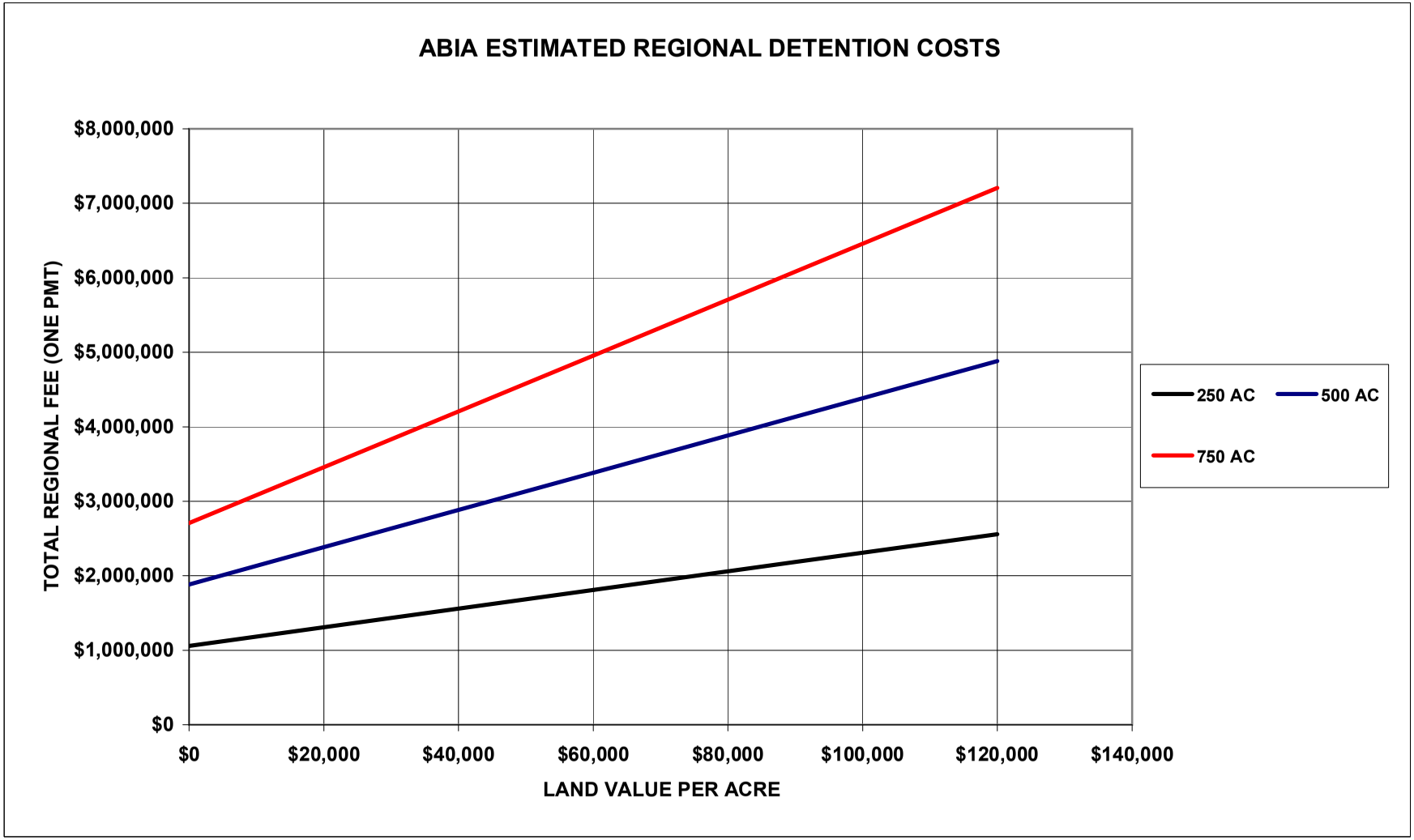
Total RSMP Fee = $927,000 x (1.3559) + $237,244.80 = $1,494,164.10

The total fee and per acre fee for ABIA RSMP participation will therefore depend highly on the total acreage proposed for participation and the market value of the land. **Figure 5-1** depicts the overall gross per participation fee for several combinations of land value and acres of participation. The gross cost could range from $1,000,000 to $7,000,000.

REGIONAL DETENTION COST COMPARISON CHART

FIGURE 5-1

Austin-Bergstrom International Airport (ABIA)
STORMWATER DRAINAGE MASTER PLAN (SWMP) UPDATE
Project No.: 4910-8107-3139



Section 6
Water Quantity Analysis

6.1 Overview

The conversion of the Air Force Base to a civilian airport initiated a Drainage Master Plan for the airport that was completed by Carter & Burgess in 1995. The 1995 Master Plan used the USACE HEC-1 Flood Hydrograph Package to perform hydrologic calculations and to determine peak runoff from drainage areas using dimensionless Soil Conservation Service (SCS) hydrographs; however, the plan did not include all of the ABIA property.

Continued development within the ABIA and the availability of more detailed information in the design phase of projects led to changes that differed from the initial plan. These changes necessitated the development of a blueprint to evaluate future drainage improvements within the ABIA property as well as assess the impacts of small development projects on the overall site. The Department of Aviation (DOA) retained the services of Alan Plummer Associates, Inc. (APA) to update the Drainage Master Plan so that it could be used as a permitting and planning tool. APA developed a detailed drainage network model of the entire airport site using the DHI's MIKE SWMM GUI with the USEPA SWMM engine. The updated Drainage Master Plan was completed in June 2003.

The COA selected CDM to prepare a Stormwater Drainage Master Plan (SWMP) Update in 2009. Tasks included converting the 2003 MIKE SWMM Drainage Master Plan Model to USEPA SWMM version 5.0, updating the SWMM based on available existing conditions data provided by the Airport, validating the SWMM based on available event data, and using the model to analyze existing levels of service, potential flooding and channel velocity problem areas, and proposed future land use conditions.

A parallel, simplified USACE HEC-HMS model was developed for ABIA to be used by the COA for permitting by the Planning and Development Review Department (PDRD).

6.2 Stormwater Management Model

An important aspect of the ABIA SWMP Update is the proper evaluation of water quantity (flooding) issues and improvement alternatives to address these issues. A thorough understanding of water quantity helps determine the most effective methods of controlling flooding, conveying flows off-site, and protecting public safety.

CDM used the USEPA SWMM v 5.0 for the water quantity analysis. This model can serve multiple purposes such as the design and sizing of drainage system components for flood control, floodplain mapping, evaluating effectiveness of BMPs for reduced wet weather pollutant loadings, etc. and is widely used for water quantity analyses.

The program performs single event or long-term (continuous) runoff (hydrologic) and routing (hydraulic) calculations. The program simulates the rates of runoff developed from hydrologic units (HUs) using a non-linear reservoir approximation (using Manning's equation). Hydrologic routing techniques are then used to route the overland flows through pipes, culverts, and channels as required.

The program has been applied extensively since its inception in 1971 and has gained worldwide acceptance. Over the years, the program has undergone many changes and modifications, although the main formulations and calculations are mostly unchanged from the original codes.

Program modifications have been performed over the years by EPA, with the help of CDM and others to streamline program functions and expand channel routing capabilities for use in stormwater master plan studies. A more complete documentation of the model's background and theory can be found in the SWMM 5.0 User's Manual.

The hydraulic flow routing uses a link-node (conduit-junction) representation of the primary stormwater management system (PSMS) in an explicit finite difference solution of the equations of gradually varied, unsteady flow. The model can perform steady, kinematic wave, or dynamic wave routing of stormwater flows through the PSMS to points of discharge or outfalls. Since it is dynamic, it simultaneously considers both the storage and conveyance aspects of stormwater management facilities. The program can simulate branched or looped networks; backwater due to tidal or non-tidal conditions; free surface flow; pressure flow or surcharge; flow reversals; flow transfer by weirs, orifices, and pumping facilities; and storage at online or offline facilities. Simulation output takes the form of water surface elevations and inundated areas at each junction and flows and velocities at each conduit.

The ABIA models include detailed information of the airport's drainage system for use in evaluating future development and stormwater management facilities by airport staff.

6.2.1 Model Conversion from MIKE SWMM to EPA SWMM

The 2003 MIKE SWMM developed by APA as part of the updated Drainage Master Plan was provided to CDM by the DOA. The MIKE SWMM EXTRAN and RUNOFF files (version 4) were used to convert the model files to SWMM version 5.0 using the SWMM 4 to SWMM 5 conversion executable file available on the EPA website http://www.epa.gov/ednnrmrl/models/swmm/. Although MIKE SWMM is a proprietary GUI program, the base input files in 2003 were compatible with SWMM 4. The 2003 MIKE SWMM used 5-, 25-, and 100-year, 3-hour duration events that were based on the COA DCM at that time. The DCM has been revised since the completion of

the 2003 Drainage Master Plan, and the SWMM 5.0 was updated accordingly with 2-, 10-, 25-, and 100-year, 24-hour events based on an SCS Type III Distribution. Additionally, two new outfalls, 23 and 24, were added to the model.

6.2.1.1 Conversion Comparison

The 2003 MIKE SWMM output was compared to the SWMM 5.0 output to verify proper conversion of the model. The SWMM 5.0 was run with the 100-yr, 3-hour time series that was used in the 2003 MIKE SWMM to determine how well the SWMM 5.0 results compared with the 2003 MIKE SWMM results. The model results compared were runoff at the various HUs, peak flow at the outfalls, peak flows in conduits, and peak depths in model nodes.

6.2.1.2 Conversion Results

The converted SWMM 5.0 compared relatively well to the 2003 MIKE SWMM. Percent differences of total runoff generated in HUs ranged between -1.0 percent and 1.3 percent. **Table 6-1** shows a comparison of peak flows at outfalls between the models. Peak flows were within 10 percent difference in 88 percent of the conduits and peak depths were within 10 percent difference in 76 percent of the junctions. The converted model showed some instability that contributed to the observed differences. Some differences may also be attributed to changes in the model engine from SWMM 4 to SWMM 5.

There are differences in naming conventions from the 2003 SWMP to the ABIA AutoCAD drawings such as those described in Section 2. Table 6-1 displays outfall numbering by model, by 2003 SWMP table descriptions, and by the ABIA system. The ABIA system labels the outfalls from the airport PSMS to the unnamed tributaries prior to the tributaries' confluences with Onion Creek and the Colorado River. In Table 6-1, the nearest ABIA outfall number is used to label the unnamed tributaries' outfalls to these receiving bodies. Additionally, outfall 7E, which represents sheet flow off the airport property east of Emma Browning Avenue, has been labeled Outfall No. 25 for this SWMP update. There are two new outfalls, Nos. 23 and 24, which were not in the old model and have been added in the update. These are not shown in the comparison table, but will be identified in the following tables and figures.

6.2.1.3 Model Upgrades

Due to the change from the 100-year, 3-hour rainfall event to the SCS Type III 100-year, 24-hour rainfall, the model needed to accommodate greater volumes of flooding than it was originally built to handle. There were approximately 130 nodes that were flooding in the converted model due to the updated design storm. Flows were surcharging at these nodes to the point that some water was getting out of the conveyance system and being lost from the model without being routed through the PSMS, resulting in elevated continuity errors. Approximately 153 overland flow conduit links and 5 stage-area storage junctions were added to the model to fix the node flooding during the update of the model to existing conditions.

Table 6-1. Comparison of Peak Flows at Outfalls between 2003 MIKE SWMM and EPA SWMM 5.0

2003 SWMP Outfall No.	ABIA [1] Outfall No.	SWWM ID	5-year Peak Flow (cfs)		Percent Difference	25-year Peak Flow (cfs)		Percent Difference	100 year Peak Flow (cfs)		Percent Difference
			MIKE SWMM [2]	SWMM 5.0		MIKE SWMM [2]	SWMM 5.0		MIKE SWMM [2]	SWMM 5.0	
Carson Creek											
1	1	JCAA0015	81.8	75.1	-8.2%	119.8	106.7	-11.0%	148.1	130.1	-12.2%
2	2	JCAB0010	31.6	33.3	5.2%	41.7	41.3	-0.9%	49.9	49.0	-1.8%
3	3	JCAD0010	97.0	98.2	1.2%	152.9	154.3	0.9%	206.4	207.5	0.5%
4	4	JCAD0080	24.5	24.5	-0.1%	45.6	45.4	-0.4%	66.0	65.8	-0.4%
5	5	JCAD0100	70.7	69.0	-2.4%	112.4	112.6	0.2%	158.2	157.8	-0.3%
6	7	JCAD0210	23.8	23.9	0.2%	41.8	41.8	0.0%	58.7	58.7	-0.1%
Sub Total			**329.4**	**323.9**	**-1.7%**	**514.2**	**502.0**	**-2.4%**	**687.3**	**668.7**	**-2.7%**
Onion Creek											
7A	8	JONS0090	1137.5	1151.6	1.2%	1711.7	1772.3	3.5%	2197.0	2285.1	4.0%
7B	10	JONV0050	24.3	24.4	0.3%	37.0	37.3	0.9%	48.2	48.3	0.2%
7C	11	JONV0070	50.6	51.0	0.8%	76.7	76.5	-0.2%	101.1	99.1	-2.0%
7D	22	JONV0090	289.2	290.7	0.5%	421.7	420.8	-0.2%	546.9	555.3	1.5%
7E	25	JONV0110	26.2	26.0	-0.6%	52.5	52.1	-0.8%	79.2	78.5	-0.8%
7F	15	JONR0205	565.3	581.2	2.8%	892.4	896.2	0.4%	1154.4	1147.1	-0.6%
7G	16	JONT0105	1671.4	1759.1	5.2%	2387.0	2546.9	6.7%	2948.0	3089.3	4.8%
Sub Total			**3764.5**	**3884.0**	**3.2%**	**5579.0**	**5802.1**	**4.0%**	**7074.8**	**7302.6**	**3.2%**
Colorado River											
9	19	JCOB0010	312.3	312.7	0.1%	552.6	552.8	0.0%	775.2	762.9	-1.6%
10	21	JCOC0010	121.3	120.4	-0.8%	268.1	250.8	-6.5%	401.1	392.8	-2.1%
Sub Total			**433.6**	**433.1**	**-0.1%**	**820.7**	**803.6**	**-2.1%**	**1176.3**	**1155.7**	**-1.8%**

Notes:
[1] *Outfalls 15, 16, and 19 are near ABIA Outfalls, where the tributaries reach receiving bodies.*
[2] *Peak Flow values for MIKE SWMM and outfall numbers taken from Table IV-1, ABIA Drainage Master Plan, July 2002*

Furthermore, the model stability issues discussed above were addressed as appropriate using standard practice modeling techniques to provide stable results.

Additional model upgrades to existing conditions are discussed below in the descriptions of the model input data.

6.2.2 Model Hydrologic Data

Hydrologic model parameters used for the model simulations are described in this Section. Appendix C-1 provides a list of hydrologic parameters applied to represent existing and ultimate build-out conditions, including: HU alphanumeric identification, width, area, percent directly connected impervious area (DCIA), slope, overland Manning's roughness values, initial abstractions, soil suction head, and soil hydraulic conductivity.

6.2.2.1 Hydrologic Units

The hydrologic portion of the model is represented by areas (subbasins) of distinct hydrologic units at a scale where all hydrologic parameters may be considered constant. Generally, HU delineation is based on a combination of topographic information, project stormwater pipes and catchments, and aerial photographs. For this SWMP Update, the HU delineation was determined in the existing 2003 model, except where noted below.

An AutoCAD drawing file of the drainage basin delineations for the airport property was provided by the DOA. CDM converted the drawing file to ArcGIS shape files for ease of manipulation with other GIS data. Because the original drainage basin CAD file was not spatially referenced to any horizontal datum, CDM applied a manual georeference to the converted shape file for proper alignment with other georeferenced data. Minor differences in area were noted in the HUs due to the file transformation and georeferencing. The updated areas of the HUs derived from the GIS shape file were used in SWMM 5.0. Two HUs were split so that they were more representative of actual overland flow patterns. Additionally, two HUs were added along the southeastern side of the airport to include areas draining to the new Outfall Nos. 23 and 24. The updated model has 789 HUs.

6.2.2.2 Rainfall

Rainfall time series for the 2-, 10-, 25-, and 100-year, 24-hour design storm events were added to the SWMM. The time series were based on an SCS Type III distribution. The SCS Type III distribution ordinates were obtained from Table 2-7 in the COA DCM. **Table 6-2** shows the precipitation totals used in SWMM, which were obtained from Table 2-4 in the DCM.

Table 6-2. Precipitation Totals for Design Storm Events in SWMM

Recurrence Interval (yr)	Duration (hr)	Depth (in)
2-year	24.00	3.44
10-year	24.00	6.11
25-year	24.00	7.63
100-year	24.00	10.20

Source: Table 2-4. Depth-Duration-Frequency Table for Austin and Travis County, Austin Drainage Criteria Manual

6.2.2.3 Impervious Area

The percentage of impervious cover for each HU in SWMM was updated based on the impervious cover maps that were created for the airport property for this project (Refer to Section 3). Shape files for the impervious areas within the airport under existing, near-term, and ultimate build-out conditions were intersected with the HUs to obtain the percentage impervious area within each HU for each land use, respectively.

6.2.2.4 Infiltration Parameters

The Green-Ampt Infiltration method was used to define the soil infiltration losses in the 2003 MIKE SWMM. All soils within the airport property were classified as silty clay so the MIKE SWMM applied uniform infiltration parameters for all the HUs in the model.

These values were transferred into the new model and were not updated in SWMM for this project.

6.2.2.5 Other Parameters

SWMM uses overland flow data in the form of width, slope, and Manning's roughness to create a physically based overland flow runoff plane to route runoff to conduits and storage for further hydraulic routing. The width, slope, and overland Manning's roughness values from the 2003 MIKE SWMM were not changed in the SWMM 5.0, except for the instances where the HUs were split as discussed above.

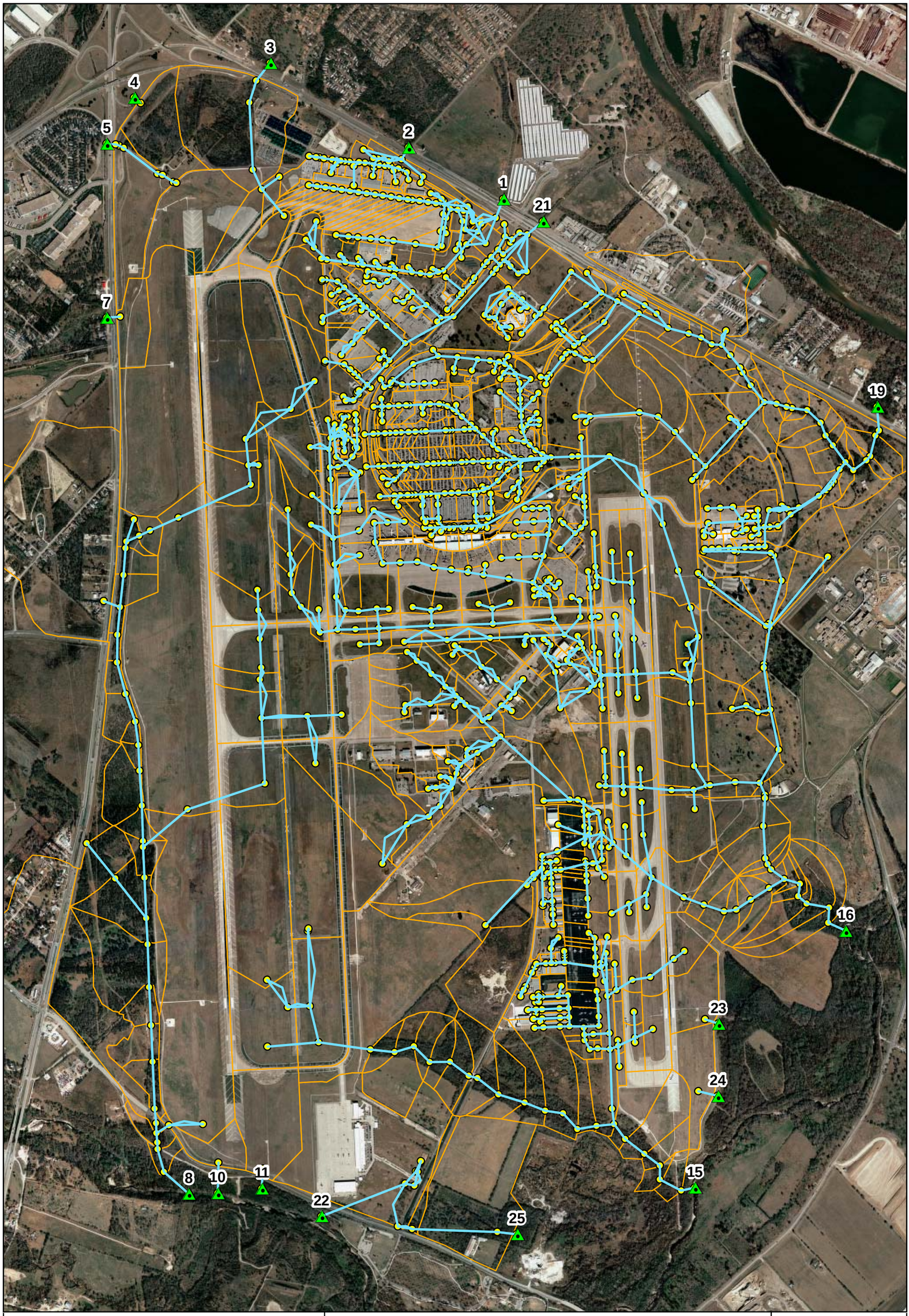
6.2.3 Model Hydraulic Data

The PSMS within the airport property consists of water quality basins, detention basins, outlet control structures, catch basins, manholes, junction boxes, headwalls, reinforced concrete pipes (RCPs), natural open channels, and man-made channels.

AutoCAD drawing files of the model network provided by the DOA were converted into GIS shape files. The model was updated where the "as-built" drawings differed from the 2003 model (Refer to Section 2, Table 2-2 for a list of "as-builts" used in the analysis). The hydraulic network consists of model nodes that represent manholes, catch basins, pipe ends, etc. and model links that represent pipes, open channels, etc. Horizontal alignment information (X, Y coordinates) for the nodes, link vertices, and HU vertices were exported from GIS into the SWMM 5.0 input file to produce a model network that closely replicates the MIKE SWMM existing PSMS. The existing model schematic as developed in GIS is shown in **Figure 6-1**. HU boundaries are shown in gold, model nodes (manholes, catch basins, pipe ends, etc.) are shown in yellow, and links (pipes, open channels, etc.) are shown in blue.

The model outfalls are labeled with the ABIA outfall numbering system with the changes described in Section 6.2.1.2. As noted in this earlier section, the ABIA outfall numbering convention occurs where the airport PSMS outlets to the unnamed tributaries prior to the tributaries' confluences with Onion Creek and the Colorado River. Many of these locations are in the interior of the SWMM and therefore are not model outfalls. In Figure 6-1, the nearest ABIA outfall number is used to label the unnamed tributaries' outfalls to the receiving bodies. Additionally, outfall No. 25, which represents sheet flow off the airport property east of Emma Browning Avenue (and therefore is a model outfall), has been added for this SWMP update.

The updated model consists of over 1,100 junctions, including 17 outfalls, 16 water quality treatment systems as storage elements, and nearly 1,300 conduits. Appendix C-2 provides a list of link hydraulic parameters including: alphanumeric identification, type, length, Manning's roughness values, width, depth, inverts, and number of barrels. Appendix C-3 provides a list of node hydraulic parameters including: alphanumeric identification, type, and invert elevation.



Legend

- Hydrologic Units (HUs)
- Model Links
- Model Nodes
- Model Outfalls

N W E S

0 625 1,250 2,500 3,750 5,000 Feet

Figure 6-1
Model Schematic
Austin - Bergstrom International Airport (ABIA)
Stormwater Drainage Master Plan (SWMP) Update
Project No.: 4910-8107-3139

CDM

6.2.3.1 Culverts and Pipes

Information regarding culvert and pipe geometries, material, invert elevations, road crown elevations, and roughness parameters was obtained from the 2003 MIKE SWMM. A site visit was conducted in April 2010 to locate a 5-ft by 8-ft rectangular box culvert under Burleson Road, immediately east of Emma Browning Avenue. This culvert was not found. The DOA confirmed that the culvert could not be found by others and that there were no plans to build one at that location. Therefore, this culvert was removed from the models and flow was directed overland toward Outfall No. 25 (as noted above, this model outfall represents sheet flow off ABIA property to Onion Creek).

6.2.3.2 Control Structures

The updated SWMM includes weirs, orifices, and flow splitter boxes associated with the water quality and detention basins that are used for flow control. There are 16 water quality and detention basins within the SWMM study area that are included in the updated model. The COA Basin IDs and the associated SWMM nodes are included **Table 6-3** (The locations of the ABIA Water Quality Basins were shown in Section 4, Figure 4-1). Water quality basins 'F' and 'TXARNG' were added since the 2003 Drainage Master Plan and are included in the updated SWMM. Model parameters for the 16 water quality/detention basins and their outlet control structures were verified with available record drawings obtained from the DOA; additionally the stage-area relationships of the 16 water-quality basins were crosschecked with the topographic contour data (Refer to Section 2.2.2).

6.2.3.3 Hydraulic Overland Flow

Hydraulic overland flow conduits were created in the model to represent flow paths over roads or over land when pipes and culverts surcharge above ground.

These features provide additional paths to downstream features while conserving flow continuity. Prior to these additions, the converted SWMM showed approximately 130 nodes that were flooding, with surcharge that was exiting the pipe/channel network and being lost from the model. Overland flow links were added in these locations to account for the water that exits the pipe/channel network and floods out onto the ground surface. Approximately 153 overflow conduit links were added to the model. The overflow links were modeled as irregular channel sections with the cross-section information extracted from the topographic contour data or trapezoidal approximations based on the topographic contour data.

6.2.3.4 Stage-Area Relationships

Stage-area information is used to represent basins and localized low areas that could not be well represented by channel cross-sections. This approach is incorporated to more accurately reflect existing storage in the modeled hydraulic network and allow detailed analysis of the peak water surface elevations and flooding extents in these areas. Stage-area information for most of the storage nodes (242 storage nodes) was obtained from MIKE SWMM as developed by APA from available topography and record drawings.

Table 6-3. Water Quality / Detention Basin Identification Numbers

Water Quality Basin Identification	ABIA Drainage Area Designation	COA Inventory Number	Type	SWMM ID
WQP-A	DA-7C	5450 5450 5451	Filtration basin Sedimentation basin Detention basin	IONK0220 IONK0080 IONK0070
WQP-B	DA-7B	5436 5456 5456	Detention basin Sedimentation basin Filtration basin	IONI1010 IONI0047 IONI0045
WQP-C	DA-7C	5438 5439 5439	Detention basin Sedimentation basin Filtration basin	IONN0180 IONN0120 IONN0160
WQP-D	DA-7B	5436 5437 5437	Detention basin Sedimentation basin Filtration basin	IONI1010 IONI1030 IONI1040
WQP-E	DA-7A	5431	Sedimentation basin Filter basin	JONF0294 JONF0296
WQP-F	DA-4	7345 7345	Sedimentation basin Filtration basin	ICOC0275 ICOC0265
WQP-G	DA-7A	5432 5432	Sedimentation basin Filtration basin	IONM0230 IONM0240
Hydraulic Control Basin	DA-7A	5457	Detention basin	IONM0170
WQP-J	DA-5C	5453 5453 5452	Filtration basin Sedimentation basin Detention basin	ICOA0320 ICOA0310 ICOA0080
WQP-M1	DA-5A	5444 5444	Sedimentation basin Filtration basin	ICOB0454 ICOB0455
WQP-L	DA-5A	5454 5455 5455	Detention basin Sedimentation basin Filtration basin	ICOC0020 ICOC0025 JCOC0160
WQP-N Airside	DA-1	5433 5434 5434 5435	Detention basin Sedimentation basin Filtration basin Holding basin	ICAA0030 JCAA0600 ICAA0750 ICAA0760
WQP-P	DA-2	5448 5449 5449	Detention basin Sedimentation basin Filtration basin	ICAB0030 ICAB0060 ICAB0070
WQP-R	DA-4	5447	Sedimentation/Filtration basin	ICOC0248
WQP-T	DA-7A	5445 5446 5446	Detention basin Filtration basin Sedimentation basin	IONB0200 IONB0160 IONB0150
WQP-TXARNG	DA-6E & DA7E	7343 7344	Sedimentation/Filtration basin Detention basin	IONV0165 IONV0170

Notes: Detentions basins - basins designed to attenuate stormwater runoff and slowly discharge from the basin Filtration basins - basins designed to filter stormwater runoff before being discharged Sedimentation basins -basin designed for settling of sediments before entering the filtration basin

1. WQP-M detains the 100-year, 24 hour design storm

Five storage nodes were added in the updated SWMM to fix node flooding issues. Stage-area relationships for these nodes were obtained from the topographic contour data.

Additionally, the stage-area relationships of the 16 water quality/detention basins within the airport were verified with record drawings provided by the airport and the topographic data.

6.2.4 Boundary Conditions

Hydraulic boundary conditions are usually specified at model outfalls in order to simulate existing tail water effects. A "FREE" boundary condition was specified in the SWMM. In such a case, the outfall stage is determined as the minimum of critical flow depth and normal flow depth in the connecting conduit. The "FREE" boundary condition was used for the validation storm event and the 2-, 10-, 25-, and 100-year storm events. However, for development of the floodplain maps, fixed stage elevations from the Onion Creek HEC-RAS model obtained from Travis County were used.

Because of the relatively steep slopes from the outfalls off the project site to Onion Creek and the Colorado River, the differences in model results in using a free boundary condition versus a fixed stage boundary condition are minimal, except at the model junctions immediately adjacent to the outfalls. A more ideal boundary condition would consist of a time series of stage data in the creek and river at each outfall, although this data was not available. However, it is known that these receiving water bodies experience peak flood depths at a much later time than the peak outflows from ABIA (Refer to Section 5), and therefore the boundary condition is similar to the free condition at the peak of the storm.

6.2.5 SWMM Validation

Model validation is performed to establish a "reality check" of predicted stages, flows, and velocities. For validation, data must be available in the form of rainfall, stage, flow, and/or high water marks. Unfortunately, there was no monitored flow or stage data at ABIA to use for this task. Discussions were held with the DOA to choose the rainfall event to use in validating the model. Based on the discussion and observations of the DOA, the November 15, 2001 storm event was chosen as the rainfall event to use. The storm produced 6.8 inches of rainfall in 24 hours (Refer to Section 2.2.5.2 for more information about this storm). Although there were no high water marks to compare model results to, this was a high intensity storm and anecdotal evidence suggests there was no flooding on the runways, taxiways, or aprons for this storm. Thus, the model should not show flooding in these areas, for this storm, where it did not exist.

6.2.5.1 Validation Model Setup

The precipitation files for this storm event were obtained from the National Climatic Data Center (NCDC) in Asheville, NC. The precipitation data were disaggregated into 5-minute intervals using NetSTORM, and the time series was then added to the SWMM 5.0. No other changes were made to the model. Therefore, the "existing condition" model was expected to be close enough to the 2001 condition to be used for validation.

6.2.5.2 Validation Model Results

The validation storm event simulation was performed in SWMM 5.0. Since high water marks were not available, a flood map was created to visualize areas that were predicted by the model to flood. This flood map was created by comparing peak stages in model nodes to the topography digital elevation map (DEM). The model results matched the observations of the airport staff. Flooding was not observed on any of the runways, taxiways or aprons. As expected, the swales and water quality basins within the ABIA property filled to near capacity in the model during the validation storm simulation. **Figure 6-2** shows the flood map with the flooding locations for the validation storm event.

6.2.6 SWMM Results

After conversion, upgrade, and validation, the ABIA SWMM was used to simulate the 2-, 10-, 25-, and 100-year, 24-hour design storm events for the existing, near-term, and ultimate build-out land use conditions, respectively (based on the updated IC Maps (Refer to Section 3). The resulting peak stages by node and peak flow and velocity by outfall from these simulations are presented in tabular form in Appendix C-4 to C-9. The SWMM is provided in Appendix I.

6.3 HEC-HMS Model

As a part of the ABIA Stormwater Master Plan Update, a HEC-HMS (HMS) model was developed to parallel the updated existing conditions SWMM. The main objective for developing the HMS model was to produce a model that would be acceptable to the PDRD as part of the permit plan submittal process.

Another objective of the HMS model was to provide a simplified version of the existing PSMS that reproduces the SWMM peak flow results at ABIA outfalls. The HEC-HMS model does not contain the refined details of SWMM in the model interior, but uses equivalent runoff and routing algorithms to reproduce the hydrographs, by storm and land use, at key junctions within the model (e.g., water quality treatment systems) and at the outfalls.

The COA was involved during the HMS model development. CDM met with the PDRD at the beginning of the model development process and then again as the HMS model was near completion. The model data reviewed by the PDRD included:

- Rainfall – SCS Type III, 24-hour rainfall distributions
- SCS curve numbers (CN);
- Subbasin delineation;
- Peak flows at the outfalls; and
- Outfall structures at receiving water bodies.

Legend

Validation Storm

Flood Depth (ft)

- 0 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- > 2

N W E S

0 625 1,250 2,500 3,750 5,000 Feet

Figure 6-2
Simulated Flood Depths - Validation Storm
Austin - Bergstrom International Airport (ABIA)
Stormwater Drainage Master Plan (SWMP) Update
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CDM

The SWMM EPA 5.0 to HEC-HMS model conversion presented some technical challenges, as there is no rainfall-runoff transform methodology in HMS that directly corresponds to SWMM methodology.

However, the HMS kinematic wave transform uses nearly equivalent runoff and routing algorithms as SWMM. Therefore, the kinematic wave rainfall to runoff transform methodology was used to develop the parallel model in HEC-HMS. During the HMS model development, CDM consulted the DCM to ensure that model parameters were consistent with those values accepted by the COA.

Additional model components considered during the HMS model development process were rainfall and infiltration. This information was extracted from SWMM and incorporated in HMS.

6.3.1 HEC-HMS Model Development

Since one of the objectives of the HEC-HMS model was to provide a simplified version of SWMM, the nearly 800 HUs in SWMM (referred to as subbasins in HMS) were merged to produce fewer, larger subbasins for the HMS model. The number of subbasins was reduced by nearly 75 percent to approximately 200. This change in subbasin delineation affects both the area and flow length parameters that are related to the rainfall-runoff transform.

In addition to the changes in subbasin delineation, drainage system infrastructure, including conveyance and storage structures, were modified to produce a simplified HMS model.

<u>Rainfall and Infiltration</u>

Rainfall data that complies with the DCM, namely the SCS Type III, 24-hour storm, were already a part of the ABIA SWMM. Therefore, the data were extracted from this model, converted from intensity (inches/hour) to depth (inches) and incorporated in the HMS model. Total rainfall for the 100-year return interval storm, which was the focus of the HMS model development, was 10.2 inches.

Infiltration ('Loss' in HMS) was accounted for using the Green-Ampt infiltration equation, which is the same method used in the ABIA SWMM. Infiltration parameters of suction head (11.5 inches), saturated hydraulic conductivity (0.063 inches/hour), and initial deficit (0.092) were the same for all subbasins within SWMM (based on nearly uniform soil properties developed and used for the existing conditions in MIKE SWMM by APA in 2003). The Green-Ampt method of infiltration and these parameters were therefore used in the HMS model development.

As precipitation becomes surface runoff over both pervious and impervious surfaces, some portion puddles and does not make it to the PSMS. In SWMM, this is referred to as initial abstraction or depression storage and is separated from infiltration. In HMS, this is referred to as initial loss when taken into account as part of the Green-Ampt

parameters. HMS "Loss 1" represents the pervious area and "Loss 2" represents the impervious area. In the ABIA SWMM, there is much more detail in storage and conveyance as opposed to the HMS model, necessitating more stored water within each subbasin in HMS that does not reach the PSMS. Therefore, the loss parameters were used to adjust HMS runoff hydrographs.

Rainfall to Runoff Transform

Hydrograph development from rainfall to runoff requires a number of parameters. For this project, the kinematic wave method in HMS was used to produce similar runoff hydrographs to those predicted by SWMM. The kinematic wave method was designed predominantly for urban areas, but can also be used for undeveloped areas. The simplified methodology developed here requires data for kinematic wave parameters related only to plane flow. There are two representative planes, Plane 1 and 2, which are related to pervious and impervious areas, respectively, similar to Green-Ampt infiltration Loss 1 and 2.

Each of these planes has an independent set of parameters that include:

- Length. Average flow length from the point where precipitation falls to where runoff enters a collection channel.
- Slope. Average slope along the flow line.
- Roughness. For both pervious and impervious surfaces, the roughness coefficients are much higher than typical Manning's n values due to shallow depth of flow.
- Percent Area. Percentage of subbasin occupied by each plane.

There are several other non-essential components included as part of the HMS kinematic wave method, however, since this task required a simplified method, the other components were not used in HEC-HMS model development and therefore, will not be described in further detail here.

Several SWMM subbasin runoff parameters were directly correlated to HMS kinematic wave parameters. These include:

- Area
- Slope
- Percent Impervious

The area is the sum of SWMM subbasin areas for each new merged HMS subbasin. The area was converted from acres for SWMM to square miles for HMS.

The slope and percent impervious are area-weighted average values of SWMM subbasins merged for HMS.

The remaining parameters required by the kinematic wave transform are average flow length and roughness. Average flow lengths were determined for each new HMS subbasin based on topographic contours, as well as the existing conveyance system. The flow length for Plane 1 and 2 were determined by taking the total subbasin flow length multiplied by the fraction of pervious (Plane 1) and impervious (Plane 2) area.

HMS roughness values generally follow the range of values that are provided as guidance in the DCM.

All HMS subbasin model parameters are included in Appendix D. The HMS model is provided in Appendix I.

6.3.2 Calibrating HMS to SWMM

HMS Subbasins

The process of matching a larger, merged HMS subbasin to the corresponding group of SWMM subbasins was somewhat iterative. Area, slope, and percent impervious values were not altered. Initial loss, flow length, and roughness were adjusted for each HMS subbasin in order to best fit the shape and peak of the sum of the SWMM subbasins, which make up the new, larger HMS subbasin. In general, individual SWMM subbasins greater than 40 acres were modeled as individual subbasins in HMS.

During the initial development of this methodology, a value for average flow length was calculated as the average of the SWMM subbasin area/width. However, this calculation was not always appropriate for the merged subbasin. Therefore, the flow length was evaluated based on geometry and topography and adjusted for each new HMS subbasin. The initial loss and roughness varies among subbasins; therefore, these values were also adjusted to achieve the best overall hydrograph fit. These values are shown in **Table 6-4(a) and 6-4(b)**.

Table 6-4(a). HMS Model Initial Loss Values

Location	Pervious Plane Initial Loss (inches)		
	Minimum	Maximum	Average
Outfall 1	0.2	0.8	0.58
Outfall 2	0.4	0.8	0.67
Outfall 3-7	0.6	0.8	0.76
Outfall 8	0.5	2	0.96
Outfall 10,11,25	0.6	0.8	0.65
Outfalls 15	0	0.9	0.39
Outfall 16	0.2	1.2	0.47
Outfall 19	0.3	2	0.62
Outfall 21	0.4	2	0.84

Table 6-4(b). HMS Model Manning's n Roughness Values

Location	Pervious Plane Roughness			Impervious Plane Roughness		
	Minimum	Maximum	Average	Minimum	Maximum	Average
Outfall 1	0.4	0.6	0.52	0.1	0.1	0.1
Outfall 2	0.4	0.6	0.53	0.1	0.1	0.1
Outfall 3-7	0.5	0.7	0.65	0.05	0.1	0.09
Outfall 8	0.25	0.5	0.37	0.1	0.15	0.11
Outfall 10,11,25	0.5	0.6	0.52	0.03	0.05	0.05
Outfall 15	0.25	0.7	0.38	0.1	0.1	0.1
Outfall 16	0.05	0.75	0.41	0.02	0.17	0.09
Outfall 19	0.35	0.8	0.48	0.05	0.1	0.05
Outfall 21	0.4	0.8	0.57	0.05	0.15	0.08

HMS Storage

The HMS models were developed from headwater to outfall and results were compared to SWMM at major confluences as the procedure worked downstream. In this way, any necessary storage, in addition to the 16 ABIA water quality basins, was identified and incorporated as the HMS model developed to ensure that the flow at major junctions was consistent with SWMM.

Additional storage areas were necessary in HMS, if they were significant enough to attenuate flow in SWMM, such as airside swales. The SWMM elevation-storage curves at these junctions were also used in HMS. In many cases, there were a number of SWMM storage junctions located within a given HMS subbasin. Therefore, the elevation-storage relationships for these junctions were combined. The WQPs were modeled in the same way. For simplification in HMS, and since many of the WQPs contain multiple basins for treatment, storage was combined and presented as a single WQP.

6.3.3 HMS to SWMM Flow Comparison

The focus of the HMS model development was the 100-year, 24-hour storm event. However, it is important that the HMS model be flexible, therefore, once the HMS model flows were consistent with SWMM flows for the 100-year event, the 2-year, 24-hour event was tested using the same HMS basin model. The results for the 2- and 100-year events for each of the major outfalls are shown in **Table 6-5.** These results are also shown graphically in **Figure 6-3** at Outfall No. 16 for the 2-year and 100-year events.

The HMS results are generally consistent with the SWMM results for both the 2-year and 100-year events. Outfall 21 has a capacity of over 1,000 cfs; however, the existing treatment ponds significantly reduce outfall flows for the 2-year storm. The relative difference (26%) is much higher than the other results, but compared to flows upstream of the treatment system, the difference (9 cfs) is minimal.

