APPENDIX C

VEGETATION MANAGEMENT PLAN

GUNTERSVILLE MUNICIPAL AIRPORT JOE STARNES FIELD

Prepared for the

City of Guntersville
341 Gunter Avenue
Guntersville, AL 35976

October 2008
Revised January 2009

BWSC | Barge Waggoner Sumner & Cannon, Inc.

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INTRODUCTION

The purpose of this document is to describe the issues and strategies related to vegetation management at the Guntersville Municipal Airport – Joe Starnes Field. This vegetation management plan has been developed to specifically address property owned by the Tennessee Valley Authority (TVA) that will be used by the Guntersville Municipal Airport. The TVA property includes approximately 116.57 acres of littoral, palustrine, and upland habitat.

Currently, the property consists of both coniferous as well as deciduous forest, dominated primarily by loblolly *(Pinus taeda)* and shortleaf pine *(Pinus echinata)* and various oak *(Quercus spp.)* and hickory *(Carya sp.)* species, respectively. In addition, there is a significant population of Chinese privet *(Ligustrum sinensis)* present within the canopy understory.

As a part of the proposed airport improvement project involving the installation of a new 5,000 foot runway, the existing vegetation located on the TVA property will require removal, revegetation and long term management of vegetation to limit the repopulation by invasive species. This plan has been developed to address all aspects of the vegetation management as well as to protect the aesthetics of the TVA property and Lake Guntersville.

SECTION 1 PROJECT AREAS

1.1 Littoral Zone

The littoral zone currently exists along the shallow protected inlets and shoreline of Lake Guntersville. These areas are located along the shoreline near the end of the existing runway and continuing approximately 2,000 feet to the northeast. The vegetation located along the shoreline consists primarily of southern wild rice *(Zizaniopsis milacea)*. The littoral communities are limited along the Lake Guntersville shoreline beyond the proposed end of the runway due to the abrupt drop off and rocky outcroppings identified on the northeastern most section of Buck Island.

1.2 Palustrine Zone

The palustrine zone consists of bottomland hardwood forest that is a seasonally saturated non-tidal wetland. This area is dominated by various deciduous species including oak *(Quercus spp.)*, hickory *(Carya sp.)*, sweet gum *(Liquidambar styraciflua)*, American sycamore *(Platanus occidentalis)*, and an understory with a significant population of Chinese privet *(Ligustrum sinensis)*.

1.3 Upland Zone

The upland area is located within the TVA Zone 3 property identified at the end of Buck Island Road and extending east-northeast along the public access trail. This area is dominated by both coniferous as well as deciduous forest, dominated primarily by loblolly *(Pinus taeda)* and shortleaf pine *(Pinus echinata)* and various oak *(Quercus spp.)* and hickory *(Carya sp.)* species, respectively. In addition to the mature hardwood and coniferous species, there is also a significant understory of Chinese privet *(Ligustrum sinensis)*.

SECTION 2 PROJECT DESCRIPTION

2.1 Vegetation Management Objectives

Objectives for the aforementioned areas are to:

1. Provide a safe approach to the Guntersville Municipal Airport runway by removing existing timber and understory allowing for the installation of suitable low growing vegetation.
2. Develop and maintain native plant communities appropriate for location adjacent to the designated airport safety areas.
3. Preserve and maintain water quality and the aesthetic value of the TVA lands.

While attempting to achieve these objectives, TVA, the City of Guntersville, and BWSC will take a long-term, integrated approach. It will strive to reduce herbicide use over the long term while making progress toward vegetation management goals over the short term. The reliance solely upon broadleaf herbicides to control invasives without additional tools would be cost prohibitive and increase potential health and environmental concerns. Therefore, an aggressive, cooperative, and fully coordinated management approach is warranted.

2.2 Vegetation Management Strategy

2.2.1 Timber Management

As previously noted, the TVA property (palustrine and upland) currently exists with mature stands of mixed coniferous and deciduous forest. As a result of the proposed airport improvement program, the existing timber will need to be harvested prior to initiating work on the new runway project. Since the property is currently owned and managed by the TVA, it is recommended as part of this vegetation management plan that the TVA coordinate the removal of the marketable timber from TVA property prior to the start of the airport improvement project.

Once the timber has been harvested, BWSC would recommend that any remaining scrub-shrub growth and understory vegetation within the upland areas be cleared and grubbed. The vegetation cleared from the upland areas could be placed into windrows and burned, following proper notification of the Alabama Forestry Commission and compliance with Alabama Department of Environmental Management (ADEM) Air Regulations Chapter 335-3-3-.01, Open Burning.

The understory vegetation remaining within the identified wetland areas could be cleared mechanically utilizing a tractor mounted boom extended brush cutter. It is important to note that while mechanized land clearing within a wetland is authorized, the use of a bull dozer or loader to move material and potentially cause inadvertent fill is not authorized without the appropriate individual permit issued by the U.S. Army Corps of Engineers (USACE), Nashville District.

2.2.2 Vegetation Management of Littoral Zone

The littoral zone of the TVA property is identified as the shoreline marsh areas that surround a significant portion of the site. This area is predominantly vegetated with southern wild rice *(Zizaniopsis milacea)*. This area has been identified in the USACE permit application to be preserved in its natural state which will have a positive effect to the shoreline habitat. It should be noted that all tree type vegetation that is identified within this area will require manual removal due to the potential obstruction issue, as related to the Federal Aviation Administration (FAA) Part 77 transition surfaces.

2.2.3 Vegetation Management of Palustrine Zones

As previously discussed in the Timber Management section of this plan, the mature stands of deciduous and coniferous trees may be removed mechanically from this area of bottomland hardwood area, so long as there is no incidental filling of wetlands. BWSC has indicated that the trees must be removed from the TVA Zone 2 and 3 areas. Following tree removal and upon the identification of rebound growth from the stumps, these areas could be treated initially with an appropriate wetland approved broadleaf herbicide, such as Rodeo® Broad Spectrum Aquatic Herbicide or an approved alternative.

Following the removal of the trees from Zone 2 and 3, the non-wetland areas would be allowed to naturally revegetate with native grasses and scrub-shrub growth. Certain areas within Zone 2 may require seeding with annual rye grass for erosion control until native warm season grasses emerge. The non-wetland areas will be cut with a bush hog type cutter approximately 2-3 times per year.

2.2.4 Vegetation Management of FAA Designated Safety Areas

The FAA designated safety areas include the Runway Safety Area (RSA), the Object Free Area (OFA) and the Runway Protection Zone (RPZ). The RSA is an area that extends from each end of the runway for a width of 150 feet and a length of 300 feet. The OFA is an area that lies parallel to the runway on both sides at a distance of 250 feet from the runway centerline. The RPZ is a trapezoid located off the end of each runway end that extends 1,000 feet from the end of the RSA and is 700 feet wide at the end of the RPZ.

It should be noted that all trees must be removed from the aforementioned safety areas in accordance with FAA guidelines. Upon removal of the trees the remaining stumps will be ground down to be level with the soil surface thereby facilitating the use of a tractor and implements to prepare the soil for planting of appropriate vegetative cover. The RSA will extend 300 feet beyond the runway end and be graded to a 5% slope and then will be seeded with the appropriate grasses based on the growing season. It should be noted that the RPZ and the Zone 3 TVA area located beyond the RPZ will allow for low growing scrub-shrub vegetation. It should be noted that it is important that the City of Guntersville have the ability to manage and address the vegetative growth of the area outside of the RSA. As a part of the long term vegetation maintenance program, it is proposed that these areas (RSA, RPZ and TVA Zone 3) be cut using a tractor and bush-hog cutter approximately 2-3 times per year.

As an alternative to the use of grass seed, BWSC suggests the use of wildflower seed in the Zone 4 area located west of U.S. Highway 431 and the ALDOT Right-of- Way along the shoreline and road bank. The use of native wildflower seeding as an alternative to grass could also be used in other FAA safety areas that might support native wildflower growth. The use of native wildflowers would also present a visually appealing aspect to the airport site from the lake, the ground, and the air. The use of low growing wildflowers would also require limited seasonal cutting and replanting, with the possibility of reducing long term annual maintenance costs.