Table 6-5. HMS to SWMM Flow Comparison at ABIA Outfalls

Location	SWMM ID	2-year flow (cfs)			100-year flow (cfs)		
		SWMM	HMS	% Delta	SWMM	HMS	% Delta
Carson Creek							
Outfall 1	JCAA0015	41	44	7.3%	172	160	-7.0%
Outfall 2	JCAB0010	28	27	3.6%	137	153	11.7%
Outfall 3	JCAD0010	49	44	-10.2%	226	239	5.6%
Outfall 4	JCAD0080	8	7	-12.5%	65	70	7.7%
Outfall 5	JCAD0100	33	32	-3.0%	176	161	-8.5%
Outfall 7	JCAD0210	9	8	-11.1%	55	51	-7.3%
Onion Creek							
Outfall 8	JONS0090	328	367	11.9%	1556	1600	2.8%
Outfall 10	JONV0050	7	7	0.0%	38	40	5.3%
Outfall 11	JONV0070	17	17	0.0%	71	77	-8.5%
Outfall 15	JONR0205	210	232	10.5%	1115	1113	-0.2%
Outfall 16	JONT0105	817	906	10.9%	3279	3479	6.1%
Colorado River							
Outfall 19	JCOB0010	122	114	-6.6%	807	867	7.4%
Outfall 21	JCOC0010	35	44	25.7%	439	482	9.8%

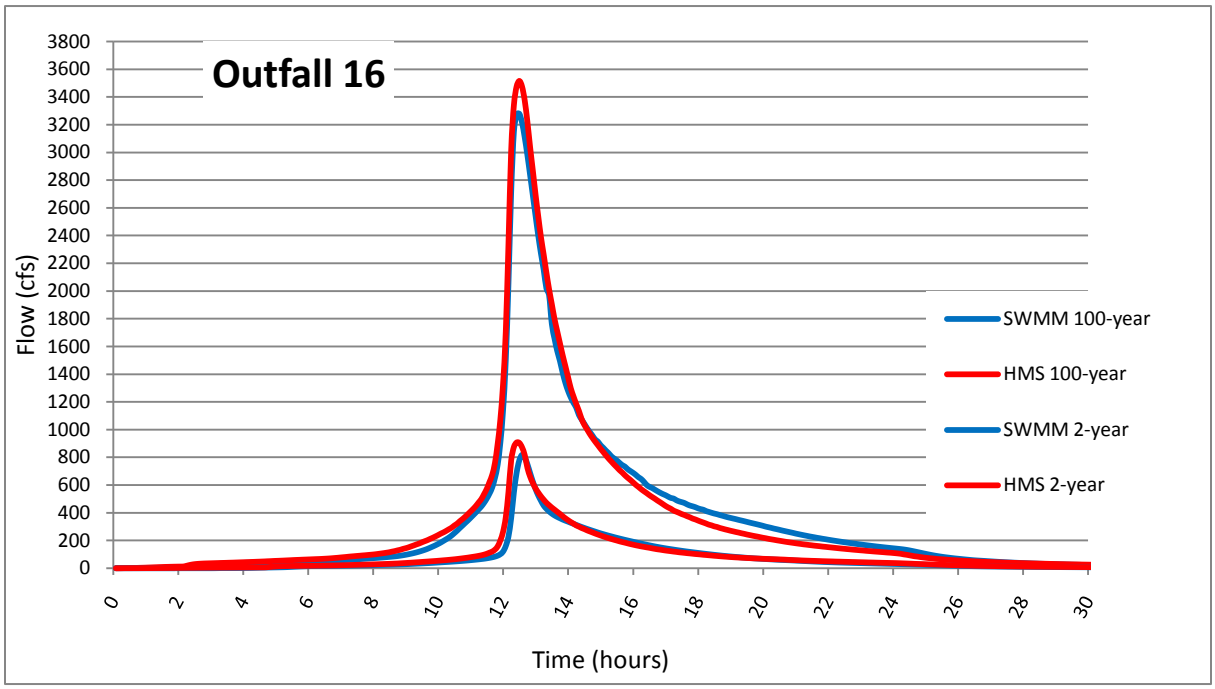


Figure 6-3. HMS to SWMM Flow Comparison for Outfall No. 16

6.4 Existing Drainage and Conveyance Deficiencies

As discussed briefly in the model validation section (Section 6.2.5), there are no drainage and conveyance deficiencies in the current ABIA PSMS that cause major flooding problems at the airport. For the November 2001 storm (6.8 inches in total volume), the airport did not shut down and there were no recorded flooding issues along runways, taxiways, or aprons. If flooding occurred in parking lots or cargo aprons, the high water marks were not recorded. The SWMM simulations show similar results for that storm.

Simulations were also performed for the 100-year, 24-hour storm (10.2 inches in total volume) under the existing land use conditions to determine if there are potential flooding problem areas to be addressed.

For existing erosion problem areas, observed conditions are reported below in Section 6.4.2. Additionally, potential future erosion problem areas were identified using the models of future land use conditions and observed conditions in Section 6.5.3.

6.4.1 Flooding Problem Areas

Figure 6-4 shows simulated flooding problem areas for the 100-year, 24-hour storm under existing land use conditions. This model simulation was performed with "free" boundary conditions as discussed in Section 6.2.4. **Figure 6-5** shows simulated flooding problem areas for the 100-year, 24-hour storm (existing land use) using fixed stage

boundary conditions in Onion Creek and for the Colorado River in the northeast corner of the model (Outfall 19 – SWMM JCOB0010). The boundary conditions were developed from the Travis County HEC-RAS model. Although the Colorado River and Onion Creek reach their flood crests well after the peak stages and flows from ABIA, the peak stages for these water bodies are used in this model. Although conservative, this boundary condition does not appreciably change the flood map in the interior of the model. The flood map in Figure 6-5 was developed using the HEC-RAS results along Onion Creek and therefore the 100-year flood extents are very similar to the FEMA 100-year flood extents along the southern boundary of ABIA.

In both maps, flooding in the interior of the project site is limited to the water quality and detention basins, the airside swales, and the PSMS ditches and creeks except for the following:

- Flooding occurs in the center of the project site near (and in some cases over) the abandoned military structures and impervious areas. This area will be completely developed according to the ultimate build-out land use plan and therefore should have a new collection and conveyance system.

- Immediately southeast of the prior location, flooding occurs in an open area adjacent to Emma Browning Avenue. The avenue is a local topographic high, and should be passable during extreme events.

Legend

100-Year Storm

Flood Depth (ft)

- 0 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- > 2

N W E S

0 625 1,250 2,500 3,750 5,000 Feet

Figure 6-4
Simulated Flood Depths - 100-Year Storm (Existing Land Use)
Austin - Bergstrom International Airport (ABIA)
Stormwater Drainage Master Plan (SWMP) Update
Project No.: 4910-8107-3139

CDM

Legend

100-Year Storm

Flood Depth (ft)

- 0 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- > 2

Onion Creek 100-Year Flood Extent

N W E S

0 650 1,300 2,600 3,900 5,200 Feet

Figure 6-5
Simulated Flood Depths - 100-Year Storm with Onion Creek BCs
Austin - Bergstrom International Airport (ABIA)
Stormwater Drainage Master Plan (SWMP) Update
Project No.: 4910-8107-3139

CDM

- In Figure 6-5, Emma Browning Avenue is predicted to be flooded at the intersection with Burleson Road. For the most part, this is due to the location of the 100-year floodplain of Onion Creek, and not due to inefficiencies of the ABIA PSMS.

- The model predicts minor flooding in the taxiway immediately east of the terminal area parking lot. This flooding is predicted to be less than 6 inches deep, to last for only a short period of time near the peak of the storm, and does not appear for the (smaller) validation storm.

- Golf Course Road is expected to flood to approximately 1-foot over a short, 400-feet stretch near culvert PCOB0110.

6.4.2 Erosion Problem Areas

A discussion of potential future erosion problems areas is included in Section 6.5.3.2. A site visit was conducted for that analysis, which included an observation of existing erosion problem areas.

6.5 Drainage and Conveyance Facilities Alternatives

In this Section, the alternatives available for drainage and conveyance facilities are modeled and compared. Specifically, detention requirements per the DCM are analyzed in conjunction with RSMP participation and water quality facilities. Detailed analysis of three specific project areas within ABIA are modeled and discussed in **Section 7**. Section 7 will also provide recommendations based on the alternatives presented here.

6.5.1 Introduction

The alternatives provided in this Section are based on probable permitting applications for developments at ABIA that may span the next 50 years. As the airport is developed, the new impervious areas must be treated for water quality and the additional runoff from these impervious areas must be attenuated. As discussed in Section 5, participation in the COA's RSMP program would benefit both the City and the airport. This Section explores the requirements to meet the DCM criteria, with and without RSMP participation. As a reference, **Figure 6-6** displays the tributary area to each model outfall and the ABIA Future Development Areas under the ultimate future land use condition. Note that the tributary area to Outfall No. 8 includes properties that are offsite.

The following alternatives are investigated for this land use condition:

- RSMP participation and 2-year onsite detention: the peak flow at every outfall was attenuated such that it is less than or equal to the peak flow through the outfalls in the existing condition for the 2-year, 24-hour storm.

- RSMP participation and erosion protection in lieu of onsite detention: the criteria to be met for this alternative are discussed below. This alternative consists of channel improvements in lieu of onsite detention.

- No RSMP participation and standard onsite detention: the peak flows are attenuated with standard onsite detention at or near the source.

- Because participation in the RSMP only covers the Onion Creek Watershed, there are areas within the project site that will require onsite detention for new development, regardless of the alternative chosen. These areas will be discussed separately.

6.5.2 RSMP Participation and 2-Year Onsite Detention

This alternative analyzed the participation in the RSMP along with onsite detention of the 2-year, 24-hour design storm event. The ultimate build-out land use condition was analyzed, and then onsite detention basins were evaluated to reduce post-development peak offsite discharges to below existing levels.

The ABIA SWMM was run for existing conditions (Section 6.2.6) to establish baseline flows to each of the 17 separate (SWMM outfalls) flowing off ABIA (Refer to Figure 6-6). These outfalls may be divided into three groups based on receiving bodies (watersheds). There are six outfalls that flow to Carson Creek, nine that flow to Onion Creek, and two that flow directly to the Colorado River.

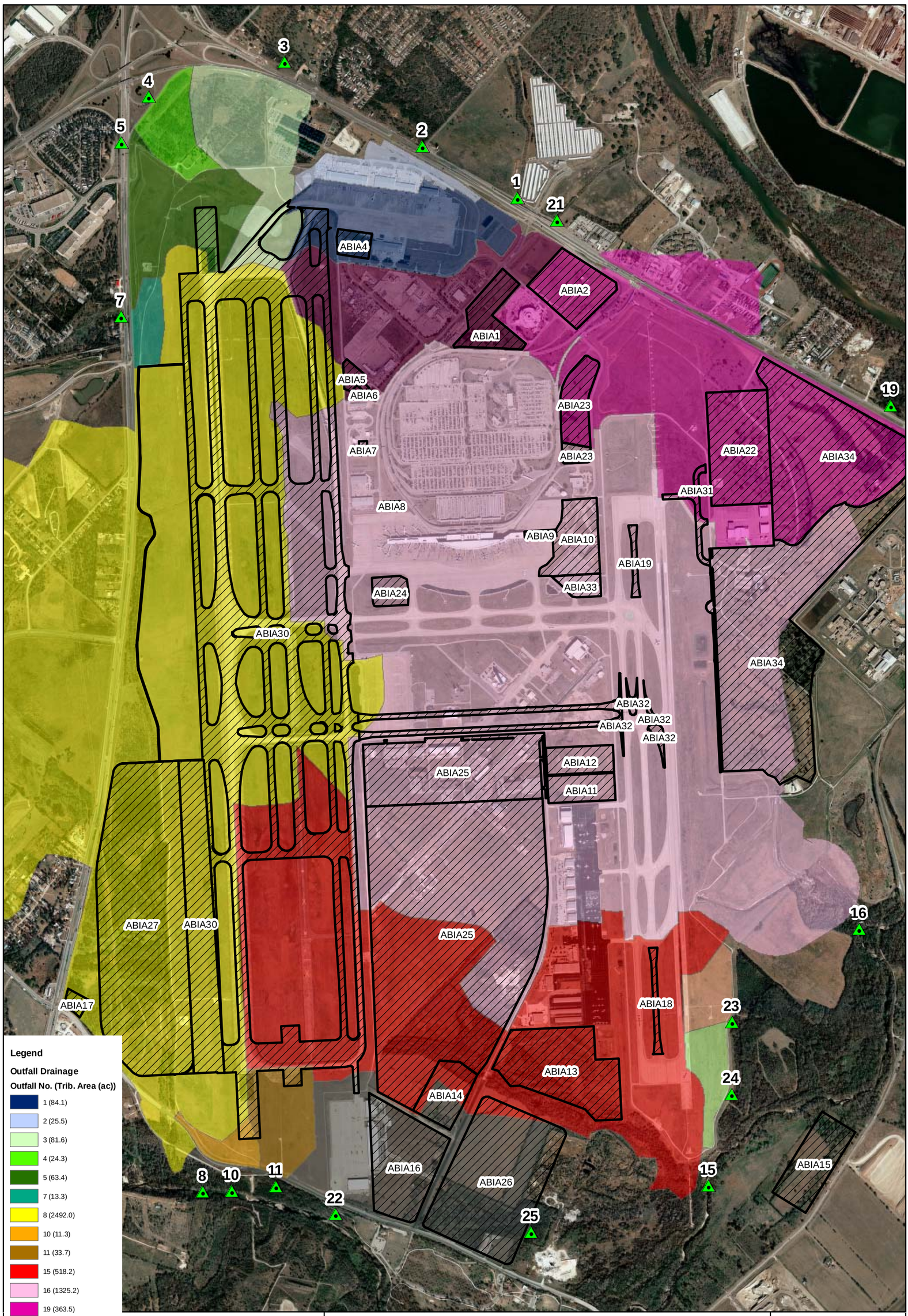
Next, the model was run for the ultimate build-out (UBO) condition with new impervious areas.

In addition, the UBO model was updated to include the new storage volumes provided by the water quality facilities (Refer to Section 4) required for all new impervious areas, which also detain runoff throughout the range of storm events. The models were then examined to determine where additional detention basins would be required to maintain peak flows for the 2-year storm at existing levels.

Table 6-6 below shows the resultant peak flows by outfall for the existing condition, the UBO condition with no detention, the UBO with water quality storage only, and UBO with 2-year peak flow detention provided.

6.5.2.1 Onion Creek Outfalls

The proposed water quality facilities (Refer to Section 4, Table 4-8 and Figure 4-14) near ABIA Outfall Nos. 10, 11, and 15 provide sufficient storage to offset the increases in peak offsite discharges. For the remaining outfalls, dry detention basins were evaluated for implementation.



Legend

Outfall Drainage

Outfall No. (Trib. Area (ac))

- 1 (84.1)
- 2 (25.5)
- 3 (81.6)
- 4 (24.3)
- 5 (63.4)
- 7 (13.3)
- 8 (2492.0)
- 10 (11.3)
- 11 (33.7)
- 15 (518.2)
- 16 (1325.2)
- 19 (363.5)
- 21 (124.3)
- 23 (17.2)
- 24 (17.6)
- 25 (157.0)
- Model Outfalls
- Future Development

N W E S

0 625 1,250 2,500 3,750 5,000 Feet

Figure 6-6
Outfall Tributary Areas
Austin - Bergstrom International Airport (ABIA)
Stormwater Drainage Master Plan (SWMP) Update
Project No.: 4910-8107-3139

CDM

ABIA Outfall No. 8

At ABIA Outfall No. 8, there was approximately a 68 percent increase in the 2-year peak flow for the UBO land use condition (with no detention) compared to existing conditions. The water quality treatment facilities for the proposed apron and commercial development within ABIA Development Area Nos. 30 and 27, as sized in Section 4, were added to the model as offline storage volumes. This reduced the peak flow at this outfall, but not to existing condition levels. The additional increases were mitigated by a 2.5-acre offline dry detention basin. This single-stage offline detention facility was located in the model west of the western ditch, approximately 2,000 feet north of Burleson Road. The goals of this alternative evaluation are to provide approximate sizes and conceptual costs for the 2-year detention option, to compare to other alternatives. Therefore, the proposed locations may vary depending upon final design. The locations described in this section were proposed based on modeled heads, topography, and open areas in the existing condition.

This dry detention basin, in conjunction with the storage provided by the water quality basins, will be capable of reducing the UBO peak offsite discharges from the 2-year design storm to approximately 1 percent below existing levels as shown in Table 6-6.

ABIA Outfall No. 10

At ABIA Outfall No. 10, there was a minor increase in the 2-year peak flow (0.3 cfs), which is below the criteria established in the DCM (0.5 cfs) for 2-year detention.

ABIA Outfall No. 11

At ABIA Outfall No. 11, there was no increase in the 2-year peak flow under UBO conditions (Refer to Table 6-6).

ABIA Outfall No. 25

At ABIA Outfall No. 25, there was approximately an 800 percent increase in the 2-year peak flow for the UBO land use condition (with no detention) compared to existing conditions. As noted previously, this outfall represents sheet flow off ABIA property east of Emma Browning Avenue. The future design likely would include a culvert-type outfall, but since the future design is unknown, for this comparison the outfall link is the same in both the existing and proposed conditions. The water quality treatment facilities for the proposed apron and commercial development within ABIA Development Area Nos. 16 and 26, as sized in Section 4, were added to the model as offline storage volumes. This reduced the peak flow at this outfall, but not to existing condition levels. However, the water quality basin nearly provides enough attenuation so that additional detention would not be needed. Therefore, it is proposed that this 2.6-acre facility be made slightly deeper (by approximately 0.5 feet) such that the peak flows at Outfall No. 25 match the existing conditions.

Table 6-6. Outfall Flow Comparison of 2-year Storm Events

ABIA[a] Outfall No.	SWWM ID	2-year, Peak Flow (cfs)						Comment
		Existing	Ultimate w/ No Detention	Difference	Ultimate w/ Water Quality	Ultimate w/ Detention (UWD)	Difference (UWD - Existing)	
Carson Creek								
1	JCAA0015	41.4	50.2	8.8	58.1	39.4	-2.0	Increase mitigated by proposed improvements[b]
2	JCAB0010	28.2	28.2	0.0	24.6	25.5	-2.7	No additional control needed
3	JCAD0010	49.4	37.2	-12.2	37.2	37.2	-12.2	No additional control needed
4	JCAD0080	8.5	8.5	0.0	8.5	8.5	0.0	No additional control needed
5	JCAD0100	34.6	28.3	-6.3	28.4	28.3	-6.3	No additional control needed
7	JCAD0210	8.7	8.7	0.0	8.7	8.7	0.0	No additional control needed
						Total	**-23.2**	
Onion Creek								
8	JONS0090	328.4	553.0	224.7	365.5	324.8	-3.6	Detention provided
10	JONV0050	6.9	7.2	0.3	7.1	7.2	0.3	Increase compensated by detention at outfall JONS0090
11	JONV0070	16.9	16.9	0.0	12.3	12.3	-4.6	No additional control needed
22	JONV0090	0.9	0.9	0.0	0.9	0.9	0.0	No additional control needed
25	JONV0110	8.3	74.4	66.1	10.8	8.3	0.0	Increase mitigated by proposed water quality ponds
15	JONR0205	211.6	399.2	187.6	160.1	164.1	-47.5	Increase mitigated by proposed water quality ponds
16	JONT0105	818.3	1006.2	187.9	843.4	814.4	-3.9	Detention provided
23	JONK0023	10.5	7.0	-3.5	7.0	7.0	-3.5	No additional control needed
24	JONK0024	8.3	5.7	-2.6	5.7	5.7	-2.6	No additional control needed
						Total	**-65.4**	
Colorado River								
19	JCOB0010	121.7	325.3	203.5	193.9	116.7	-5.0	Detention provided
21	JCOC0010	35.1	74.3	39.3	69.2	5.5	-29.6	Increase mitigated by improvements at Project Area 1[c]
						Total	**-34.6**	

Notes:

a. Outfalls 15, 16, and 19 are near ABIA Outfalls, where the tributaries reach receiving bodies.

b. 2-yr peak discharge was obtained from the detailed model for ABIA outfall # 1

c. 2-yr peak discharge was obtained from the detailed model for ABIA Project Area 1

The dry basin will be regulated by a control structure capable of providing water quality treatment (up to a depth of 4 feet) via sand filtration as well as attenuation of runoff from larger storms with minimal additional ponding. It may be necessary to increase the size of the under-drain in order to provide drawdown with 48 hours, per the DCM. The facility is proposed to be located as shown in Figure 4-14 (Section 4), and will be capable of reducing the UBO peak offsite discharges from the 2-year design storm to existing levels as shown in Table 6-6. The additional storage volume necessary to meet this condition is approximately 1.3 ac-ft.

ABIA Outfall No. 15

At Outfall No. 15, there was approximately a 90 percent increase in the 2-year peak flow for the UBO land use condition (with no detention) compared to existing conditions. The water quality treatment facilities for the proposed developments within ABIA Development Area Nos. 13, 14, and (a portion of) 25, as sized in Section 4, were added to the model as offline storage volumes. This reduced the peak flow at this outfall to below existing condition levels. No further detention would be necessary to meet the 2-year detention criteria.

ABIA Outfall No. 16

At ABIA Outfall No. 16, there was approximately a 23 percent increase in the 2-year peak flow for the UBO land use condition (with no detention) compared to existing conditions. The water quality treatment facilities for the proposed developments within multiple ABIA Development Areas (Refer to Figures 6-6 and 4-14) as sized in Section 4, were added to the model as offline storage volumes. This reduced the peak flow at this outfall, but not to existing condition levels. The additional increases were mitigated by a 1.0-acre offline dry detention basin.

The single-stage offline facility is proposed to be located along the northern tributary, at the southern end of ABIA Development Area No. 34. The 1.0-acre offline dry detention basin will provide the additional attenuation required to meet the 2-year detention requirement. The single-stage offline facility will be capable of reducing the UBO peak offsite discharges from the 2-year design storm to existing levels as shown in Table 6-6.

ABIA Outfall Nos. 23 & 24

There is no proposed development for these outfalls. No mitigation is required.

6.5.2.2 Colorado River Outfalls

The Colorado River outfalls are not covered by RSMP program. However, ABIA Outfall No. 19 discharges directly to the river at elevated flood stages. Additionally, the Colorado River is a controlled water body with a peak flood stage that occurs well after the peak of ABIA discharges. Therefore, the area tributary to this outfall falls under similar conditions as the areas tributary to Onion Creek. For the purposes of this alternative, Outfall No. 19 will be treated as if the 100-year detention would not be required and only 2-year detention would be required. For Outfall No. 21, there are

adjacent landowners that could be affected by increases in peak flows; therefore, flows from this outfall were detained for the 100-year storm.

ABIA Outfall No. 19

At ABIA Outfall No. 19, there was approximately a 167 percent increase in the 2-year peak flow for the UBO land use condition (with no detention) compared to existing conditions. The water quality treatment facilities for the proposed developments within multiple ABIA Development Areas (Refer to Figures 6-6 and 4-14) as sized in Section 4, were added to the model as offline storage volumes. This reduced the peak flow at this outfall, but not to existing condition levels. The additional increases were mitigated by a 3.0-acre offline dry detention basin. The single-stage offline facility was located in the model approximately one-half mile upstream from the outfall, near the confluence of two tributaries. This dry detention basin, in conjunction with the storage provided by the water quality basins, will be capable of reducing the UBO peak offsite discharges from the 2-year design storm to below existing levels as shown in Table 6-6.

ABIA Outfall No. 21

At ABIA Outfall No. 21, there was approximately a 112 percent increase in the 2-year peak flow under the proposed development, with no additional detention. Because this outfall would not be covered under RSMP, there are also increases in peak flow for the 100-year storm that were evaluated with SWMM (Refer to Section 6.5.5 below). The localized improvements designed to provide attenuation of the 100-year storm also reduce the 2-year peak flow to approximately 84 percent below existing conditions. It should be noted that the peak offsite discharge from ABIA Outfall No. 21 listed in Table 6-6 was obtained from the detailed model for Project Area 1 (Refer to Section 7).

6.5.2.3 Carson Creek Outfalls

The Carson Creek outfalls are not covered by the RSMP. For Carson Creek Outfall Nos. 2, 3, 4, 5, and 7, the peak 2-year offsite discharges for the UBO conditions are equal to or less than that for existing conditions, as shown in Table 6-6. This is because the areas that are tributary to these outfalls are nearly built-out under existing land use conditions.

ABIA Outfall No. 1

At ABIA Outfall No. 1, there was approximately a 20 percent increase in the 2-year peak flow under the proposed development, with no additional detention. Because this outfall would not be covered under RSMP, there are also increases in peak flow for the 100-year storm that were evaluated with SWMM (Refer to Section 6.5.5 below). The localized improvements designed to provide attenuation of the 100-year storm also reduce the 2-year peak flow to approximately 5 percent below existing conditions. It should be noted that the peak offsite discharge from ABIA outfall No. 1 listed in Table 6-6 was obtained from the model built to mitigate the 100-year peak flows.

6.5.2.4 Conceptual Opinion of Probable Construction Cost: 2-Year Detention

A detailed Engineer's conceptual estimate of probable cost of construction has been developed for the three proposed onsite detention facilities. It was determined that a 3.0-acre dry detention facility will be required to mitigate flow increases at ABIA Outfall No. 19 for an estimated conceptual cost of $1,037,000 (Refer to **Table 6-7**). A 2.5-acre dry detention facility will be required to offset flow increases at ABIA Outfall No. 8 for an estimated conceptual cost of $821,000 (Refer to Table 6-7). Finally, a 1.0-acre dry detention facility will be required to offset flow increases at ABIA Outfall No. 16 for an estimated conceptual cost of $400,000 (Refer to Table 6-7). The combined conceptual construction cost is approximately $2.3 million for the three onsite dry detention facilities. Cumulatively, the three detention facilities will have an approximate footprint of 6.5 acres and provide approximately 58 ac-ft of storage at top of bank (assuming a depth of 10 feet).

It should be noted that there are significant economies of scale associated with the construction of regional detention facilities. Costs may be significantly higher if development occurs as multiple small developments and individual, smaller facilities are constructed on a project-by-project basis.

6.5.3 RSMP Participation and Erosion Control

This alternative evaluates RSMP participation with erosion control in lieu of 2-year onsite detention. The DCM states that offsite control of the 2-year storm is permitted when the rate of erosion would not be increased between the point of discharge and the offsite facility. The term "offsite facility" is applied to receiving water bodies such as Lake Travis, Town Lake, and Decker Lake. Since peak stages and flows in Onion Creek and in the Colorado River would not be affected by increases in the 2-year peak runoff from ABIA, they should be considered as offsite control (they are not affected by increases in the 100-year storm peak runoff per Section 5).

6.5.3.1 Modeling Approach

The vast majority of proposed future development on the ABIA property will produce storm runoff that will discharge through one of four main channels. Three of these channels discharge to Onion Creek (Outfall Nos. 8, 15, and 16) and one discharges to the State Highway 71 right-of-way and subsequently drains to the Colorado River (Outfall No. 19). The COA regulations generally consider earth lined channels erosion resistant if the anticipated flow velocity in the 100-year storm event is less than or equal to six feet per second. The ABIA SWMM was used to identify channel segments on the ABIA site that will have 100-year flow velocities in excess of six feet per second. The locations of these channel segments are depicted graphically in **Figure 6-7**. This figure was only used as a reference to provide a general idea of where velocities are expected to be high in the project area for intense storms. This does not mean that erosion cannot (or does not) occur in locations that are not presented in this figure. There are gaps in the reaches as

Table 6-7. Engineer's Opinion of Probable Conceptual Construction Cost

Item	Units	Quantity	Unit Cost	Total
ABIA Outfall Number 19: JCOB0010-Det - 3.0 acre dry detention				
Mobilization	LS	1		$33,000
Sediment and Erosion Control	LF	2,885	$5	$14,000
Clearing and Grubbing	AC	3	$6,900	$21,000
Excavation	CY	45,980	$10	$460,000
Embankment	CY	2,410	$10	$24,000
Maintenance Access	SY	3,213	$5	$16,000
60" RCP Inflow Pipe	LF	300	$205	$62,000
60" Mitered End Section	EA	4	$4,800	$19,000
12" RCP Drainage Pipe	LF	100	$30	$3,000
12" Mitered End Section	EA	2	$1,100	$2,000
Control Structure	EA	1	$10,000	$10,000
Sod	SY	6,006	$5	$30,000
		Sub-Total		$694,000
		Contingency	30%	$208,000
		Sub-Total		$902,000
		Engineering, Survey, and Permitting	15%	$135,000
		Total		$1,037,000
ABIA Outfall Number 8: JONS0090-DET - 2.5 acre dry detention				
Mobilization	LS	1		$26,000
Sediment and Erosion Control	LF	2,885	$5	$14,000
Clearing and Grubbing	AC	3	$6,900	$17,000
Excavation	CY	38,317	$10	$383,000
Embankment	CY	2,200	$10	$22,000
Maintenance Access	SY	2,933	$5	$15,000
60" RCP Inflow Pipe	LF	100	$205	$21,000
60" Mitered End Section	EA	2	$4,800	$10,000
12" RCP Drainage Pipe	LF	100	$30	$3,000
12" Mitered End Section	EA	2	$1,100	$2,000
Control Structure	EA	1	$10,000	$10,000
Sod	SY	5,136	$5	$26,000
		Sub-Total		$549,000
		Contingency	30%	$165,000
		Sub-Total		$714,000
		Engineering, Survey, and Permitting	15%	$107,000
		Total		$821,000
ABIA Outfall Number 16: JONT0105-DET - 1.0 acre dry detention				
Mobilization	LS	1		$13,000
Sediment and Erosion Control	LF	2,885	$5	$14,000
Clearing and Grubbing	AC	1	$6,900	$17,000
Excavation	CY	15,327	$10	$383,000
Embankment	CY	1,391	$10	$22,000
Maintenance Access	SY	1,855	$5	$15,000
60" RCP Inflow Pipe	LF	100	$205	$21,000
60" Mitered End Section	EA	2	$4,800	$10,000
12" RCP Drainage Pipe	LF	100	$30	$3,000
12" Mitered End Section	EA	2	$1,100	$2,000
Control Structure	EA	1	$10,000	$10,000
Sod	SY	2,405	$5	$26,000
		Sub-Total		$268,000
		Contingency	30%	$80,000
		Sub-Total		$348,000
		Engineering, Survey, and Permitting	15%	$52,000
		Total		$400,000
			GRAND TOTAL	**$2,258,000**

ASSUMPTIONS:

1. Prices include all labor, equipment, materials, O&P.
2. Mobilization based on 5% earthwork cost.
3. Sediment & Erosion Control based on staked silt fence & assumed pond sizes.
4. Excavated material suitable for berm construction
5. No allowance for selling excess material.
6. Disposal of excess material included in cost of Excavation.
7. *Maintenance access constructed of 12" soil stabilization 18' wide.*
8. Ponds geometry: ~2L=W, 3H:1V Side slopes, Freeboard = 1', Berm height = 2'.
9. Control structure 10' x 4' modified with overflow weir & orifice
10. RCP price includes trenching, compaction, & backfilling.
11. Costs are in 2010 dollars.
12. Costs do not include wetland mitigation, maintenance, or monitoring.
13. Costs do not include potential hazardous remediation.

the cross-sectional area varies along each stream or ditch. Figure 6-7 displays the reaches in color codes delineated by Manning's n values. For locations where the Manning's roughness is 0.013 (and some locations with values of 0.02), the channel is already concrete-lined and further erosion control would not be necessary.

6.5.3.2 Onsite Inspection

For the purposes of evaluation, each of the four major discharge channels was segmented and analyzed to determine the potential need for current (Type A) or future (Type B) channel improvements to minimize the erosion hazard. **Figure 6-8**, the *Erosion Control Improvements Map* depicts each of these segments with a colored line and provides an identifying letter. These segments are generally areas with known erosion problems or those which are anticipated to experience higher (> 6 ft/s) velocities under future developed conditions. Except for gold, colors were used strictly for the purposes of differentiating between segments and are not meant to identify varying channel conditions or velocities. In addition to modeling, limited site inspections were conducted to determine the general existing condition of most of the ABIA discharge channels. For each channel identified, several representative sections were visually inspected to determine the general condition based on the following criteria:

- The relative uniformity of the channel including bottom width, side slopes, and smooth grading (i.e., free of ruts and holes).
- The relative condition of adjacent banks and bluffs in overbank areas, noting vegetative cover and apparent slope stability.
- The condition of the channel lining including vegetation, rock rubble, gabions and/or concrete lining.
- Other unique or notable channel characteristics.

Significant on site channels which are not predicted to experience high flow velocities are shown in gold. These channels were not inspected. Representative photographs of most of the inspected channels are included in **Figure 6-9**. Individual segment conditions are as follows:

<u>Segments A and B</u>

These segments represent the northern and southern ends of the manmade trapezoidal ditch paralleling the west side of the east runway complex. This earthen channel is heavily vegetated and is in good condition. The channel is characterized by relatively uniform side slopes and contains very few defects. About 800 linear feet of the southern end of the channel (upstream of the confluence with the unnamed tributary, in segment B) may ultimately experience high flow velocities (>6 ft/s) in the future. Based on the

current channel condition, this is the only area that is currently anticipated to require enhancement in the future.

Segments C, D, E, F and G [of the East Runway Complex]

Segment E represents a short section downstream of the confluence of the C-F and D-G channels. All of these channels are lined with gabion mattresses installed in conjunction with the landfill closure project. The gabions are generally in good condition. Vegetation has been established in several areas. A short segment at the west end of Segment D is not currently lined and may therefore require improvement in the future. The gabions at the extreme downstream end of Segment E have been undermined by erosion. This channel complex in general is unlikely to need significant enhancement in the future.

Segments H and I

Segments H and I represent the continuation of the C-D-E-F-G channel complex through a natural channel system extending to Onion Creek (model Outfall No. 16). The total channel length is approximately 1300 feet with Segment H representing about 250 feet of the total. This channel is in poor condition throughout. Cut banks on the outside edge of stream meanders are undergoing active sloughing and lee bar deposits (on the inside edge of meanders) are very loose and unconsolidated. A previous concrete channel lining improvement about midway through Segment I has been completely destroyed by erosion and now represents a stream blockage. The east side of Segment H contains a severely eroded bluff approximately 40 feet high.

- Segment H is in need of repair and will likely require a large wall or significant earthwork to stabilize the bluff. Segment I contains several smaller bluffs (generally less than 10 feet in height) but is being similarly eroded. The entire length of segments H and I require repair. Although repair cost estimates presented hereafter assume a channel lining repair, a detailed analysis of Segments H and I should be completed prior to selecting a final repair approach.

Segment J

- Segment J is a natural channel that passes through the old golf course and discharges to the State Highway 71 right-of-way (model Outfall No. 19). This segment contains steep, heavily wood side slopes with sparse ground cover vegetation (due to the shade). The bottom of the channel is generally littered with an unconsolidated mat of decaying vegetation. Sand and gravel are evident in a few areas, particularly in the west end of the segment. Segment J contains a small impoundment that encourages the deposition of material in the channel bottom. The unconsolidated material in the bottom of Segment J represents an extreme erosion hazard. The channel will require significant maintenance and improvement prior to significant additional development in the upstream basin. Enhancement of the existing impoundment to serve as a permanent sediment trap might be considered.

Legend

High Velocity Reaches

Manning's n

- 0.013
- 0.02
- 0.0215
- 0.03
- 0.035
- 0.07

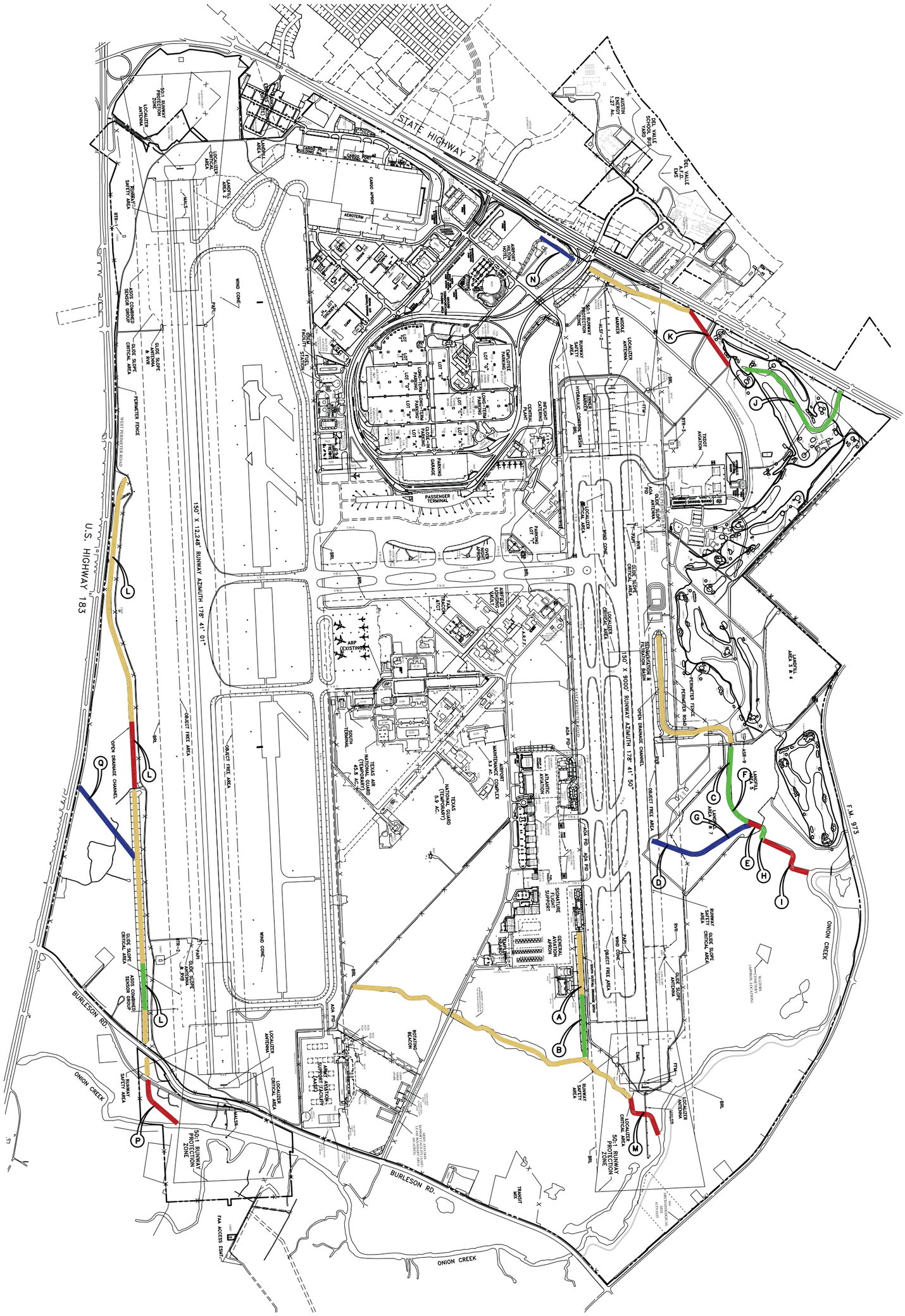
Model Outfalls

N W E S

0 625 1,250 2,500 3,750 5,000 Feet

Figure 6-7
Reaches with Velocity > 6 ft/s for the 100-Year Storm
Austin - Bergstrom International Airport (ABIA)
Stormwater Drainage Master Plan (SWMP) Update
Project No.: 4910-8107-3139

CDM



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LEGEND

EXISTING CHANNEL NOT REVIEWED

EXISTING CHANNEL REQUIRING IMPROVEMENTS

0 350 700 1,400 2,100 2,800

N

FIGURE 6-8
EROSION CONTROL IMPROVEMENTS
Austin-Bergstrom International Airport (ABIA)
STORMWATER DRAINAGE MASTER PLAN (SWMP) UPDATE
Project No.: 4910-8107-3139

CDM
Texas P.E. Firm No. F-3043

Austin-Bergstrom International Airport (ABIA)
STORMWATER DRAINAGE MASTER PLAN (SWMP) UPDATE
Project No.: 4910-8107-3139

Photo 1 Channel Segment A viewed from the east looking downstream toward the south.

Photo 2 Channel Segment B viewed from the north looking directly downstream toward the south.

Photo 3 Channel Segment C viewed from the north looking directly downstream toward the south. Note pilot channel. Curve in distance is gabion lined.

Photo 4 Channel Segment D viewed from the west looking directly downstream toward the east.

Photo 5 Channel Segment E viewed from the east looking westward (upstream) Channel is gabion lined; note vegetation.

Photo 6 Channel Segment F viewed from the southeast looking upstream toward the northwest.

Photo 7 Channel Segment G viewed from the east looking southwestward (upstream). Channel is gabion lined; note vegetation.

Photo 8 Channel Segment H viewed from the south looking upstream. Note extreme erosion on cut bank on northeast side of channel.

Photo 9 Channel Segment I viewed from the west looking downstream to the east. Note scour and concave shape of cut bank.

Photo 10 Failed concrete slope paving in Channel Segment I. Channel flow is passing under the concrete

Photo 11 Channel Segment J viewed from the northwest looking downstream to the southeast. Organic debris is in the channel centerline.

Photo 12 Utility duct bank concrete dumped along the southwest bank of Channel Segment J.

Photo 13 Channel Segment K viewed from the roadway looking upstream to the northwest.

Photo 14 Channel Segment K viewed from the roadway looking downstream to the southeast.

Photo 15 Lower section of Channel Segment L looking upstream from the south. Note the height of the weeds and lack of ground cover vegetation.

Photo 16 Upper portion of Channel Segment L viewed from the east looking upstream to the north.

Segment K

Segment K is a concrete lined rectangular channel that straddles the old golf course access road about eighty yards east of State Highway 71. The channel is about 1,000 feet in length and appears to be in good condition. Being constructed of concrete, Segment K is erosion resistant and is unlikely to require erosion control improvements in the future other than the construction of a transition section in conjunction with the improvements to Segment J downstream.

Segments L, P and Q

Segment L represents a collection of manmade trapezoidal channels paralleling the west side of the west runway. Portions of this channel are currently over-vegetated with several areas containing stalk-like weeds in excess of 10 feet tall. These tall weeds can choke out ground cover vegetation over time and leave the channel bottom susceptible to erosion. The channel is currently in moderate to good condition. Two individual sections of Segment L and a side channel (Segment Q) are projected to experience high velocity flows in the future. These three sections total about 3,300 feet of manmade channel. A fourth section (Segment P) represents approximately 900 feet of natural channel immediately upstream of Onion Creek (model Outfall No. 8). Protection of the three manmade channel sections might be accomplished with the establishment of dense ground cover vegetation in the channel since these sections are linear and therefore free of bends. Segment P contains bends in a natural channel and is in the same general geologic structure (and is therefore similarly erodible) as the Segment H-I channel complex. It is therefore reasonable to assume that this lower section will require future erosion control improvements.

Segment M

Segment M represents the natural discharge channel of the A-B channel system at the south end of the east runway complex. This segment is approximately 850 feet long and is located off the south end of the east runway, immediately upstream of Onion Creek (model Outfall No. 15). Similar to the lower portion of Segment L, this area is likely to experience erosion problems in the future and should therefore be considered a candidate for channel improvements. Note that Segment M occupies an area that was off limits to all personnel during the site visit and no pictures of this segment are available. This channel segment should be inspected when the area becomes accessible in the future.

Segment N

Segment N is a trapezoidal ditch paralleling State Highway 71 just west of Presidential Boulevard. The channel is approximately 660 feet long and is currently in good condition. The model indicates velocities in excess of six feet per second in the ultimate developed condition. Similar to Segment L however, Segment N is linear and protection of the channel might be accomplished with the establishment of dense ground cover

vegetation. In the proposed Project No. 1 in Section 7, this channel is replaced with sub-surface drainage beneath a proposed parking lot; therefore, erosion protection would be unnecessary.

6.5.3.3 Estimation of Channel Improvement Costs

Channel improvements on the ABIA site will generally be divided into two categories including:

- Type A. Improvements required to correct existing erosion problems.
- Type B. Improvements required to mitigate future flow velocity increases.

The type "A" improvements will be required regardless of what detention approach (on site systems or RSMP) is used for future ABIA development. Most of the type "B" improvements will be needed only if RSMP is selected as the detention approach, as flow discharges through the outfall channels will increase.

The actual method of channel stabilization used in any given location will be site specific to each channel segment. Detailed design of erosion control improvements is beyond the scope of this report; however, potential erosion control projects were conceptually identified to contain some or all of the following components:

- Channel Lining. Estimates were prepared for both concrete channel lining and gabion channel lining.
- Transition Sections. Most improved sections will require one or two transitions to align with the existing adjacent channel sections. Transitions were not expected to be required in areas where two channel lining projects abut one another (the transition was included in the cost of the lining).
- Earthwork. Installing channel lining will require some earthwork. Some segments (such as Segments H and I) will require supplementary grading to correct deficiencies outside of the main channel section.
- Revegetation. Channels being improved with dense ground cover vegetation were assumed to require revegetation in the channel itself. Channels requiring significant earth moving work were expected to have adjacent disturbed areas that will also require revegetation.
- Contingency. A 30 percent contingency was added to each estimate to cover erosion controls and other project specific items that may be required.

Improvements other than those detailed above may certainly be appropriate and effective for any given channel segment. The intent of the assumptions detailed above was to identify one possible improvement scenario for each segment for the purposes of preparing conceptual cost information. Most channel improvements will require a

development permit from the City of Austin Planning and Development Review Department and many may require the approval of waivers and variances to allow work in the critical water quality zone. Provisions approving variances to specific sections of the City Code which would allow future channel repairs and improvements can be included in the new proposed ABIA Development Ordinance. This ordinance provision should specifically state that variances are granted from Sections 25-8-341 (Cut Requirements), 25-8-342 (Fill Requirements) and 25-3-392 (Critical Water Quality Zone) for the purposes of constructing channel repairs.

Table 6-8 details the tabular calculation of improvement costs. The estimated present value of improvements necessary to correct existing erosion problems (Segments H and I) is approximately $830,000 ($1,300,000 if gabions are used). Per City of Austin Watershed Protection staff, in some scenarios, it might be possible that the cost of these improvements can be credited against a portion of the RSMP participation fee. The estimated present value of improvements necessary to address erosion concerns caused by future development is approximately $2,020,000 ($4,300,000 if gabions are used). Because these improvements would be necessary to address erosion associated with future development, these costs cannot be credited against RSMP fees. The total estimate cost is about $2,850,000 for concrete lining or $5,700,000 for gabion lining. The future improvement estimates include an allowance for an extra 3,000 feet of channel improvement that might be required.

6.5.4 Onsite Detention of the 100-Year Storm (No RSMP)

This alternative evaluates the condition where no RSMP participation occurs and onsite detention is necessary for the 100-year, 24-hour design storm as to not create potential offsite impacts.

As an interim step in the SWMP Update, the project team assessed the water quality and water quantity facilities needs for ABIA under the ultimate built-out land use condition, compared those needs to the proposed RSMP participation and presented the comparison at a workshop of relevant stakeholders including the project team, the DOA, PDRD, and the WDP. One purpose of this workshop was to determine whether participation in the RSMP would be feasible based on the timing and rate of peak flows to Onion Creek, the fee structure of this participation, the approximate cost in construction and loss of developable area for retaining stormwater onsite in lieu of RSMP participation.

This section summarizes the modeling support for the scenario where there would be onsite detention in lieu of RSMP participation for the Onion Creek Watershed. The modeling support to address qualifications for RSMP participation was presented earlier, in Section 5.

TABLE 6-8. PRELIMINARY ESTIMATE OF CHANNEL IMPROVMENT COSTS (GABION LINING)

REQUIRED CURRENT IMPROVEMENTS AND POTENTIAL FUTURE IMPROVEMENTS

Austin-Bergstrom International Airport (ABIA)
STORMWATER DRAINAGE MASTER PLAN (SWMP) UPDATE
Project No.: 4910-8107-3139

Description	Channel Length (Ft)	Gabion Channel Lining				Transition Sections				Earthwork				Revegetation				Contingency 30%	Total
		Quantity	Unit	Unit Cost	Subtotal ($)	Quantity	Unit	Unit Cost	Subtotal ($)	Quantity	Unit	Unit Cost	Subtotal ($)	Quantity	Unit	Unit Cost	Subtotal ($)	($)	($)
Type "A" Repairs - Required																			
Segment H	250	3,000	SY	75	225000	1	SY	8000	8000	25,000	CY	10	250000	3,000	SY	3	9000	147,600	$639,600.00
Segment I	1030	5,720	SY	75	429000	1	SY	12000	12000	8,300	CY	10	83000	5,600	SY	3	16800	162,240	$703,040.00
Subtotal Type "A"	1280																		$1,342,640.00
Type "B" Repairs - Future																			
Segment B	1000	5,555	SY	75	416625	2	EA	8000	16000	925	CY	10	9250	2,220	SY	3	6660	134,561	$583,095.50
Segment J	2400	8,000	SY	75	600000	2	EA	8000	16000	4,000	CY	10	40000	13,000	SY	3	39000	208,500	$903,500.00
Segment L	1800	0	SY	75	0	0	EA	8000	0	1,000	CY	10	10000	8,000	SY	3	24000	10,200	$44,200.00
Segment M	850	4,700	SY	75	352500	2	EA	12000	24000	2,000	CY	10	20000	3,800	SY	3	11400	122,370	$530,270.00
Segment N	660	0	SY	75	0	0	EA	8000	0	300	CY	10	3000	3,600	SY	3	10800	4,140	$17,940.00
Segment P	900	5,000	SY	75	375000	2	EA	12000	24000	2,100	CY	10	21000	4,000	SY	3	12000	129,600	$561,600.00
Segment Q	1440	6,400	SY	75	480000	2	EA	8000	16000	1,600	CY	10	16000	4,600	SY	3	13800	157,740	$683,540.00
Miscellaneous Channels	3000	10,000	SY	75	750000	2	EA	8000	16000	550	CY	10	5500	3,300	SY	3	9900	234,420	$1,015,820.00
Subtotal Type "A"	12050																		$4,339,965.50
Total Preliminary Estimate	13330																		$5,682,605.50

Initial feedback from WPD at the April 2010 workshop was that RSMP participation would likely be acceptable since ABIA is near the bottom of the Onion Creek Watershed. Onsite detention of stormwater does not provide significant improvement to the Onion Creek peak flows as the peak flows (and stages) of Onion Creek occur well after the peak outfall from ABIA. Therefore, participation would result in monies being spent further upstream in the basin where it would be more beneficial to the watershed as a whole.

6.5.4.1 Onsite Detention

A technical memorandum titled "Facility Needs Assessment – Stormwater Drainage" has been prepared for the DOA. This memo has been attached to this SWMP update as Appendix E. The memo describes the methodology used to simulate onsite detention for the 100-year design storm such that the peak flows at each outfall in the model for the ultimate built-out land use condition are no greater than the peak flows for the existing condition. The ultimate built-out land use condition increases imperviousness in the hydrologic component of the model, which in turn increases runoff and flows. **Table 6-9** below shows the resultant peak flows by outfall for the existing and UBO conditions.

The area that is tributary to the Carson Creek watershed is nearly built-out under the existing condition, thus the UBO condition simulations indicate little change. Therefore, the Carson Creek outfalls were eliminated from the rest of this exercise.

Detention basins are added to the model, similar to, although much bigger than existing detention basins and those simulated for the 2-year storm detention alternatives discussed in previous sections.

As the ultimate design of the future development is unknown at this time, detention basins are not necessarily located where they may ultimately be built. In model space, they are conceptual. However, care was taken to only allow reasonable depths of ponding based on regional topography. The model was also examined such that the detention areas did not cause upstream flooding.

Basin sizes were adjusted until the outfall flows matched, or were less than the existing condition land use peak flows. Table 6-9 displays the results of the model simulations after the detention storage has been added. The total storage area for each watershed represents the approximate interior area needed and does not account for the area necessary for basin berms or setback requirements.

The model simulations indicate that approximately 55 acres of interior storage is necessary to mitigate the peaks of the outfall flows for the Onion Creek watershed and an additional 11 acres is needed for the Colorado River Watershed.

Because of the uncertainties in the number of basins that would be built to provide the necessary storage, as well as the size and shape of each, a factor of 1.5 has been applied to each of these areas to account for the space needed for their application (i.e. berm

area, etc.). Therefore, the final surface areas required are 82 acres in the Onion Creek Watershed and 16 acres in the Colorado River Watershed (corresponding to approximately 620 and 100 ac-ft volumes, respectively).

Table 6-9. Peak Flows by Outfall with Detention and Detention Sizing

Onion Creek		100-year Peak Flow (cfs)			Storage Area (ac)	Peak Depth (ft)	Peak Storage (ac-ft)
		Existing	UBO w Storage	Delta			
8	JONS0090	1,556.9	1,541.3	-15.6	18.4	11.0	201.8
10	JONV0050	38.3	39.2	0.9	NA	NA	NA
11	JONV0070	71.5	71.5	0.0	NA	NA	NA
22	JONV0090	111.0	111.3	0.3	2.3	9.2	21.0
25	JONV0110	85.3	83.1	-2.2	4.9	6.8	33.2
15	JONR0205	1,105.5	1,061.7	-43.8	8.3	12.2	101.4
16	JONT0105	3,286.9	3,270.8	-16.1	20.7	12.8	265.8
24	JONK0024	50.0	50.0	0.0	NA	NA	NA
23	JONK0023	60.2	60.2	0.0	NA	NA	NA
			Totals	-77	54.6		623
Colorado River		**100-year Peak Flow (cfs)**			**Storage Area (ac)**	**Peak Depth (ft)**	**Peak Storage (ac-ft)**
		Existing	UBO w Storage	Delta			
19	JCOB0010	809.6	789.3	-20.3	9.8	9.9	96.6
21	JCOC0010	439.7	410.1	-29.6	0.9	6.9	6.2
			Totals	-50	10.7		103

From the preliminary water quality assessment of the Onion Creek watershed, 23 to 30 acres may be necessary to locate water quality treatment facilities onsite, regardless of participation in the RSMP. The 23 acre value was determined using a factor of 1.25 to account for splitter boxes and sloped pond berms. The range to 30 acres was recommended based on a sensitivity analysis of the underlying assumptions. The remaining onsite detention area estimate if there were no participation in RSMP, after removing the necessary water quality area, ranges from 52 to 59 acres (corresponding to a storage volume of approximately 450 ac-ft).

6.5.4.2 Conceptual Cost Estimate of Onsite Detention

An estimate of conceptual cost for the Onion Creek portion of the onsite detention scenario has been developed as a direct comparison to RSMP participation. For this estimate, basins are expected to be dug down, with minimal berms to avoid a high-hazard dam classification (and to match existing onsite detention geometries). A table of cost estimates in Appendix E (Table 3 in the memorandum) gives the conceptual construction cost breakdown, excluding the value of the developable land. The total costs are estimated to be approximately $14 million. Correspondingly, the conceptual cost for the basins in the Colorado Watershed would be about $3 million, for a total of $17 million.

6.5.5 Exceptions to RSMP

The participation in the RSMP program is limited to the Onion Creek watershed as discussed in Section 5. However, the Colorado River watershed is very similar in that the peak flows and flood stages should occur significantly later than the peak runoff from ABIA. For Outfall No. 19 in the northeast corner of the model, it is expected that peak flood stages off ABIA property on the north side of State Highway 71 will be completely a result of upstream Colorado River flows, and not from ABIA runoff. This outfall flows directly from ABIA to the river, without adjacent property owners that could be adversely affected.

This is not true of the second Colorado River Outfall No. 21 or of the Carson Creek outfalls. In each of these cases, there are ditches or streams from the ABIA outfall leading to the river and creek. These conveyances are not in the ABIA model; however, it is very likely that increased flows through these outfalls could cause adverse impacts to adjacent property owners in terms of peak flows, velocities, and stages. For this reason, onsite detention of the 100-year storm may be necessary for Outfall Nos.1-5, 7, and 21.

With exception to areas tributary to Outfall No. 1, the Carson Creek basin is either already built-out, or in the runway/ taxiway area that is not expected to develop further. Therefore, in the ultimate built-out land use condition, only Outfall No. 1 shows an increase in peak flood stage over the existing condition. No additional detention is necessary for Outfall Nos. 2, 3, 4, 5, or 7.

6.5.5.1 Carson Creek Outfall No. 1

As shown in the impervious cover maps in Section 3, additional development is proposed north of Freight Lane, adjacent to the Cargo Ramp serving FedEx, DHL, UPS, and the USPS. In the final built-out land use condition, this new impervious area adds approximately 10 cfs to the peak flow at Outfall No. 1 for the 100-year storm.

This peak flow may be attenuated with additional detention in an open area near the location where Freight Lane curves north toward State Highway 71, or by expanding the existing detention basin 'N'. Although it is likely more cost effective to expand basin 'N', the former alternative has been modeled to provide the reader a better idea of the size requirement.

Figure 6-10 shows the approximate location of the proposed development, existing model nodes and conveyance, proposed conveyance including upgrades, and the proposed detention pond to mitigate increased peak flow. The proposed detention basin requires a storage volume of 3.2 acre-feet. At 8 feet deep, the pond is 0.16 acres at the bottom and 0.66 acres at the top. Although not specifically modeled, the pond may drain by gravity into the system that serves existing Basin 'N'.

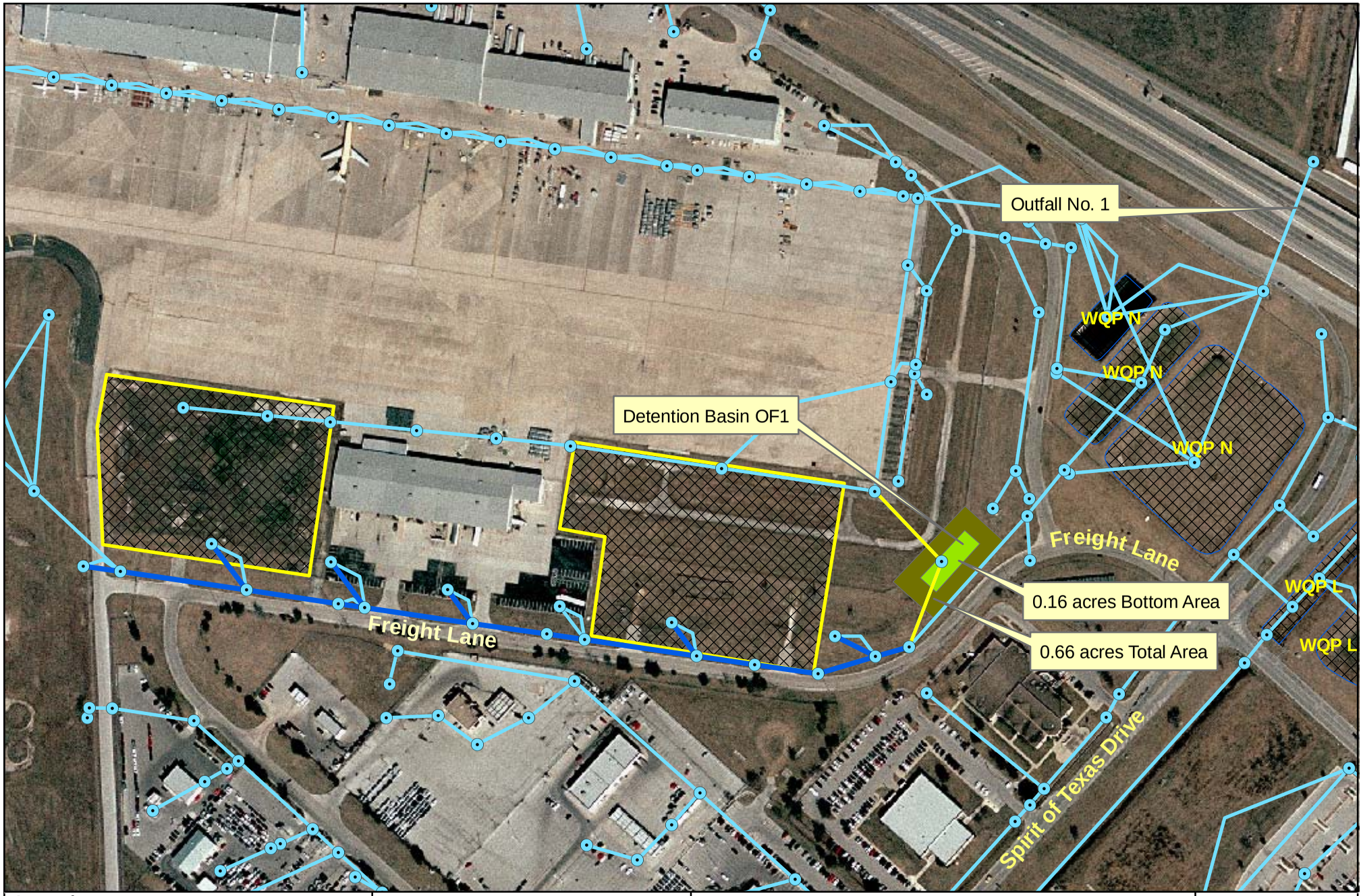
The detention basin is dug into the ground in the manner of neighboring Basin 'N', with little or no berming. The basin is simulated to be approximately 8 feet deep for a total storage volume of 3.2 acre-feet. The basin is simulated offline, but could be placed inline as is Basin 'N'. In the offline scenario, the existing 4-feet diameter pipe adjacent to Freight Lane would remain; however, the flow would be diverted to the basin with a second 4-feet diameter pipe. A secondary 2-feet diameter pipe also would be necessary to convey inflow from the cargo area drainage. In order to provide a level of service similar to the rest of ABIA, namely no flooding for the 100-year storm, it would also be necessary in increase pipe sizes upstream of the basin. A complete list of additional pipes, upgraded pipe sizes and costs are provided in Appendix F, Tables F-1(a) to F-1(c).

To not create adverse offsite impacts with the development around this cargo area, it is necessary to include this detention basin to all of the alternatives. The conceptual cost of this project is expected to be approximately $650,000.

6.5.5.2 Colorado River Outfall No. 21

The Colorado River Outfall No. 21 has similar issues as the Outfall No. 1. Any increase in peak flow through this outfall would potentially have adverse impacts to adjacent landowners. Although it is possible that future widening of State Highway 71 may provide the opportunity to mitigate these impacts downstream, it was decided by the DOA that for the purposes of this SWMP update that onsite detention be used to keep the future development peak flows less than or equal to existing peak flows.

The development in question is included in one of the detailed project areas that are studied in Section 7 (specifically, Section 7.2.1 describes the detention requirements for this outfall). To not create adverse offsite impacts with the development tributary to this outfall, it is necessary to include these detention basins to all of the alternatives. The conceptual cost of this project is expected to be approximately $1.8 million (the cost estimate of this project is presented in Appendix F, Table F-2).



Legend

- Model Nodes
- Conveyance Upgrades
- Proposed Conveyance
- Existing Conveyance
- Future Development Areas
- Proposed Basin Bottom
- Proposed Basin Top
- ABIA Existing Systems

N W E S

0 50 100 200 300 400 Feet

Figure 6-10
Proposed 100-Year Detention for Outfall No. 1
Austin-Bergstrom International Airport (ABIA)
Stormwater Drainage Master Plan (SWMP) Update
Project No,: 4910-8107-3139

CDM

Section 7
Alternatives Evaluation

7.1 Overview

The purpose of this section is to present the alternatives analysis performed as part of this SWMP Update. In Section 7.2, stormwater management strategies for three project areas that include near-term development projects are evaluated. These strategies include projects to provide stormwater facilities to serve areas where near-term developments are proposed.

In Section 7.3, the airport-wide long-term stormwater management alternatives that have been presented in the previous sections are discussed, along with opinions of probable costs for each. The three long-term stormwater management alternatives include:

1. Participation in the RSMP program in the Onion Creek watershed, water quality treatment, and 2-year onsite detention;

2. Participation in the RSMP program in the Onion Creek watershed, water quality treatment and channel improvements (in lieu of 2-year onsite detention);

3. 100-year storm onsite detention (no RSMP participation) and water quality treatment.

7.2 Alternatives for Three Near-Term Project Development Areas

In a meeting on June 29, 2010, the DOA and the project team identified three project areas for consolidated conveyance, water quality, and detention facilities for alternative analysis. Within each of these project areas, conceptual solutions have been developed to address one or more near-term development parcels. The project areas as shown in **Figure 7-1** are as follows:

- Project Area No. 1: Consolidated facilities to accommodate the new (ABIA) North Parking Lot (ABIA Development Area No. 2), and a third party development adjacent to the Hilton Hotel (ABIA Development Area No. 1).

- Project Area No. 2: Consolidated facilities to accommodate third party development immediately north of the general aviation area that includes Atlantic Aviation Support and the Raptor Hangar (ABIA Development Area Nos. 11 and 12).

- Project Area No. 3: Consolidated facilities to accommodate third party development immediately south of the general aviation area (ABIA Development Area No. 13).

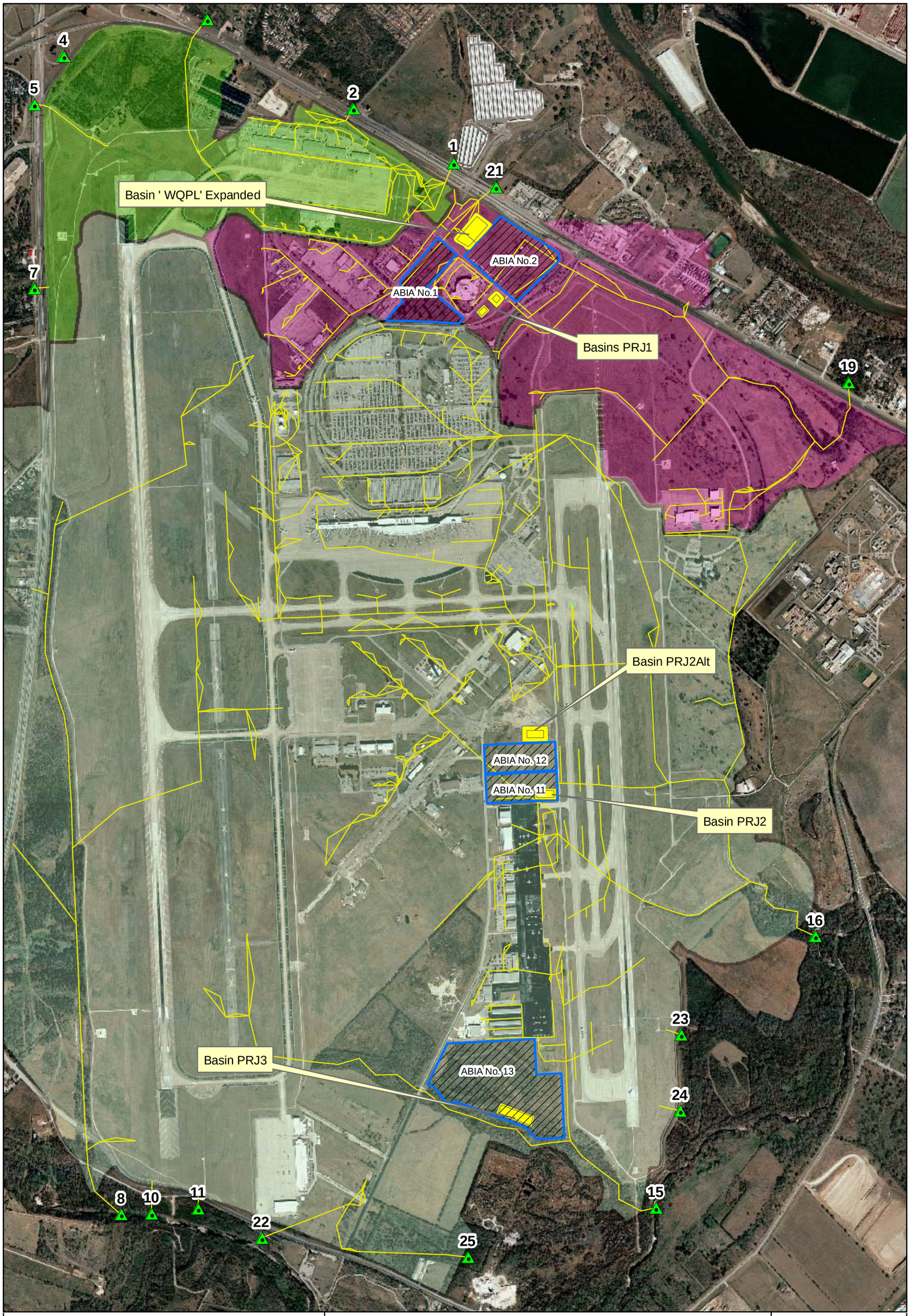
7.2.1 Project Area No. 1

Figure 7-2 shows a site map of Project Area No. 1, which is composed of two parcels that may be developed in the near future; a new parking lot for the parcel labeled ABIA Development Area No. 2 (20.3 ac), and a third party development for the parcel labeled ABIA Development Area No. 1 (14.6 ac). The site is bounded by the Spirit of Texas Drive on the northwest, State Highway 71 on the northeast, and Presidential Boulevard on the south. The Hilton Hotel and existing water quality systems 'WQP L' and 'WQP M' are adjacent to the site. The design for the developments is unknown at this time, but both are expected to be approximately 80 percent impervious within the boundaries displayed in Figure 7-2.

Stormwater flows leave the site through two outfalls to the Colorado River. The first is Outfall No. 21, which is composed of four barrels of 4-ft by 5-ft rectangular box culverts under State Highway 71. The 100-year peak flow in this culvert under existing conditions is approximately 440 cfs. This outfall flows to a ditch that conveys flows for approximately one-half mile before the confluence with the Colorado River. This ditch is not in the ABIA SWMM, however, it is likely that increased flows could increase stages in this ditch and cause adverse impacts to adjacent landowners. For this reason, the goal of this alternative is to detain the 100-year storm onsite. Note that in the alternatives described in Section 6, and evaluated in Section 7.3, this outfall is not included in the RSMP and 2-year detention studies. It is recommended that 100-year detention be used at this site, as outlined below.

The second outfall from this project area in comprised of two barrels of 4-ft by 8-ft rectangular box culverts under Presidential Boulevard. The peak flow in this culvert under existing conditions is approximately 80 cfs. Flows from this culvert are conveyed to Outfall No. 19 to the Colorado River. Outfall No. 19 is also a culvert under State Highway 71, but in this case is much closer to the river. The 100-year flood plain is so close to the outfall that it is likely flows from ABIA do not affect peak stages on the other side of the highway at this location. This is because peak flows from ABIA runoff occur well before the peak flow (and peak flood stage) of the river. For this reason, Outfall No. 19 has been included in the 2-year detention study. However, the project area outfall under Presidential Boulevard is treated with the same "no increase in peak flow" boundary condition as Outfall No. 21 for the following reasons:

- Increasing the flow under Presidential Boulevard (from 80 cfs to approximately 160 cfs) would raise peak stages and flows in the ditch that conveys the flow to Outfall No. 19.
- Raising peak stages may cause adverse offsite impacts, including in the ditch that passes by the north end of the airfield and potentially in existing developments that are also tributary to Outfall No. 19.



Legend

Model Outfalls

Watersheds

Carson Creek

Colorado River

Onion Creek

Model Links

Near Term Project Areas

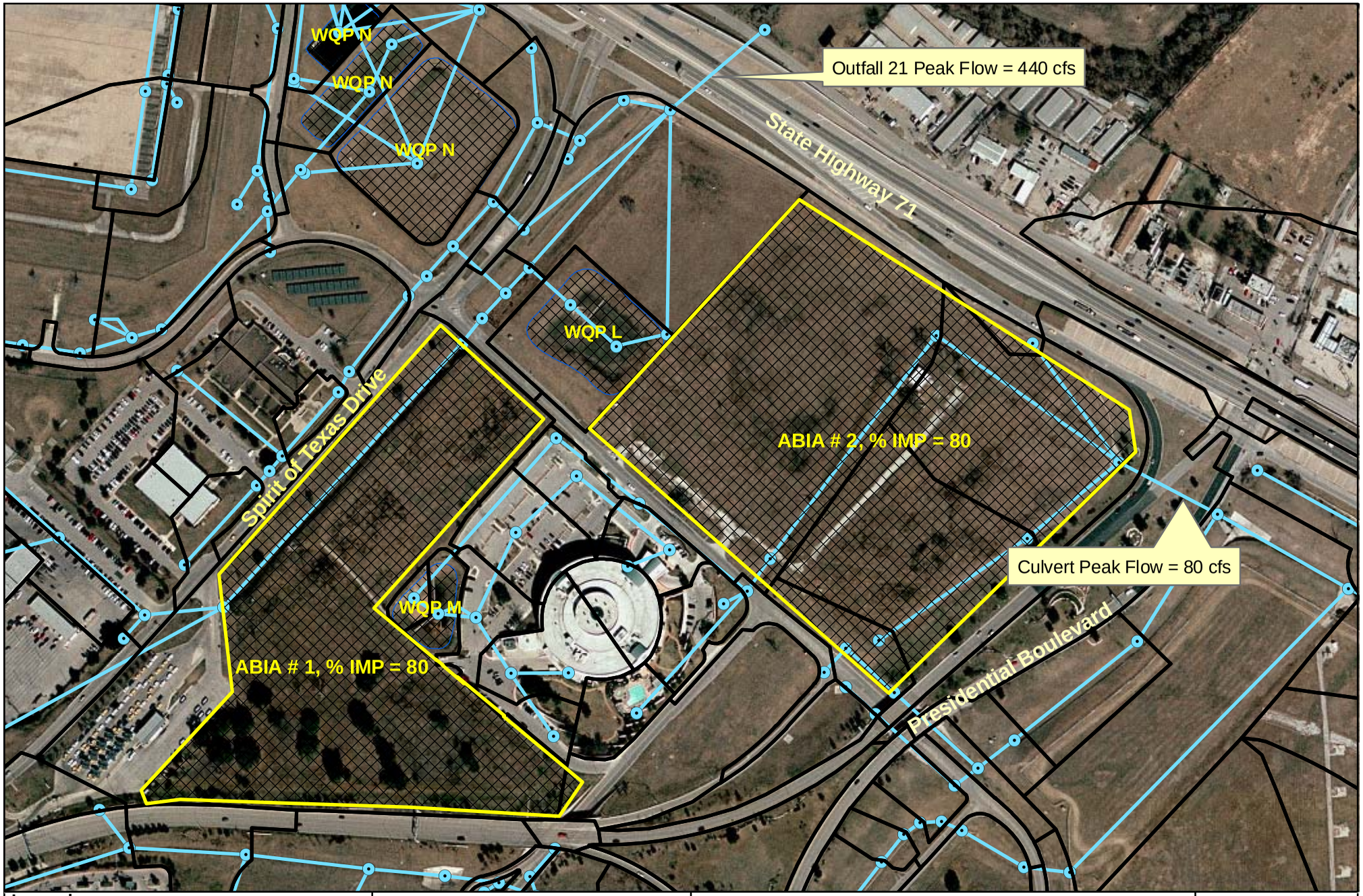
Project Basins

N W E S

0 600 1,200 2,400 3,600 4,800 Feet

Figure 7-1
Project Location Map
Austin - Bergstrom International Airport (ABIA)
Stormwater Drainage Master Plan (SWMP) Update
Project No.: 4910-8107-3139

CDM



Legend

- Model Nodes
- Existing Conveyance
- Existing HUs
- ABIA Existing Systems
- Future Development Areas

N W E S

0 75 150 300 450 600 Feet

Figure 7-2
Project Area 1 - Site Map
Austin-Bergstrom International Airport (ABIA)
Stormwater Drainage Master Plan (SWMP) Update
Project No,: 4910-8107-3139

CDM

7.2.1.1 Model Setup - Hydrology

Figure 7-3 displays the topography for this project site and the re-delineation of hydrologic units (HUs) in the propose parking lot. The color map of the topography digital elevation map (DEM) is set to one-foot increments over the range of elevations in this area.

The third party development site is subdivided into two parts as well, but without a design plan, the delineation is simply based on topography.

In the proposed alternative model, the HUs were converted from pervious open land to 80 percent impervious areas. In the proposed parking lot, runoff from the impervious surface was routed to the remaining 20 percent pervious surface. This is based on landscaped medians that are lower than the parking surface (as opposed to raised islands). This environmentally friendly landscaping provides water conservation and additional water quality treatment and is in accord with the COA City Council Resolution No. 20090806-35 for alternative water management methods. For stormwater, landscaped medians provide some additional infiltration and reduce peak runoff. This method was not used in the third party development since there is no design for the development at this time.

The plan is to use the existing water quality and detention system 'WQP L' and resize as necessary. Because the proposed parking lot site slopes away from system 'WQP L', only about one-third of the ABIA Area No.2 site will be conveyed to the upsized system 'WQP L' (all of ABIA Area No. 1 is treated and detained by system 'WQP L'). The remaining two-thirds of the parking lot will be treated and detained by a new proposed system southeast of the Hilton Hotel (System 'PRJ1').

7.2.1.2 Model Setup - Hydraulics

There are existing ditches that run through both development sites. For the proposed parking lot, it is expected that these ditches will be removed and the area re-graded. The grading necessary to develop this parcel into a parking lot is not included in the conceptual cost estimate in the next subsection. For the ditch along Spirit of Texas Drive in Area No. 1, the DOA has indicated that it is likely that the ditch will remain.

<u>Water Quality and Detention Basins</u>

Figure 7-4 shows a schematic of the proposed alternative for this project. System 'WQP L' is to be used for both water quality and detention as in the existing design. There is not enough vertical drop from the inlet to the basin in the ditch adjacent to Spirit of Texas Drive (junction ICOC0030) to Outfall No. 21 to allow the water quality basin to be separate and higher than the detention. The proposed size of system 'WQP L' includes the existing footprint for existing water quality treatment, plus the new proposed water quality treatment area and additional space for the necessary detention. Under intense storm conditions such as during the 100-year storm, the entire 10-ft deep basin fills up and pumps are needed to remove the stormwater after the storm because the invert of

Outfall No. 21 is above the bottom of system 'WQP L'. Note the depth of system 'WQP L' has not been changed from the existing system.

For the second system 'PRJ1', the design is similar to the existing water quality and detention system 'WQP N'. The diversion weir from the junction where water enters the site to the detention basin is set 2.5 feet higher than the invert of the pipe that flows directly to the water quality basin. Thus, under normal flow conditions, water flows to the water quality basin until full and then it flows to the detention basin.

In this case, the bottoms of both basins are high enough above the outfall under Presidential Boulevard that pumps are not needed. Proposed facility attributes are shown in **Table 7-1(a) and 7-1(b)**. (Note that the areas and volumes in Table 7-1(a) include the dimensions of only the proposed additions, as the existing area and volume are not included in the values shown in the table).

Table 7-1(a). Proposed Change in Basin Sizes*

Basin WQP L	Bottom Area (ac)	Total Footprint (ac)	Volume (ac-ft)	Bottom Elevation (ft)	Top Elevation (ft)
WQ	0.29	0.7	5.0	486	496
Detention	1.25	1.7	14.8	486	496
Combined	1.54	2.4	19.8	486	496

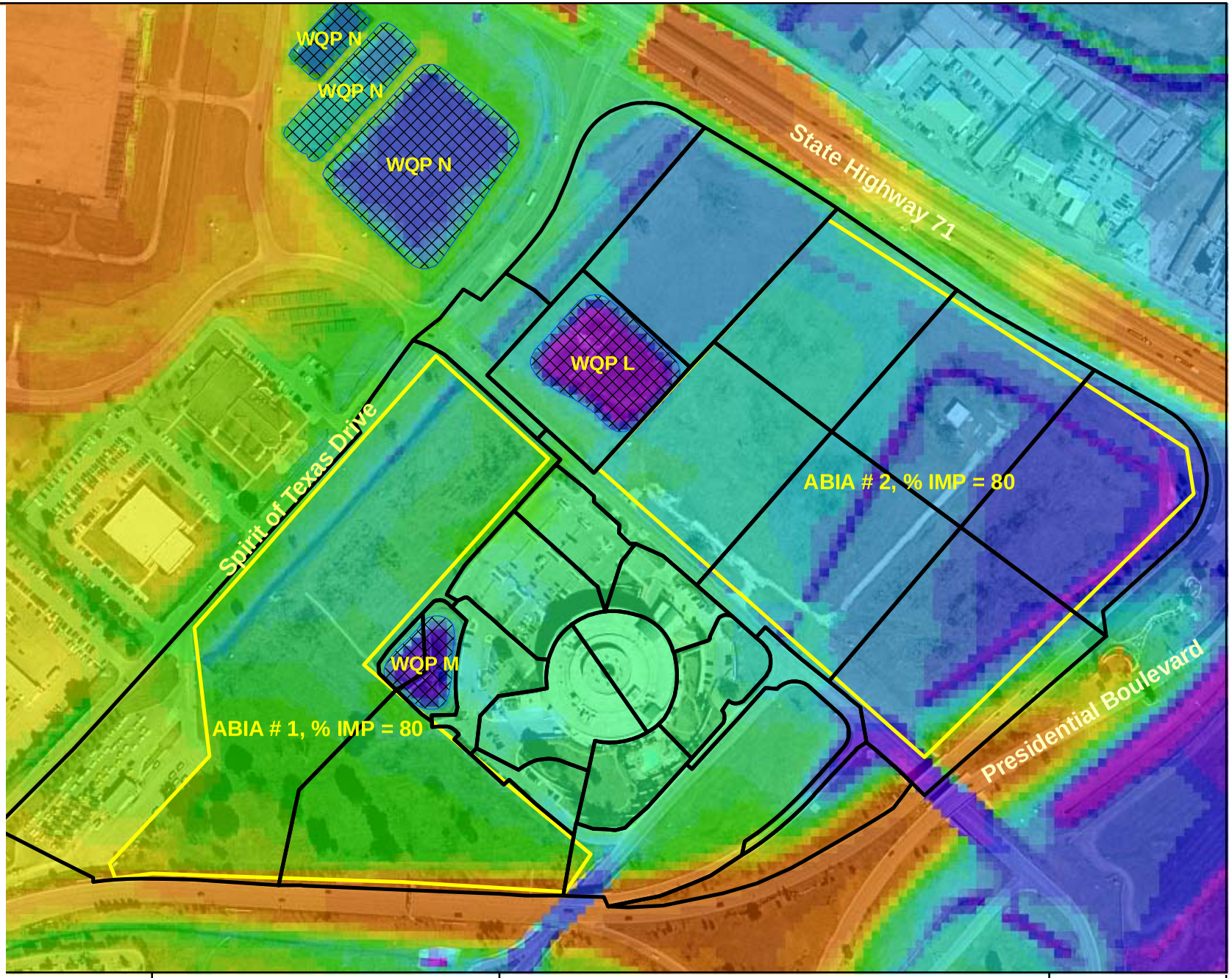
* For system WQP L, the existing area and volume has been subtracted from the total size after upgrade

Table 7-1(b). Proposed Basin Sizes

Basin 'PRJ1'	Bottom Area (ac)	Total Footprint (ac)	Volume (ac-ft)	Bottom Elevation (ft)	Top Elevation (ft)
WQ	0.19	0.45	1.4	489	500
Detention	0.18	0.83	5.0	487	498
Combined	0.37	1.28	6.4	487	500

Although the depth of the water quality basin for 'PRJ1' is over 10 feet, the peak depth for the 100-year storm is only 4.5 feet, so the additional volume is not used. It is possible that the area will be graded so this basin is not as deep. The basins do not necessarily need to be aligned in the configuration shown in Figure 7-4. The basin size and bottom inverts are more important than location and top elevation.

The existing system 'WQP L' currently employs two 5-HP pumps for a total of about 1000 gpm potential maximum discharge rate. It would take approximately 150 hours to empty this basin if it were to completely fill during a storm. Therefore, the pumps would need to be upgraded to three times the current capacity to empty the basin in approximately 48 hours (i.e. requiring four additional pumps of similar capacity). The pumps use an 8-inch force main to convey water for approximately 600 feet to the outfall.



Legend

Topography

Elevation (ft)

- 600 - 650
- 550 - 600
- 520 - 550
- 515 - 520
- 510 - 515
- 509 - 510
- 508 - 509
- 507 - 508
- 506 - 507
- 505 - 506
- 504 - 505
- 503 - 504
- 502 - 503
- 501 - 502
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- 492 - 493
- 491 - 492
- 490 - 491
- 485 - 490
- 480 - 485
- 475 - 480
- 450 - 475
- 425 - 450
- 400 - 425
- 392 - 400
- New HU Boundaries
- Future Development Areas
- ABIA Existing Systems

N W E S

0 75 150 300 450 600 Feet

Figure 7-3
Project Area 1 - Topography
Austin-Bergstrom International Airport (ABIA)
Stormwater Drainage Master Plan (SWMP) Update
Project No,: 4910-8107-3139

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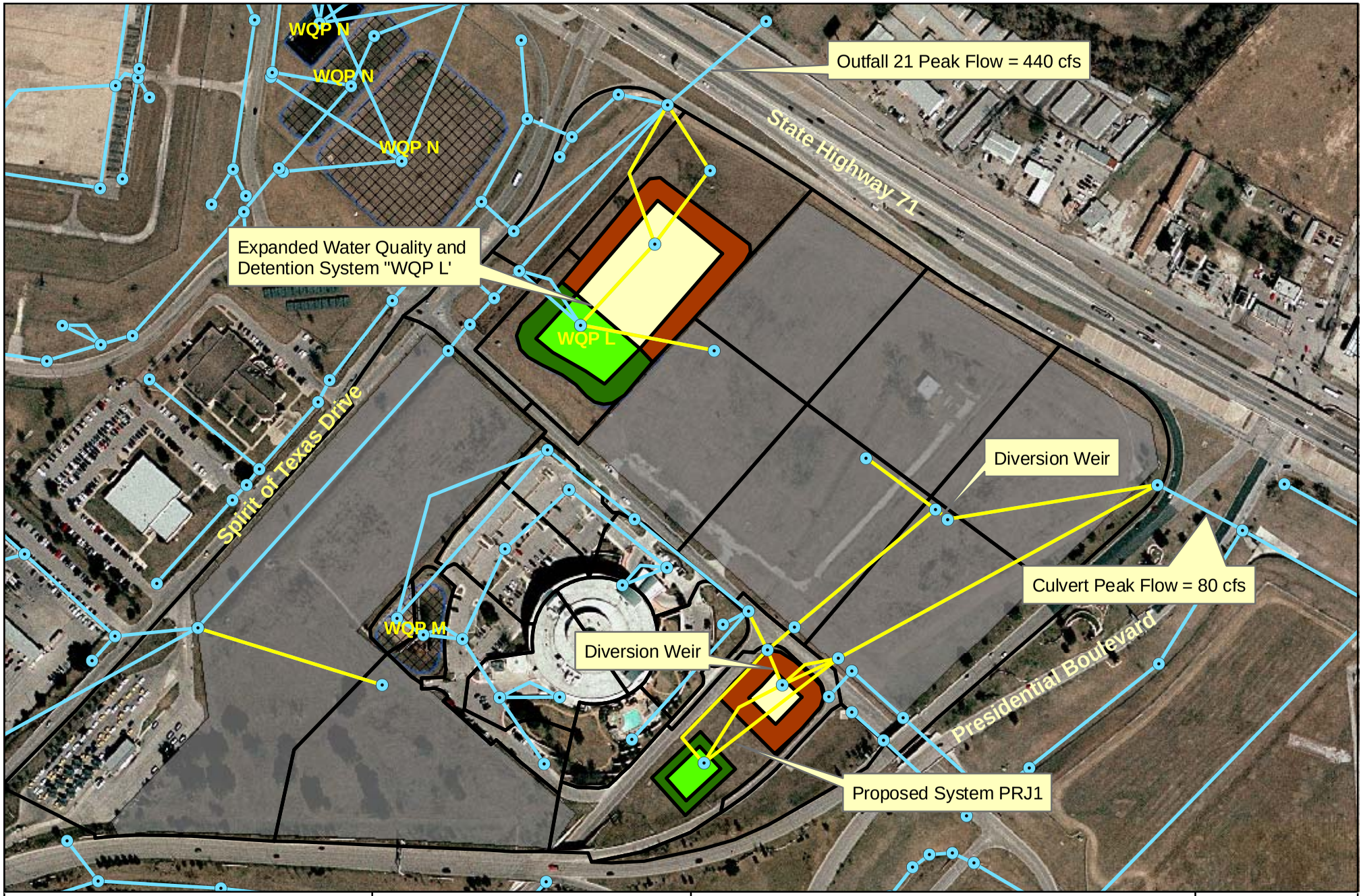


Legend

- Model Nodes
- Proposed Conveyance
- Existing Conveyance
- New HU Boundaries
- Future Development Areas
- ABIA Existing Systems

Proposed Systems

Top/Bot - Type

- WQ Basin Bottom
- Detention Bottom
- WQ Basin Top Area
- Detention Top Area

N W E S

0 75 150 300 450 600 Feet

Figure 7-4
Project Area 1 - Proposed Schematic
Austin-Bergstrom International Airport (ABIA)
Stormwater Drainage Master Plan (SWMP) Update
Project No,: 4910-8107-3139

CDM

This should be upgraded to a 12-inch diameter force main to allow for a similar head loss with the increased flow. It is likely the force main will be shorter because the proposed larger system is closer to the outfall, however, an 8-inch diameter force main would still be inadequate.