SECTION 3 PROJECT MONITORING

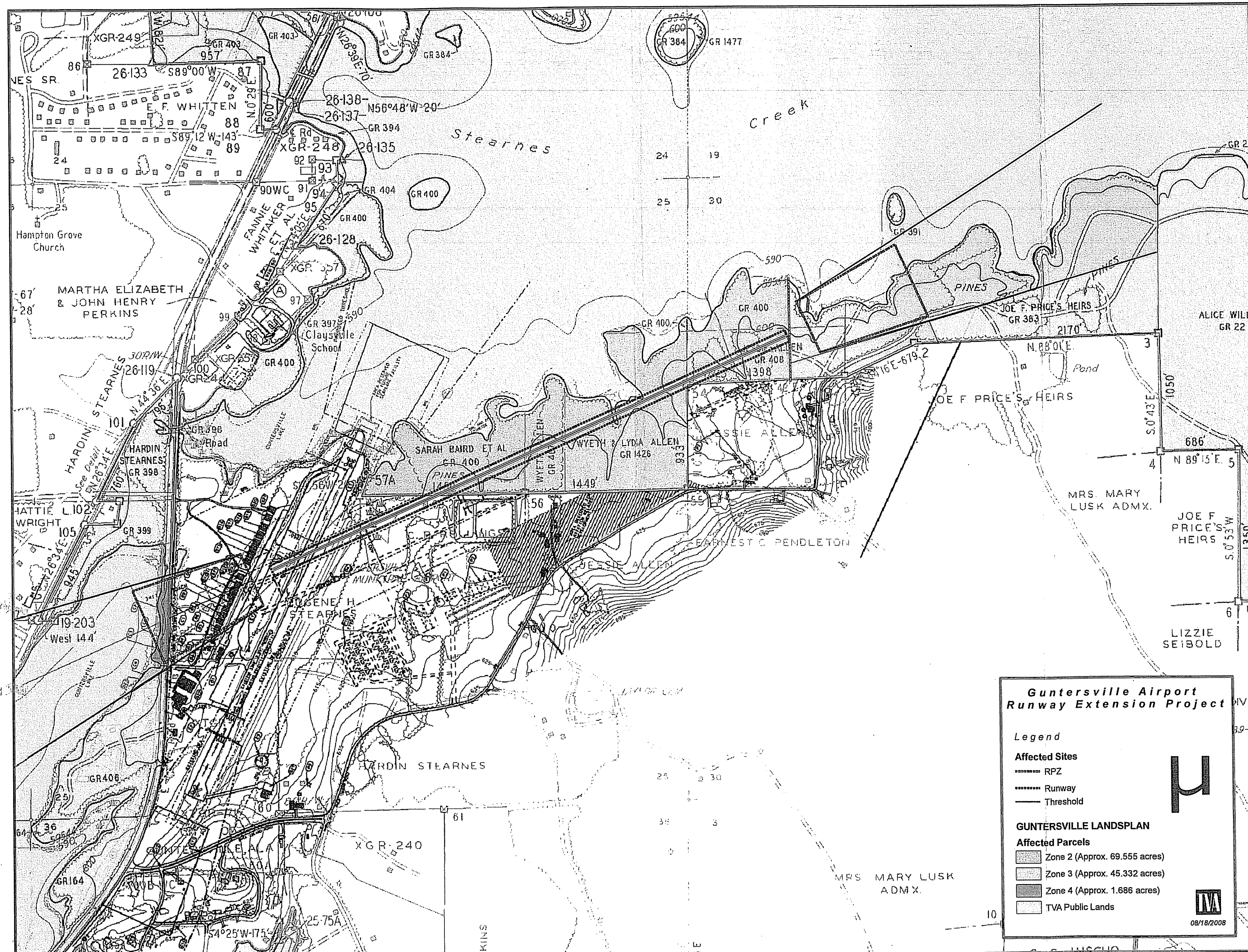
3.1 Cooperation with TVA

BWSC views this vegetation management program as one with integrated cooperation between the TVA, Alabama Department of Transportation Aeronautics Bureau (ALDOT), and the City of Guntersville in order to be successful. The first step in this program will involve the removal of the harvestable timber from the TVA property, followed by the clearing and grubbing of the site in preparation for the runway construction activities. The previously discussed vegetation management plan will also be integral for compliance with the stormwater mitigation requirements of the Alabama Department of Environmental Management (ADEM) Construction Stormwater Permit Program.

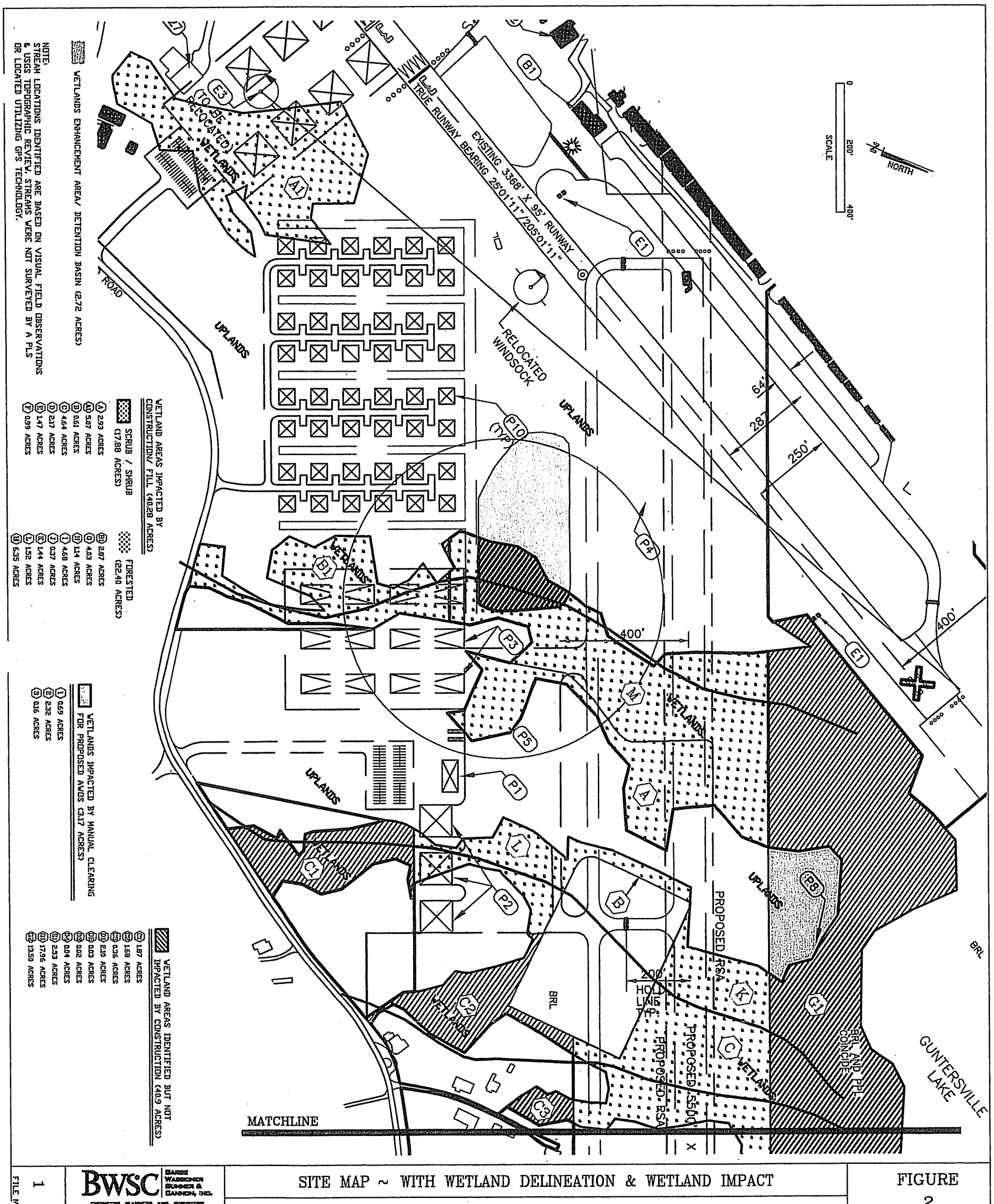
3.2 Reporting

During the initial stages of this project BWSC recommends that quarterly status reports be provided to the TVA, ALDOT, and the City of Guntersville outlining the current status of the airport improvement projects and ongoing site work. The quarterly report could be as simple as an e-mail form noting the project milestones (i.e., timber removal, site clearing, construction activities, initial site revegetation, etc.).