Other Project Components

In the following list of project components, only primary conveyance features have been added to the primary stormwater management system (PSMS). Secondary inlets and pipes that convey runoff from portions of the lot and development are modeled with the hydrologic elements of the parcels as equivalent flows. Since there is no design, it would be difficult to estimate exactly what the secondary system would be. There will be additional costs associated with these secondary systems; however, these costs should be considered part of the development costs. The costs for the major storage conveyance features were included in the following estimate.

- ABIA01_Drain02: Approximately 400 ft of 4-ft diameter pipe from the backside of ABIA Area No. 1 to the ditch along Spirit of Texas Drive. It is expected that the remainder of this area will have secondary pipes connecting directly to this ditch.
- An additional four 5-HP pumps with a design point for each pump of 24 feet of head at 500 gpm (not modeled) to complement the two existing pumps that drain system 'WQP L' (also not modeled).
- Up to 600 ft of 12-inch diameter force main (not modeled).
- NewPLPipe_01: Approximately 300 feet of 3-ft by 4-ft box culvert (or equivalent) from the parking lot median to an inlet for system 'WQP L'.
- NewPLPipe_02: Approximately 300 feet of 3-ft by 4-ft box culvert (or equivalent) from the parking lot median to the parking lot diversion weir (NewPLBypassWeir).
- NewPLBypassWeir: This parking lot diversion weir allows flows to bypass the water quality and detention basins ('PRJ1') at the peak of the most intense storms. This weir has been sized to pass approximately the same peak flow as the existing condition, while keeping the peak stage in the parking lot below the anticipated grade. The weir is a transverse weir, 10 ft in length with an invert 3 feet above the invert of the pipe to system 'PRJ1'.
- NewPLPipe_03: Approximately 400 feet of 3-ft by 5-ft box culvert (or equivalent) from the parking lot diversion weir (NewPLBypassWeir) to the culvert under Hotel Road.
- NewPLPipe_04: Approximately 100 feet of 3-ft by 5-ft box culvert (or equivalent). This is the culvert under Hotel Road to the diversion weir at system 'PRJ1'.

- Area01Weir02: This is the diversion weir at system 'PRJ1'. This weir allows flow to first go to the water quality basin, then to the detention basin. The weir is a transverse weir, 10 ft in length with an invert 2.5 feet above the invert of the pipe to the water quality basin.

- ICOB0360_InletPipe: Approximately 250 feet of 3-ft diameter pipe (or equivalent) from the diversion weir to the water quality basin 'PRJ1'.

- ICOB0360_WQ-out: This link in the model represents the water quality basin's under drain. It does not have enough capacity to affect peak stages and flows in the model. It is modeled as a 6-inch diameter pipe from the water quality basin 'PRJ1' to the collection junction on the north side of Hotel Road.

- ICOB0360_Outlet: Approximately 100 feet of 2-ft diameter pipe (or equivalent) from the detention basin 'PRJ1' to the collection junction on the north side of Hotel Road.

- NewPLPipe_05: Approximately 850 feet of 3-ft diameter pipe (or equivalent) from the collection junction on the north side of Hotel Road to the upstream end of the outlet culvert under Presidential Boulevard.

- NewPLBypass: Approximately 450 feet of 3-ft diameter pipe (or equivalent) from the parking lot diversion weir (NewPLBypassWeir) to the upstream end of the outlet culvert under Presidential Boulevard.

7.2.1.3 Model Results

The results of the simulation with the proposed detention and conveyance was that the peak flows through outfall No. 21 was 432 cfs, which is slightly less than in the existing condition, and that the 100-year peak flow through the culvert under Presidential Boulevard was 81 cfs, or approximately the same as in the existing condition.

Although peak stages did rise slightly onsite, none of the increases caused increased flooding, as they were still below grade at the peak. **Table 7-2** presents a list of the junctions in the model where increases occurred and a relevant indicator elevation at that point (generally ground, but for ditches and streams the indicator is bank elevation). The table also provides peak elevations for the proposed junctions, which are all below the likely grade of the new developments.

7.2.1.4 Water Quality

The sizes of the water quality basins for this project were developed in Section 4. The required sizes are 0.28 acre for the parking lot (ABIA Development Area No. 2), and 0.2 acres for the third party development (ABIA Development Area No. 1). Since one-third of the parking lot is to be treated in system 'WQP L' with the third party development, the values used were an additional 0.29 acre for System 'WQP L', and 0.19 acre for the new system 'PRJ1'. These capture volumes were developed using the half-inch criteria (Refer to Section 4).

Table 7-2. Relevant Peak Stages by Junction – Project 1

Junction	Peak Stage (ft)		Delta (ft)	Indicator Elev. (ft)	Description
	Existing	Proposed			
New Junctions					
ABIA01_Grate02	NA	500.9	NA	501.0	below expected grade
NewPLGrate_01	NA	495.9	NA	496.0	below expected grade
NewPLGrate_02	NA	495.5	NA	496.0	below expected grade
NewPLGrate_03	NA	494.5	NA	496.0	below expected grade
NewPLJunction_01	NA	493.8	NA	496.0	below expected grade
NewPLJunction_02	NA	493.7	NA	496.0	below expected grade
ICOB0360_WQ	NA	493.8	NA	500.0	below expected grade
ICOB0360_DP	NA	493.7	NA	500.0	below expected grade
NewPLjunct01	NA	490.8	NA	496.0	below expected grade
Existing Junctions					
ICOB0380	494.8	495.7	0.9	498.0	at hotel, but well underground
ICOC0060	497.2	497.4	0.2	500.0	below grade
JCOC0050	497.0	497.2	0.2	498.0	within ditch
JCOC0040	496.8	496.9	0.1	498.0	within ditch
ICOC0170	500.5	500.6	0.1	504.0	below grade
JCOC0070	500.4	500.5	0.1	501.0	within ditch
ICOC0175	500.5	500.6	0.1	502.0	below grade
ICOB0390	496.4	496.4	0.1	500.0	at hotel, but well below grade

The water quality control in the proposed alternative consists of enlarging the existing sedimentation/filtration system to provide the required water quality volume for both basin 'WQP L' and basin 'PRJ1'. The water quality volume also serves as part of the volume required for 2-year detention. Reducing the water quality volume required by the sedimentation/filtration system will not reduce the total detention volume and will therefore not reduce the overall size of the detention/water quality system.

The following water quality features were considered for this project:

- Batch Reactor. Construct Batch Reactor BMPs instead of sedimentation/filtration systems for 'WQP L' and basin 'PRJ1'. The proposed 'WQP L' is a pumped system and the pumps can be operated to convert the system to operate as a batch reactor (12-hour hold time and 48-hour drawdown time). Since 'WQP L' is pumped, the required additional water quality volume could be created by constructing a deeper basin through removal of the existing sand filter media and under-drain pipe system thus reducing the water quality footprint.
- Parking Lot Swales/Infiltration. The proposed model assumes that the 20 percent pervious surface is to be landscaped medians in ABIA Area No. 2. The soil in this area is predominately Type D (relatively low hydraulic conductivity). The parking lot swales could be used as water quality storage and routed to 'WQP L' and basin 'PRJ1'. Assuming that about half of the pervious area could be developed as swales and could be routed to the water quality basins, the average depth of the swales would be approximately 0.4 ft. The water quality volume of 'WQP L' could be reduced by 12,300 cf and the water quality volume of basin 'PRJ1" could be reduced

by 24,600 cf. Limited infiltration could additionally be calculated for the swales (using Type D soil parameters).

- While reducing the water quality volume does not reduce the overall basin size (since the 100-year detention is still required), it does reduce the size of the sand filter required in the sedimentation/filtration basin.

7.2.1.5 Conceptual Opinion of Probable Construction Cost

An Engineer's conceptual estimate of probable cost of construction has been developed for the proposed project facilities (Refer to Appendix F-1). The estimated cost for this project is $1,800,000, which is approximately $51,500 per acre of development. This cost is limited to the water quality, detention, and primary stormwater management facilities. Additional costs for grading and secondary conveyance facilities are likely, but dependant on final design.

7.2.2 Project Area No. 2

Figure 7-5 shows a site map of Project Area No. 2, which is composed of two parcels, each covering 9.8 acres for a total project area of 19.6 acres (ABIA Development Area Nos. 11 and 12) that may be developed in the near future. These parcels are adjacent to the east runway, north of the existing general aviation area and Water Quality Basin 'WQP D'. The site is bounded by the East Perimeter Road on the east, the apron area that includes Atlantic Aviation Support and the Raptor Hangar on the south, Emma Browning Avenue on the west and an empty lot to the north. The design for the developments is unknown at this time, but both are expected to be approximately 80 percent impervious within the boundaries displayed in Figure 7-5.

Stormwater flows leave the site through Outfall No. 16 to Onion Creek. Because this outfall is expected to be covered by the RSMP, peak flows were not detained on-site for the 100-year storm in the following proposed configuration. However, 2-year detention was confirmed as described below.

7.2.2.1 Model Setup - Hydrology

Figure 7-6 displays the topography for this project site. The color map of the topography DEM is set to one-foot increments over the range of elevations in this area. Re-delineation of the HUs was not necessary for this project, as all the HUs runoff toward the proposed facilities. For the proposed alternative model in the footprint of the development areas, the HUs were converted from mostly pervious open land to 80 percent impervious areas. Total imperviousness by HU was area weighted between these areas and the existing imperviousness in the remaining areas.

7.2.2.2 Model Setup - Hydraulics

The plan for this project area was to route the stormwater to a new water quality basin (sized in Section 4), and then use the existing capacity in the Detention Basin 'WQP D' to further attenuate flows. The goal was to not allow any increases in peak stage in other areas of the airport where flooding is expected to occur for the laO-year design storm.

There are existing ditches that run along the southern edge of the development site. It is possible that this ditch will remain, but to be conservative, this conveyance has been evaluated as underground pipes.

There is a large pile of material that covers approximately one-third of the project site. It is assumed that this will be removed prior to the development of this site; however, this mound does not affect the model simulations for this project.

The expected grading of the site may remove existing storage in the lower elevations next to the East Perimeter Road. This possible removal of existing storage has been accounted for in the model by removing storage elements. The proposed project basins need to account for this (and any other) loss of existing floodplain storage.

Water Quality Basin

Figure 7-7 shows a schematic of the proposed alternative for this project. Two water quality basins are presented in this figure; however, the northern basin is an alternative if the chosen location is unacceptable. Water quality basin 'PRJ2' represents the proposed basin for this project. It is located onsite, in a similar manner as the existing system 'WQP D'. This location is ideal as it represents the topographic low of the area and due to the proximity to existing conveyance facilities. However, if it is deemed unacceptable to use this portion of the development for a water quality basin, the northern alternative may be used. In the case of the northern alternative ('PRJ2Alt'), the basin needs to be deeper because of topography, and the conveyance pipes to and from the facility would need to be longer and bigger. The northern alternative is not preferred by DOA.

Basin 'PRJ2' is sized for water quality; with a 0.58 acre bottom area (both ABIA Development Area Nos. 11 and 12 require 0.29 acre of treatment as determined in Section 4). For this basin, the design is similar to existing water quality basins at the airport.

There is a diversion weir at the junction where water enters the basin to the existing conveyance facilities (including system 'WQP D'). The weir crest is set 4.0 feet higher than the invert of the pipe that flows directly to the water quality basin. Thus, under normal flow conditions, water flows to the water quality basin until full, and then it flows to the existing PSMS.

Proposed facility attributes are a basin bottom of 0.58 ac, total footprint of 1.1 ac, bottom elevation of 470 ft and top elevation of approximately 477 ft. Additional detention is not required for the 100-year storm due to the expected participation in the RSMP and the results presented below. For the 2-year storm, the peak depth in this basin is simulated as approximately 6 feet. This is higher than the design depth for water quality treatment; therefore, the under drain should be designed such that the basin drains completely in 48 hours.

Other Project Components

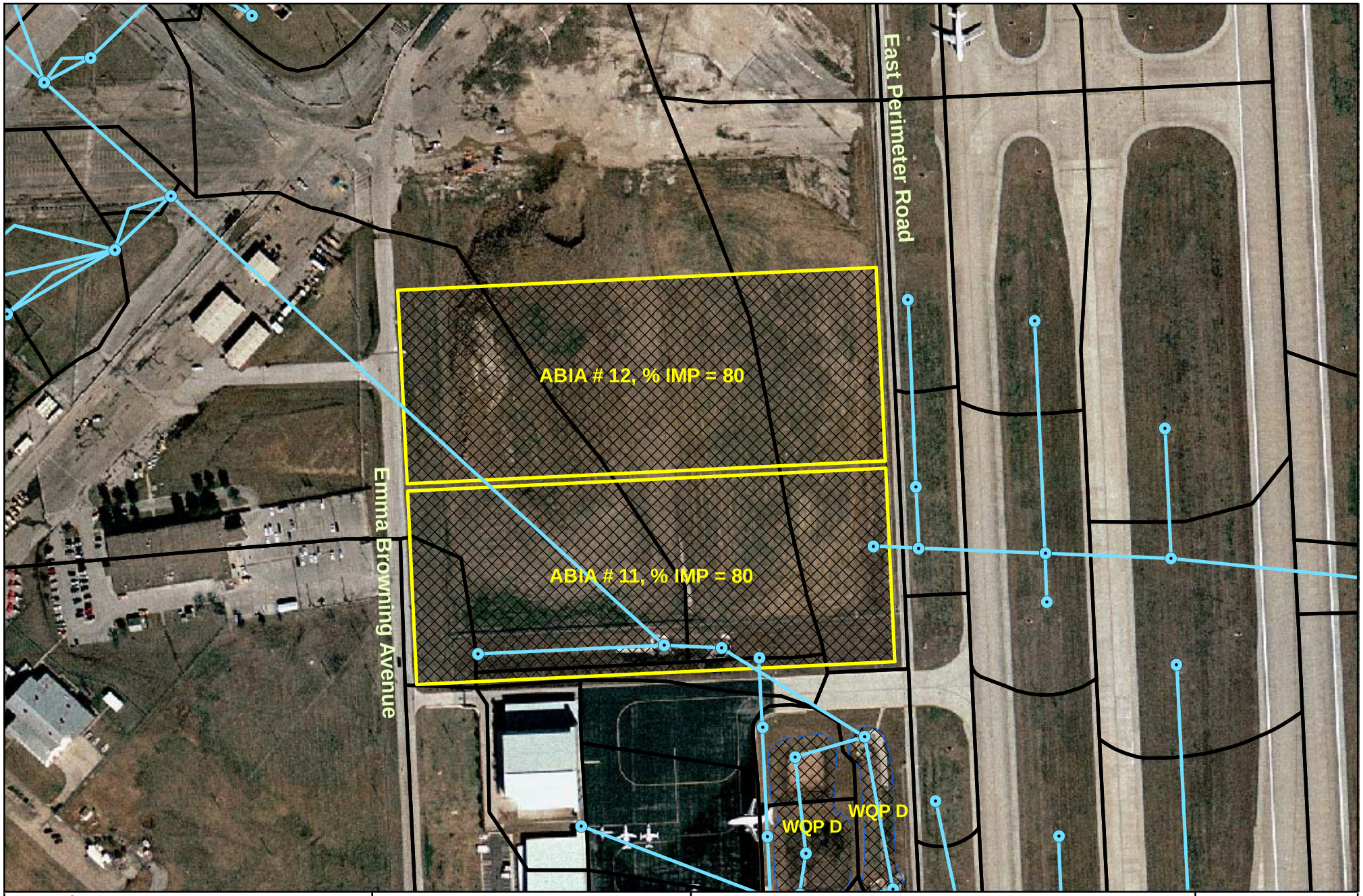
In the following list of project components, only primary conveyance features have been added to the PSMS. Secondary inlets and pipes that convey runoff from portions of the developments are modeled with the hydrologic elements of the parcels as equivalent flows. Since there is no design, it would be difficult to estimate exactly what the secondary system would be. There will be additional costs associated with these secondary systems; however, these costs should be considered part of the development costs. The costs for the major storage and conveyance features were included in the following estimate.

- PONH0015: Approximately 130 ft of 7-ft diameter pipe (or equivalent). This is an extension of existing pipe PONH0010 to the junction IONI1120 (the headwall of the triple 6-ft diameter pipes to system 'WQP D'). This short extension replaces an existing ditch.
- Area2_Pipe01: Approximately 460 ft of 2-ft diameter pipe from SubCatchIONI1130 to Area2_inlet02. This replaces an existing ditch.
- Area2_pipe02: Approximately 170 feet of 4-ft diameter pipe (or equivalent) from Area2_inlet02 to the diversion weir (Area2_weir02).
- Area2_weir02: This is the diversion weir at Basin 'PRJ2'. This weir allows flow to first go to the water quality basin, then to existing conveyance facilities including detention basin 'WQP D'. The weir is transverse, 15 ft in length with an invert 4.0 feet above the invert of the pipe to the water quality basin.
- Area2_pipe03: Approximately 50 feet of 4-ft diameter pipe (or equivalent) from the diversion weir to the water quality basin 'PRJ2'.

7.2.2.3 Model Results

The results of the simulation with the proposed detention and conveyance was that the peak flows through outfall No. 16 was 812 cfs for the 2-year design storm, which is slightly less than in the existing condition (818 cfs).

Although peak stages did rise slightly onsite, none of the increases caused increased flooding, as they were still underground at the peak. **Table 7-3** presents a list of the junctions in the model where increases occurred and a relevant indicator elevation at that point (generally ground, but for ditches and streams the indicator is bank elevation). The table also provides peak elevations for the proposed junctions, which are all below the likely grade of the new developments.



Legend

- Model Nodes
- Existing Conveyance
- Existing HUs
- ABIA Existing Systems
- Future Development Areas

N W E S

0 65 130 260 390 520 Feet

Figure 7-5
Project Area 2 - Site Map
Austin-Bergstrom International Airport (ABIA)
Stormwater Drainage Master Plan (SWMP) Update
Project No,: 4910-8107-3139

CDM

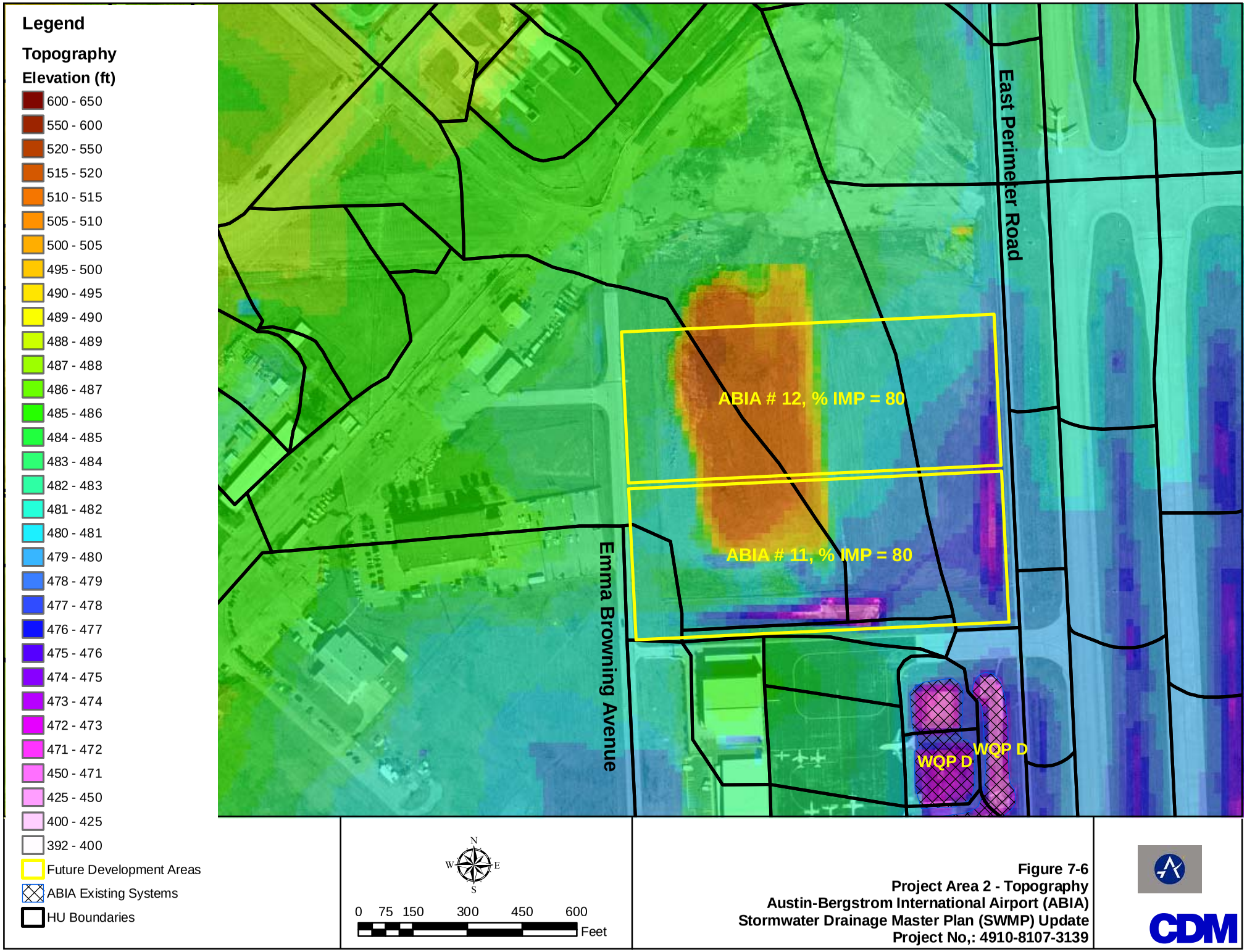


Figure 7-6
Project Area 2 - Topography
Austin-Bergstrom International Airport (ABIA)
Stormwater Drainage Master Plan (SWMP) Update
Project No,: 4910-8107-3139

CDM

Legend

- Model Nodes
- Proposed Conveyance
- Existing Conveyance
- HU Boundaries
- Future Development Areas
- ABIA Existing Systems

Proposed WQ Basins

Top/Bottom

- Basin Bottom
- Basin Top Area

N W E S

0 62.5 125 250 375 500 Feet

Figure 7-7
Project Area 2 - Proposed Schematic
Austin-Bergstrom International Airport (ABIA)
Stormwater Drainage Master Plan (SWMP) Update
Project No,: 4910-8107-3139

CDM

Table 7-3. Relevant Peak Stages by Junction – Project 2

Junction	Peak Stage (ft)		Delta (ft)	Indicator Elev. (ft)	Description
	Existing	Proposed			
New Junctions					
Area2_inlet01	NA	479.2	NA	480.0	below expected grade
Area2_inlet02	NA	478.7	NA	480.0	below expected grade
Area2_inlet03	NA	477.4	NA	480.0	below expected grade
WQBasinArea2	NA	477.3	NA	480.0	below expected grade
Existing Junctions					
IONH0010	471.4	472.4	0.9	468.0	ditch will be removed with re-grading
IONI1120	470.6	471.1	0.5	468.0	ditch will be removed with re-grading
IONI0570	467.0	467.4	0.4	476.0	below grade
JONI0560	467.8	468.3	0.4	478.9	below grade
IONI0020	468.6	469.0	0.4	477.0	existing detention storage - below berm elevation
JONI1140	468.7	469.1	0.4	480.0	below grade
JONI1110	469.3	469.7	0.4	478.0	existing detention storage - below berm elevation
JONI0580	465.7	466.1	0.4	476.1	below grade
IONI0590	464.3	464.5	0.2	470.0	below stream bank
IONT0099	458.8	459.0	0.2	474.0	below stream bank
IONT0098	455.6	455.8	0.2	471.0	below stream bank
IONI0591	462.9	463.1	0.2	476.0	below stream bank
IONI0593	460.8	461.0	0.2	472.0	below stream bank
JONI0650	466.8	467.0	0.1	472.3	below grade
IONT0106	440.9	441.0	0.1	454.0	below stream bank
IONT0103	437.9	438.0	0.1	454.0	below stream bank
IONT0100	452.0	452.1	0.1	454.0	below stream bank
IONT0104	433.5	433.6	0.1	454.0	below stream bank
IONT0101	446.7	446.7	0.1	454.0	below stream bank
JONT0105	428.4	428.4	0.1	454.0	below stream bank
IONT0097	451.9	451.9	0.1	464.0	below stream bank
IONT0096	451.8	451.9	0.1	468.0	below stream bank
IONT0102	442.1	442.2	0.1	454.0	below stream bank

7.2.2.4 Water Quality

The sizes of the water quality basins for this project were developed in Section 4. The required sizes are 0.29 acre for ABIA Development Area No. 11 and 0.29 acre for ABIA Development Area No. 12. These detention sizes were developed using the half-inch plus criteria (Refer to Section 4).

If the 2-year detention option is selected, a single basin can serve as both the water quality control and the 2-year detention facility for Project Area 2. In this case, reducing the water quality volume will not result in a smaller combined facility. Therefore, other water quality BMPs such as the batch reactor or reducing the water quality volume do not provide significant cost savings.

If erosion control is selected in place of 2-year detention, reduction in the water quality volume provides more opportunities for cost savings. The following options could be

used to reduce the water quality volume thereby reducing the footprint of the water quality control.

- Vegetative Filter Strips. The two development projects in this area, ABIA Project Area No. 11 and ABIA Project Area No. 12 are airside apron areas. Runoff from the apron fringes could be treated by vegetative filter strips. The east side of the two project areas is the best suited for filter strips due to the topography of the site. A filter strip with dimensions of 25-ft length and 830-ft width (total area of 20,750 sq ft) could be placed along the east side of these two development areas. This would reduce the water quality volume required in the sedimentation/filtration system from 1.80 ac-ft to 1.68 ac-ft. A loading analysis incorporating the 100 percent removal efficiency of vegetative filter strips could reduce the required water quality volume of the sedimentation/filtration basin even further.

- Batch reactor. The sedimentation/filtration basin could be converted to a batch reactor. The batch reactor requires an equivalent water quality volume as the sedimentation/filtration basin and could provide hazardous material trap functionality. A pumped batch reactor system allows the basin to be constructed deeper and thereby reduce the basin footprint (up to 50 percent).

- Rainwater harvesting. Rainwater harvesting could be installed on the buildings that are part of this development. Reduction in the sedimentation/filtration water quality volume resulting from a rainwater harvesting system would be similar to that of the vegetative filter strip as described above.

7.2.2.5 Conceptual Opinion of Probable Construction Cost

An Engineer's conceptual estimate of probable cost of construction has been developed for the proposed project facilities (Refer to Appendix F-2). The estimated cost for this project is $520,000, which is approximately $26,500 per acre of development. This cost is limited to the water quality and primary conveyance facilities. Additional costs for grading and secondary conveyance facilities are likely but dependant on final design.

7.2.3 Project Area No. 3

Figure 7-8 shows a site map of Project Area No. 3, which is for ABIA Development Area No. 13 (42.5 ac) that may be developed in the near future. The site is adjacent to the east runway, bounded by the East Perimeter Road on the east, Emma Browning Avenue on the west, the unnamed tributary to Onion Creek on the south, and the general aviation area on the north (near the General Aviation Apron, the T-Hangars, Temple Inland, and Water Quality Basin 'WQP C'). The design for the development is unknown at this time, but is expected to be approximately 90 percent impervious within the boundaries displayed in Figure 7-8. Stormwater flows leave the site through the unnamed tributary to Onion Creek. For the purposes of this SWMP update, this outfall is labeled Outfall No. 15, although it is only near ABIA Outfall No. 15 (Refer to Section 6). Because this

outfall is expected to be covered by the RSMP, peak flows were not detained on-site for the 100-year storm in the following proposed configuration. However, 2-year detention was confirmed as described below.

7.2.3.1 Model Setup - Hydrology

Figure 7-9 displays the topography for this project site. The color map of the topography DEM is set to one-foot increments over the range of elevations in this area. Because the HUs in the existing configuration contain both banks of the stream, it was necessary to re-delineate the HUs into pervious and impervious parcels. The impervious HUs were set at 90 percent impervious cover, while the remaining portions were nearly 0 percent impervious. The areas, flow path lengths and slopes were recalculated for each new HU.

7.2.3.2 Model Setup - Hydraulics

The plan for this project area was to route the stormwater to a new water quality basin (sized in Section 4) prior to outfall to the stream. The goal was to not allow any increases in peak stage in other areas of the airport where flooding is expected to occur for the 100-year design storm.

Water Quality Basin

Figure 7-10 shows a schematic of the proposed alternative for this project with the water quality basin located near the existing stream. Basin 'PRJ3' is sized for water quality, with a 1.38 acre bottom area. For this basin, the design is similar to existing water quality basins at the airport. The attributes of basin 'PRJ3' are: basin bottom of 1.38 ac, total footprint of 2.1 ac, bottom elevation of 463 ft and top elevation of approximately 470 ft. Additional detention is not required for the 100-year storm due to the expected participation in the RSMP and the results presented below. For the 2-year storm, the peak depth in this basin is simulated as approximately 5.3 feet. This is higher than the design depth for water quality treatment; therefore, the under drain should be designed such that the basin drains completely in 48 hours.

Other Project Components

In the following list of project components, only primary conveyance features have been added to the PSMS. Secondary inlets and pipes that convey runoff from portions of the developments are modeled with the hydrologic elements of the parcels as equivalent flows. Since there is no design, it would be difficult to estimate exactly what the secondary system would be. There will be additional costs associated with these secondary systems; however, these costs should be considered part of the development costs. The costs for the major conveyance features will be included in the following estimate.

- Area03_pipe01: Approximately 500 ft of 2.5-ft diameter pipe from SubCatchIONR0270B to Area03_inlet02.
- Area03_pipe02: Approximately 300 ft of 4.0-ft diameter pipe from Area03_inlet02 to Area03_inlet03.

- Area03_pipe03: Approximately 280 ft of 4.0-ft diameter pipe from Area03_inlet03 to Area03_inlet04, which represents the collection junction just upstream of the water quality basin.
- Area03_pipe06: Approximately 200 ft of 3.0-ft diameter pipe from SubCatchIONK0440B to Area03_inlet05.
- Area03_pipe05: Approximately 380 ft of 4.0-ft diameter pipe from Area03_inlet05 to Area03_inlet04, which represents the collection junction just upstream of the water quality basin.
- Area03_pipe04: Approximately 50 ft of 4.0-ft diameter pipe from Area03_inlet04 to the water quality basin.

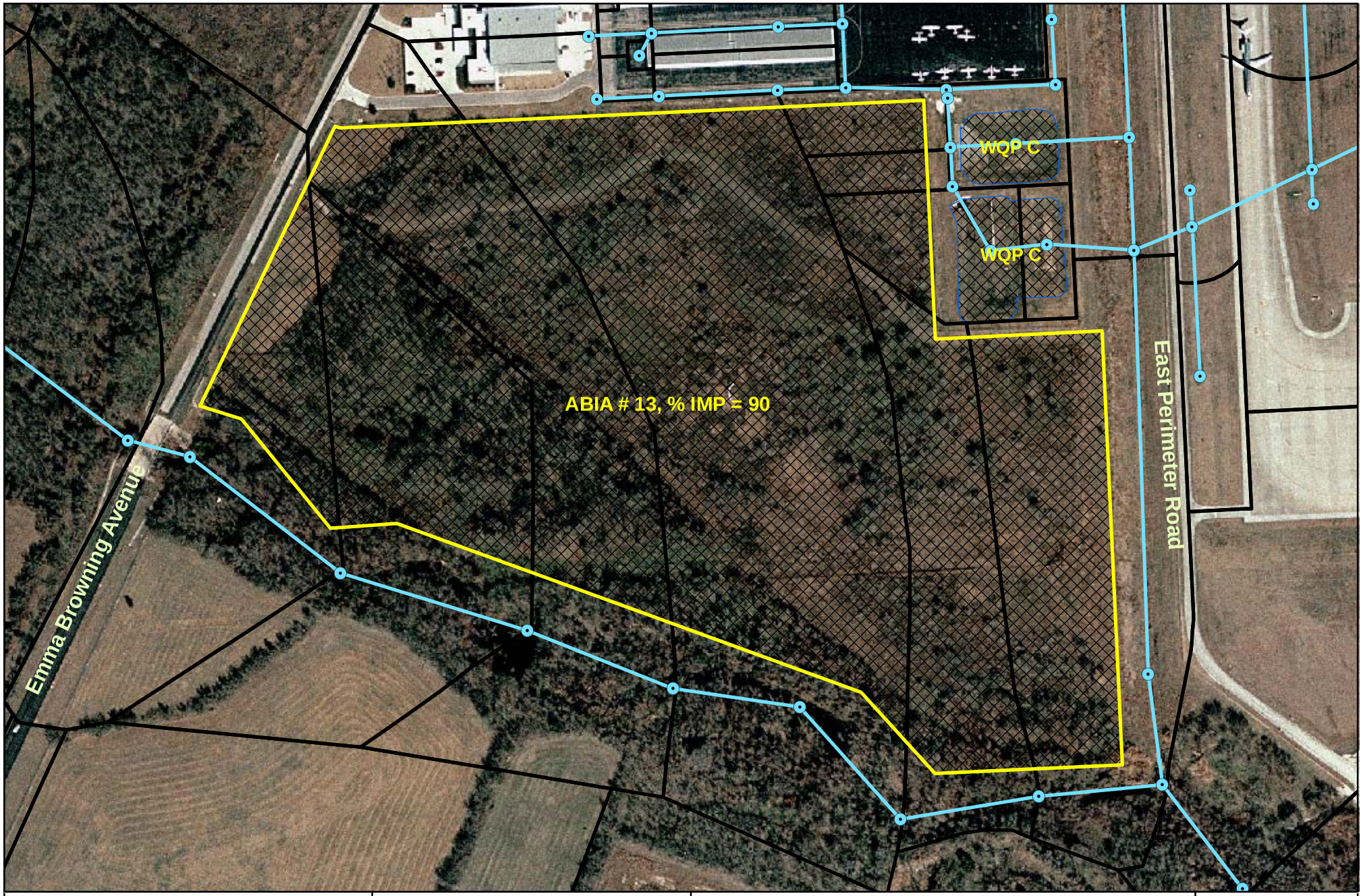
7.2.3.3 Model Results

The result of the simulation with the proposed detention and conveyance was that the peak flows through outfall No. 15 was 211 cfs for the 2-year design storm, which is equal to the existing condition.

Although peak stages did rise slightly onsite (up to 0.6 ft), none of the increases caused increased flooding, as they were still well below the banks of the stream at the peak. **Table 7-4** presents a list of the junctions in the model where increases occurred and a relevant indicator elevation at that point (generally ground, but for ditches and streams the indicator is bank elevation). The table also provides peak elevations for the proposed junctions, which are all below the likely grade of the new developments.

Table 7-4. Relevant Peak Stages by Junction – Project 3

Junction	Peak Stage (ft)		Delta (ft)	Indicator Elev. (ft)	Description
	Existing	Proposed			
New Junctions					
Area03_inlet01	NA	472.1	NA	472.0	at expected grade
Area03_inlet02	NA	471.6	NA	472.0	below expected grade
Area03_inlet03	NA	471.1	NA	472.0	below expected grade
Area03_inlet04	NA	469.1	NA	472.0	below expected grade
Area03_inlet05	NA	470.7	NA	472.0	below expected grade
Area03_inlet06	NA	471.4	NA	472.0	below expected grade
Existing Junctions					
JONR0295	453.2	453.7	0.6	464.0	below Stream Bank
IONR0330	445.2	445.7	0.5	461.0	below Stream Bank
IONR0320	445.4	445.9	0.5	462.0	below Stream Bank
IONK0440	448.7	449.2	0.5	462.0	below Stream Bank
IONR0350	442.8	443.3	0.5	460.0	below Stream Bank
IONR0300	451.1	451.6	0.5	462.0	below Stream Bank
IONR0310	449.9	450.4	0.5	462.0	below Stream Bank
IONR0340	444.4	444.8	0.5	461.0	below Stream Bank
IONR0360	437.5	437.8	0.3	460.0	below Stream Bank
JONR0205	429.1	429.4	0.3	460.0	below Stream Bank
JOND0340	485.7	485.8	0.2	499.0	below Stream Bank



Legend

- Model Nodes
- Existing Conveyance
- Existing HUs
- ABIA Existing Systems
- Future Development Areas

N W E S

0 62.5 125 250 375 500 Feet

Figure 7-8
Project Area 3 - Site Map
Austin-Bergstrom International Airport (ABIA)
Stormwater Drainage Master Plan (SWMP) Update
Project No,: 4910-8107-3139

CDM

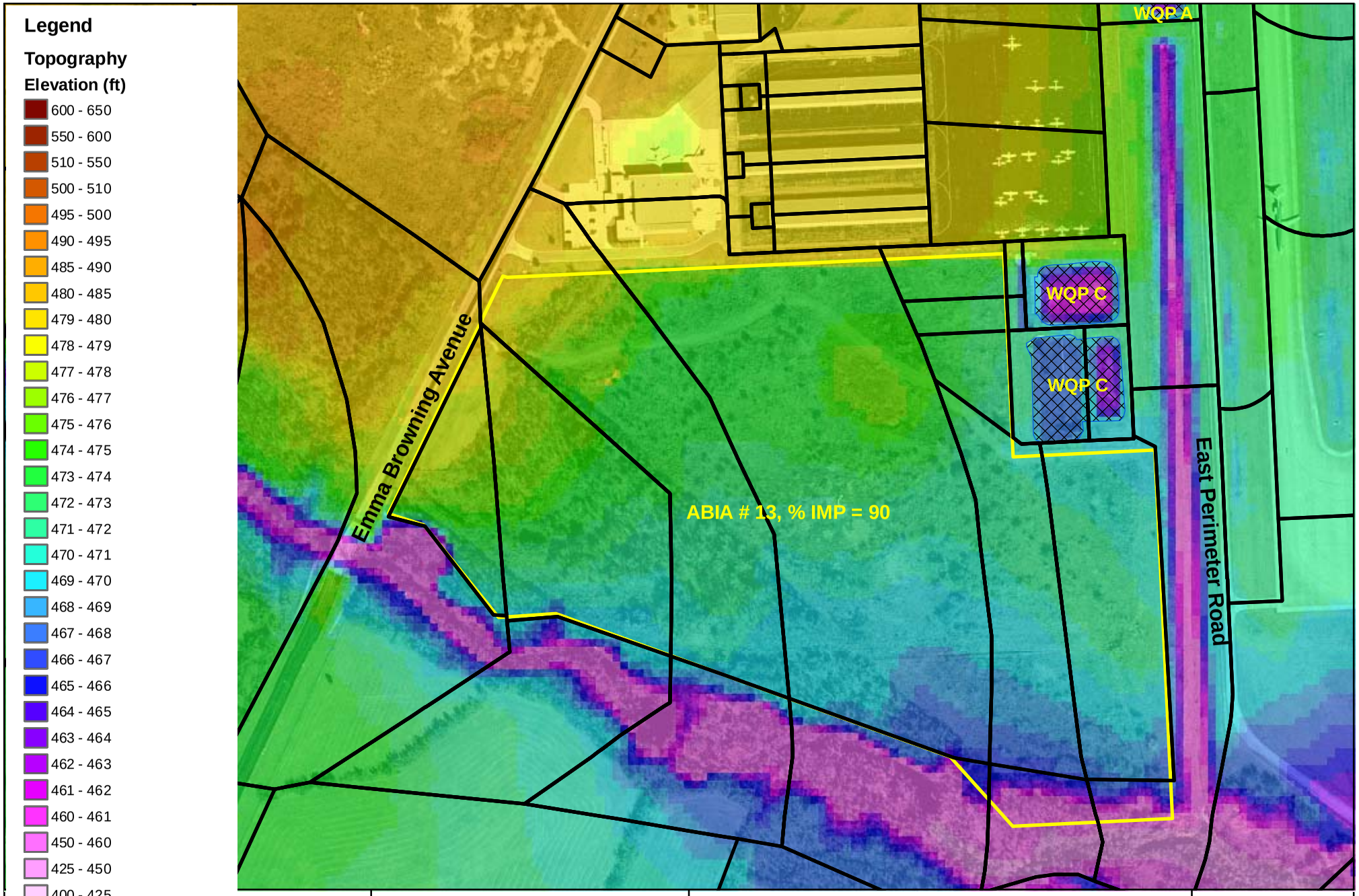
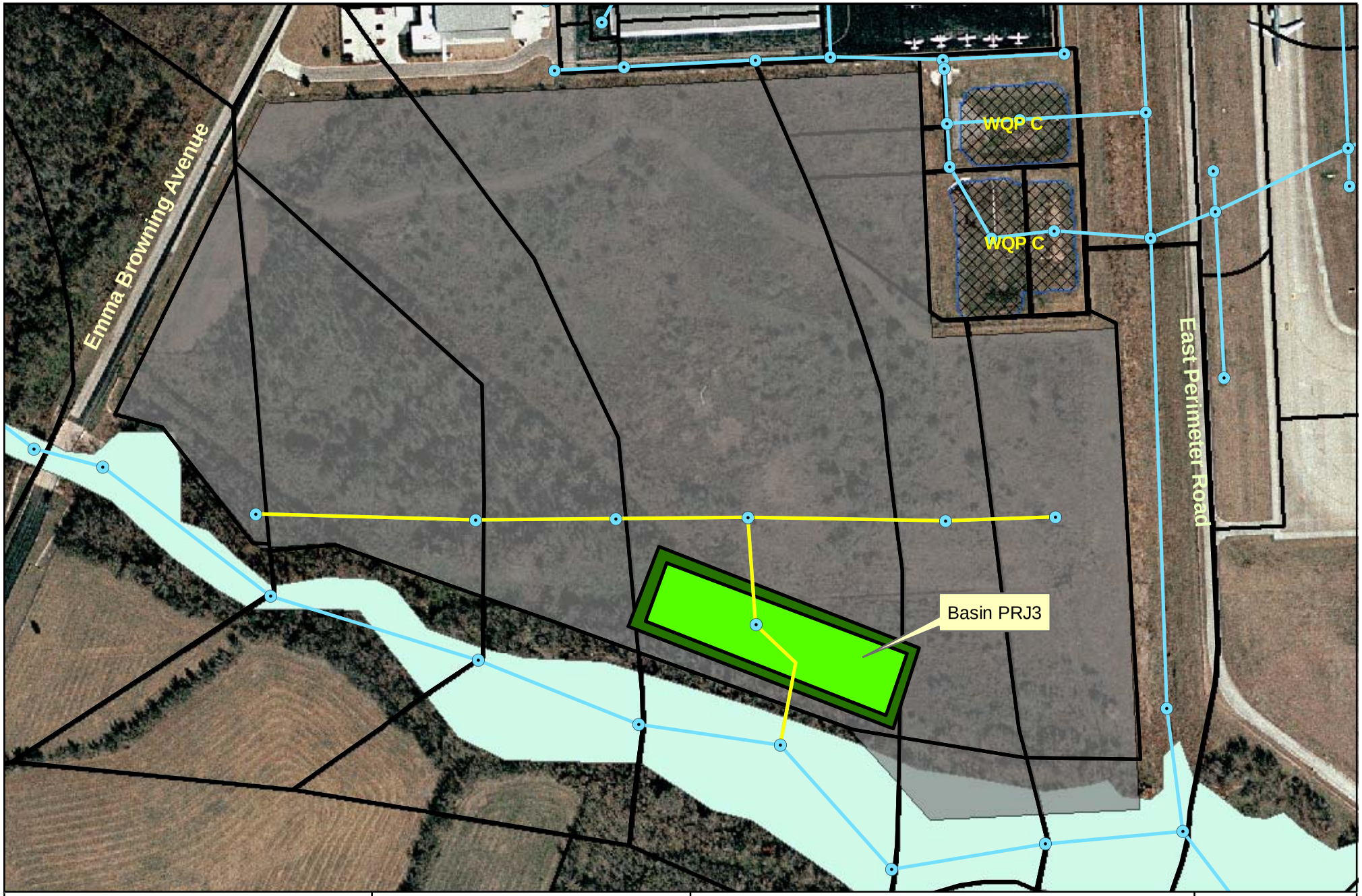


Figure 7-9
Project Area 3 - Topography
Austin-Bergstrom International Airport (ABIA)
Stormwater Drainage Master Plan (SWMP) Update
Project No,: 4910-8107-3139

CDM



Legend

- Model Nodes
- Proposed Conveyance
- Existing Conveyance
- HU Boundaries
- Future Development Areas
- ABIA Existing System
- 100-yr Flood Extent

Proposed WQ Basins

Top/Bottom

- Basin Bottom
- Basin Top Area

N W E S

0 62.5 125 250 375 500 Feet

Figure 7-10
Project Area 3 - Proposed Schematic
Austin-Bergstrom International Airport (ABIA)
Stormwater Drainage Master Plan (SWMP) Update
Project No,: 4910-8107-3139

CDM

7.2.3.4 Water Quality

The size of the water quality basin for this project was developed in Section 4. The required size is 1.38 acre for ABIA Development Area No. 13. The detention size was developed using the half-inch plus criteria (Refer to Section 4).