BWSC has developed this plan to outline the steps necessary to achieve success with this airport improvement project. The successful implementation of this vegetation management plan will ultimately lead to a safe and visually appealing airport facility.



Guntersville Airport
Runway Extension Project
Legend
Affected Sites
RPZ
Runway
Threshold
GUNTERSVILLE LANDSPLAN
Affected Parcels
Zone 2 (Approx. 69.555 acres)
Zone 3 (Approx. 45.332 acres)
Zone 4 (Approx. 1.686 acres)
TVA Public Lands
TVA
08/18/2008
Stearnes
Creek
E. F. WHITTEN
Hampton Grove Church
MARTHA ELIZABETH & JOHN HENRY PERKINS
FANNIE WHITAKER ET AL
Claysville School
SARAH BAIRD ET AL
WYETH & LYDIA ALLEN
GR 1426
JOE F. PRICE'S HEIRS
GR 383
ALICE WILL
GR 22
Pond
JOE F PRICE'S HEIRS
MRS. MARY LUSK ADMX.
JOE F PRICE'S HEIRS
LIZZIE SEIBOLD
EARNEST C PENDLETON
JESSIE ALLEN
EUGENE H STEARNES
HARDIN STEARNES
HATTIE L. WRIGHT
MRS MARY LUSK ADMX.
XGR-240
PINES



BWSC
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ENGINEERS PLANNERS AND SURVEYORS