If the 2-year detention option is selected, a single basin can serve as both the water quality control and the 2-year detention facility for Project Area 3. In this case, reducing the water quality volume will not result in a smaller combined facility. Therefore, other water quality BMPs such as the batch reactor or reducing the water quality volume do not provide significant cost savings.

Project Area 3 is located in the southern portion of ABIA near the 100-year floodplain of Onion Creek. Floodplain fringe areas are good candidates for the irrigation areas used in retention/irrigation systems. Using a retention/irrigation system in this area would result in a smaller overall water quality basin. The irrigation area required is approximately 4.25 acres (0.1 acres of irrigation area for each 1 acre of drainage area at 80 percent impervious cover). The higher removal rate of retention irrigation could be used to offset areas with limited or no treatment.

If erosion control is selected in place of 2-year detention, reduction in the water quality volume provides more opportunities for cost savings. The following options could be used to reduce the water quality volume thereby reducing the footprint of the water quality control.

- Filter Strips. Assuming that 1,500 feet of filter strips with a 25-foot length could be installed in this development area would reduce the require water quality volume of the sedimentation/filtration basin from 4.25 ac-ft to 4.01 ac-ft. A loading analysis incorporating the 100 percent removal efficiency of vegetative filter strips could reduce the required water quality volume of the sedimentation/filtration basin even further.

- Batch Reactor. A batch reactor could be used in place of the sedimentation/filtration basin. The batch reactor requires an equivalent water quality volume as the sedimentation/filtration basin and could provide hazardous material trap functionality. A pumped batch reactor system allows the basin to be constructed deeper and thereby reduce the basin footprint.

- Vegetative Swales. Vegetated swales could be implemented between the adjacent roads and development to provide treatment and conveyance.

7.2.3.5 Conceptual Opinion of Probable Construction Cost

An Engineer's conceptual estimate of probable cost of construction has been developed for the proposed project facilities (Refer to Appendix F-3). The estimated cost for this project is $910,000, which is approximately $21,400 per acre of development. This cost is

limited to the water quality and primary conveyance facilities. Additional costs for grading and secondary conveyance facilities are likely but dependant on final design.

7.3 Airport-Wide, Long-Term Alternatives

In this section, the airport-wide, long-term alternatives are discussed and opinions of probable costs are provided for each alternative.

7.3.1 Alternative No. 1 - RSMP Participation in the Onion Creek Watershed

Alternative No. 1 Consists of:

- Participation in the RSMP program for all development in the Onion Creek drainage basin. In this alternative, RSMP participation replaces the need for detention of the 100-year storm within the Onion Creek watershed.
- Water Quality Treatment. These facilities are the same for all alternatives.
- Onsite detention for facilities constructed within the Carson Creek and Colorado River drainage basins. These facilities are the same for all alternatives.
- Erosion protection as described below in Alternatives No. 1a and No. 1b.

7.3.1.1 Erosion Control Alternatives

If the DOA chooses to participate in the RSMP in the Onion Creek Watershed, it must also provide stormwater facilities and/or improvements to control erosion for the smaller, more frequent storms. The two erosion control alternatives considered for this report include:

1. Alternative No. 1a: RSMP with 2-Year Onsite Detention
2. Alternative No. 1b: RSMP with Channel Improvements to Provide Non-Erodible Conveyance to Onion Creek

Alternative No. 1a consists of the items included in Alternative No. 1 described above plus erosion control via 2-year onsite detention. Alternative No. 1b consists of the items included in Alternative No. 1 described above plus erosion control via outlet channel repair and bank stabilization.

As a practical application, ABIA may choose to use 2-year detention for some new development and channel improvements for others. Considerations for comparing erosion control alternatives include the following:

- Erosion control alternatives should be evaluated on a case-by-case basis at the time of design development.

- A potentially significant advantage of channel improvements over 2-year onsite detention is that channel repair and stabilization occupies no space on the development parcel.

- The modeling in Sections 6 and 7 indicate that in many areas, the 2-year design storm is detained onsite with the new water quality controls (or by minor increases in size of the water quality controls). For sites where this is the case, the 2-year detention would likely be significantly less expensive than channel improvements with little or no impact on the overall footprint of stormwater facilities.

- The DCM allows for offsite erosion control of the 2-year storm if non-erodible channels are used from the development to the offsite control. This recommendation is contingent on both Onion Creek and the Colorado River being considered "offsite control". Although not specifically listed in the DCM, these water bodies should be considered offsite control near this project site, because increases in peak flow at this location would not affect the peak flow or flood stage of either body. Non-erodible channels are channels that are either concrete lined, or grass-lined with lower peak velocities. As discussed in Section 6.5.4, many of the outfalls from ABIA would need to be upgraded to meet this definition.

- In Section 6.5.2.4, it was estimated that two relatively large 2-year detention facilities would be required to augment the new water quality basins in the Onion Creek Watershed. Combined, these two facilities cover 3.5 acres and are expected to cost approximately $1,221,000.

- In Section 6.5.3.3, opinions of probable costs for channel improvements required for erosion control to mitigate future development were developed for improvements within the Onion Creek Watershed; they range from $2,323,000 to $4,945,000 (the higher amount if gabions are used).

The decision for which erosion control alternative to use should be made on a case-by-case basis at the time of design development. For example, in the ultimate build-out land use condition, there is a proposed cargo area adjacent to the west runway near Outfall No. 8 to Onion Creek (refer to Development Area 27 on Figure 3-3). Although the development may not occur for decades, it is expected that when it does, the existing ditch to Outfall No. 8 would be converted to an underground box culvert or to a rectangular concrete channel, to maximize the developable cargo area. If design were to advance in this manner, then channel improvements would likely be much more cost effective than 2-year onsite detention because a large portion of the channel improvement would be inherent to the project design. Additional channel work would likely only entail a stilling basin between Burleson Road and Onion Creek in this case. Also, the site designer would have the flexibility of looking at alternative water quality solutions (i.e., infiltration) that could further reduce the water quality control footprint for this development.

7.3.1.2 Advantages and Disadvantages of RSMP Participation

There are significant advantages of RSMP participation, including the following:

- RSMP participation minimizes the size and footprint of on-site stormwater detention facilities at ABIA, which makes more of the airport property available for development when compared with onsite detention facilities. As estimated in Section 6.5, approximately 100 acres of land would be required for onsite detention within the Onion Creek drainage basin if DOA does not participate in the RSMP.

- RSMP participation may be cheaper than onsite detention facilities, depending on the final rate structure and fee agreed upon and the timing of both fee payment and development onsite.

- RSMP, in conjunction with some of the alternative water quality approaches discussed in this report can provide a better, holistic solution that minimizes the overall footprint of stormwater facilities. For example, there are some opportunities to reduce the overall footprint of water quality facilities by providing solutions that combine infiltration with sedimentation/filtration. For areas that participate in RSMP, this footprint reduction is directly applied to the site stormwater facility footprint. However, if the same water quality solution is implemented in an area without RSMP, there is minimal reduction in the overall stormwater facility footprint at that site because decreases in water quality volume are offset by resultant increases in detention volume.

- There is more benefit to the surrounding community and the Onion Creek watershed. It was shown in Section 5 that peak flows in Onion Creek are not impacted by peak flows from ABIA; therefore, more benefit can be realized on a watershed basis by providing funding to support needed regional facilities rather than paying to construct onsite facilities.

- DOA might be able to receive a credit towards the RSMP fee if it implements erosion control measures in the outlet channels.

Disadvantages of RSMP participation may include the following:

- The potential for increased erosion within ABIA outlet channels due to lack of onsite detention. This could lead to costs associated with additional channel rehabilitation and reinforcement and increased operations and maintenance costs.

- Uncertainty in the pricing of participation in RSMP, especially with the uncertainty of the timing and extent of development at ABIA, which may result in payment of RSMP before actual project development. (Note that at the time of this report the fee structure and payment schedule for RSMP participation had not been determined).

7.3.1.3 Opinion of Probable Costs

Opinions of probable costs for Alternatives No. 1a and No. 1b are shown in **Table 7-5**.

Table 7-5a. Alternative No. 1a – Opinion of Probable Cost

Item	Cost
Participation in RSMP	$1,000,000 - 3,000,000
Water Quality	$13,374,500
100-Yr Detention Cost for Carson Creek	$650,000
100-Yr Detention Cost for Colorado River	$3,000,000
2-Yr Onsite Detention Cost	$1,221,000
Total	$19,245,500 - $22,245,500

Table 7-5b. Alternative No. 1b – Opinion of Probable Cost

Item	Cost
Participation in RSMP	$1,000,000 - $3,000,000
Water Quality	$13,374,500
100-Yr Detention Cost for Carson Creek	$650,000
100-Yr Detention Cost for Colorado River	$3,000,000
Channel Improvements	$2,323,000 - $4,945,000
Total	$20,347,500 - $24,969,500

7.3.2 Alternative No. 2 – 100-Year Onsite Detention for the Entire Site

Alternative No. 2 consists of:

- 100-year onsite detention for facilities located in the Onion Creek drainage basin.
- Onsite detention for facilities constructed within the Carson Creek and Colorado River drainage basins.
- Water quality treatment.

7.3.2.1 Advantages and Disadvantages of 100-Year Onsite Detention

The advantages and disadvantages of 100-year onsite detention are represented by the reverse of the advantages and disadvantages discussed in Section 7.3.1.2 related to RSMP.

The advantages are summarized as follows:

- Provides better erosion control for onsite drainage channels.
- Costs are incurred at the time of development.

The disadvantages are summarized as follows:

- Requires large tracts of land, typically on or adjacent to the development property.
- More expensive.

- Minimizes the benefit of alternative approaches to water quality. Where 100-year onsite detention is used, there is less benefit to reducing the water quality facility volume (i.e. by providing partial treatment via infiltration), because any reduction in water quality volume results in an equal increase in detention volume. There may still be some benefit depending on the layout and depth of the basins, but the benefit in overall footprint reduction would be relatively small.

- Does not reduce the peak flows in Onion Creek.

7.3.2.2 Opinion of Probable Costs

Opinions of probable costs for Alternative No. 2 are shown in **Table 7-6**.

Table 7-6. Alternative No. 2 – Opinion of Probable Construction Cost

Item	Cost
100-Year Detention for Onion Creek	$14,000,000
100-Year Detention for Carson Creek	$650,000
100-Yr Detention for Colorado River	$3,000,000
Water Quality	$13,374,500
Total	$31,024,500

7.4 Phasing

It is difficult to develop a useful phasing plan at this time given the general nature of the stormwater master plan and uncertainty with respect to the nature and timing of development at ABIA. However, this section addresses some issues that should be considered as it relates to the planning and phasing of stormwater facilities at ABIA.

7.4.1 Consolidation of Facilities

Since "Opening Day", stormwater facilities have been developed and implemented on a project-by-project basis. There has been little attempt to plan or build stormwater facilities that could be large enough to serve large developments and/or multiple project developments at ABIA.

Given the uncertainty of the timing, extent, and location of development at ABIA, it is difficult to plan for consolidated onsite facilities. There are risks associated with making initial investments of putting infrastructure in place without knowing when a revenue stream will be in place to recover the costs.

Nevertheless, such facilities can be feasible under certain conditions and provide better solutions than individual facilities scattered throughout each individual development. Therefore, DOA may want to consider these facilities in the future as development occurs.

Some advantages of consolidated facilities include:

- Establishes clearer planning scenarios for DOA and developers
- Economies of scale associated with construction of large facilities at one time, rather than smaller facilities over numerous projects
- Better land use if consolidated facilities are located away from developable property
- Improved overall performance of stormwater management facilities
- Simplified operational requirements

Section 8
Site Development Ordinance

8.1 Future Site Development

Concurrent with the Stormwater Master Plan Update, DOA is developing a new (or revised) site development ordinance for all future development at ABIA.

8.1.1 Key Provisions

Key provisions that DOA is seeking for the new/revised ordinance include the following:

- Designation of the site as A Master Development Site Plan
- Variances to the Land Development Code
- Designation of a portion of the site as "constrained" that will remain subject to the original ordinance water quality provision of 0.5-inch capture volume for all impervious cover within the limits of the constrained area
- New exhibits, consisting of the following:
    - Master Development Site Plan
    - Water Quality Plan
    - RSMP Participation Tracking Table
- Periodic review and update at 10-year intervals
- Master Development Site Plan does not expire
- Inclusion of private development on airport property
- Granting authority to PDRD to process variances administratively

The reader is referred to the actual ordinance for specific language and provisions, which may vary from this report. As of the writing of this final SWMP Update Report, the new/revised ordinance had not been finalized. Appendix G has been provided for insertion of the final Ordinance upon approval by Austin City Council.

Section 9
Recommendations

9.1 Introduction

This Stormwater Master Plan Update identifies existing stormwater deficiencies at ABIA, provides recommendations and a framework for implementation of water quality BMPs, evaluates stormwater facilities for future development and/or redevelopment, and compares alternatives for consideration by DOA. Additionally, example conceptual stormwater solutions were developed for three project development areas.

Provided herein are general recommendations for correction of existing deficiencies and implementation of new stormwater facilities at ABIA.

9.2 Recommendations

9.2.1 Recommendation No. 1 - Implement Channel Stabilization Improvements in Channel Segments H and I

It is recommended that the DOA correct existing erosion problems at Outfall No. 16. This may be necessary for permitting, to protect ABIA's Primary Stormwater Management System (PSMS), and potentially for participation in the RSMP.

The most severe existing erosion problems are at channels H and I as detailed in Section 6.5.3. The east side of Segment H contains a severely eroded bluff on the order of 40 feet high. Segment H is in need of stabilization and repair. Segment I contains several smaller bluffs (generally less than 10 feet in height), but it is being similarly eroded. The entire 1,300 ft length of segments H and I require stabilization and repair.

The improvements could include either armoring the channel (sheet pile or concrete wall) and/or re-grading the bank failures to create a greater flow area and lower, stable velocities in the stream reaches. It should be noted that there is a concrete obstruction in the channel that may have been a previous channel lining which has failed. An increased cross-section option would be more stable for this tributary and also improve the transition to offsite Onion Creek (potentially avoiding future erosion issues to mitigate offsite).

The conceptual cost estimates for improvements necessary to stabilize Segments H and I range from approximately $986,000, to $1,527,000.

Given the severe nature of erosion within this channel, at the time of design development, DOA may want to consider a restoration that explores additional redesign of stream geometry, location and slope. Such a project would require more advanced

modeling of the channel, including upstream segments and transition into Onion Creek. A project of this nature could cost $2,000,000 or more (just for Segments H and I).

As recommended in Section 6, Outfall 15 should be inspected to determine the condition of that channel. It is recommended that any existing, severe erosion problems that are identified in Channel Segment M be stabilized in a manner similar to Segments H and I.

As noted in Section 6, the downstream end of Segment E, which feeds directly into Segment H, has experienced some erosion undermining the existing gabions. For the purposes of this report, it was considered that these gabions would be repaired as part of the work to repair Segment H and the costs for recommendation No. 1 include the costs to repair this portion of Segment E. Should DOA choose not to perform these repairs, it is expected that condition in Segment E will continue to get worse and a larger bank failure could lead to a channel blockage and reduction in LOS during a storm event.

9.2.2 Recommendation No. 2 – Participate in the RSMP Program for Onion Creek

It is recommended that DOA participate in the RSMP for the Onion Creek watershed. The major advantages to DOA are as follows:

- RSMP is estimated to be less expensive,
- RSMP makes more real estate available for development at ABIA,
- RSMP participation will likely result in a reduction of operations and maintenance costs,
- There is more benefit to the surrounding community and the Onion Creek watershed if funds are applied to the RSMP program rather than onsite detention facilities, and
- Potentially, all or a portion of the costs of Recommendation No. 1 may be used to offset the RSMP participation fee.

Based on a land value of $8,112 per acre, the RSMP program is estimated to cost between $1,000,000 and $3,000,000 over the next 50 years (see Section 5) under the buy-in program. The cost to construct 100-year onsite detention facilities in the Onion Creek drainage area, not including the value of the real estate, is estimated to be $14,000,000 for the ultimate built-out land use condition (approximately a 50-year time horizon). Since the ultimate design of the future development is not known, this figure also does not account for primary and secondary drainage systems to convey water to the facilities and reduce flooding in the future developments.

Participation in the RSMP program maximizes the amount of land that ABIA may be able to develop in the future. It is estimated in Section 6.5.4 that approximately 82 acres would be necessary in the Onion Creek Watershed to accommodate these detention facilities. A portion of this area would be offset by necessary water quality treatment facilities, but this is still a large loss of potentially developable ABIA property (estimated at 50 to 60 acres).

In Section 5, it was shown that the peak flows in the Onion Creek Watershed are not affected by changes in the peak flow off the ABIA property. Therefore, spending large sums of money to detain the 100-year storm onsite does not benefit the surrounding communities. By participating in the RSMP program, monies may be spent elsewhere in the watershed where they could be put to better use.

Flows and velocities in the onsite tributaries would be affected by this recommendation; therefore, erosion control must be provided. It is recommended that erosion control be evaluated on a case-by-case basis and implemented as follows:

- For areas where the water quality facility mitigates the 2-year peak flow, provide 2-year detention (e.g., Outfall 15, depending on final configuration of Development Area 25 – See Section 7.2.3)

- For areas where the water quality facility does not mitigate the 2-year peak flow (e.g., Outfall 8), perform a feasibility analysis to compare the additional storage required to mitigate the 2-year peak flow versus channel stabilization, and implement the approach that provides the most benefit in terms of cost effectiveness and land use (as discussed in Section 7.3.1.1).

9.2.3 Recommendation No. 3 – Use Vegetative Filter Strips/Swales and Infiltration Water Quality Treatment for All Airside Facilities

It is recommended that DOA continue to use vegetative filter strips/swales and infiltration water quality treatment systems for all airside facilities, including runways, taxiways, taxilanes, and other apron areas that do not convey aircraft de-icing fluids or other hazardous materials. As demonstrated by this report, these systems meet FAA airside requirements and provide cost-effective treatment of stormwater pollutants, with 100 percent removal credit provided under an agreement with the COA WPD for these technologies for captured runoff. These facilities are well suited for airside water quality treatment because they eliminate the need for water quality structures near runways and taxiways, are consistent with good runway/taxiway design which promotes sheet flow from impervious surfaces, and control standing water to shallow, short duration conditions in these areas.

9.2.4 Recommendation No. 4 – Consider Use of Alternative Landside BMPs

As development occurs, alternative BMPs that provide equivalent water quality treatment to standard sedimentation/filtration systems, while minimizing the overall water quality footprint, should be considered on a case-by-case basis for all landside development. These technologies include:

- Vegetative filter strips/infiltration swale options similar to the proposed equivalent treatment approach for airside facilities, which could potentially provide all or a portion of the water quality treatment for a new development. These swale infiltration systems can have detention and or retention components and include landscaped medians/perimeters and rain gardens. Additionally, these options meet City of Austin goals for providing environmentally sensitive solutions for new development at City sites, including landscaped medians in parking lots and use of rainfall runoff for onsite irrigation.

- Retention/irrigation systems that may be deeper and allow a smaller footprint than an equivalently sized sedimentation/filtration system. These opportunities to use and harvest/recycle stormwater would reduce potable water irrigation for landscaping and also provide additional pollutant removal by further treating flow and reducing volume of discharge by the vegetative uptake.

9.2.5 Recommendation No. 5 – Continue to Implement and Enhance Operational BMPs

It is recommended that DOA continue to implement non-structural BMP practices that remove stormwater pollutants and improve the quality of runoff at ABIA. These include:

- Continue implementing the BMPs listed in the ABIA Storm Water Pollution Prevention Plan (SWPPP)

- Continue airside and landside pavement sweeping and pavement washdown operations

- Maintain system logs and a database of the frequency of sweeping and paving washdown operations, areas swept/washed down, weight of material removed, and the concentrations of key parameters removed (such as the 10 ECM constituents in section Table 4-3)

- Update and enhance the Integrated Pest Management plan - especially as it pertains to BMP maintenance

- Consider extending the current water quality monitoring program to document and verify the water quality loading generated from select ABIA facilities and operational performance of BMPs such as sweeping and pavement washing.

9.2.6 Recommendation No. 6 – Consider Proposed Solutions and Approach for Three Project Development Areas

Conceptual plans are included in Section 7 for three near-term project development areas. At the time of design development for these areas, it is recommended that DOA consider the conceptual plans included in this Stormwater Master Plan Update. Additionally, alternative water quality approaches for each area are identified which warrant further evaluation at the time of design development.

These plans also provide a template for the future planning and design development for other stormwater facilities at ABIA.

9.3 Cost Summary

Conceptual planning level estimates of probable capital costs for recommended improvements are provided in **Table 9-1**.

Table 9-1. Conceptual Planning Level Costs for Recommended Improvements

Item	Cost [2] Range (2010 $)
Stabilization of Channels Segments H and I	$986,000 - $1,527,000
RSMP Participation for Facilities in Onion Creek Watershed	$1,000,000 - $3,000,000
Water Quality [1]	$13,375,000
Erosion Protection for Facilities in Onion Creek Watershed [3]	$1,221,000 - $4,945,000

(1) Cost includes sedimentation/filtration systems for Onion, Colorado, and Carson. Costs for Alternative BMPs may vary.
(2) Costs include 15% for engineering, surveying, and permitting.
(3) Range covers both options of 2-year detention and future channel improvements with gabion lining.

Costs for alternative BMPs should be considered on a case-by-case basis. The planning level water quality cost estimates provided in this section were developed in Section 4. These estimates are based on standard sedimentation/filtration systems sized for either 1/2-inch capture or 1/2-inch plus capture as shown in Section 4.

Estimates of conceptual capital costs were developed for each of the three Project Areas and these costs are summarized below in **Table 9-2**.

Table 9-2. Estimates of Conceptual Capital Costs for Three Project Development Areas

Item	Cost (2010 $)	Cost (2010 $)/ Acre
Project Area No. 1	$1,800,000	$52,000
Project Area No. 2	$520,000	$27,000
Project Area No. 3	$910,000	$22,000

APPENDICES

APPENDIX A

WATER QUALITY INFORMATION AND SUPPORT DOCUMENTATION

APPENDIX A.1

WATER QUALITY POND INFORMATION

Appendix A-1. Additional Water Quality Pond Information

Designation	ABIA #	Areas Served	Zone	Outfall	Basin	SWMM DA to Control	DA Contributing to Control (acres)	Source	Sed/Fil Type	Filter Area (ft)	Sed Area (sf)	WQ Height (ft)	WQ Volume (cf)	WQ Volume (AF)	Source	Impervious Cover (%)	Source	Capture Depth (in)	Source	Calculated Capture Depth (in)	Site Plan #	Sheet #	Dwg Status	Date	Source	Notes
WQP TANG	7343	TXARNG	3	22	Onion	90.1	31.31	WPD Site Plan	Partial	13,455	8,100	5.8	214,918	4.93	WPD Site Plan	82	WPD Site Plan	1.128	WPD Site Plan	1.89	SP-02-0236C	20	Released*	05/03/2004	WPD	Phase 1 development
WQP F	7345	ABIA Propane Facility	4b	21	Carson	4.51	0.71	ABIA Site Plan	Partial	560	2,160	1.2	3,489	0.08	ABIA Site Plan	79	ABIA Site Plan	1.09	ABIA Site Plan	1.35	SP-03-0059C	C301	WPD Released ABIA As Built	WPD 05/14/2003 ABIA 05/14/2003	WPD, ABIA	WPD set incomplete ABIA additional sheets
WQP L	5455	Rental Car Companies; GSEM	4b	21	Carson	117.76	123.0	Site Plan	Partial	7,536	17,424	10	488,240	11.21	Site Plan (measured)	78.3	Site Plan (calculated)	-	-	1.09	ABIA: SP-94-0438C.0913(B) WPD SP-98-0384D	C302, C304	ABIA As Built WPD Released	ABIA 05/13/1997 WPD 01/14/1999	ABIA	WPD set incomplete ABIA additional sheets (as-built)
WQP M	5444	ABIA Hotel	4b	20	Colorado	7.79	10.0	Site Plan	Partial	3,952	3,337	12	137,500	3.16	Site Plan (measured)	61.92	Site Plan	0.92 (req) 3.8 (prov)	Site Plan	3.79	SP-99-0151	06	Released*	07/02/1999	WPD	WQ pond detains 100-yr
WQP N	5434	Cargo Landside (sed/fil)	10	1	Carson	81.71	27.93	Site Plan	Full	8640.0	15,600	3.5	70,656	1.62	Site Plan	75	Site Plan	0.50	Site Plan	0.70	SP-94-0482(C-912(b)				WPD	Adjusted for WQP-P change
WQP N	5434	Cargo Ramp (holding)	10	1	Carson		42.97	Site Plan	Full	NA	-	-	78,614	1.80	Site Plan	75	Site Plan	0.50	Site Plan	0.50	SP-94-0482(C-912(b)	C0311	Released*		WPD	WPD provided bid set ABIA has revisions, need more info
WQP P	5449	Northwest Landside Cargo Area	4c	2	Carson	20.08	18.51	Site Plan	Full	2,080	3,690	-	44,060	1.01	Site Plan	-	-	-	-	0.66	SP-96-0004C	C0306	Released*	01/09/1996	WPD	Evaluate with WQP N
WQP R	5447	GSEM	4b	21	Carson	1.57	1.55	Site Plan	Partial	664	2,746	3.5	7023.0	0.16	Site Plan	88.0	Site Plan	1.18	Site Plan	1.25	SP-98-0265	C0301, C0502	Released*	11/30/1998	WPD	
WQP-T	5446	Belly Freight/Fuel Farm	4a	16	Onion	12.17	4.48	Site Plan	Partial	1825	5776	5.25	16,594	0.38	WPD email	79.0	Site Plan	1.09	Site Plan	1.02	SP-98-0266C	C0301, C0502	Released*	11/24/2001	WPD	
WQP G	5432	Terminal Building, Roadways, Parking Areas	5a	16	Onion	226.91	169.89	Site Plan	Full	17,300	31,100	9.0	345,463	7.93	Site Plan	-	Site Plan	0.50	Site Plan	0.56	SP-94-0438C-912(d)	C0336	Released*	08/14/1995	WPD	Midfield cross taxiway site plan No impervious cover numbers (1/2 inch capture)
WQP A	5450	South FBO Ramp	6	13	Onion	22.40	26.60	ABIA Site Plan	Full	3,204	5,858	7.5	52,425	1.20	ABIA Site Plan	<20%	ABIA Site Plan	0.50	ABIA Site Plan	0.54	SP-98-0218C	C0310	Released*	09/08/1998	WPD	WPD plans incomplete, indicate "not built"
WQP B	5456	North FBO Ramp	6	16	Onion	23.30	25.00	ABIA Site Plan	Full	2,538	5,278	7.3	46,141	1.06	ABIA Site Plan	<20%	ABIA Site Plan	0.50	ABIA Site Plan	0.51	WP: SP-98-0320 ABIA: SP-94-0438C-0-12K	C0311	Released*	11/12/2001	WPD	WPD plan note "need original site plan for pond"\
WQP C	5439	T-Hangar Ramp, South Corporate Hangars	6	13	Onion	25.13	24.87	Site Plan	Full	6459.0	31769.0	3.7	108,086	2.48	Site Plan	81.82	Site Plan	1.112	Site Plan	1.197	SP-00-2256C	C311	Released*	09/19/2000	WPD	
WQP D	5437	North FBO Ramp	6	16	Onion	14.54	22.18	Site Plan	Full	4,786	28,278	8.0	110,591	2.54	Site Plan	77.37	Site Plan	0.50	Site Plan	1.37	SP-01-0293C	C0313, C0314	Released*	10/31/2001	WPD	
WQP E	5431	Terminal Apron	12	16	Onion	27.91	37.85	ABIA Memo	Partial	-	-	-	70,000	1.61	WPD Email	-	-	0.50	ABIA Memo	0.51	SP-94-0438C.0912(a)	-	Released*	02/05/1998	WPD email	WPD set incomplete
WQP J	5453	TxDOT Flight Services	11	19	Colorado	17.70	13.88	Site Plan	Full	1,400	6,864	6.0	25,872	0.59	Site Plan	20.0	Site Plan	0.50	Site Plan	0.51	SP-94-0438C.0912(H)	C0320, C0321		12/19/2000?	WPD	

* Released = Stamped with "Site Plan Release"

APPENDIX A.2

INTEGRATED PEST MANAGEMENT TACTICS DOCUMENT

APPENDIX A-2

Integrated Pest Management Tactics
For Austin Bergstrom International Airport,
Department of Aviation/Field Maintenance

Field Maintenance has embraced a pro-active approach to establishing and maintaining a workable Integrated Pest Management program, which ultimately will produce a workable balance between lowering the use of pesticides/herbicides, while preserving the necessary harmonic balance which must exist between environmental concerns and maintaining a pest free and aesthetically pleasing commercial enterprise.

The IPM program has been in effect for the past year and consists of the following preventative measures:

1. Cultural practices - This is a major portion of the IPM program. The approximate 90 of landscape at ABIA is inspected on a daily basis in an effort to remove any condition, which might pose as a favorable habitat for pests to seek safe harbor or weeds to propagate. When such conditions are found, the situation is dealt with in an effort to disrupt those favorable conditions that, if allowed to remain, would promote a proliferation of the problem. Field Maintenance has its own cadre of personnel who are specialist in several areas with many years of experience.

2. Site sanitation - This is an on-going effort which not only removes unsightly debris from the venue, but also denies pests a prime food source. This 7-day a week effort greatly reduces the chances that pest or vermin will find ABIA as an attractive habitat.

3. Biological control - Biological control measures are encouraged to manifest themselves naturally. These control measures mainly consists of beneficial insects, spiders and microbial agents, which are attracted to ABIA because of the native plant material and the limited use of spray material. The attraction and use of natural occurring biological control agents has been highly successful as <u>no</u> pesticides have been used on the ornamentals contained within the landscape during the past calendar year.

4. Plant material - The plant material chosen was done so mainly because of its adaptation capabilities to Austin's climate. Because the plants are indigenous to the state, they are less likely to develop diseases or have bacterial problems and haven't proved to be an attractive nuisance as far as insects are concerned.

5. Assessment/Evaluation - As a step to any successful program, realistic assessment goals must be established or a summative evaluation must be conducted in order to establish a database from which conclusive facts can be drawn. The evaluation chosen for the IPM program is an on-going process, which is primarily quantitative in nature. It is designed to measure pest/weed problems, severity or impact, any self-imposed impediments and success or failure of abatement efforts.

Given the geographical location and the method of past usage of the property on which ABIA is located, a certain amount of herbicides have to be used to curb the growth of unwanted weeds such as Johnsongrass and common Bermudagrass. The herbicide of choice has been Roundup Pro. Roundup is a glyphosate and commonly used in a salt form even though it is an acid. The EPA classifies it as a class II chemical. Roundup is a broad-spectrum, nonselective herbicide and is generally distributed as a water-soluble concentrate. It is listed as having a LD rating of 50 with an estimated half-life of 47 days.

The mixture ratio is usually held at 5%, which reduces the half-life of the chemical as well as reducing the toxicity level. Roundup is used as a selective spray in ornamental beds and along the fence lines of ABIA, both inside and out. Specific use herbicides such as Image are used occasionally for the control of nutgrass. The mixture ratio is strictly followed using the manufacture's mixture suggestions. Other specific use herbicides such as Fusilade, which is used as a 'spray over the top' herbicide, is used only in ornamental beds.

It is strongly felt that our IPM program has been highly successful and should continue as such for years to come.

APPENDIX A.3

EXAMPLE POLLUTANT LOAD CALCULATIONS RULE:

1/2-INCH RULE

Pollutant Loading Estimates
Example Watershed - 1/2-inch Rule
10 acres

Rainfall (in.) 32.5

BASELINE - UNDEVELOPED							TSS		Total Phosphorus		Total Nitrogen		COD		BOD		Lead		TOC		Zinc	
Location	Area (Acres)	Imper. Cover%	Imp. Area (Acres)	Rf	Runoff (inches)	Runoff (Ac-ft)	Conc. (mg/L)	Load (lb/year)	Conc. (mg/L)	Load (lb/year)	Conc. (mg/L)	Load (lb/year)	Conc. (mg/L)	Load (lb/year)	Conc. (mg/L)	Load (lb/year)	Conc. (mg/L)	Load (lb/year)	Conc. (mg/L)	Load (lb/year)	Conc. (mg/L)	Load (lb/year)
DA-3A	10.00	0.00	0.00	0.030	0.96	0.8	55	10.0	0.04	0.01	0.54	0.1	22	4.00	8	1.45	0.003	0.001	6	1.09	0.008	0.001

PROPOSED CONDITIONS							TSS		Total Phosphorus		Total Nitrogen		COD		BOD		Lead		TOC		Zinc	
Location	Area (Acres)	Imper. Cover%	Imp. Area (Acres)	Rv	Runoff (inches)	Runoff (Ac-ft)	Conc. (mg/L)	Load (lb/year)	Conc. (mg/L)	Load (lb/year)	Conc. (mg/L)	Load (lb/year)	Conc. (mg/L)	Load (lb/year)	Conc. (mg/L)	Load (lb/year)	Conc. (mg/L)	Load (lb/year)	Conc. (mg/L)	Load (lb/year)	Conc. (mg/L)	Load (lb/year)
DA-3A	10.00	80.00	8.00	0.642	20.85	17.4	110	433.3	0.16	0.63	1.82	7.17	79	311.22	8	31.516	0.030	0.118	19	74.85	0.05	0.20

PROJECTED INCREASE IN LOAD			423.3	0.62	7.07	307.22	30.06	0.118	73.76	0.20
BYPASSED AREA	0.00									
AREA REMAINING	10.00									
LOAD BYPASSED			0	0	0	0	0	0	0	0
LOAD REMAINING			433.3	0.63	7.17	311.22	31.52	0.12	74.85	0.20
CAPTURE VOLUME IN INCHES (1/2-inch Rule)	0.50	**PERCENT LOAD CAPTURE**	73%	73%	73%	73%	73%	73%	73%	73%
CAPTURED LOAD			316.3	0.46	5.23	227.19	23.01	0.09	54.64	0.14
PERCENT REMOVAL	**Filtration**		87%	61%	31%	67%	51%	80%	61%	80%
LOAD REMOVED			275.2	0.28	1.62	152.22	11.73	0.069	33.33	0.12
LOAD DISCHARGED			158.1	0.35	5.55	159.00	19.78	0.049	41.52	0.08
BASE POND VOLUME (AC-FT)			0.42							
BASE POND VOLUME (CU. FT.)			18,150							
REQUIRED VOLUME = BASE POND VOLUME + 20% FOR SEDIMENT STORAGE			21,780							

APPENDIX A.4

EXAMPLE POLLUTANT LOAD CALCULATIONS RULE:

1/2-INCH PLUS RULE

Pollutant Loading Estimates
Example Watershed - 1/2-inch Plus Rule
10 acres

Conversion Factor 0.2267
FC and FS conversion 1.03E+06

Rainfall (in.) **32.5**

BASELINE-UNDEVELOPED							TSS		Total Phosphorus		Total Nitrogen		COD		BOD		Lead		TOC		Zinc	
Location	Area (Acres)	Imper. Cover%	Imp. Area (Acres)	Rf	Runoff (inches)	Runoff (Ac-ft)	Conc. (mg/L)	Load (lb/year)	Conc. (mg/L)	Load (lb/year)	Conc. (mg/L)	Load (lb/year)	Conc. (mg/L)	Load (lb/year)	Conc. (mg/L)	Load (lb/year)	Conc. (mg/L)	Load (lb/year)	Conc. (mg/L)	Load (lb/year)	Conc. (mg/L)	Load (lb/year)
DA-3A	10.00	0.00	0.00	0.030	0.96	0.8	55	10.0	0.04	0.01	0.54	0.1	22	4.00	8	1.45	0.003	0.001	6	1.09	0.008	0.001

PROPOSED CONDITIONS							TSS		Total Phosphorus		Total Nitrogen		COD		BOD		Lead		TOC		Zinc	
Location	Area (Acres)	Imper. Cover%	Imp. Area (Acres)	Rv	Runoff (inches)	Runoff (Ac-ft)	Conc. (mg/L)	Load (lb/year)	Conc. (mg/L)	Load (lb/year)	Conc. (mg/L)	Load (lb/year)	Conc. (mg/L)	Load (lb/year)	Conc. (mg/L)	Load (lb/year)	Conc. (mg/L)	Load (lb/year)	Conc. (mg/L)	Load (lb/year)	Conc. (mg/L)	Load (lb/year)
DA-3A	10.00	80.00	8.00	0.642	20.85	17.4	110	433.3	0.16	0.63	1.82	7.17	79	311.22	8	31.516	0.030	0.118	19	74.85	0.05	0.20

PROJECTED INCREASE IN LOAD				**423.35**		**7.07**	**307.22**	**30.06**	**0.118**	**73.76**	**0.20**
BYPASSED AREA	**0.00**										
AREA REMAINING	**10.00**										
LOAD BYPASSED				**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
LOAD REMAINING				**433.3**	**0.63**	**7.17**	**311.22**	**31.52**	**0.12**	**74.85**	**0.20**
CAPTURE VOLUME IN INCHES (10% Rule)		**1.10**	**PERCENT LOAD CAPTURE**	**91%**	**91%**	**91%**	**91%**	**91%**	**91%**	**91%**	**91%**
CAPTURED LOAD				**394.3**	**0.57**	**6.52**	**283.21**	**28.68**	**0.11**	**68.11**	**0.18**
PERCENT REMOVAL	**Filtration**			**87%**	**61%**	**31%**	**67%**	**51%**	**80%**	**61%**	**80%**
LOAD REMOVED				**343.1**	**0.35**	**2.02**	**189.75**	**14.63**	**0.086**	**41.55**	**0.14**
LOAD DISCHARGED				**90.3**	**0.28**	**5.15**	**121.47**	**16.89**	**0.032**	**33.30**	**0.05**
BASE POND VOLUME (AC-FT)				**0.92**							
BASE POND VOLUME (CU. FT.)				**39,930**							
REQUIRED VOLUME = BASE POND VOLUME + 20% FOR SEDIMENT STORAGE				**47,916**							

APPENDIX A.5

EXAMPLE POLLUTANT LOAD CALCULATIONS RULE:

VEGETATIVE FILTER STRIP

Pollutant Loading Estimates
Vegetative Filter Strip Example
10 acres

Rainfall (in.) **32.5**

BASELINE - UNDEVELOPED							TSS		Total Phosphorus		Total Nitrogen		COD		BOD		Lead		TOC		Zinc	
Location	Area (Acres)	Imper. Cover%	Imp. Area (Acres)	Rf	Runoff (inches)	Runoff (Ac-ft)	Conc. (mg/L)	Load (lb/year)	Conc. (mg/L)	Load (lb/year)	Conc. (mg/L)	Load (lb/year)	Conc. (mg/L)	Load (lb/year)	Conc. (mg/L)	Load (lb/year)	Conc. (mg/L)	Load (lb/year)	Conc. (mg/L)	Load (lb/year)	Conc. (mg/L)	Load (lb/year)
DA-3A	10.00	0.00	0.00	0.030	0.96	0.8	55	10.0	0.04	0.01	0.54	0.1	22	4.00	8	1.45	0.003	0.001	6	1.09	0.008	0.001

PROPOSED CONDITIONS							TSS		Total Phosphorus		Total Nitrogen		COD		BOD		Lead		TOC		Zinc	
Location	Area (Acres)	Imper. Cover%	Imp. Area (Acres)	Rv	Runoff (inches)	Runoff (Ac-ft)	Conc. (mg/L)	Load (lb/year)	Conc. (mg/L)	Load (lb/year)	Conc. (mg/L)	Load (lb/year)	Conc. (mg/L)	Load (lb/year)	Conc. (mg/L)	Load (lb/year)	Conc. (mg/L)	Load (lb/year)	Conc. (mg/L)	Load (lb/year)	Conc. (mg/L)	Load (lb/year)
DA-3A	10.00	74.00	7.40	0.571	18.57	15.5	110	386.0	0.16	0.56	1.82	6.39	79	277.19	8	28.070	0.030	0.105	19	66.67	0.05	0.18

PROJECTED INCREASE IN LOAD			**376.0**	**0.55**	**6.29**	**273.19**	**26.62**	**0.105**	**65.58**	**0.17**
BYPASSED AREA	**0.00**									
AREA REMAINING	**10.00**									
LOAD BYPASSED			**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
LOAD REMAINING			**386.0**	**0.56**	**6.39**	**277.19**	**28.07**	**0.11**	**66.67**	**0.18**
CAPTURE VOLUME IN INCHES (10% Rule)	1.04	**PERCENT LOAD CAPTURE**	**93%**	**93%**	**93%**	**93%**	**93%**	**93%**	**93%**	**93%**
CAPTURED LOAD			**358.9**	**0.52**	**5.94**	**257.79**	**26.10**	**0.10**	**62.00**	**0.16**
PERCENT REMOVAL			**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
LOAD REMOVED			**358.9**	**0.52**	**5.94**	**257.79**	**26.10**	**0.098**	**62.00**	**0.16**
LOAD DISCHARGED			**27.0**	**0.04**	**0.45**	**19.40**	**1.96**	**0.007**	**4.67**	**0.01**
BASE POND VOLUME (AC-FT)			**0.87**							
BASE POND VOLUME (CU. FT.)			**37,752**							
REQUIRED VOLUME = BASE POND VOLUME + 20% FOR SEDIMENT STORAGE			**45,302**							

APPENDIX A.6

TECHNICAL MEMO:

ANALYSIS OF VEGETATIVE FILTER STRIPS

Prepared by:
Crespo Consulting Services, Inc.
October 15, 2010

Crespo Consulting Services, Inc.
Civil & Environmental Engineering

Crespo Consulting Services, Inc.
Firm # 1758

Date: October 15, 2010

To: Mike Kelly, COA Watershed Protection
From: ABIA Department of Aviation (DOA), Crespo Consulting Services, Inc., and CDM

Subject: ABIA Stormwater Master Plan Update - Analysis of vegetative filter strips treating runoff from ABIA runways and taxiways

Summary

This memo describes the analysis performed to determine parameters for vegetative filter strips in the runway and taxiway areas of the Austin Bergstrom International Airport (ABIA). The SWMP project team has performed analyses to evaluate the runoff quantity and quality from runway-taxiways areas to identify the appropriate equivalent amount of vegetative filter strip length and area to meet or exceed Environmental Criteria Manual requirements. Based on the analysis below, we recommend that vegetative filter strips be sized as follows for ABIA runways, taxiways, and taxilanes:

For an impervious area with a flow length L (in ft), the adjoining vegetative filter strip flow length must be 0.33*L per ft of runway-taxiway (or an area ratio of (1:0.33; or 33 sq ft of filter strip for 100 sq ft of pavement). Thus for a runway that is 200 ft wide, with a center crown (100 feet of flow length on each side), the vegetative filter strip requirement would be 33 ft/ft runway on each side. A minimum of 25 feet of vegetative filter strip length would be used for smaller flow length conditions, consistent with the filter strip requirements in the Environmental Criteria Manual (ECM).

Analysis

1. Size a vegetative filter strip using ECM criteria

For 100% impervious cover (IC), the table in section 1.6.7.B of the Environmental Criteria Manual requires 2.49 acres of vegetative filter strip for every 1 acre of impervious cover. In the case of a runway with a flow length from the crown of the runway to the edge of pavement of length L, the resulting vegetative filter strip would have a flow length of 2.49*L. Thus for L=100 ft, the required vegetative filter strip would have a flow length of 249 feet.

2. Adjust the infiltration rate to a value obtained from the Travis County Soil Survey.

The minimum and maximum ranges for hydraulic conductivity from the Travis County were used to determine an average hydraulic conductivity and a safety factor of 2 was applied. Example Case study 3 (Rain garden Infiltration System) discusses adjusting the hydraulic conductivity and the use of a safety factor of 2.

Table 2

Hydraulic Conductivity	(in/hr)	(ft/hr)
Minimum	0.63	0.05
Maximum	2.00	0.17
Average	1.32	0.11
Safety Factor	2.00	
Adjusted k	0.66	0.05

from Travis County Soil Survey

Soil depth and water capacity from the soil survey are shown below for reference.

Table 3

Lewisville (LcA, etc.)		
Soil Depth (in)	Available Water Capacity (in/in)	Total Water Capacity (in)
29	0.20	5.80
43	0.15	6.45
72		12.25

Table 4

Altoga (AgB, etc.)		
Soil Depth (in)	Available Water Capacity (in/in)	Total Water Capacity (in)
60	0.165	9.90

3. Calculate the filter strip using ECM Rainwater Harvesting Example A Option A

City staff determined that ECM Rainwater Harvesting Example A Option A was suitable for calculating the filter strip length required in the airfields at ABIA. Using this example, the required filter strip flow length is calculated to be 8.2 ft for a 100 ft impervious cover flow length (or 0.082*L) as shown below for a 48-hour drawdown time. A runoff depth of 1.3 inches was used as the depth for 90% capture by the filter strip. Since the capture depth is based entirely on infiltration, the assumed removal rate for the captured runoff is 100%.

Table 5

Runoff Depth	1.3	in	
k	0.66	in/hr	Travis County Soil Survey
	0.055	ft/hr	
Impervious Area			
Length	100	ft	
Width	1	ft	
Area	100	sf	Length * Width
Runoff Volume	10.83	cf	Area/Runoff Depth
Drawdown Time	48	hr	
Filter Strip			
Filter Strip Area	8.21	sf	(2 *WQV)/(Drawdown Time * k)
Width	1	ft	
Length	8.2	ft	Area/Width

4. After discussion with City Staff, the Drawdown time of 48-hours may be too long for vegetative filter strips. A short filter strip may not detain the runoff long enough for full infiltration to occur. An analysis of storms at ABIA of a similar rainfall depth to 1.3 inches indicates that a drawdown time of 12 hours is representative. The resulting filter strip flow length is calculated to be 32.8 ft for a 100 ft impervious cover flow length (or 0.328*L) as shown below.

Table 6

Runoff Depth	1.3	in	
k	0.66	in/hr	Travis County Soil Survey
	0.055	ft/hr	
Impervious Area			
Length	100	ft	
Width	1	ft	
Area	100	sf	Length * Width
Runoff Volume	10.83	cf	Area/k
Drawdown Time	12	hr	
Filter Strip			
Filter Strip Area	32.83	sf	(2 *WQV)/(Drawdown Time * k)
Width	1	ft	
Length	32.8	ft	Area/Width

5. Check the Hydraulic Loading Rate (Vegetative Filter Strips - ECM 1.6.7).

The Hydraulic Loading Rate must be lower than 0.05 cfs for a 2-year storm.

Table 8

max HLR cfs/ft	C	Intensity in/hr	width	length	area acres	HLR cfs/ft	
0.05	0.73	5.76	1	32.8	0.0008	0.003	2-year
0.05	0.73	12.5	1	32.8	0.0008	0.007	100-year

6. Edge of pavement construction functions as a level spreader.

   FAA safety regulations determine the construction of runways and taxiways and limit the types of structures that can be planed near runways and taxiways. Structures such as flow spreaders and level spreaders as used in some vegetative filter strips cannot be used in the runway/taxiway areas, although level spreaders are recommended in the ECM. Current edge of pavement is a smooth transition from pavement to a well maintained vegetative filter strip preserving sheet flow from the paved areas. Frequent inspections are performed by airport personnel to ensure that runoff from the runway/taxiways does not create rivulets that could be a safety hazard. Representative photos of the runway filter strips are shown below.

Recommendations

Based on this analysis for site specific conditions related to ABIA, it is recommended that the filter strip criteria for ABIA summarized as:

1. A ratio of 1 ft of impervious cover to 0.33 ft of vegetative filter strip length is more than adequate to meet a water quality requirement of 90% capture with 100% removal (33 sq ft of filter strip for every 100 sq ft of runway-taxiway pavement).
2. The 25 ft minimum vegetative filter strip length should be used as per the ECM.
3. The FAA and ABIA slope requirements of runways, taxiways, and taxilanes and adjacent sloped grassy areas result in sheet flow from the edge of pavement in these areas. The airport performs routine inspections and maintenance to ensure concentrated flow does not occur. No additional level spreading devices are needed.

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APPENDIX A.7

TECHNICAL MEMO:

RUNWAY VEGETATED FILTER STRIP COMPENSATORY CREDIT ANALYSIS

Crespo Consulting Services, Inc.
Civil & Environmental Engineering

Crespo Consulting Services, Inc.
Firm # 1758

Date: April 18, 2011

To: Mike Kelly, COA Watershed Protection
From: ABIA Department of Aviation (DOA), Crespo Consulting Services, Inc., and CDM

Subject: ABIA Stormwater Drainage Master Plan Update –Runway Vegetated Filter Strip Compensatory Credit Analysis

Summary

This memorandum describes the analysis performed to determine the compensatory credit for stormwater runoff treatment by Vegetated Filter Strips (VFSs) in the runway/taxiway areas for use in meeting all or a portion of the stormwater treatment required for proposed future development in the ABIA Constrained Development Area (CDA). In many cases, the VFSs are portions or perimeter of existing and proposed swales along the airside areas. The analysis consists of the following steps:

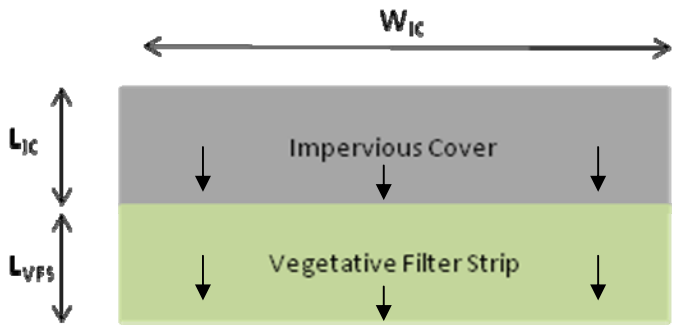
1. **VFS Removal Efficiency** - An analysis of load removed for four (4) selected indicator constituents by the Vegetated Filter Strips (VFS) in the runway/taxiway area (Total Suspended Solids, Total Phosphorous, Total Nitrogen, and Lead. The analysis includes a determination of the removal efficiency of the minimum required VFS and the maximum allowed VFS.
2. **VFS Credit Areas** - Delineation of Vegetated Filter Strips designated for use in generating compensatory treatment credit.
3. **VFS Credit Area Loading Analysis** – Use the removal efficiencies from (1) above and the VFS Credit Areas from (2) above to determine the excess treatment and additional load removed by the VFS Credit Area.
4. **Constrained Development Area Loading Analysis -** An analysis of stormwater runoff treatment under the COA 1/2-inch and 1/2-inch plus rules for proposed development in the in the CDA.
5. **ABIA Receiving Waters**. – Discussion of the location of ABIA in the Carson Creek, Onion Creek and Colorado River watersheds.
6. **Proposed Compensatory Treatment Agreement** – Proposed guidelines for a compensatory treatment credit agreement.

Previous work:

1. October 15, 2010 VFS Memorandum – establishes the minimum required VFS sizing based on ABIA soil types. This memorandum establishes the runway/taxiway VFS

required area as 33 square feet of VFS for every 100 square feet of contributing impervious cover area (or 33% of the contributing impervious cover area). The minimum VFS flow length is 25 feet. This sizing provides treatment equal to or better than the required treatment of a sedimentation/ filtration system with a 1/2-inch plus capture. See Figure 1 for a diagram of a typical VFS.

Figure 1. Vegetative Filter Strip Layout



LIC – Length of Impervious Cover
WIC – Width of Impervious Cover
LVFS – Length of VFS
↓ – Flow Direction

2. Constrained Development Area – ABIA established the CDA to delineate the part of the airport with the highest development density where there are significant space and economic constraints that limit the practicable size of water quality ponds. Due to these constraints, the 1/2-inch capture volume appeared to be the maximum practicable for this area. The CDA is generally the area including and to the north of the main passenger terminal (see Figure 2).

3. ABIA Stormwater Drainage Master Plan Update – The report provided a general discussion of the physical constraints and general water quality conditions related to the CDA. In this draft report, the general basis for the proposal of the CDA included:

   - Overall, the ABIA Stormwater Drainage Master Plan Update provides for enhanced water quality treatment that meets or exceeds the current 1/2-inch treatment level as well as the 1/2-inch plus capture using sedimentation filtration.

   - The CDA surrounds the key existing elements of the current facility (the main terminal and the existing cargo area). Much of the future development will be necessarily constrained to be within close proximity to these key elements.

- Existing drainage infrastructure, including pipes and culverts under roadways, highways and runways limit the location, size and types of controls.
- Much of the CDA was originally developed based on 1/2-inch capture volume as set out in the current ABIA ordinance and approved design drawings. These existing 1/2-inch systems were built generally between 1994 and 2000 and have site specific space and hydraulic constraints.
- Existing and future vegetative/infiltration controls, primarily on the airside, provide enhanced water quality treatment.
- Regular pavement sweeping and washdowns of the parking lots/garages and aprons provides some additional pollutant removal.
- Most of the area was included in the original development of the airport, and much of the future development will be re-development over existing impervious cover
- Some of the existing impervious cover in this area pre-exists ABIA from the Bergstrom Air Force Base.

Methodology

This section describes the key formulas used to evaluate the performance of Vegetative Filter strips and the sand filters in the CDA.

The load removed for a BMP, such as a sand filter or a VFS, is[2]:

$$L_R = L_1 \times F \times R$$

Where:

L_R = Load removed (pounds)
L_I = Post development load for site (pounds)
F = Fraction of load captured by the BMP
R = BMP treatment efficiency (Efficiency Ratio) – the percent reduction in pollutant concentration

The post development load for a site (L_I) is calculated from the following equation[1]

$$L_I = A \times P \times R_V \times C \times 0.2267$$

Where:

A = Drainage area (acres)
P = Annual precipitation (inches)
R_V = Runoff Coefficient

C = Concentration (mg/L)
0.2267 conversion factor

For pond systems such as sedimentation/filtration ponds, F is a function of runoff capture volume and percent impervious cover[2]. For a VFS, F is equal to the fraction of runoff infiltrated by the VFS, sometimes referred to as the Runoff Capture Efficiency.

The BMP treatment efficiency is considered to be 100% for a VFS. The BMP treatment efficiencies for a sedimentation/filtration pond is less than 100% and are variable by parameter as shown in section 1.6.5.C of the Environmental Criteria Manual (ECM).

[1]City of Austin Environmental Criteria Manual 1.6.9.3 equation 1
[2]Complying with the Edwards Aquifer Rules, Technical Guidance on Best Management Practices, 1999

1. VFS Runoff Capture Efficiency

The VFS analysis in the October 15 Memorandum used the City of Austin Environmental Criteria manual (ECM) Rainwater Harvesting Example A Option A which uses simplifying assumptions of hydraulic conductivity, drawdown time, and a runoff event of 1.3-inches,the water quality volume required for water quality pond with 100% impervious cover within the drainage area. This method is adequate for sizing the filter strips for typical rainfall events, but is not suitable for determining annual treatment loading.

A critical parameter in the loading analysis is fraction of the load captured, or the runoff capture efficiency – the ratio of total runoff to the runoff that is infiltrated by the VFS. Three models were considered for use in estimating runoff capture efficiency for this analysis:

- SWMM - a dynamic rainfall-runoff simulation model used for single event or long-term (continuous) simulation of runoff quantity and quality from primarily urban areas and tracks the quantity and quality of runoff generated.
- Adams Papa - uses a statistical representation of rainfall, hydrology and network performance which allow solutions to be evaluated.
- VFS Haan_Barfield_Hayes – The Haan_Barfield_Hayes model is adapted from Adams Papa model used by the City. It includes rainfall and runoff statistics along with the physical and hydraulic characteristics of the VFS.

The Haan_Barfield_Hayes was chosen for this analysis after discussions with City Staff (Watershed Protection). The "33%" vegetative filter strips and the proposed maximum 150-ft VFS were evaluated using infiltration as the only treatment mechanism – filtering of particles by the vegetation was not used. The hydraulic conductivity for ABIA soils of 0.66 in/hr was used (as

described in the October 15, 2010 ABIA VFS memo). A typical slope of 2% was used as determined from COA contour data for the airport site. A rational value for the impervious area of 0.75 (2-year return period) and a maximum rainfall intensity of 5.76 in/hr (2-year, 5 min intensity) were used – both from the DCM – for the hydraulic loading rate. For this analysis, current maintenance practices of vegetated areas were assumed to continue.

The impervious area was set to 1- acre with an impervious flow length of 100 feet. The resulting width of impervious cover was 435 feet. VFS flow lengths of both 33 feet and 150 feet were modeled. The results for the "33%" VFS is 76% Runoff Capture Efficiency attributable to infiltration, and 93% for the 150-ft VFS.

Both SWMM and the Adams Papa model were used to generally verify the results of the Haan_Barfield_Hayes model. In SWMM, the VFS were modeled using a 1 acre impervious cover and infiltration basins (435 feet times L) for the filter strips. A very shallow flow depth was used based on estimated sheet flow depth across the strip (i.e. no actual ponding). Horton and Green Ampt infiltration methods yielded similar results. The Adams Papa also modeled the VFS as an infiltration basin with a small ponding depth (0.02 inches). The Adams Papa model used a constant infiltration rate. The SWMM and the Adams Papa model results were comparable to the Haan_Barfield_Hayes results.

Additional combinations of impervious cover flow length and VFS flow length were then modeled using the Haan_Barfield_Hayes model. The runoff capture efficiencies are summarized in Table 1. The VFS flow lengths are 33% of the impervious cover flow length (the minimum VFS length), 100-ft, and 150-ft. Also shown in Table 1 is the difference in runoff capture efficiency between the "33%" value and the 100-ft and 150-ft values.

Table 1. Calculated VFS Runoff Capture Efficiencies

System Characteristics				33% VFS (Min)		Maximum VFS		
L_{IC} (ft)	W_{IC} (ft)	A_{IC} (sf)	A_{IC} (acre)	L_{VFS} min (ft)	Runoff Capture Efficiency %	L_{VFS} max (ft)	Runoff Capture Efficiency %	Increase Above Minimum %
75	435	32625	0.75	25	76	100	93	17
80	435	34800	0.80	26	76	100	92	16
100	435	43500	1.00	33	76	100	90	14
150	435	65250	1.50	50	76	100	86	10
75	435	32625	0.75	25	76	150	95	19
80	435	34800	0.80	26	76	150	95	19
100	435	43500	1.00	33	76	150	93	17
150	435	65250	1.50	50	76	150	90	14

L_{IC} – Length of Impervious Cover
W_{IC} – Width of Impervious Cover
A_{IC} – Area of Impervious Cover
A_{VFS} – Area of VFS
L_{VFS} – Length of VFS

2. VFS Credit Area Selection

The runway and taxiway areas were examined and sections of runway/taxiway with impervious cover flow lengths in the range of 75-ft to 150-ft and VFS flow length of 100-ft or 150-ft were identified (referred to as VFS Credit areas). Since a VFS designed to the 33% requirement meet the 1/2-inch plus treatment requirement, filter strips with longer flow lengths provide a significant amount of treatment over the 1/2 – inch plus requirement. These VFS Credit Areas were selected using the following set of guidelines:

1. VFS Credit Areas should be located on straight portions of runways and taxiway, avoiding curves.
2. VFS Credit Areas should be located away from inside corners.
3. VFS Credit Areas should not be located over swales, ditches, berms, or any conveyances.
4. VFS Credit Areas should meet VFS slope requirements in the ECM.
5. VFS Credit Areas should not interfere with minimum VFS required for future runway development based on a 50-year planning horizon as designated in ABIA future development plans, as shown in the Stormwater Drainage Master Plan Update as shown on the Ultimate Future Impervious Cover map.

A total of 41 VFS Credit Areas were identified and are indicated in Figure 2. VFS Credit Areas are categorized based on 2 parameters: the flow length of impervious cover, and the flow length of the VFS. Table 2 shows information about each VFS Credit Area.

Table 2. VFS Credit Area Parameters

Reference Number	Impervious Cover Flow Length (ft)	VFS Flow Length (ft)	VFS Width (ft)	VFS Area (acres)	Analysis Category (IC-VFS)
33	75	150	2,495	8.6	75-150
34	75	150	1,435	4.9	75-150
36	75	150	975	3.4	75-150
		Subtotal	**5,195**	**16.9**	
14	85	105	1,150	2.8	80-100
48	85	135	1,200	3.7	80-100
40	90	110	900	2.3	80-100
		Subtotal	**3,250**	**8.8**	
7	85	150	1,200	4.1	80-150
9	85	150	1,475	5.1	80-150
10	85	150	1,075	3.7	80-150
11	85	150	535	1.8	80-150
1	90	150	1,525	5.3	80-150
2	90	150	1,330	4.6	80-150
3	90	150	4,665	16.1	80-150
4	90	150	1,255	4.3	80-150
5	90	150	235	0.8	80-150
6	90	150	235	0.8	80-150
35	90	150	660	2.3	80-150
53	90	150	900	3.1	80-150
44	90	150	315	1.1	80-150
		Subtotal	**15,405**	**53.0**	
32	140	150	895	3.1	100-150
38	140	150	610	2.1	100-150
39	140	150	260	0.9	100-150
		Subtotal	**1,765**	**6.1**	
37	140	115	575	1.5	100-100
31	145	130	1,035	3.1	100-100
30	145	135	1,660	5.1	100-100
		Subtotal	**3,270**	**9.8**	
19	150	150	2,740	9.4	150-150
20	150	150	1,440	5.0	150-150
21	150	150	767	2.6	150-150
22	150	150	1,172	4.0	150-150
23	150	150	2,704	9.3	150-150
24	150	150	2,646	9.1	150-150
25	150	150	1,202	4.1	150-150
26	150	150	350	1.2	150-150
27	150	150	1,220	4.2	150-150
28	150	150	2,645	9.1	150-150
29	150	150	1,260	4.3	150-150
41	150	150	975	3.4	150-150
42	150	150	925	3.2	150-150
13	175	150	410	1.4	150-150
43	190	150	300	1.0	150-150
12	230	150	475	1.6	150-150
		Subtotal	**23,631**	**73.1**	
		TOTAL	**52,516**	**167.6**	

3. VFS Credit Area Loading Analysis

The amount of treatment over the required treatment amount for a given section of impervious cover is determined by calculating the difference between the annual load treated by the minimum VFS required and the annual load treated by a larger VFS. The minimum treatment (as described in the October 15 Memo) is obtained from a VFS with a flow length of runway/taxiway VFS as 33 square feet for every 100 square feet of impervious cover flow contributing area, or 33% of the impervious cover contributing area. This analysis proposes a maximum VFS flow length of 150 feet. This is the typical maximum length of sheet flow for developed areas as described in the COA

Drainage Criteria Manual (2.4.2.A).

Loading analysis of the VFS Credit Area was performed using the runoff capture efficiencies (fraction of the load captured) developed in Section 1 above and applied to the VFS Credit Areas described in Table 2. Annual loadings of four constituents were calculated – Total Suspended Solids (TSS), Total Phosphorous (TP), Total Nitrogen (TN, and Lead (Pb). These constituents were selected, in discussions with Watershed Protection, as representative of a range of different stormwater parameters. The developed runoff loads for each of the constituents were determined using equations and concentrations provided in COA ECM Section 1.6.9.3.B for both a 33% VFS and a larger VFS. The captured load calculation method is also described in ECM 1.6.9.3.B.

A sample calculation spreadsheet for a 100-ft impervious cover and 150-ft VFS is shown in Table 3. The total load removed for a 33% VFS and a 150-ft VFS are calculated. The difference between these loads – the load differential – for each of the four selected constituents is presented near the top of the spreadsheet. Similar Load Differentials were calculated for other combinations of impervious cover flow length and VFS flow length. The load differential is the amount of treatment above the required 1/2-inch plus treatment performed by the VFS.

Table 4 summarizes the load differential values developed for the various impervious cover and VFS flow lengths using spreadsheet analysis as shown in Table 3 and develops a load differential rate in pounds per year per acre of impervious cover.

Table 5 shows the calculated treatment over the required minimum treatment for the various length categories of VFS Credit Areas summarized in Table 2. The load differential rates from Table 4 are applied to the amount of VFS in a given category to determine the total annual load treated that is in excess of the minimum required treatment (33% VFS).

Table 3. 100-ft impervious cover/150-ft VFS Loading Spreadsheet

Pollutant Loading Estimates - ABIA Runway/Taxiway Vegetative Filter Strips

100ft Flow Length IC

150ft Max VFS

Inputs

Drainage Area (Acres)	1.00
Existing IC (Acres)	0.00
Total Pervious (Acres)	1.00
Future IC (%)	100.00
Rainfall (in.)	32.50

Results	TSS	Total Phosphorus	Total Nitrogen	Lead
Load Differential (lb/yr)	124.54	0.181	2.06	0.034

Difference bewtween 33% VFS Load Removed and 100ft VFS Load Removed

33% VFS

Location	Area (Acres)	Imper. Cover%	Imp. Area (Acres)	Rv	Runoff (inches)	Runoff (Ac-ft)	TSS Conc. (mg/L)	TSS Load (lb/year)	Total Phosphorus Conc. (mg/L)	Total Phosphorus Load (lb/year)	Total Nitrogen Conc. (mg/L)	Total Nitrogen Load (lb/year)	Lead Conc. (mg/L)	Lead Load (lb/year)
100ft Flow Length IC	1.00	100.00	1.00	0.904	29.38	2.4	110	732.6	0.16	1.07	1.82	12.12	0.030	0.200
PROJECTED LOAD								732.57		1.07		12.12		0.20
						PERCENT LOAD CAPTURED*		76%		76%		76%		76%
CAPTURED LOAD								556.75		0.81		9.21		0.15
TREATMENT EFFICIENCY**		Vegetive Filter Strip						100%		100%		100%		100%
LOAD REMOVED								556.8		0.81		9.21		0.152
								17						

150ft VFS

Location	Area (Acres)	Imper. Cover%	Imp. Area (Acres)	Rv	Runoff (inches)	Runoff (Ac-ft)	TSS Conc. (mg/L)	TSS Load (lb/year)	Total Phosphorus Conc. (mg/L)	Total Phosphorus Load (lb/year)	Total Nitrogen Conc. (mg/L)	Total Nitrogen Load (lb/year)	Lead Conc. (mg/L)	Lead Load (lb/year)
100ft Flow Length IC	1.00	100.00	1.00	0.904	29.38	2.4	110	732.6	0.16	1.07	1.82	12.12	0.030	0.200
PROJECTED LOAD								732.57		1.07		12.12		0.20
						PERCENT LOAD CAPTURED*		93%		93%		93%		93%
CAPTURED LOAD								681.29		0.99		11.27		0.19
TREATMENT EFFICIENCY**		Vegetive Filter Strip						100%		100%		100%		100%
LOAD REMOVED								681.3		0.99		11.27		0.186
	*Runoff Capture Efficiency							4.54						
	** Efficiency Ratio													

Conversion Factor	2.7204
FC and FS conversion fa	1.03E+06

Conversion factor is 0.2267 x 12 (COA conversion x 12 in/ft)

$$L_I = A \times P \times R_V \times C \times 0.2267$$

ECM 1.6.9.3 Eqn 1

A	Area (acres)
P	Annual Precipitation (inches)
Rv	Runoff Coefficient
C	Concentration (mg/L)
0.2267	Conversion Factor

Table 4. VFS Load Removal Rates

VFS Parameters				TSS		Total Phoprorous		Total Nitrogen		Lead	
L_{IC}	A_{IC}	L_{VFS} min	L_{VFS} max	Load Differential*		Load Differential*		Load Differential*		Load Differential*	
(ft)	(Acre)	(ft)	(ft)	lb/yr	lb/yr/A_{IC}	lb/yr	lb/yr/A_{IC}	lb/yr	lb/yr/A_{IC}	lb/yr	lb/yr/A_{IC}
75	0.75	25	100	93.4	124.71	0.136	0.18	1.55	2.07	0.25	0.3338
80	0.80	26	100	93.77	117.37	0.136	0.17	1.55	1.94	0.26	0.3254
100	1.00	33	100	102.56	102.70	0.149	0.15	1.7	1.70	0.28	0.2804
150	1.50	50	100	124.54	83.14	0.181	0.12	2.06	1.38	0.034	0.0227
75	0.75	25	150	104.39	139.38	0.152	0.20	1.73	2.31	0.028	0.0374
80	0.80	26	150	111.35	139.38	0.162	0.20	1.84	2.30	0.03	0.0376
100	1.00	33	150	109.89	110.04	0.16	0.16	1.82	1.82	0.03	0.0300
150	1.50	50	150	153.84	102.70	0.224	0.15	2.55	1.70	0.042	0.0280

*lb/yr values calculated as in example show in Table 3.

Table 5. VFS Treatment Over the Required Minimum Treatment

VFS Parameters				Treatment Over 1/2-inch Plus			
L_{IC}	W_{IC}	A_{IC}	L_{VFS}	TSS	TP	TN	Pb
(ft)	(ft)	(Acre)	(ft)	(lb/yr)	(lb/yr)	(lb/yr)	(lb/yr)
75	5,195	8.94	100	1,115	1.62	18.51	2.986
80	15,405	28.29	100	3,321	4.82	54.89	9.208
100	1,765	4.05	100	416	0.60	6.90	1.136
150	23,631	81.37	100	6,766	9.83	111.91	1.847
75	0	0.00	150	0	0.00	0.00	0.000
80	3,250	5.97	150	832	1.21	13.75	0.224
100	3,270	7.51	150	826	1.20	13.68	0.226
150	0	0.00	150	0	0.00	0.00	0.000
	TOTAL	**136.14**		**13,276**	**19.29**	**219.64**	**15.63**

LIC – Length of Impervious Cover
WIC – Width of Impervious Cover
AIC – Area of Impervious Cover
A_{VFS} – Area of VFS
L_{VFS} – Length of VFS

4. Constrained Development Area Loading Analysis

ABIA has designated the central-north area of the airport as a Constrained Development Area, due to physical and economic constraints associated with airport viability (shown in Figure 2). ABIA performs sweeping and washdown operations in this area. Most existing water quality treatment in the Constrained Development Area is designed to meet the 1/2-inch capture rule as described in the current ABIA ordinance. ABIA has proposed that future development in the CDA would remain subject to the 1/2-inch rule.

ABIA plans a total of 14 developments in the Constrained Development Area, excluding runway and taxiway development projects. Using the same loading analysis method used in Section 3, the load

for the proposed development under both the 1/2 -inch and 1/2-inch plus rules was calculated. A sample spreadsheet showing the loading calculations is presented in Table 6. The difference between these two loadings is the treatment deficit. The loading calculations are summarized in Table 7.

Table 3. ABIA CDA Development Calculation Spreadsheet

Pollutant Loading Estimates - ABIA Constrained Development Area

Development Area 1

Inputs

Drainage Area (Acres)	14.65
Existing IC (Acres)	0.02
Total Pervious (Acres)	14.63
Future IC (%)	80.00
Rainfall (in.)	32.50

Results	TSS	Total Phosphorus	Total Nitrogen	Lead
Load Differential (lb/yr)	1204.62	1.23	7.10	0.30

Difference bewtween 1/2-inch load removed and 1/2-inch plus load removedand 100ft VFS Load Removed

Future Conditions 1/2-Inch							TSS		Total Phosphorus		Total Nitrogen		Lead	
Location	Area (Acres)	Imper. Cover%	Imp. Area (Acres)	Rv	Runoff (inches)	Runoff (Ac-ft)	Conc. (mg/L)	Load (lb/year)	Conc. (mg/L)	Load (lb/year)	Conc. (mg/L)	Load (lb/year)	Conc. (mg/L)	Load (lb/year)
Development Area 1	14.63	80.00	11.70	0.642	20.85	25.4	110	7607.8	0.16	11.07	1.82	125.87	0.030	2.075
PROJECTED LOAD								7607.78		11.07		125.87		2.07
CAPTURE VOLUME IN INCHES (1/2-inch Rule)			0.50			PERCENT LOAD CAPTURED*		73%		73%		73%		73%
CAPTURED LOAD								5553.68		8.08		91.89		1.51
TREATMENT EFFICIENCY**		Filtration						87%		61%		31%		80%
LOAD REMOVED								4831.7		4.93		28.49		1.212

Future Conditions 1/2-Inch Plus							TSS		Total Phosphorus		Total Nitrogen		Lead	
Location	Area (Acres)	Imper. Cover%	Imp. Area (Acres)	Rv	Runoff (inches)	Runoff (Ac-ft)	Conc. (mg/L)	Load (lb/year)	Conc. (mg/L)	Load (lb/year)	Conc. (mg/L)	Load (lb/year)	Conc. (mg/L)	Load (lb/year)
Development Area 1	14.63	80.00	11.70	0.642	20.85	25.4	110	7607.8	0.16	11.07	1.82	125.87	0.030	2.075
PROJECTED LOAD								7607.78		11.07		125.87		2.07
CAPTURE VOLUME IN INCHES (10% Rule)			1.10			PERCENT LOAD CAPTURED*		91%		91%		91%		91%
CAPTURED LOAD								6938.29		10.09		114.80		1.89
TREATMENT EFFICIENCY**		Filtration						87%		61%		31%		80%
LOAD REMOVED								6036.3		6.16		35.59		1.514

*Runoff Capture Efficiency
** Efficiency Ratio

Conversion Factor	2.7204	(0.2267 * 12)
FC and FS conversion fact	1.03E+06	

$$L_I = A \times P \times R_V \times C \times 0.2267$$

ECM 1.6.9.3 Eqn 1

A	Area (acres)
P	Annual Precipitation (inches)
Rv	Runoff Coefficient
C	Concentration (mg/L)
0.2267	Conversion Factor

Table 7. ABIA Constrained Development Area Loading Calculations

Existing				Proposed			Difference Between 1/2" treatement vs 1/2"plus treatment (lb/year)				
ABIA Development	Watershed	Area (acres)	IC (acres)	IC (%)	New IC (acres)	1/2" plus Capture (inches)	TSS	Total P	Total N	Lead	Notes
1	Colorado	14.65	0.02	80	11.71	1.1	1204.62	1.23	7.10	0.30	1/2" treatment provided by WQP L
2	Colorado	20.35	0	80	16.28	1.1	1675.59	1.71	9.88	0.42	
4	Carson	4.45	0	100	4.45	1.3	623.95	0.64	3.68	0.19	1/2" treatment provided by WQP N
4-new	Carson	3.64	0	90	3.28	1.2	401.74	0.41	2.37	0.115	1/2" treatment provided by WQP N
5	Colorado	2.24	0	80	1.79	1.1	184.44	0.19	1.09	0.046	1/2" treatment provided by WQP L
6	Colorado	0.45	0.01	90	0.40	1.2	48.56	0.050	0.29	0.014	1/2" treatment provided by WQP L
7	Onion	0.61	0	70	0.43	1.0	33.44	0.034	0.20	0.0003	
8	Onion	0.66	0	80	0.53	1.1	53.52	0.055	0.32	0.013	
9	Onion	1.09	1.01	100	0.08	1.3	11.22	0.011	0.066	0.0035	Original ABIA ordinance 1/2-inch capture area
10	Onion	17.97	9.75	100	8.22	1.3	1152.56	1.18	6.79	0.36	Original ABIA ordinance 1/2-inch capture area
23	Colorado	12.69	0	100	12.69	1.3	1779.31	1.81	10.49	0.55	
23	Onion	2.76	0	100	2.76	1.3	386.99	0.39	2.28	0.120	
24	Onion	5.47	0	100	5.47	1.3	766.97	0.78	4.52	0.24	
32	Onion			100	0.00	1.3	0	0	0	0	Taxiways treated by Vegetated Filter Strips
33	Onion	4.59	4.58	100	0.02	1.3	1.40	0.0014	0.0083	0.00043	
Total		**91.61**	**15.36**		**68.09**		**8324.3**	**8.49**	**49.08**	**2.37**	

5. Watershed Discussion

The main portion of ABIA (study area) is located east of US-183, south of SH-71, west of FM-973, and north of Burleson Road. The study area lies in 3 watersheds (See Figure 3) – Carson Creek, Onion Creek, and the Colorado River. Nearly all of the VFS Credit Areas are located in the Onion Creek watershed. The Constrained Development Area is also within the 3 watersheds of Carson, Onion, and the Colorado. The proposed developments in the Constrained Development Area are distributed between the three watersheds as shown in Table 8.

Table 8. Proposed ABIA development in the Constrained Development Area by Watershed

Watershed	Proposed Development	
	(acres)	(%)
Colorado	50.4	55%
Carson	8.1	9%
Onion	33.2	36%
Total	**91.6**	**100%**

As shown in Figure 3, the Colorado River is close to ABIA and is the ultimate receiving water for runoff from the Carson and Onion watersheds and all of the runoff from the ABIA site. The Carson Creek confluence with the Colorado River is approximately 7.3 miles upstream from the Onion Creek

confluence with the Colorado River. The additional treatment provided by the VFS Credit Areas to ABIA discharges to Onion Creek is beneficial to Onion Creek. The City and Travis County both have plans for parks, trails, and other recreational uses of Onion Creek downstream from ABIA and would benefit from the additional treatment of discharges into Onion Creek.

Generally, the credit treatment surplus and the area requiring additional treatment would be located in the same watershed, although there is no City requirement in this regard.

6. Proposed Treatment Credit Agreement

The treatment over the required minimum treatment provided by the VFS Credit Areas is compared to the difference between the 1/2 -inch treatment and 1/2-inch plus treatment in the Constrained Development Areas and is shown in Table 9.

Table 9. Comparison of VFS Credit Area Treatment and Constrained Development Area Treatment

Source	TSS (lb/yr)	TP (lb/yr)	TN (lb/yr)	Pb (lb/yr)
VFS Credit Area Treatment	13,276	19.29	219.64	15.63
Constrained Development Zone Treatment Difference	8,324	8.49	49.08	2.37

As shown in Table 9, the VFS Credit Area treatment exceeds the Constrained Development Area treatment difference for the four constituents analyzed. The VFS Credit Areas, therefore, provide a reasonable amount of treatment to compensate for the proposed 1/2-inch treatment in the CDA. The VFS Credit Areas provide significantly better treatment for nutrients (and many other parameters) compared to standard sedimentation/filtration.

The designated VFS Credit Areas provide compensatory treatment offsets for the proposed ABIA development in the Constrained Development areas based on this water quality analysis. The specific aspects of the compensatory credit used for offsets in the Constrained Development Areas include:

1. Water quality treatment for new runway/taxiway areas will be provided by vegetated filter strips or equivalent BMPs under the 1/2-inch plus rule as described in the ABIA Stormwater Drainage Master Plan.
2. Water quality treatment in the Constrained Development Area will be provided under the 1/2-inch rule. Some areas in the Constrained Development Area are in the original ABIA ordinance 1/2 -inch area and have existing water quality ponds designed to meet the 1/2 –inch rule. Other areas in the Constrained Development Area are outside the original ordinance area and have existing water quality treatment designed to meet the ½-inch plus rule. In addition to the primary BMP implemented in the Constrained Development

Area to meet the ½-inch rule, additional BMPs (such as parking lot landscape runoff capture, filter strips, swales, infiltration basins, rain gardens, and Manufactured Treatment Devices) shall be implemented where practicable.

3. The VFS Credit Areas as described in this memorandum will serve as compensatory treatment areas that will offset the difference between the 1/2-inch and 1/2-inch plus treatment in the Constrained Development Area.
4. All other ABIA proposed development is subject to the 1/2-inch plus rule for water quality treatment or equivalent treatment.
5. The VFS Credit Areas were located with consideration of the ultimate runway and taxiway development. The credit should remain valid even with minor variations in the ultimate layout as long as minimum width and areal coverage are met.
6. If future area of runway impervious cover is significantly larger than the proposed development plans in the ABIA Stormwater Drainage Master Plan, the amount of VFS used for the credit may need to be re-evaluated by future updates of the Stormwater Drainage Master Plan.

This proposal does not require a treatment credit "bank" or a bookkeeping system since the VFS Credit areas have been selected to allow for the ultimate development of the runways and taxiways based on a 50-year planning horizon. In addition, since the excess treatment exceeds the Constrained Development Area treatment to offset, ABIA will exceed the City requirements for water quality treatment. The entire ABIA site shall exceed 1/2 inch plus load reduction requirements, considering the load reduction for the entire site on a campus wide basis.

4/18/2011

STATE OF TEXAS
L. S. STECHER
55645
REGISTERED
PROFESSIONAL ENGINEER

4/18/2011

STATE OF TEXAS
JOHN ROB MIDDLETON
106174
LICENSED
PROFESSIONAL ENGINEER

L. Stephen Stecher, PE (TBPE No. 55645)
President/Principal

John Rob Middleton, PE (TBPE No. 106174)
Staff Engineer

APPENDIX B.1

REGIONAL DETENTION STUDY REPORT

Prepared by:
AXIOM ENGINEERS INC.

CD/DVD
(ELECTRONIC COPY ONLY)

APPENDIX B.2

REGIONAL STORMWATER MANAGEMENT PROGRAM PARTICIPATION APPROVAL LETTER

City of Austin
Watershed Protection Department
April 12, 2011

APPENDIX B.1

REGIONAL DETENTION STUDY REPORT

Prepared by:
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APPENDIX B.2

REGIONAL STORMWATER MANAGEMENT PROGRAM PARTICIPATION APPROVAL LETTER

City of Austin
Watershed Protection Department
April 12, 2011

City of Austin

Founded by Congress, Republic of Texas, 1839
Watershed Protection and Development Review Department
P.O. Box 1088. Austin. Texas 78767

April 12, 2011

RSMP Request Status:
APPROVED

Mr. Joseph Medici, P.E.
City of Austin Aviation Dept.
2716 Spirit of Texas
Austin, Texas 78719

Re: RSMP (Regional Stormwater Management Program) Request
Austin Bergstrom International Airport (ABIA), State Highway 71 at U.S Highway 183
Onion Creek Watershed, (ONI-RS-2010-0012R)

Dear Mr. Medici:

Office of the Director (OD) staff have reviewed the above request to participate in the RSMP for the Onion Creek watershed per the requirements found in the City of Austin's DCM (Drainage Criteria Manual), Section 1.2.2.E. This pertinent section states, "Regulation of peak flows to allowable levels.....shall be achieved by storage on-site or off-site or by participation in an approved Regional Stormwater Management Program (RSMP)." The project will consist of commercial-type development on 4250 acres. The Airport drains directly to multiple unnamed tributaries of Onion Creek, which then outfall into the main branch of Onion Creek.

Based on the submitted information, there will be no adverse impacts to downstream roadways or structures. Therefore, RSMP participation is hereby approved. The current RSMP fee estimates for 300 acres of net impervious cover, valid until September 30, 2011, is **$1,494,164.1,** assuming a construction cost component of **$1,256,919.30 and** a Land Cost Component of **$237,244.80** (Land Cost Component based on certified appraisal provided by the City of Austin's Office of Real Estate Services).

Information on the RSMP program along with the RSMP Agreement may be found on the City's web site at http://www.ci.austin.tx.us/watershed/rsmp.htm. Please contact me at 512.974.3386 should there be any questions.

Sincerely,

José M. Guerrero, P.E.
Office of the Director

Watershed Protection Department

Attachments

XC: Mapi Vigil, P.E., Watershed Engineering Division, WPD
Roxanne Cook. P.E., Watershed Engineering Division, WPD
Forrest Nikorak, P.E., Land Use Review, PDRD
Jennifer Groody, P.E., Land Use Review, PDRD
Julie M. Lipton, Land Use Review, PDRD

The City of Austin is committed to compliance with the Americans with Disabilities Act.
Reasonable modifications and equal access to communications will be provided upon request.

REGIONAL STORMWATER MANAGEMENT PROGRAM

RSMP Commercial and Multi-Family Developments

Project Name ABIA RSMP Application [300 Acres I.C.]