SITE MAP ~ WITH WETLAND DELINEATION & WETLAND IMPACT

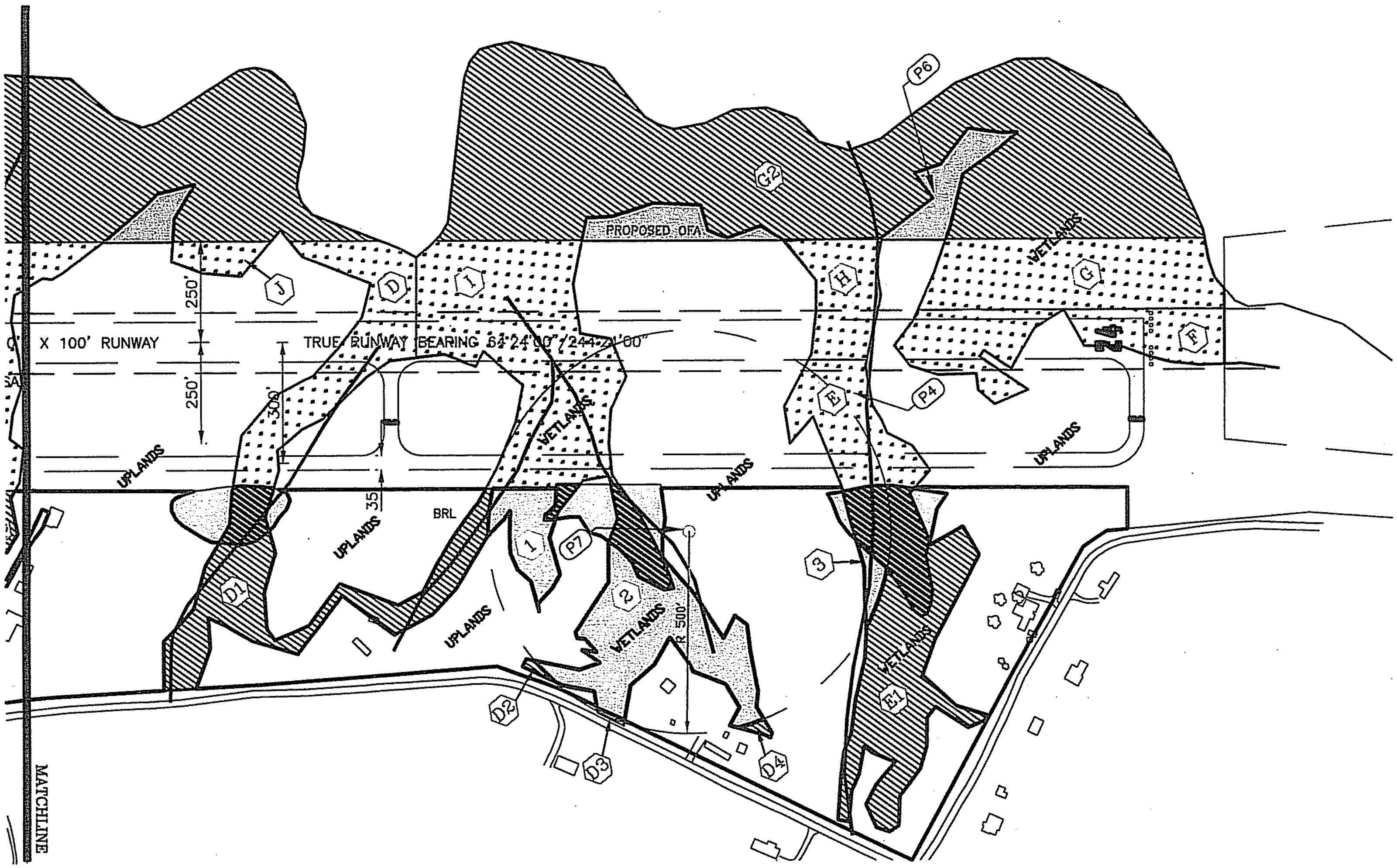
GUNTERSVILLE MUNICIPAL – JOE STARNES FIELD
GUNTERSVILLE, ALABAMA

FIGURE 2

DR.	CHK.	DATE	DESCRIPTION
GS	WFH	2-28-03	ORIGINAL ISSUE
TAH	GKB	12-22-04	REVISED
JEH	GKB	6-30-08	REVISED

1 OF 2

FILE N° '06-00



0 200' 400'
SCALE

WETLAND AREAS IMPACTED BY CONSTRUCTION/ FILL (40.28 ACRES)

SCRUB / SHRUB (17.88 ACRES)

(A) 2.93 ACRES
(A1) 5.07 ACRES
(B) 0.61 ACRES
(C) 4.64 ACRES
(D) 2.17 ACRES
(E) 1.47 ACRES
(F) 0.99 ACRES

FORESTED (22.40 ACRES)

(B1) 2.87 ACRES
(G) 4.03 ACRES
(H) 1.14 ACRES
(I) 4.68 ACRES
(J) 0.37 ACRES
(K) 1.44 ACRES
(L) 1.52 ACRES
(M) 6.35 ACRES

WETLANDS IMPACTED BY MANUAL CLEARING FOR PROPOSED AWOS (3.17 ACRES)

(1) 0.69 ACRES
(2) 2.32 ACRES
(3) 0.16 ACRES

WETLAND AREAS IDENTIFIED BUT NOT IMPACTED BY CONSTRUCTION (40.9 ACRES)

(C1) 1.87 ACRES
(C2) 1.68 ACRES
(C3) 0.36 ACRES
(D1) 2.10 ACRES
(D2) 0.03 ACRES
(D3) 0.02 ACRES
(D4) 0.04 ACRES
(E1) 2.53 ACRES
(G1) 17.96 ACRES
(G2) 13.50 ACRES

WETLANDS ENHANCEMENT AREA/ DETENTION BASIN (2.72 ACRES)

NOTE:
STREAM LOCATIONS IDENTIFIED ARE BASED ON VISUAL FIELD OBSERVATIONS & USGS TOPOGRAPHIC REVIEW. STREAMS WERE NOT SURVEYED BY A PLS OR LOCATED UTILIZING GPS TECHNOLOGY.