Input Total Site Area and Impervious Cover Percent

OR

Input Impervious Cover Acres

Total Site Area		acres	
Impervious Cover %		percent	Reset
Impervious Cover	300	acres	Calculate

Construction Cost Component (CCC)

Impervious Acres

	From	To	Cost per impervious acre	Impervious Acres		Sub-Total Cost
A1	0.00	1.00	$60,000	1	ac.	$ 60000
A2	1.01	2.00	$18,000	1	ac.	$ 18000
A3	2.01	5.00	$8,000	3	ac.	$ 24000
A4	5.01	10.00	$6,000	5	ac.	$ 30000
A5	10.01	20.00	$5,000	10	ac.	$ 50000
A6	20.01	50.00	$4,000	30	ac.	$ 120000
A7	50.01	100.00	$2,500	50	ac.	$ 125000
A8	100.01	>	$2,500	200	ac.	$ 500000
			SUB TOTAL	300	ac.	$ 927000

ENR AF = ENR 2010 / ENR 2002

ENR 2002 = 6579 and ENR 2010 = 8920.45

CCC Sub Total ($)	ENR AF	Adjusted CCC Total
927000	x 1.3559	= $ 1256919.3

Land Cost Component (LCC)

Part A - Land Cost per Acre

Type values into boxes that state user input

Certified Appraisal Land Valuation ($)		Certified Appraisal Land Area (ac.)	Certified Appraisal Cost Per Acre	
27695448	÷	3414	= $ 8112.32	Calculate
User Input		User Input		

Part B - Land Cost Area

Cost per Acre		Land Cost Area	Land Cost Component (LCC)	
8112.32	x 0.05 x	584.9	= $ 237244.7983!	Calculate
		User Input		

TOTAL COST (For Planning Purposes Only - Actual Fee Must Be Calculated By City Staff)

(Adjusted CCC)	(LCC)	**TOTAL**	
$ 1256919.3	+ $ 237244.7983!	= $ 1494164.1	Calculate All

Return to RSMP

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P.O. Box 1088, Austin, TX 78767 (512) 974-2000

APPENDIX C

SWMM
INPUT & OUTPUT FILES

CD/DVD
(ELECTRONIC COPY ONLY)

APPENDIX D

HMS INPUT PARAMETERS

Appendix 6-D

Outfall 1

LOSS

	INITIAL LOSS (IN)	LOSS PLANE 1	MOISTURE DEFICIT	SUCTION (IN)	CONDUCTIVITY (IN/HR)	IMPERVIOUS (%)
SUBCATCHICAA0020-0760 (Plane 1)	0.7	0.7	0.092	11.5	0.063	0
SUBCATCHICAA0020-0760 (Plane 2)		-				
SUBCATCHICAA0085-0330 (Plane 1)	0.8	0.8	0.092	11.5	0.063	0
SUBCATCHICAA0085-0330 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHICAA0170-0740 (Plane 1)	0.6	0.6	0.092	11.5	0.063	0
SUBCATCHICAA0170-0740 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHICAA0351-0490 (Plane 1)	0.2	0.2	0.092	11.5	0.063	0
SUBCATCHICAA0351-0490 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHICAA0540-0840 (Plane 1)	0.6	0.6	0.092	11.5	0.063	0
SUBCATCHICAA0540-0840 (Plane 2)	0	-	0.092	11.5	0.063	100

TRANSFORM-FLOW PLANES

	LENGTH (FT)	SLOPE (FT/FT)	ROUGHNESS	ROUGHNESS PLANE 1	ROUGHNESS PLANE 2	AREA (%)
SUBCATCHICAA0020-0760(Plane 1)	676	0.111	0.6	0.6	-	100
SUBCATCHICAA0020-0760(Plane 2)				-		
SUBCATCHICAA0085-0330(Plane 1)	948	0.0132	0.6	0.6	-	50
SUBCATCHICAA0085-0330(Plane 2)	948	0.0132	0.1	-	0.1	50
SUBCATCHICAA0170-0740(Plane 1)	405	0.0099	0.5	0.5	-	38
SUBCATCHICAA0170-0740(Plane 2)	654	0.0099	0.1	-	0.1	62
SUBCATCHICAA0351-0490(Plane 1)	1	0.01	0.4	0.4	-	1
SUBCATCHICAA0351-0490(Plane 2)	631	0.01	0.1	-	0.1	99
SUBCATCHICAA0540-0840(Plane 1)	433	0.0111	0.5	0.5	-	43
SUBCATCHICAA0540-0840(Plane 2)	572	0.0111	0.1	-	0.1	57

Outfall 2

LOSS

	INITIAL LOSS (IN)	LOSS PLANE 1	MOISTURE DEFICIT	SUCTION (IN)	CONDUCTIVITY (IN/HR)	IMPERVIOUS (%)
SUBCATCHICAB0020 (Plane 1)	0.8	0.8	0.092	11.5	0.063	0
SUBCATCHICAB0020 (Plane 2)		-				
SUBCATCHICAB0030-0070 (Plane 1)	0.8	0.8	0.092	11.5	0.063	0
SUBCATCHICAB0030-0070 (Plane 2)		-				
SUBCATCHICAB0079-0330 (Plane 1)	0.4	0.4	0.092	11.5	0.063	0
SUBCATCHICAB0079-0330 (Plane 2)	0	-	0.092	11.5	0.063	100

Appendix 6-D

TRANSFORM-FLOW PLANES

	LENGTH (FT)	SLOPE (FT/FT)	ROUGHNESS	ROUGHNESS PLANE 1	ROUGHNESS PLANE 2	AREA (%)
SUBCATCHICAB0020(Plane 1)	1043	0.0122	0.6	0.6	-	100
SUBCATCHICAB0020(Plane 2)				-		
SUBCATCHICAB0030-0070(Plane 1)	361	0.136	0.6	0.6	-	100
SUBCATCHICAB0030-0070(Plane 2)				-		
SUBCATCHICAB0079-0330(Plane 1)	165	0.0449	0.4	0.4	-	13
SUBCATCHICAB0079-0330(Plane 2)	1067	0.0449	0.1	-	0.1	87

Outfall 3-7

LOSS

	INITIAL LOSS (IN)	LOSS PLANE 1	MOISTURE DEFICIT	SUCTION (IN)	CONDUCTIVITY (IN/HR)	IMPERVIOUS (%)
SUBCATCHICAD0020 (Plane 1)	0.7	0.7	0.092	11.5	0.063	0
SUBCATCHICAD0020 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHICAD0050 (Plane 1)	0.6	0.6	0.092	11.5	0.063	0
SUBCATCHICAD0050 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHICAD0060 (Plane 1)	0.8	0.8	0.092	11.5	0.063	0
SUBCATCHICAD0060 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHICAD0070 (Plane 1)	0.8	0.8	0.092	11.5	0.063	0
SUBCATCHICAD0070 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHICAD0090 (Plane 1)	0.8	0.8	0.092	11.5	0.063	0
SUBCATCHICAD0090 (Plane 2)		-				
SUBCATCHICAD0110 (Plane 1)	0.8	0.8	0.092	11.5	0.063	0
SUBCATCHICAD0110 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHICAD0170 (Plane 1)	0.8	0.8	0.092	11.5	0.063	0
SUBCATCHICAD0170 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHICAD0220 (Plane 1)	0.8	0.8	0.092	11.5	0.063	0
SUBCATCHICAD0220 (Plane 2)	0	-	0.092	11.5	0.063	100

TRANSFORM-FLOW PLANES

	LENGTH (FT)	SLOPE (FT/FT)	ROUGHNESS	ROUGHNESS PLANE 1	ROUGHNESS PLANE 2	AREA (%)
SUBCATCHICAD0020(Plane 1)	1623	0.0417	0.6	0.6	-	91
SUBCATCHICAD0020(Plane 2)	160	0.0417	0.05	-	0.05	9
SUBCATCHICAD0050(Plane 1)	730	0.0073	0.5	0.5	-	61
SUBCATCHICAD0050(Plane 2)	467	0.0073	0.1	-	0.1	39
SUBCATCHICAD0060(Plane 1)	239	0.0137	0.7	0.7	-	68
SUBCATCHICAD0060(Plane 2)	112	0.0137	0.1	-	0.1	32
SUBCATCHICAD0070(Plane 1)	547	0.0148	0.7	0.7	-	70

SUBCATCHICAD0070(Plane 2)	234	0.0148	0.1	-	0.1	30
SUBCATCHICAD0090(Plane 1)	1260	0.0264	0.7	0.7	-	100
SUBCATCHICAD0090(Plane 2)				-		
SUBCATCHICAD0110(Plane 1)	1962	0.0203	0.7	0.7	-	99
SUBCATCHICAD0110(Plane 2)	20	0.0203	0.1	-	0.1	1
SUBCATCHICAD0170(Plane 1)	1094	0.0198	0.7	0.7	-	83
SUBCATCHICAD0170(Plane 2)	224	0.0198	0.1	-	0.1	17
SUBCATCHICAD0220(Plane 1)	953	0.0359	0.6	0.6	-	97
SUBCATCHICAD0220(Plane 2)	29	0.0359	0.1	-	0.1	3

Outfall 8

LOSS

	INITIAL LOSS (IN)	LOSS PLANE 1	MOISTURE DEFICIT	SUCTION (IN)	CONDUCTIVITY (IN/HR)	IMPERVIOUS (%)
IONP0010-0050 (Plane 1)	0.5	0.5	0.092	11.5	0.063	0
IONP0010-0050 (Plane 2)	0	-	0.092	11.5	0.063	100
IONP0073-0120 (Plane 1)	1	1	0.092	11.5	0.063	0
IONP0073-0120 (Plane 2)	0	-	0.092	11.5	0.063	100
IONP0075 (Plane 1)	1	1	0.092	11.5	0.063	0
IONP0075 (Plane 2)	0	-	0.092	11.5	0.063	100
IONP0125 (Plane 1)	2	2	0.092	11.5	0.063	0
IONP0125 (Plane 2)		-				
IONP0130-0170 (Plane 1)	1	1	0.092	11.5	0.063	0
IONP0130-0170 (Plane 2)		-				
IONP0180-IONQ0190 (Plane 1)	0.5	0.5	0.092	11.5	0.063	0
IONP0180-IONQ0190 (Plane 2)	0	-	0.092	11.5	0.063	100
IONQ0010-0050 (Plane 1)	0.5	0.5	0.092	11.5	0.063	0
IONQ0010-0050 (Plane 2)	0	-	0.092	11.5	0.063	100
IONQ0060 (Plane 1)	1	1	0.092	11.5	0.063	0
IONQ0060 (Plane 2)	0	-	0.092	11.5	0.063	100
IONQ0070-0080 (Plane 1)	1	1	0.092	11.5	0.063	0
IONQ0070-0080 (Plane 2)	0	-	0.092	11.5	0.063	100
IONQ0100-0120 (Plane 1)	0.5	0.5	0.092	11.5	0.063	0
IONQ0100-0120 (Plane 2)	0	-	0.092	11.5	0.063	100
IONQ0140-IONS0080 (Plane 1)	1	1	0.092	11.5	0.063	0
IONQ0140-IONS0080 (Plane 2)	0	-	0.092	11.5	0.063	100
IONQ0180 (Plane 1)	2	2	0.092	11.5	0.063	0
IONQ0180 (Plane 2)		-				
IONS0050 (Plane 1)	0.5	0.5	0.092	11.5	0.063	0

IONS0050 (Plane 2)	0	-	0.092	11.5	0.063	100

TRANSFORM-FLOW PLANES

	LENGTH (FT)	SLOPE (FT/FT)	ROUGHNESS	ROUGHNESS PLANE 1	ROUGHNESS PLANE 2	AREA (%)
IONP0010-0050(Plane 1)	2852	0.0145	0.3	0.3	-	78
IONP0010-0050(Plane 2)	814	0.0145	0.1	-	0.1	22
IONP0073-0120(Plane 1)	1336	0.0183	0.4	0.4	-	98
IONP0073-0120(Plane 2)	27	0.0183	0.1	-	0.1	2
IONP0075(Plane 1)	3751	0.00702	0.35	0.35	-	86
IONP0075(Plane 2)	611	0.00702	0.1	-	0.1	14
IONP0125(Plane 1)	2901	0.0098	0.5	0.5	-	100
IONP0125(Plane 2)				-		
IONP0130-0170(Plane 1)	2171	0.0115	0.25	0.25	-	100
IONP0130-0170(Plane 2)				-		
IONP0180-IONQ0190(Plane 1)	2003	0.0093	0.4	0.4	-	99
IONP0180-IONQ0190(Plane 2)	24	0.0093	0.1	-	0.1	1
IONQ0010-0050(Plane 1)	2029	0.0147	0.3	0.3	-	62
IONQ0010-0050(Plane 2)	1231	0.0147	0.1	-	0.1	38
IONQ0060(Plane 1)	566	0.0167	0.4	0.4	-	59
IONQ0060(Plane 2)	394	0.01667	0.15	-	0.15	41
IONQ0070-0080(Plane 1)	3619	0.0085	0.4	0.4	-	76
IONQ0070-0080(Plane 2)	869	0.0085	0.1	-	0.1	24
IONQ0100-0120(Plane 1)	936	0.0075	0.3	0.3	-	51
IONQ0100-0120(Plane 2)	911	0.0075	0.1	-	0.1	49
IONQ0140-IONS0080(Plane 1)	4547	0.0189	0.4	0.4	-	99
IONQ0140-IONS0080(Plane 2)	23	0.0189	0.1	-	0.1	1
IONQ0180(Plane 1)	12346	0.0086	0.45	0.45	-	100
IONQ0180(Plane 2)				-		
IONS0050(Plane 1)	4261	0.00491	0.3	0.3	-	84
IONS0050(Plane 2)	812	0.00491	0.1	-	0.1	16

Outfall 10, 11, 25 (transient)

LOSS

	INITIAL LOSS (IN)	LOSS PLANE 1	MOISTURE DEFICIT	SUCTION (IN)	CONDUCTIVITY (IN/HR)	IMPERVIOUS (%)
SUBCATCHIONV0030 (Plane 1)	0.75	0.75	0.092	11.5	0.063	0
SUBCATCHIONV0030 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHIONV0060 (Plane 1)	0.6	0.6	0.092	11.5	0.063	0
SUBCATCHIONV0060 (Plane 2)	0	-	0.092	11.5	0.063	100

SUBCATCHIONV0080 (Plane 1)	0.6	0.6	0.092	11.5	0.063	0
SUBCATCHIONV0080 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHIONV0085 (Plane 1)	0.7	0.7	0.092	11.5	0.063	0
SUBCATCHIONV0085 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHIONV0100 (Plane 1)	0.6	0.6	0.092	11.5	0.063	0
SUBCATCHIONV0100 (Plane 2)	0	-	0.092	11.5	0.063	100

TRANSFORM-FLOW PLANES

	LENGTH (FT)	SLOPE (FT/FT)	ROUGHNESS	ROUGHNESS PLANE 1	ROUGHNESS PLANE 2	AREA (%)
SUBCATCHIONV0030(Plane 1)	961	0.0158	0.5	0.5	-	86
SUBCATCHIONV0030(Plane 2)	157	0.0158	0.05	-	0.05	14
SUBCATCHIONV0060(Plane 1)	1188	0.0072	0.5	0.5	-	80
SUBCATCHIONV0060(Plane 2)	297	0.0072	0.05	-	0.05	20
SUBCATCHIONV0080(Plane 1)	2114	0.0049	0.6	0.6	-	67
SUBCATCHIONV0080(Plane 2)	1041	0.0049	0.03	-	0.03	33
SUBCATCHIONV0085(Plane 1)	1700	0.0021	0.5	0.5	-	92
SUBCATCHIONV0085(Plane 2)	148	0.0021	0.05	-	0.05	8
SUBCATCHIONV0100(Plane 1)	788	0.0005	0.5	0.5	-	96
SUBCATCHIONV0100(Plane 2)	33	0.0005	0.05	-	0.05	4

Outfall 15

LOSS

	INITIAL LOSS (IN)	LOSS PLANE 1	MOISTURE DEFICIT	SUCTION (IN)	CONDUCTIVITY (IN/HR)	IMPERVIOUS (%)
IONK00-10-30 (Plane 1)	0.353	0.353	0.092	11.5	0.063	0
IONK00-10-30 (Plane 2)	0	-	0.092	11.5	0.063	100
IONK00-40-50 (Plane 1)	0.353	0.353	0.092	11.5	0.063	0
IONK00-40-50 (Plane 2)	0	-	0.092	11.5	0.063	100
IONK0070 (Plane 1)	0.35294	0.35294	0.092	11.5	0.063	0
IONK0070 (Plane 2)	0	-	0.092	11.5	0.063	100
IONK0-080-220 (Plane 1)	0.5	0.5	0.092	11.5	0.063	0
IONK0-080-220 (Plane 2)	0	-	0.092	11.5	0.063	100
IONK0125 (Plane 1)	0.0408163	0.0408163	0.092	11.5	0.063	0
IONK0125 (Plane 2)	0	-	0.092	11.5	0.063	100
IONK0200-140 (Plane 1)	0.222	0.222	0.092	11.5	0.063	0
IONK0200-140 (Plane 2)	0	-	0.092	11.5	0.063	100
IONK0210 (Plane 1)	0.41	0.41	0.092	11.5	0.063	0
IONK0210 (Plane 2)	0	-	0.092	11.5	0.063	100
IONK0240-230 (Plane 1)	0.38095	0.38095	0.092	11.5	0.063	0

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IONK0240-230 (Plane 2)	0	-	0.092	11.5	0.063	100
IONK0250 (Plane 1)	0.15054	0.15054	0.092	11.5	0.063	0
IONK0250 (Plane 2)	0	-	0.092	11.5	0.063	100
IONK0-290-260 (Plane 1)	0.222	0.222	0.092	11.5	0.063	0
IONK0-290-260 (Plane 2)	0	-	0.092	11.5	0.063	100
IONK0-330-300 (Plane 1)	0.02	0.02	0.092	11.5	0.063	0
IONK0-330-300 (Plane 2)	0	-	0.092	11.5	0.063	100
IONK0-350-340 (Plane 1)	0.5	0.5	0.092	11.5	0.063	0
IONK0-350-340 (Plane 2)	0	-	0.092	11.5	0.063	100
IONK0-360-430 (Plane 1)	0.353	0.353	0.092	11.5	0.063	0
IONK0-360-430 (Plane 2)	0	-	0.092	11.5	0.063	100
IONK0390 (Plane 1)	0.5	0.5	0.092	11.5	0.063	0
IONK0390 (Plane 2)	0	-	0.092	11.5	0.063	100
IONK0440 (Plane 1)	0.7	0.7	0.092	11.5	0.063	0
IONK0440 (Plane 2)	0	-	0.092	11.5	0.063	100
IONN0-010-330 (Plane 1)	0.105	0.105	0.092	11.5	0.063	0
IONN0-010-330 (Plane 2)	0	-	0.092	11.5	0.063	100
IONN0090 (Plane 1)	0.7	0.7	0.092	11.5	0.063	0
IONN0090 (Plane 2)		-				
IONN0-100-180 (Plane 1)	0.857	0.857	0.092	11.5	0.063	0
IONN0-100-180 (Plane 2)		-				
IONN0-340-360 (Plane 1)	0.041	0.041	0.092	11.5	0.063	0
IONN0-340-360 (Plane 2)	0	-	0.092	11.5	0.063	100
IONR0010 (Plane 1)	0.5	0.5	0.092	11.5	0.063	0
IONR0010 (Plane 2)	0	-	0.092	11.5	0.063	100
IONR0020 (Plane 1)	0.5	0.5	0.092	11.5	0.063	0
IONR0020 (Plane 2)	0	-	0.092	11.5	0.063	100
IONR0050 (Plane 1)	0.5	0.5	0.092	11.5	0.063	0
IONR0050 (Plane 2)	0	-	0.092	11.5	0.063	100
IONR0060 (Plane 1)	0.5	0.5	0.092	11.5	0.063	0
IONR0060 (Plane 2)	0	-	0.092	11.5	0.063	100
IONR0080 (Plane 1)	0.5	0.5	0.092	11.5	0.063	0
IONR0080 (Plane 2)	0	-	0.092	11.5	0.063	100
IONR0-210-310 (Plane 1)	0.353	0.353	0.092	11.5	0.063	0
IONR0-210-310 (Plane 2)	0	-	0.092	11.5	0.063	100
IONR0-320-360 (Plane 1)	0.5	0.5	0.092	11.5	0.063	0
IONR0-320-360 (Plane 2)	0	-	0.092	11.5	0.063	100

TRANSFORM-FLOW PLANES

Appendix 6-D

	LENGTH (FT)	SLOPE (FT/FT)	ROUGHNESS	ROUGHNESS PLANE 1	ROUGHNESS PLANE 2	AREA (%)
IONK00-10-30(Plane 1)	1074.64	0.011125	0.3	0.3	-	76
IONK00-10-30(Plane 2)	339.36	0.011125	0.1	-	0.1	24
IONK00-40-50(Plane 1)	652.605	0.012285	0.35	0.35	-	70
IONK00-40-50(Plane 2)	286.395	0.012285	0.1	-	0.1	30
IONK0070(Plane 1)	84.55	0.02	0.4	0.4	-	95
IONK0070(Plane 2)	4.45	0.02	0.1	-	0.1	5
IONK0-080-220(Plane 1)	244.9	0.2	0.4	0.4	-	79
IONK0-080-220(Plane 2)	65.1	0.2	0.1	-	0.1	21
IONK0125(Plane 1)	16.56	0.0202	0.3	0.3	-	12
IONK0125(Plane 2)	121.44	0.0202	0.1	-	0.1	88
IONK0200-140(Plane 1)	524.02	0.015546	0.35	0.35	-	53
IONK0200-140(Plane 2)	460.98	0.015546	0.1	-	0.1	47
IONK0210(Plane 1)	450	0.01176	0.3	0.3	-	75
IONK0210(Plane 2)	150	0.01176	0.1	-	0.1	25
IONK0240-230(Plane 1)	278.32	0.010925	0.4	0.4	-	71
IONK0240-230(Plane 2)	113.68	0.010925	0.1	-	0.1	29
IONK0250(Plane 1)	1	0.01	0.35	0.35	-	0
IONK0250(Plane 2)	203	0.01	0.1	-	0.1	100
IONK0-290-260(Plane 1)	2.05	0.01	0.35	0.35	-	1
IONK0-290-260(Plane 2)	612.95	0.01	0.1	-	0.1	99
IONK0-330-300(Plane 1)	75.645	0.02	0.3	0.3	-	31
IONK0-330-300(Plane 2)	170.355	0.02	0.1	-	0.1	69
IONK0-350-340(Plane 1)	136.71	0.00855	0.3	0.3	-	32
IONK0-350-340(Plane 2)	297.29	0.00855	0.1	-	0.1	68
IONK0-360-430(Plane 1)	561.834	0.01092	0.35	0.35	-	69
IONK0-360-430(Plane 2)	257.166	0.01092	0.1	-	0.1	31
IONK0390(Plane 1)	903	0.005	0.45	0.45	-	95
IONK0390(Plane 2)	48	0.005	0.1	-	0.1	5
IONK0440(Plane 1)	1274	0.016	0.5	0.5	-	98
IONK0440(Plane 2)	26	0.016	0.1	-	0.1	2
IONN0-010-330(Plane 1)	131	0.0103853	0.25	0.25	-	16
IONN0-010-330(Plane 2)	669	0.0103853	0.1	-	0.1	84
IONN0090(Plane 1)	450	0.015	0.6	0.6	-	100
IONN0090(Plane 2)				-		
IONN0-100-180(Plane 1)	1000	0.06	0.7	0.7	-	100
IONN0-100-180(Plane 2)				-		
IONN0-340-360(Plane 1)	1	0.01	0.25	0.25	-	0
IONN0-340-360(Plane 2)	400	0.01	0.1	-	0.1	100

IONR0010(Plane 1)	1914	0.0069	0.42	0.42	-	87
IONR0010(Plane 2)	286	0.0069	0.1	-	0.1	13
IONR0020(Plane 1)	1337	0.0104	0.45	0.45	-	76
IONR0020(Plane 2)	422	0.0104	0.1	-	0.1	24
IONR0050(Plane 1)	1215	0.0035	0.45	0.45	-	75
IONR0050(Plane 2)	405	0.00347	0.1	-	0.1	25
IONR0060(Plane 1)	974	0.0073	0.45	0.45	-	68
IONR0060(Plane 2)	459	0.0073	0.1	-	0.1	32
IONR0080(Plane 1)	1934	0.0063	0.4	0.4	-	78
IONR0080(Plane 2)	546	0.0063	0.1	-	0.1	22
IONR0-210-310(Plane 1)	3766	0.015	0.25	0.25	-	99
IONR0-210-310(Plane 2)	34	0.015	0.1	-	0.1	1
IONR0-320-360(Plane 1)	1543	0.0471	0.35	0.35	-	89
IONR0-320-360(Plane 2)	187	0.0471	0.1	-	0.1	11

Outfall 16

LOSS

	INITIAL LOSS (IN)	LOSS PLANE 1	MOISTURE DEFICIT	SUCTION (IN)	CONDUCTIVITY (IN/HR)	IMPERVIOUS (%)
IONI0045-IONI1100 (Plane 1)	0.5	0.5	0.092	11.5	0.063	0
IONI0045-IONI1100 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHIONA0010-0170 (Plane 1)	0	-	0.092	11.5	0.063	100
SUBCATCHIONA0010-0170 (Plane 2)		-				
SUBCATCHIONA0080-0210 (Plane 1)	0.2	0.2	0.092	11.5	0.063	0
SUBCATCHIONA0080-0210 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHIONB0010-0050 (Plane 1)	0.8	0.8	0.092	11.5	0.063	0
SUBCATCHIONB0010-0050 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHIONB00130-0170 (Plane 1)	0.4	0.4	0.092	11.5	0.063	0
SUBCATCHIONB00130-0170 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHIONB0060 (Plane 1)	0.4	0.4	0.092	11.5	0.063	0
SUBCATCHIONB0060 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHIONB0080-0190 (Plane 1)	0.6	0.6	0.092	11.5	0.063	0
SUBCATCHIONB0080-0190 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHIONB0200 (Plane 1)	0.5	0.5	0.092	11.5	0.063	0
SUBCATCHIONB0200 (Plane 2)		-				
SUBCATCHIONC0035 (Plane 1)	0	-	0.092	11.5	0.063	100
SUBCATCHIONC0035 (Plane 2)		-				
SUBCATCHIONC0040-0220 (Plane 1)	0.7	0.7	0.092	11.5	0.063	0
SUBCATCHIONC0040-0220 (Plane 2)	0	-	0.092	11.5	0.063	100

SUBCATCHIONC0100 (Plane 1)	0.4	0.4	0.092	11.5	0.063	0
SUBCATCHIONC0100 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHIONC0110-0240 (Plane 1)	0.7	0.7	0.092	11.5	0.063	0
SUBCATCHIONC0110-0240 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHIONC0130-0170 (Plane 1)	0.4	0.4	0.092	11.5	0.063	0
SUBCATCHIONC0130-0170 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHIONC0180-0210 (Plane 1)	0.4	0.4	0.092	11.5	0.063	0
SUBCATCHIONC0180-0210 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHIONC0190 (Plane 1)	0.4	0.4	0.092	11.5	0.063	0
SUBCATCHIONC0190 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHIONC0200 (Plane 1)	0.4	0.4	0.092	11.5	0.063	0
SUBCATCHIONC0200 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHIONC0230 (Plane 1)	0.4	0.4	0.092	11.5	0.063	0
SUBCATCHIONC0230 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHIOND0020-0520 (Plane 1)	0.4	0.4	0.092	11.5	0.063	0
SUBCATCHIOND0020-0520 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHIOND0530-IOND0770 (Plane 1)	0.4	0.4	0.092	11.5	0.063	0
SUBCATCHIOND0530-IOND0770 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHIOND0570-1310 (Plane 1)	0.4	0.4	0.092	11.5	0.063	0
SUBCATCHIOND0570-1310 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHIOND0605-0990 (Plane 1)	0.4	0.4	0.092	11.5	0.063	0
SUBCATCHIOND0605-0990 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHIOND1340-1660 (Plane 1)	0.2	0.2	0.092	11.5	0.063	0
SUBCATCHIOND1340-1660 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHIOND1530 (Plane 1)	0.4	0.4	0.092	11.5	0.063	0
SUBCATCHIOND1530 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHIOND1550-IONE0020 (Plane 1)	0.7	0.7	0.092	11.5	0.063	0
SUBCATCHIOND1550-IONE0020 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHIONE0010-0360 (Plane 1)	0.4	0.4	0.092	11.5	0.063	0
SUBCATCHIONE0010-0360 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHIONE0110-IONF0410 (Plane 1)	0	-	0.092	11.5	0.063	100
SUBCATCHIONE0110-IONF0410 (Plane 2)		-				
SUBCATCHIONF0010-0260 (Plane 1)	0.2	0.2	0.092	11.5	0.063	0
SUBCATCHIONF0010-0260 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHIONF0050-0380 (Plane 1)	0.7	0.7	0.092	11.5	0.063	0
SUBCATCHIONF0050-0380 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHIONF0160-170 (Plane 1)	0.4	0.4	0.092	11.5	0.063	0
SUBCATCHIONF0160-170 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHIONG0020-0150 (Plane 1)	0.3	0.3	0.092	11.5	0.063	0

SUBCATCHIONG0020-0150 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHIONG0060 (Plane 1)	0.6	0.6	0.092	11.5	0.063	0
SUBCATCHIONG0060 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHIONG0070-0250 (Plane 1)	0.3	0.3	0.092	11.5	0.063	0
SUBCATCHIONG0070-0250 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHIONG0080-0280 (Plane 1)	0.3	0.3	0.092	11.5	0.063	0
SUBCATCHIONG0080-0280 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHIONG0090-0100 (Plane 1)	0.3	0.3	0.092	11.5	0.063	0
SUBCATCHIONG0090-0100 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHIONG0110-0490 (Plane 1)	0.4	0.4	0.092	11.5	0.063	0
SUBCATCHIONG0110-0490 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHIONG0130-0135 (Plane 1)	0.4	0.4	0.092	11.5	0.063	0
SUBCATCHIONG0130-0135 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHIONG0160-0170 (Plane 1)	0.5	0.5	0.092	11.5	0.063	0
SUBCATCHIONG0160-0170 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHIONG0190-0220 (Plane 1)	0.3	0.3	0.092	11.5	0.063	0
SUBCATCHIONG0190-0220 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHIONG0290-0320 (Plane 1)	0.6	0.6	0.092	11.5	0.063	0
SUBCATCHIONG0290-0320 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHIONG0330-0340 (Plane 1)	0.4	0.4	0.092	11.5	0.063	0
SUBCATCHIONG0330-0340 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHIONG0350-0510 (Plane 1)	0.5	0.5	0.092	11.5	0.063	0
SUBCATCHIONG0350-0510 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHIONH0010-IONI1130 (Plane 1)	0.6	0.6	0.092	11.5	0.063	0
SUBCATCHIONH0010-IONI1130 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHIONH0020-0250 (Plane 1)	1	1	0.092	11.5	0.063	0
SUBCATCHIONH0020-0250 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHIONH0035-0090 (Plane 1)	0.3	0.3	0.092	11.5	0.063	0
SUBCATCHIONH0035-0090 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHIONH0260-0430 (Plane 1)	0.3	0.3	0.092	11.5	0.063	0
SUBCATCHIONH0260-0430 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHIONI0020 (Plane 1)	0.4	0.4	0.092	11.5	0.063	0
SUBCATCHIONI0020 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHIONI0090-IONI250-280 (Plane 1)	0.2	0.2	0.092	11.5	0.063	0
SUBCATCHIONI0090-IONI250-280 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHIONI0095-160 (Plane 1)	0.2	0.2	0.092	11.5	0.063	0
SUBCATCHIONI0095-160 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHIONI0180 (Plane 1)	0.5	0.5	0.092	11.5	0.063	0
SUBCATCHIONI0180 (Plane 2)	0	-	0.092	11.5	0.063	100

SUBCATCHIONI0210-240 (Plane 1)	0	-	0.092	11.5	0.063	100
SUBCATCHIONI0210-240 (Plane 2)		-				
SUBCATCHIONI0380-0400 (Plane 1)	0.3	0.3	0.092	11.5	0.063	0
SUBCATCHIONI0380-0400 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHIONI0410-0435 (Plane 1)	0.7	0.7	0.092	11.5	0.063	0
SUBCATCHIONI0410-0435 (Plane 2)	0.1	-	0.092	11.5	0.063	100
SUBCATCHIONI0430 (Plane 1)	0.5	0.5	0.092	11.5	0.063	0
SUBCATCHIONI0430 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHIONI0570-620 (Plane 1)	0.3	0.3	0.092	11.5	0.063	0
SUBCATCHIONI0570-620 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHIONI0630-640 (Plane 1)	0.3	0.3	0.092	11.5	0.063	0
SUBCATCHIONI0630-640 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHIONI0660-0690 (Plane 1)	0.5	0.5	0.092	11.5	0.063	0
SUBCATCHIONI0660-0690 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHIONI1150 (Plane 1)	0.3	0.3	0.092	11.5	0.063	0
SUBCATCHIONI1150 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHIONJ0440-0540 (Plane 1)	0.3	0.3	0.092	11.5	0.063	0
SUBCATCHIONJ0440-0540 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHIONJ0490 (Plane 1)	0.8	0.8	0.092	11.5	0.063	0
SUBCATCHIONJ0490 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHIONJ0550 (Plane 1)	0.8	0.8	0.092	11.5	0.063	0
SUBCATCHIONJ0550 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHIONJ0575 (Plane 1)	0.8	0.8	0.092	11.5	0.063	0
SUBCATCHIONJ0575 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHIONL0035 (Plane 1)	0.7	0.7	0.092	11.5	0.063	0
SUBCATCHIONL0035 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHIONL0036-IONJ0560 (Plane 1)	0.4	0.4	0.092	11.5	0.063	0
SUBCATCHIONL0036-IONJ0560 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHIONL0040-0070 (Plane 1)	0.4	0.4	0.092	11.5	0.063	0
SUBCATCHIONL0040-0070 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHIONL0080-0130 (Plane 1)	0.4	0.4	0.092	11.5	0.063	0
SUBCATCHIONL0080-0130 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHIONL0140-0190 (Plane 1)	0.4	0.4	0.092	11.5	0.063	0
SUBCATCHIONL0140-0190 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHIONM0010-0160 (Plane 1)	0.8	0.8	0.092	11.5	0.063	0
SUBCATCHIONM0010-0160 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHIONM0230-0240 (Plane 1)	0.4	0.4	0.092	11.5	0.063	0
SUBCATCHIONM0230-0240 (Plane 2)		-				
SUBCATCHIONM0255 (Plane 1)	0.6	0.6	0.092	11.5	0.063	0

SUBCATCHIONM0255 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHIONT0005-0020 (Plane 1)	0.3	0.3	0.092	11.5	0.063	0
SUBCATCHIONT0005-0020 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHIONT0030 (Plane 1)	0.5	0.5	0.092	11.5	0.063	0
SUBCATCHIONT0030 (Plane 2)	0.1	-	0.092	11.5	0.063	100
SUBCATCHIONT0050-0210 (Plane 1)	0.3	0.3	0.092	11.5	0.063	0
SUBCATCHIONT0050-0210 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHIONT0070 (Plane 1)	0.6	0.6	0.092	11.5	0.063	0
SUBCATCHIONT0070 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHIONT0080-0096 (Plane 1)	1.2	1.2	0.092	11.5	0.063	0
SUBCATCHIONT0080-0096 (Plane 2)	0.1	-	0.092	11.5	0.063	100
SUBCATCHIONT0097-IONI0593 (Plane 1)	0.5	0.5	0.092	11.5	0.063	0
SUBCATCHIONT0097-IONI0593 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHIONT0100-0106 (Plane 1)	0.6	0.6	0.092	11.5	0.063	0
SUBCATCHIONT0100-0106 (Plane 2)	0.1	-	0.092	11.5	0.063	100
SUBCATCHIONT0110-160 (Plane 1)	0.6	0.6	0.092	11.5	0.063	0
SUBCATCHIONT0110-160 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHIONT0170-205 (Plane 1)	0.2	0.2	0.092	11.5	0.063	0
SUBCATCHIONT0170-205 (Plane 2)	0	-	0.092	11.5	0.063	100

TRANSFORM-FLOW PLANES

	LENGTH (FT)	SLOPE (FT/FT)	ROUGHNESS	ROUGHNESS PLANE 1	ROUGHNESS PLANE 2	AREA (%)
IONI0045-IONI1100(Plane 1)	272	0.0641	0.5	0.5	-	52
IONI0045-IONI1100(Plane 2)	251	0.0641	0.1	-	0.1	48
SUBCATCHIONA0010-0170(Plane 1)	226	0.0472	0.05	0.05	-	100
SUBCATCHIONA0010-0170(Plane 2)				-		
SUBCATCHIONA0080-0210(Plane 1)	7	0.0123	0.3	0.3	-	5
SUBCATCHIONA0080-0210(Plane 2)	149	0.0123	0.05	-	0.05	95
SUBCATCHIONB0010-0050(Plane 1)	128	0.012	0.5	0.5	-	68
SUBCATCHIONB0010-0050(Plane 2)	61	0.012	0.05	-	0.05	32
SUBCATCHIONB00130-0170(Plane 1)	178	0.0864	0.4	0.4	-	40
SUBCATCHIONB00130-0170(Plane 2)	262	0.0864	0.1	-	0.1	60
SUBCATCHIONB0060(Plane 1)	172	0.012	0.4	0.4	-	64
SUBCATCHIONB0060(Plane 2)	97	0.012	0.1	-	0.1	36
SUBCATCHIONB0080-0190(Plane 1)	384	0.0126	0.4	0.4	-	63
SUBCATCHIONB0080-0190(Plane 2)	225	0.0126	0.1	-	0.1	37
SUBCATCHIONB0200(Plane 1)	323	0.009	0.6	0.6	-	100
SUBCATCHIONB0200(Plane 2)				-		
SUBCATCHIONC0035(Plane 1)	414	0.0237	0.05	0.05	-	100

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SUBCATCHIONC0035(Plane 2)				-		
SUBCATCHIONC0040-0220(Plane 1)	324	0.0112	0.5	0.5	-	40
SUBCATCHIONC0040-0220(Plane 2)	492	0.0112	0.05	-	0.05	60
SUBCATCHIONC0100(Plane 1)	280	0.0211	0.4	0.4	-	55
SUBCATCHIONC0100(Plane 2)	229	0.0211	0.1	-	0.1	45
SUBCATCHIONC0110-0240(Plane 1)	386	0.017	0.6	0.6	-	48
SUBCATCHIONC0110-0240(Plane 2)	418	0.017	0.1	-	0.1	52
SUBCATCHIONC0130-0170(Plane 1)	457	0.0102	0.4	0.4	-	54
SUBCATCHIONC0130-0170(Plane 2)	389	0.0102	0.1	-	0.1	46
SUBCATCHIONC0180-0210(Plane 1)	752	0.0099	0.4	0.4	-	62
SUBCATCHIONC0180-0210(Plane 2)	451	0.0099	0.1	-	0.1	38
SUBCATCHIONC0190(Plane 1)	46	0.0166	0.4	0.4	-	18
SUBCATCHIONC0190(Plane 2)	208	0.0166	0.1	-	0.1	82
SUBCATCHIONC0200(Plane 1)	281	0.0073	0.4	0.4	-	56
SUBCATCHIONC0200(Plane 2)	220	0.0073	0.1	-	0.1	44
SUBCATCHIONC0230(Plane 1)	375	0.0099	0.4	0.4	-	42
SUBCATCHIONC0230(Plane 2)	518	0.0099	0.1	-	0.1	58
SUBCATCHIOND0020-0520(Plane 1)	469	0.0135	0.4	0.4	-	35
SUBCATCHIOND0020-0520(Plane 2)	876	0.0135	0.1	-	0.1	65
SUBCATCHIOND0530-IOND0770(Plane 1)	6	0.013	0.4	0.4	-	2
SUBCATCHIOND0530-IOND0770(Plane 2)	332	0.013	0.1	-	0.1	98
SUBCATCHIOND0570-1310(Plane 1)	72	0.0135	0.4	0.4	-	12
SUBCATCHIOND0570-1310(Plane 2)	506	0.0135	0.1	-	0.1	88
SUBCATCHIOND0605-0990(Plane 1)	170	0.012	0.4	0.4	-	22
SUBCATCHIOND0605-0990(Plane 2)	613	0.012	0.03	-	0.03	78
SUBCATCHIOND1340-1660(Plane 1)	105	0.0128	0.4	0.4	-	13
SUBCATCHIOND1340-1660(Plane 2)	695	0.0128	0.015	-	0.015	87
SUBCATCHIOND1530(Plane 1)	632	0.0026	0.4	0.4	-	89
SUBCATCHIOND1530(Plane 2)	78	0.0026	0.1	-	0.1	11
SUBCATCHIOND1550-IONE0020(Plane 1)	298	0.0147	0.6	0.6	-	44
SUBCATCHIOND1550-IONE0020(Plane 2)	383	0.0147	0.05	-	0.05	56
SUBCATCHIONE0010-0360(Plane 1)	316	0.0594	0.4	0.4	-	29
SUBCATCHIONE0010-0360(Plane 2)	788	0.0594	0.1	-	0.1	71
SUBCATCHIONE0110-IONF0410(Plane 1)	397	0.0345	0.05	0.05	-	100
SUBCATCHIONE0110-IONF0410(Plane 2)				-		
SUBCATCHIONF0010-0260(Plane 1)	11	0.0069	0.3	0.3	-	4
SUBCATCHIONF0010-0260(Plane 2)	296	0.0069	0.05	-	0.05	96
SUBCATCHIONF0050-0380(Plane 1)	318	0.051	0.5	0.5	-	60
SUBCATCHIONF0050-0380(Plane 2)	216	0.051	0.05	-	0.05	40

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SUBCATCHIONF0160-170(Plane 1)	11	0.0039	0.4	0.4	-	3
SUBCATCHIONF0160-170(Plane 2)	442	0.0039	0.1	-	0.1	97
SUBCATCHIONG0020-0150(Plane 1)	473	0.0181	0.4	0.4	-	74
SUBCATCHIONG0020-0150(Plane 2)	163	0.0181	0.1	-	0.1	26
SUBCATCHIONG0060(Plane 1)	233	0.0139	0.5	0.5	-	51
SUBCATCHIONG0060(Plane 2)	223	0.0139	0.05	-	0.05	49
SUBCATCHIONG0070-0250(Plane 1)	273	0.0116	0.4	0.4	-	39
SUBCATCHIONG0070-0250(Plane 2)	432	0.0116	0.1	-	0.1	61
SUBCATCHIONG0080-0280(Plane 1)	248	0.0111	0.4	0.4	-	39
SUBCATCHIONG0080-0280(Plane 2)	387	0.0111	0.1	-	0.1	61
SUBCATCHIONG0090-0100(Plane 1)	378	0.0144	0.4	0.4	-	52
SUBCATCHIONG0090-0100(Plane 2)	349	0.0144	0.1	-	0.1	48
SUBCATCHIONG0110-0490(Plane 1)	361	0.014	0.4	0.4	-	54
SUBCATCHIONG0110-0490(Plane 2)	308	0.014	0.1	-	0.1	46
SUBCATCHIONG0130-0135(Plane 1)	488	0.0082	0.4	0.4	-	59
SUBCATCHIONG0130-0135(Plane 2)	339	0.0082	0.1	-	0.1	41
SUBCATCHIONG0160-0170(Plane 1)	312	0.0147	0.45	0.45	-	80
SUBCATCHIONG0160-0170(Plane 2)	81	0.0147	0.1	-	0.1	20
SUBCATCHIONG0190-0220(Plane 1)	386	0.0083	0.4	0.4	-	58
SUBCATCHIONG0190-0220(Plane 2)	283	0.0083	0.1	-	0.1	42
SUBCATCHIONG0290-0320(Plane 1)	711	0.0111	0.4	0.4	-	63
SUBCATCHIONG0290-0320(Plane 2)	427	0.0111	0.1	-	0.1	37
SUBCATCHIONG0330-0340(Plane 1)	266	0.012	0.4	0.4	-	58
SUBCATCHIONG0330-0340(Plane 2)	196	0.012	0.1	-	0.1	42
SUBCATCHIONG0350-0510(Plane 1)	826	0.0135	0.45	0.45	-	73
SUBCATCHIONG0350-0510(Plane 2)	311	0.0135	0.1	-	0.1	27
SUBCATCHIONH0010-IONI1130(Plane 1)	1302	0.0059	0.4	0.4	-	78
SUBCATCHIONH0010-IONI1130(Plane 2)	367	0.0059	0.1	-	0.1	22
SUBCATCHIONH0020-0250(Plane 1)	1722	0.0096	0.65	0.65	-	50
SUBCATCHIONH0020-0250(Plane 2)	1713	0.0096	0.17	-	0.17	50
SUBCATCHIONH0035-0090(Plane 1)	808	0.0119	0.5	0.5	-	51
SUBCATCHIONH0035-0090(Plane 2)	786	0.0119	0.15	-	0.15	49
SUBCATCHIONH0260-0430(Plane 1)	686	0.0079	0.3	0.3	-	61
SUBCATCHIONH0260-0430(Plane 2)	438	0.0079	0.1	-	0.1	39
SUBCATCHIONI0020(Plane 1)	325	0.0072	0.5	0.5	-	73
SUBCATCHIONI0020(Plane 2)	120	0.0072	0.1	-	0.1	27
SUBCATCHIONI0090-IONI250-280(Plane 1)	100	0.0213	0.3	0.3	-	36
SUBCATCHIONI0090-IONI250-280(Plane 2)	175	0.0213	0.05	-	0.05	64
SUBCATCHIONI0095-160(Plane 1)	272	0.0084	0.3	0.3	-	34

SUBCATCHIONI0095-160(Plane 2)	530	0.0084	0.05	-	0.05	66
SUBCATCHIONI0180(Plane 1)	379	0.0114	0.5	0.5	-	73
SUBCATCHIONI0180(Plane 2)	140	0.0114	0.1	-	0.1	27
SUBCATCHIONI0210-240(Plane 1)	749	0.01	0.05	0.05	-	100
SUBCATCHIONI0210-240(Plane 2)				-		
SUBCATCHIONI0380-0400(Plane 1)	610	0.0045	0.35	0.35	-	82
SUBCATCHIONI0380-0400(Plane 2)	134	0.0045	0.1	-	0.1	18
SUBCATCHIONI0410-0435(Plane 1)	1885	0.0051	0.65	0.65	-	96
SUBCATCHIONI0410-0435(Plane 2)	72	0.0051	0.015	-	0.015	4
SUBCATCHIONI0430(Plane 1)	1885	0.0048	0.35	0.35	-	75
SUBCATCHIONI0430(Plane 2)	628	0.0048	0.1	-	0.1	25
SUBCATCHIONI0570-620(Plane 1)	443	0.0138	0.3	0.3	-	61
SUBCATCHIONI0570-620(Plane 2)	287	0.0138	0.1	-	0.1	39
SUBCATCHIONI0630-640(Plane 1)	463	0.0165	0.3	0.3	-	53
SUBCATCHIONI0630-640(Plane 2)	411	0.0165	0.1	-	0.1	47
SUBCATCHIONI0660-0690(Plane 1)	436	0.0129	0.3	0.3	-	50
SUBCATCHIONI0660-0690(Plane 2)	431	0.0129	0.1	-	0.1	50
SUBCATCHIONI1150(Plane 1)	469	0.019	0.35	0.35	-	60
SUBCATCHIONI1150(Plane 2)	313	0.019	0.1	-	0.1	40
SUBCATCHIONJ0440-0540(Plane 1)	984	0.0117	0.35	0.35	-	68
SUBCATCHIONJ0440-0540(Plane 2)	470	0.0117	0.02	-	0.02	32
SUBCATCHIONJ0490(Plane 1)	330	0.28	0.6	0.6	-	80
SUBCATCHIONJ0490(Plane 2)	82	0.28	0.05	-	0.05	20
SUBCATCHIONJ0550(Plane 1)	693	0.0158	0.5	0.5	-	86
SUBCATCHIONJ0550(Plane 2)	113	0.0158	0.05	-	0.05	14
SUBCATCHIONJ0575(Plane 1)	556	0.013	0.6	0.6	-	98
SUBCATCHIONJ0575(Plane 2)	8	0.013	0.05	-	0.05	2
SUBCATCHIONL0035(Plane 1)	964	0.0105	0.5	0.5	-	81
SUBCATCHIONL0035(Plane 2)	226	0.0105	0.1	-	0.1	19
SUBCATCHIONL0036-IONJ0560(Plane 1)	1505	0.0147	0.35	0.35	-	87
SUBCATCHIONL0036-IONJ0560(Plane 2)	231	0.0147	0.1	-	0.1	13
SUBCATCHIONL0040-0070(Plane 1)	235	0.0127	0.4	0.4	-	37
SUBCATCHIONL0040-0070(Plane 2)	394	0.0127	0.1	-	0.1	63
SUBCATCHIONL0080-0130(Plane 1)	743	0.0138	0.35	0.35	-	53
SUBCATCHIONL0080-0130(Plane 2)	666	0.0138	0.1	-	0.1	47
SUBCATCHIONL0140-0190(Plane 1)	481	0.0118	0.35	0.35	-	66
SUBCATCHIONL0140-0190(Plane 2)	244	0.0118	0.1	-	0.1	34
SUBCATCHIONM0010-0160(Plane 1)	884	0.041	0.6	0.6	-	47
SUBCATCHIONM0010-0160(Plane 2)	1010	0.041	0.1	-	0.1	53

SUBCATCHIONM0230-0240(Plane 1)	326	0.2	0.4	0.4	-	100
SUBCATCHIONM0230-0240(Plane 2)				-		
SUBCATCHIONM0255(Plane 1)	840	0.008	0.5	0.5	-	82
SUBCATCHIONM0255(Plane 2)	184	0.008	0.1	-	0.1	18
SUBCATCHIONT0005-0020(Plane 1)	1349	0.0096	0.4	0.4	-	97
SUBCATCHIONT0005-0020(Plane 2)	42	0.0096	0.1	-	0.1	3
SUBCATCHIONT0030(Plane 1)	1526	0.0058	0.55	0.55	-	95
SUBCATCHIONT0030(Plane 2)	80	0.0058	0.02	-	0.02	5
SUBCATCHIONT0050-0210(Plane 1)	1211	0.0142	0.4	0.4	-	99
SUBCATCHIONT0050-0210(Plane 2)	7	0.0142	0.1	-	0.1	1
SUBCATCHIONT0070(Plane 1)	1520	0.0085	0.55	0.55	-	98
SUBCATCHIONT0070(Plane 2)	31	0.0085	0.1	-	0.1	2
SUBCATCHIONT0080-0096(Plane 1)	1289	0.0474	0.75	0.75	-	95
SUBCATCHIONT0080-0096(Plane 2)	65	0.0474	0.015	-	0.015	5
SUBCATCHIONT0097-IONI0593(Plane 1)	2032	0.0305	0.3	0.3	-	95
SUBCATCHIONT0097-IONI0593(Plane 2)	114	0.0305	0.1	-	0.1	5
SUBCATCHIONT0100-0106(Plane 1)	1745	0.0348	0.6	0.6	-	99
SUBCATCHIONT0100-0106(Plane 2)	21	0.0348	0.03	-	0.03	1
SUBCATCHIONT0110-160(Plane 1)	1147	0.0061	0.5	0.5	-	80
SUBCATCHIONT0110-160(Plane 2)	279	0.0061	0.1	-	0.1	20
SUBCATCHIONT0170-205(Plane 1)	1618	0.006	0.3	0.3	-	71
SUBCATCHIONT0170-205(Plane 2)	661	0.006	0.1	-	0.1	29

Outfall 19

LOSS

	INITIAL LOSS (IN)	LOSS PLANE 1	MOISTURE DEFICIT	SUCTION (IN)	CONDUCTIVITY (IN/HR)	IMPERVIOUS (%)
SUBCATCHICOA0015-ICOB0045 (Plane 1)	0.8	0.8	0.092	11.5	0.063	0
SUBCATCHICOA0015-ICOB0045 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHICOA0080-0320 (Plane 1)	2	2	0.092	11.5	0.063	0
SUBCATCHICOA0080-0320 (Plane 2)		-				
SUBCATCHICOA0100-0290 (Plane 1)	0.6	0.6	0.092	11.5	0.063	0
SUBCATCHICOA0100-0290 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHICOA0353-0400 (Plane 1)	0.6	0.6	0.092	11.5	0.063	0
SUBCATCHICOA0353-0400 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHICOA0450 (Plane 1)	0.6	0.6	0.092	11.5	0.063	0
SUBCATCHICOA0450 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHICOB0020-0040 (Plane 1)	0.5	0.5	0.092	11.5	0.063	0
SUBCATCHICOB0020-0040 (Plane 2)	0	-	0.092	11.5	0.063	100

SUBCATCHICOB0050-0090 (Plane 1)	0.3	0.3	0.092	11.5	0.063	0
SUBCATCHICOB0050-0090 (Plane 2)		-				
SUBCATCHICOB0100 (Plane 1)	0.4	0.4	0.092	11.5	0.063	0
SUBCATCHICOB0100 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHICOB0105-0267 (Plane 1)	0.6	0.6	0.092	11.5	0.063	0
SUBCATCHICOB0105-0267 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHICOB0120-0135 (Plane 1)	1	1	0.092	11.5	0.063	0
SUBCATCHICOB0120-0135 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHICOB0140-0160 (Plane 1)	0.5	0.5	0.092	11.5	0.063	0
SUBCATCHICOB0140-0160 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHICOB0170-0200 (Plane 1)	0.5	0.5	0.092	11.5	0.063	0
SUBCATCHICOB0170-0200 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHICOB0210-0235 (Plane 1)	0.8	0.8	0.092	11.5	0.063	0
SUBCATCHICOB0210-0235 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHICOB0270-0310 (Plane 1)	0.4	0.4	0.092	11.5	0.063	0
SUBCATCHICOB0270-0310 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHICOB0280 (Plane 1)	0.4	0.4	0.092	11.5	0.063	0
SUBCATCHICOB0280 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHICOB0300-0640 (Plane 1)	0.4	0.4	0.092	11.5	0.063	0
SUBCATCHICOB0300-0640 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHICOB0340-0660 (Plane 1)	0.4	0.4	0.092	11.5	0.063	0
SUBCATCHICOB0340-0660 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHICOB0360-0390 (Plane 1)	0.4	0.4	0.092	11.5	0.063	0
SUBCATCHICOB0360-0390 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHICOB0400-0454 (Plane 1)	0.5	0.5	0.092	11.5	0.063	0
SUBCATCHICOB0400-0454 (Plane 2)	0	-	0.092	11.5	0.063	100

TRANSFORM-FLOW PLANES

	LENGTH (FT)	SLOPE (FT/FT)	ROUGHNESS	ROUGHNESS PLANE 1	ROUGHNESS PLANE 2	AREA (%)
SUBCATCHICOA0015-ICOB0045(Plane 1)	1540	0.012	0.6	0.6	-	97
SUBCATCHICOA0015-ICOB0045(Plane 2)	42	0.012	0.05	-	0.05	3
SUBCATCHICOA0080-0320(Plane 1)	468	0.0746	0.8	0.8	-	100
SUBCATCHICOA0080-0320(Plane 2)				-		
SUBCATCHICOA0100-0290(Plane 1)	1	0.0094	0.5	0.5	-	1
SUBCATCHICOA0100-0290(Plane 2)	245	0.0094	0.05	-	0.05	99
SUBCATCHICOA0353-0400(Plane 1)	44	0.0254	0.5	0.5	-	10
SUBCATCHICOA0353-0400(Plane 2)	380	0.0254	0.05	-	0.05	90
SUBCATCHICOA0450(Plane 1)	882	0.0045	0.5	0.5	-	97
SUBCATCHICOA0450(Plane 2)	27	0.0045	0.05	-	0.05	3

SUBCATCHICOB0020-0040(Plane 1)	1563	0.0471	0.6	0.6	-	99
SUBCATCHICOB0020-0040(Plane 2)	24	0.0471	0.05	-	0.05	1
SUBCATCHICOB0050-0090(Plane 1)	1596	0.0325	0.35	0.35	-	100
SUBCATCHICOB0050-0090(Plane 2)				-		
SUBCATCHICOB0100(Plane 1)	2145	0.0094	0.4	0.4	-	92
SUBCATCHICOB0100(Plane 2)	187	0.0094	0.05	-	0.05	8
SUBCATCHICOB0105-0267(Plane 1)	513	0.0226	0.5	0.5	-	93
SUBCATCHICOB0105-0267(Plane 2)	37	0.0226	0.05	-	0.05	7
SUBCATCHICOB0120-0135(Plane 1)	1483	0.0071	0.7	0.7	-	97
SUBCATCHICOB0120-0135(Plane 2)	46	0.0071	0.05	-	0.05	3
SUBCATCHICOB0140-0160(Plane 1)	827	0.0069	0.4	0.4	-	84
SUBCATCHICOB0140-0160(Plane 2)	161	0.0069	0.05	-	0.05	16
SUBCATCHICOB0170-0200(Plane 1)	1974	0.0053	0.4	0.4	-	97
SUBCATCHICOB0170-0200(Plane 2)	61	0.0053	0.05	-	0.05	3
SUBCATCHICOB0210-0235(Plane 1)	1312	0.0111	0.45	0.45	-	94
SUBCATCHICOB0210-0235(Plane 2)	91	0.0111	0.1	-	0.1	6
SUBCATCHICOB0270-0310(Plane 1)	1399	0.0124	0.4	0.4	-	99
SUBCATCHICOB0270-0310(Plane 2)	20	0.0124	0.05	-	0.05	1
SUBCATCHICOB0280(Plane 1)	2039	0.0042	0.4	0.4	-	85
SUBCATCHICOB0280(Plane 2)	360	0.0042	0.05	-	0.05	15
SUBCATCHICOB0300-0640(Plane 1)	521	0.0096	0.4	0.4	-	81
SUBCATCHICOB0300-0640(Plane 2)	126	0.0096	0.05	-	0.05	19
SUBCATCHICOB0340-0660(Plane 1)	1197	0.0049	0.4	0.4	-	93
SUBCATCHICOB0340-0660(Plane 2)	85	0.0049	0.05	-	0.05	7
SUBCATCHICOB0360-0390(Plane 1)	527	0.0161	0.4	0.4	-	85
SUBCATCHICOB0360-0390(Plane 2)	96	0.0161	0.05	-	0.05	15
SUBCATCHICOB0400-0454(Plane 1)	186	0.0724	0.5	0.5	-	33
SUBCATCHICOB0400-0454(Plane 2)	382	0.0724	0.05	-	0.05	67

Outfall 21

	INITIAL LOSS (IN)	LOSS PLANE 1	MOISTURE DEFICIT	SUCTION (IN)	CONDUCTIVITY (IN/HR)	IMPERVIOUS (%)
SUBCATCHICOC0020-0540 (Plane 1)	0.7	0.7	0.092	11.5	0.063	0
SUBCATCHICOC0020-0540 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHICOC0060 (Plane 1)	2	2	0.092	11.5	0.063	0
SUBCATCHICOC0060 (Plane 2)	0.3	-	0.092	11.5	0.063	100
SUBCATCHICOC0090-0320 (Plane 1)	1.5	1.5	0.092	11.5	0.063	0
SUBCATCHICOC0090-0320 (Plane 2)	1	-	0.092	11.5	0.063	100
SUBCATCHICOC0101-0105 (Plane 1)	0.6	0.6	0.092	11.5	0.063	0

SUBCATCHICOC0101-0105 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHICOC0110 (Plane 1)	0.7	0.7	0.092	11.5	0.063	0
SUBCATCHICOC0110 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHICOC0112-0360 (Plane 1)	0.5	0.5	0.092	11.5	0.063	0
SUBCATCHICOC0112-0360 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHICOC0150 (Plane 1)	0.85	0.85	0.092	11.5	0.063	0
SUBCATCHICOC0150 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHICOC0170-0196 (Plane 1)	0.7	0.7	0.092	11.5	0.063	0
SUBCATCHICOC0170-0196 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHICOC0202-0215 (Plane 1)	0.6	0.6	0.092	11.5	0.063	0
SUBCATCHICOC0202-0215 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHICOC0245-0248 (Plane 1)	1	1	0.092	11.5	0.063	0
SUBCATCHICOC0245-0248 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHICOC0290 (Plane 1)	0.5	0.5	0.092	11.5	0.063	0
SUBCATCHICOC0290 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHICOC0390 (Plane 1)	0.85	0.85	0.092	11.5	0.063	0
SUBCATCHICOC0390 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHICOC0460-0563 (Plane 1)	0.4	0.4	0.092	11.5	0.063	0
SUBCATCHICOC0460-0563 (Plane 2)	0	-	0.092	11.5	0.063	100
SUBCATCHICOC0520 (Plane 1)	0.8	0.8	0.092	11.5	0.063	0
SUBCATCHICOC0520 (Plane 2)	0	-	0.092	11.5	0.063	100

	LENGTH (FT)	SLOPE (FT/FT)	ROUGHNESS	ROUGHNESS PLANE 1	ROUGHNESS PLANE 2	AREA (%)
SUBCATCHICOC0020-0540(Plane 1)	589	0.0394	0.55	0.55	-	74
SUBCATCHICOC0020-0540(Plane 2)	203	0.0394	0.05	-	0.05	26
SUBCATCHICOC0060(Plane 1)	851	0.0032	0.8	0.8	-	88
SUBCATCHICOC0060(Plane 2)	116	0.0032	0.05	-	0.05	12
SUBCATCHICOC0090-0320(Plane 1)	306	0.0544	0.75	0.75	-	23
SUBCATCHICOC0090-0320(Plane 2)	1024	0.0544	0.15	-	0.15	77
SUBCATCHICOC0101-0105(Plane 1)	241	0.009	0.4	0.4	-	28
SUBCATCHICOC0101-0105(Plane 2)	613	0.009	0.15	-	0.15	72
SUBCATCHICOC0110(Plane 1)	495	0.0109	0.55	0.55	-	67
SUBCATCHICOC0110(Plane 2)	244	0.0109	0.05	-	0.05	33
SUBCATCHICOC0112-0360(Plane 1)	57	0.0101	0.5	0.5	-	10
SUBCATCHICOC0112-0360(Plane 2)	508	0.0101	0.1	-	0.1	90
SUBCATCHICOC0150(Plane 1)	735	0.0311	0.55	0.55	-	90
SUBCATCHICOC0150(Plane 2)	82	0.0311	0.05	-	0.05	10
SUBCATCHICOC0170-0196(Plane 1)	23	0.01	0.55	0.55	-	3
SUBCATCHICOC0170-0196(Plane 2)	671	0.01	0.05	-	0.05	97

Appendix 6-D

SUBCATCHICOC0202-0215(Plane 1)	39	0.0105	0.55	0.55	-	8
SUBCATCHICOC0202-0215(Plane 2)	436	0.0105	0.1	-	0.1	92
SUBCATCHICOC0245-0248(Plane 1)	361	0.036	0.7	0.7	-	69
SUBCATCHICOC0245-0248(Plane 2)	165	0.036	0.15	-	0.15	31
SUBCATCHICOC0290(Plane 1)	998	0.0165	0.55	0.55	-	86
SUBCATCHICOC0290(Plane 2)	163	0.0165	0.05	-	0.05	14
SUBCATCHICOC0390(Plane 1)	910	0.0217	0.55	0.55	-	86
SUBCATCHICOC0390(Plane 2)	148	0.0217	0.05	-	0.05	14
SUBCATCHICOC0460-0563(Plane 1)	409	0.0115	0.4	0.4	-	68
SUBCATCHICOC0460-0563(Plane 2)	190	0.0115	0.05	-	0.05	32
SUBCATCHICOC0520(Plane 1)	788	0.0088	0.6	0.6	-	45
SUBCATCHICOC0520(Plane 2)	964	0.0088	0.05	-	0.05	55

APPENDIX E

FACILITY NEEDS ASSESSMENT
STORMWATER DRAINAGE

TECHNICAL MEMORANDUM

Prepared by:

CDM
June 22, 2010

CDM

Memorandum

To: *ABIA*

From: *CDM*

Date: *June 22, 2010*

Subject: *Facility Needs Assessment – Stormwater Drainage*

This memorandum presents the assessment of facility needs for the Austin-Bergstrom International Airport (ABIA) as part of the Stormwater Drainage Master Plan Update (SWMP). In particular, this memorandum addresses the water quantity (drainage) portion of Task 1.6 of the scope of the SWMP: Drainage and Water Quality Facility Needs for ABIA Build-out Conditions.

Purpose

The purpose of this task was to develop a conceptual level understanding of storm water facility needs, associated land area requirements and conceptual costs to accommodate future development on ABIA property. To that end, impervious cover maps were developed that provide the airport layout plan in the ultimate built-out condition.

The remainder of the task is divided into two parts: water quality facilities needs, which must be maintained on-site; and drainage facilities needs, which may be maintained on-site, or mitigated as part of the City of Austin's Regional Stormwater Management Plan (RSMP) for the Onion Creek Watershed.

Water Quality

A preliminary water quality facility needs assessment was conducted to estimate the allowable pollutant load for 10 parameters using the City of Austin's standard treatment systems to determine the required pollutant load reduction and load removal requirements for build-out conditions. The results of this preliminary assessment are presented in a separate memorandum.

The changes in impervious area from existing to build-out land use are estimated to be 780 acres in the Onion Creek Watershed. The amount of on-site detention required for water quality treatment was estimated to be between 23 and 30 acres using required treatment volumes and an average pond depth of 5 ft. A sensitivity analysis to pond depth and other parameters was used to determine the range of detention area. Since facilities to address

detention and water quality requirements are typically combined, the determination of required acreage for on-site detention will exclude this land area identified for water quality facilities.

Water Quantity (Drainage)

The purpose of the preliminary drainage facilities needs assessment was to estimate the additional on-site detention necessary to accommodate all additional surface runoff from the ultimate build-out impervious conditions, including a conceptual cost estimate, and compare that to the costs of participation in the City of Austin's RSMP.

It is important to note that the decision of whether or not to participate in RSMP or to provide design guidance for on-site detention is an intermediate milestone within this project and needed to be analyzed and discussed by stakeholders prior to project completion. This task was developed to provide estimates for this analysis for the April 27, 2010 workshop between the ABIA, City regulators and ABIA's consultants.

Participation in RSMP is contingent upon meeting requirements that include future development not causing downstream impacts in the watershed (flooding or erosion). ABIA and ABIA's consultants have provided the City with a separate report (ABIA Regional Detention Study, June 2010) that documents simulated runoff from ABIA under build-out conditions and the resulting peak flows in Onion Creek. The City's Regional Onion Creek Watershed HEC-HMS model was used for these simulations with the 100-year storm event. The report indicates that future development does not cause substantial increases to the peak flows in Onion Creek under a variety of test scenarios (the largest deviation was four orders of magnitude (1/10,000) smaller than the peak flow and within the error of the model). The tested scenarios included ones with no on-site facilities (RSMP Participation) and ones with on-site detention facilities.

Therefore, the modeling indicates that there are no significant changes to offsite flows (and thus flooding) whether or not there are detention facilities built on-site. This is largely due to the timing of peak flows. The ABIA site is very near the downstream end of the watershed and thus peak flows occur much earlier off the site than occur for the watershed as a whole.

Participation in the RSMP would be beneficial to the City because the monies could be spent further upstream in the basin where facilities would mitigate flooding. One additional item that will need to be addressed for participation in the RSMP is erosion in the outlet channels. This item will be addressed (under separate scope tasks) sufficiently to allow for RSMP participation.

This report has shown that RSMP participation is likely, although as of the April 27, 2010 workshop, the costs of participation were to be determined. It still was necessary to estimate the size and conceptual costs of on-site detention for comparison purposes. The remainder of

this memorandum documents the methodology to find estimates of on-site detention necessary to not increase flows off the site, and the resulting estimates and conceptual costs.

Estimates of On-site Detention - Methodology

In this case, on-site detention is to be used to reduce the flows off-site under ultimate build-out conditions to the peak flows that are simulated under existing conditions for the 100-year design storm. Note that the comparisons under this task are of the flows as they flow off the site, as opposed to the RSMP, which was concerned with flows in receiving bodies (such as Onion Creek).

This comparison was conducted with the US Environmental Protection Agency (EPA) Stormwater Management Model (SWMM) that was developed for ABIA under an older SWMP and updated for this project. This model is much more detailed than the HEC-HMS model used for the more regional analysis, but only extends coverage to the ABIA property. In this case, the receiving water bodies act as boundary conditions.

The model was run for existing conditions to establish baseline flows to the outfalls. There are 17 separate outfalls flowing off the property. These outfalls may be divided into three groups based on receiving bodies (watersheds). There are six outfalls that flow to Carson Creek, nine that flow to Onion Creek, and two that flow directly to the Colorado River.

Next, the model was converted to the ultimate build-out (UBO) condition, which basically increases imperviousness in the hydrologic component of the mode, which in turn increases runoff and flows. **Table 1** below shows the resultant peak flows by outfall for the existing and UBO conditions, respectfully. Note that the timing of peak flows are not always coincident; therefore, the "Total" peak flow is an approximation.

The area that is tributary to the Carson Creek watershed is nearly built-out under the existing condition, thus the UBO condition simulations indicate little change. Therefore, the Carson Creek outfalls were eliminated from the rest of this exercise. The outfall numbering system comes from the 2003 SWMP, while the labels match the SWMM labels.

The largest increases (by percentage) are expected to be at outfalls 7E, 7F, and 9. There are significant increases in impervious areas to be developed tributary to these outfalls.

The goal of this task is to add on-site detention at these outfalls until the post-development condition results in peak flows that are less than or equal to the pre-development (existing condition) peak flows. Due to the complexity of the system, a simple "shave the peak" volume calculation tends to under-predict the storage needed to mitigate the excess flows.

Table 1. Peak Flows by Outfall with no Onsite Detention

Carson Creek Outfalls		Peak Flow (cfs)		
		Existing	UBO	Delta
1	JCAA0015	172.0	176.4	4.5
2	JCAB0010	146.8	146.8	0.0
3	JCAD0010	217.5	214.1	-3.4
4	JCAD0080	65.7	65.7	0.0
5	JCAD0100	176.1	157.4	-18.7
6	JCAD0210	54.9	54.9	0.0
			Total	-18

Onion Creek Outfalls		Peak Flow (cfs)		
		Existing	UBO	Delta
7A	JONS0090	1,556.9	1,962.7	405.8
7B	JONV0050	38.3	39.2	0.9
7C	JONV0070	71.5	71.5	0.0
7D	JONV0090	111.0	127.0	16.1
7E	JONV0110	85.3	411.7	326.4
7F	JONR0205	1,105.5	1,806.0	700.5
7G	JONT0105	3286.9	4147.8	860.9
24	JONK0024	50.0	50.0	0.0
23	JONK0023	60.2	60.2	0.0
			Total	2,311

Colorado River Outfalls		Peak Flow (cfs)		
		Existing	UBO	Delta
9	JCOB0010	809.6	1,321.4	511.8
10	JCOC0010	439.7	508.1	68.4
			Total	580

Therefore, detention ponds were added to the model with the UBO condition at each outfall, and resized in an iterative process until the desired reduction in peak flow was achieved.

As the ultimate design of the future development is unknown at this time, detention ponds are not necessarily located where they may ultimately be built. In model space, they are conceptual. However, care was taken to only allow reasonable depths of ponding based on regional topography. The model was also examined such that the detention areas did not cause upstream flooding.

These conceptual detention ponds were given vertical walls to find the interior storage space necessary to mitigate the peak flows. Because the final number (it is most likely in final design the storage will be distributed among multiple ponds), size, and shape of the ponds is unknown, it is impossible to exactly estimate the future pond stage-area-storage relationships. The total area needed to accommodate the ponds will be adjusted at the end of the exercise to account for inside and outside berm areas and breaking the detention into multiple pieces.

Maximum pond depths are managed by overflow weirs in the model. The weirs are designed as to not have much of an effect on the peak flow and are set at elevations that allow for reasonable pond depths and freeboard. Low flow orifices have not been added because they would not change the peak flow results.

Estimates of On-site Detention - Results

Table 2 displays the results of the model simulations after the detention storage has been added. Again, the timing of the peak flows are not always coincident; therefore, the "Total" peak flow is an approximation. As discussed earlier, the total storage area (in acres) for each watershed represents the approximate interior area needed and does not account for the area necessary for pond berms or setback requirements.

Table 2. Peak Flows by Outfall with Detention and Detention Sizing

Onion Creek		Peak Flow (cfs)			Storage Area (Ac)	Peak Depth (ft)	Peak Storage (Ac-ft)
		Existing	UBO w Storage	Delta			
7A	JONS0090	1,556.9	1,541.3	-15.6	18.4	11.0	201.8
7B	JONV0050	38.3	39.2	0.9			
7C	JONV0070	71.5	71.5	0.0			
7D	JONV0090	111.0	111.3	0.3	2.3	9.2	21.0
7E	JONV0110	85.3	83.1	-2.2	4.9	6.8	33.2
7F	JONR0205	1,105.5	1,061.7	-43.8	8.3	12.2	101.4
7G	JONT0105	3,286.9	3,270.8	-16.1	20.7	12.8	265.8
24	JONK0024	50.0	50.0	0.0			
23	JONK0023	60.2	60.2	0.0			
			Totals	-77	54.6		623

Colorado River		Peak Flow (cfs)			Storage Area (Ac)	Peak Depth (ft)	Peak Storage (Ac-ft)
		Existing	UBO w Storage	Delta			
9	JCOB0010	809.6	789.3	-20.3	9.8	9.9	96.6
10	JCOC0010	439.7	410.1	-29.6	0.9	6.9	6.2
			Totals	-50	10.7		103

The model simulations indicate that approximately 55 acres of interior storage is necessary to mitigate the peaks of the outfall flows for the Onion Creek watershed and an additional 11 acres is needed for the Colorado River Watershed.

Because of the uncertainties in the number of ponds that would be built to provide the necessary storage, as well as the size and shape of each, a factor of 1.5 has been applied to each of these areas to account for the space needed for their application (i.e. berm area, etc.). Therefore, the final surface areas are 82 acres in the Onion Creek Watershed and 16 acres in the Colorado River Watershed (corresponding to approximately 620 and 100 acre-ft volumes, respectively).

It should be noted that RSMP participation only covers the Onion Creek Watershed, although this watershed does cover a majority of the site. Thus, in order to compare on-site detention to participation in the RSMP, it was determined that only the Onion Creek Watershed should be considered. From the preliminary water quality assessment of the Onion Creek watershed, 23 to 30 acres may be necessary to locate water quality treatment facilities on-site, regardless of participation in the RSMP.

The remaining on-site detention area estimate if there were no participation in RSMP, after removing the necessary water quality area, ranges from 52 to 59 acres.

As noted, the RSMP does not cover the Colorado River Watershed. Peak flows in the Colorado River are less likely to be significantly altered with the excess flows in the case of no on-site detention than they would for Onion Creek (which have already been shown to be negligible). This is again due to the disparate timing of the peak flows, but also because the Colorado is a managed watershed. It is unknown at the time of this writing whether excess flows from development in this watershed would be routed to the Colorado, re-directed to Onion Creek, or retained on-site.

Estimates of On-site Detention - Conceptual Cost

An estimate of conceptual cost for the Onion Creek portion of the on-site detention scenario has been developed as a direct comparison to RSMP participation. For this estimate, basins are expected to be dug down, with minimal berms to avoid a high-hazard dam classification (and to match existing on-site detention geometries). Table 3 gives the conceptual cost breakdown, excluding the value of the land. The total costs are estimated to be approximately $14 million.

Table 3. Conceptual Costs of Onsite Detention for the Onion Creek Watershed

Item	Units	Quantity	Unit Cost	Total
Mobilization	LS	1		$445,000
Sediment and Erosion Control	LF	15,010	$5	$75,000
Clearing and Grubbing	AC	55	$6,900	$380,000
Excavation	CY	731,700	$10	$7,317,000
Embankment	CY	59,100	$10	$591,000
Maintenance Access	SY	25,400	$5	$127,000
Control Structure	EA	5	$9,500	$48,000
Discharge Pipe	LF	100	$90	$9,000
End treatment	EA	5	$1,900	$10,000
Sod	SY	67,800	$5	$339,000
		Sub-Total		$9,341,000
		Contingency	30%	$2,802,300
		Sub-Total		$12,143,000
		Engineering, Survey, and Permitting	15%	$1,821,000
		Grand Total		**$13,964,000**

Assumptions:

1. Prices include all labor, equipment, materials, O&P.
2. Mobilization based on 5% earthwork cost.
3. Sediment and Erosion Control based on staked silt fence and assumed basin sizes.
4. Excavated material suitable for berm construction.
5. No allowance for selling excess material.
6. Disposal of excess material included in cost of Excavation.
7. Maintenance access constructed of 12" soil stabilization 18' wide.
8. Basins geometry: ~2L=W, 3H:1V Side slopes, Freeboard = 3', Berm height = 3'.
9. Costs do not include wetland mitigation, maintenance, or monitoring.
10. Costs do not include potential hazardous remediation.
11. Control structure 10'x4' modified with overflow weir and orifice.
12. Discharge pipe 24" RCP. Price includes trenching, compaction, and backfilling.
13. End treatment mitered end section.
14. Total storage volume = 453.56 Ac*ft.
15. Costs are in 2010 dollars.

APPENDIX F

CONCEPTUAL CAPITAL COSTS

TABLE F-1
(a) / (b) / (c)

ENGINEER'S OPINION OF CONCEPTUAL CONSTRUCTION COSTS:

OUTFALL NO. 1

Table F-1(a). Engineer's Opinion of Conceptual Construction Cost - Outfall No. 1

Item	Units	Quantity	Unit Cost	Total
Carson Creek Outfall Number 1: 0.7 acre dry detention				
Mobilization	LS	1		$7,000
Sediment and Erosion Control	LF	2,885	$5	$14,000
Clearing and Grubbing	AC	1	$6,900	$5,000
Excavation	CY	5,296	$10	$53,000
Embankment	CY	1,130	$10	$11,000
Maintenance Access	SY	1,507	$5	$8,000
48" RCP Inflow Pipe	LF	300	$100	$30,000
48" Mitered End Section	EA	2	$1,700	$3,000
24" RCP Drainage Pipe	LF	100	$35	$4,000
24" Mitered End Section	EA	2	$900	$2,000
Control Structure	EA	1	$10,000	$10,000
Sod	SY	734	$5	$4,000
		Sub-Total		$150,000
		Contingency	30%	$45,000
		Subtotal		$196,000
		Engineering, Surveying, and Permitting	15%	$29,000
		Dry Detention Basin Total		$225,000

Assumptions:

1. Prices include all labor, equipment, materials, O&P.
2. Mobilization based on 5% earthwork cost.
3. Sediment and Erosion Control based on staked silt fence and assumed pond sizes.
4. Excavated material suitable for berm construction.
5. No allowance for selling excess material.
6. Disposal of excess material included in cost of Excavation.
7. Maintenance access constructed of 12" soil stabilization 18' wide.
8. Ponds geometry: ~2L=W, 3H:1V Side slopes, Freeboard = 1', Berm height = 2'.
9. Control structure 10'x4' modified with overflow weir and orifice.
10. RCP price includes trenching, compaction, and backfilling.
11. Costs are in 2010 dollars.
12. Costs do not include wetland mitigation, maintenance, or monitoring.
13. Costs do not include potential hazardous remediation.

Table F-1(b). List of Pipe Upgrades and Conceptual Costs - Outfall No. 1

Item	Units	Quantity	Unit Cost	Total
Pipe Costing[3]				
24" RCP	LF	730	$35	$26,000
36" RCP	LF	365	$70	$26,000
48" RCP	LF	635	$100	$64,000
54" RCP	LF	894	$150	$134,000
60" RCP	LF	173	$205	$35,000
		Sub-Total		$285,000
		Contingency	30%	$86,000
		Subtotal		$371,000
		Engineering, Surveying, and Permitting	15%	$56,000
		Pipe Total		$427,000

Assumptions:

1. Prices include all labor, equipment, materials, O&P.
2. RCP price includes trenching, compaction, and backfilling.
3. Detailed pipe list provided below

Table F-1(c). Pipe Upgrades

Pipe Upgrades			
Circular Pipe	Length (ft)	Old Diam. (ft)	New Diam. (ft)
PCAA0070	173	4	5
PCAA0080	136	3.5	4.5
PCAA0090	143	3.5	4.5
PCAA0100	134	3.5	4.5
PCAA0110	245	3.5	4.5
PCAA0120	75	3.5	4.5
PCAA0130	161	3.5	4.5
PCAA0140	235	3	4
PCAA0150	50	3	4
PCAA0160	200	3	4
PCAA0170	280	2.5	3
PCAA0200	120	1.5	2
PCAA0210	95	1.5	2
PCAA0230	85	1.5	2
PCAA0260	95	1.75	2
PCAA0270	125	1.5	2
PCAA0280	85	1.5	3
New Pipe			
Circular Pipe	Length (ft)	Old Diam. (ft)	New Diam. (ft)
AddStorage-IN1	150	N/A	4
AddStorage-IN2	210	N/A	2

TABLE F-2

ENGINEER'S OPINION OF CONCEPTUAL CONSTRUCTION COST:

PROJECT AREA 1

Table F-2. Engineer's Opinion of Conceptual Construction Cost: Project Area 1

Item	Units	Quantity	Unit Cost	Total
Project Area Number 1: Water Quality and Dry Detention				
Mobilization	LS	1		$58,000
Sediment and Erosion Control	LF	1,617	$5	$8,000
Clearing and Grubbing	AC	2	$6,900	$17,000
Excavation	CY	31,787	$10	$318,000
Embankment	CY	2,156	$10	$22,000
Sand Filter	CY	648	$35	$23,000
Maintenance Access	SY	2,874	$5	$14,000
5 H.P. Pump Station	EA	4	$60,000	$240,000
12" Forcemain	LF	600	$60	$36,000
6" RCP Underdrain Pipe	LF	250	$25	$6,000
12" RCP Drainage Pipe	LF	600	$30	$18,000
24" RCP Drainage Pipe	LF	100	$35	$4,000
36" RCP Drainage Pipe	LF	1,550	$70	$109,000
48" RCP Drainage Pipe	LF	400	$100	$40,000
12" Mitered End Section	EA	8	$1,100	$9,000
24" Mitered End Section	EA	2	$1,345	$3,000
36" Mitered End Section	EA	6	$1,895	$11,000
48" Mitered End Section	EA	2	$4,140	$8,000
Reinforced Concrete Box Culvert (3'x4')	LF	600	$145	$87,000
Reinforced Concrete Box Culvert (3'x5')	LF	500	$300	$150,000
Bypass Weir (custom structure)	EA	2	$3,600	$7,000
Control Structure	EA	1	$10,000	$10,000
Sod	SY	3,849	$5	$19,000
		Sub-Total		$1,217,000
		Contingency	30%	$365,000
		Sub-Total		$1,582,000
		Engineering, Survey, and Permitting	15%	$237,000
		Total		**$1,819,000**

Assumptions:

1 . Prices include all labor, equipment, materials, O&P.
2 . Mobilization based on 5% earthwork cost.
3 . Sediment and Erosion Control based on staked silt fence and assumed basin sizes.
4 . Excavated material suitable for berm construction.
5 . No allowance for selling excess material.
6 . Disposal of excess material included in cost of Excavation.
7 . Maintenance access constructed of 12" soil stabilization 18' wide.
8 . Basin geometry: 3H:1V Side slopes, Freeboard = 1', Berm height = 2'.
9 . Control structure 10'x2.5' modified with overflow weir.
10 . RCP price includes trenching, compaction, and backfilling.
11 . Costs are in 2010 dollars.
12 . Costs do not include wetland mitigation, maintenance, or monitoring.
13 . Costs do not include potential hazardous remediation.

TABLE F-3

ENGINEER'S OPINION OF CONCEPTUAL CONSTRUCTION COST:

PROJECT AREA 2

Table F-3. Engineer's Opinion of Conceptual Construction Cost: Project Area 2

Item	Units	Quantity	Unit Cost	Total
Project Area Number 2: Basin PRJ2- Water Quality				
Mobilization	LS	1		$17,000
Sediment and Erosion Control	LF	1,094	$5	$5,000
Clearing and Grubbing	AC	1	$6,900	$8,000
Excavation	CY	9,486	$10	$95,000
Embankment	CY	1,459	$10	$15,000
Sand Filter	CY	1,326	$35	$46,000
Maintenance Access	SY	1,946	$5	$10,000
6" RCP Underdrain Pipe	LF	250	$25	$6,000
24" RCP Drainage Pipe	LF	460	$35	$16,000
48" RCP Drainage Pipe	LF	230	$100	$23,000
84" RCP Drainage Pipe	LF	130	$290	$38,000
24" Mitered End Section	EA	4	$1,345	$5,000
48" Mitered End Section	EA	6	$4,140	$25,000
84" Mitered End Section	EA	2	$6,250	$13,000
Bypass Weir (custom structure)	EA	2	$3,600	$7,000
Control Structure	EA	1	$10,000	$10,000
Sod	SY	1,555	$5	$8,000
		Sub-Total		$347,000
		Contingency	30%	$104,000
		Sub-Total		$451,000
		Engineering, Survey, and Permitting	15%	$68,000
		Total		**$519,000**

Assumptions:

1 . Prices include all labor, equipment, materials, O&P.
2 . Mobilization based on 5% earthwork cost.
3 . Sediment and Erosion Control based on staked silt fence and assumed basin sizes.
4 . Excavated material suitable for berm construction.
5 . No allowance for selling excess material.
6 . Disposal of excess material included in cost of Excavation.
7 . Maintenance access constructed of 12" soil stabilization 18' wide.
8 . Basin geometry: 3H:1V Side slopes, Freeboard = 1', Berm height = 2'.
9 . Control structure 15'x4' modified with overflow weir.
10 . RCP price includes trenching, compaction, and backfilling.
11 . Costs are in 2010 dollars.
12 . Costs do not include wetland mitigation, maintenance, or monitoring.
13 . Costs do not include potential hazardous remediation.

TABLE F-4

ENGINEER'S OPINION OF CONCEPTUAL CONSTRUCTION COST:

PROJECT AREA 3

Table F-4. Engineer's Opinion of Conceptual Construction Cost: Project Area 3

Item	Units	Quantity	Unit Cost	Total
Project Area Number 3: Basin PRJ3- Water Quality				
Mobilization	LS	1		$29,000
Sediment and Erosion Control	LF	1,512	$5	$8,000
Clearing and Grubbing	AC	2	$6,900	$14,000
Excavation	CY	19,650	$10	$197,000
Embankment	CY	2,016	$10	$20,000
Sand Filter	CY	3,219	$35	$113,000
Maintenance Access	SY	2,688	$5	$13,000
6" RCP Underdrain Pipe	LF	250	$25	$6,000
30" RCP Drainage Pipe	LF	500	$60	$30,000
36" RCP Drainage Pipe	LF	200	$70	$14,000
48" RCP Drainage Pipe	LF	1,010	$100	$101,000
30" Mitered End Section	EA	2	$1,700	$3,000
36" Mitered End Section	EA	2	$1,895	$4,000
48" Mitered End Section	EA	8	$4,140	$33,000
Control Structure	EA	1	$10,000	$10,000
Sod	SY	3,124	$5	$16,000
		Sub-Total		$611,000
		Contingency	30%	$183,000
		Sub-Total		$794,000
		Engineering, Survey, and Permitting	15%	$119,000
		Total		**$913,000**

Assumptions:

1 . Prices include all labor, equipment, materials, O&P.
2 . Mobilization based on 5% earthwork cost.
3 . Sediment and Erosion Control based on staked silt fence and assumed basin sizes.
4 . Excavated material suitable for berm construction.
5 . No allowance for selling excess material.
6 . Disposal of excess material included in cost of Excavation.
7 . Maintenance access constructed of 12" soil stabilization 18' wide.
8 . Basin geometry: 3H:1V Side slopes, Freeboard = 1', Berm height = 2'.
9 . Control structure with overflow weir.
10 . RCP price includes trenching, compaction, and backfilling.
11 . Costs are in 2010 dollars.
12 . Costs do not include wetland mitigation, maintenance, or monitoring.
13 . Costs do not include potential hazardous remediation.

APPENDIX G

ABIA SITE
DEVELOPMENT ORDINANCE

"INSERT FINAL ORDINANCE UPON CITY COUNCIL APPROVAL"

APPENDIX H

STORMWATER DRAINAGE MASTER PLAN UPDATE

FINAL REPORT

MAY 2011

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APPENDIX I

SWMM MODELS / HMS MODELS

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