BWSC BARGE WAGGONER SUMNER & CANNON, INC. ENGINEERS PLANNERS AND SURVEYORS

DR.	CHK.	DATE	DESCRIPTION
GS	WFH	2-28-03	ORIGINAL ISSUE
TAH	GKB	12-22-04	REVISED
JEM	GKB	6-30-08	REVISED

2 OF 2

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SITE MAP ~ WITH WETLAND DELINEATION & WETLAND IMPACT

GUNTERSVILLE MUNICIPAL - JOE STARNES FIELD
GUNTERSVILLE, ALABAMA

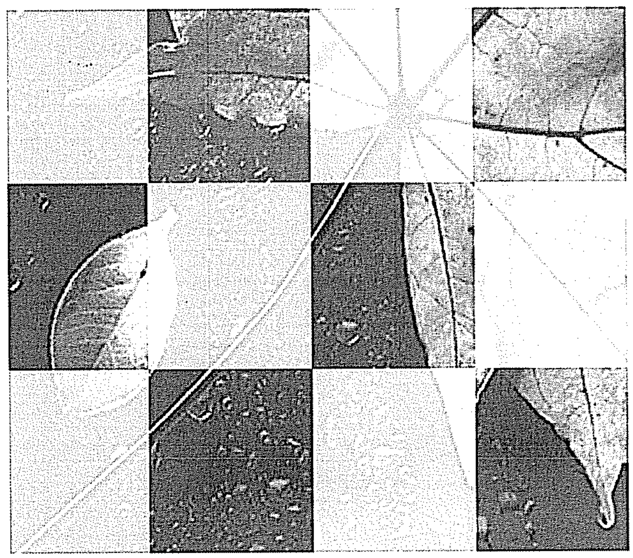
FIGURE 2

APPENDIX D

JOINT USACE / TVA APPLICATION

AND

WETLAND MITIGATION PLAN



Guntersville Municipal-Joe Starnes Field

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Figure 2 Site Map with Wetlands Delineation & Wetland Impacts

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INTRODUCTION

A joint U.S. Army Corps of Engineers (USACE) Section 404 permit and Tennessee Valley Authority (TVA) 26(a) permit will be sought to allow for the relocation of the existing runway and the construction of a parallel taxiway in association with the existing Guntersville Municipal – Joe Starnes Field facility to comply with Federal Aviation Administration (FAA) design standards. The mitigation plan narrative is being provided here to discuss details associated with the proposed compensatory wetland and stream mitigation and to provide project justification.

In an attempt to provide a comprehensive wetland and stream impact analysis, Barge Waggoner Sumner & Cannon, Inc. (BWSC) evaluated the long-term (10yrs) projected design requirements of the project in relation to consistency with FAA airport design guidelines. The need for the relocation of the existing runway was documented in a Runway Justification Study approved by the FAA on May 30, 2002. The Runway Justification Study demonstrated an existing and additional aviation demand that exceeds the FAA criteria for relocating a runway at the airport from its existing location, to a new runway orientation and ultimate length of 5,500 feet. The performance characteristics of the turbojet aircraft expected to utilize the airport necessitates the construction of a new runway for enhanced operational safety.

Based on these design projections, the Guntersville Municipal – Joe Starnes Field expansion project will require 40.28 acres of long-term permanent impacts to wetlands. The following Mitigation Plan and its attachments have been prepared utilizing the *Guidelines for Developing Freshwater Wetlands Mitigation Plans and Proposals* (March 1994) and the *Model Compensatory Mitigation Plan Checklist for Aquatic Resource Impacts* under the Corps Regulatory Program Pursuant to Section 404 of *The Clean Water Act* and Section 10 of *The Rivers and Harbors Act.*

SECTION 1

EXECUTIVE SUMMARY AND MITIGATION PLAN CHECKLIST

A total of 83.54 acres of Jurisdictional Wetlands have been identified at the location of the proposed airport improvements. The 83.54 acres of wetlands were identified during the wetland delineation conducted in February 2003 by Wetland Sciences, Inc. (WSI) and Barge Waggoner Sumner & Cannon, Inc. (BWSC). There are 40.28 acres of directly impacted wetlands associated with the proposed airport improvements. The 40.28 acres of directly impacted wetlands are located adjacent to and east of the existing Guntersville Municipal – Joe Starnes Field, Guntersville, Marshall County, Alabama.

The proposed airport improvements include the initial construction of a 5,000-foot long runway with a parallel taxiway. In addition, aircraft hangars, a terminal building and support facilities will be located in the area immediately south of the proposed runway and taxiway. The 40.28 acres of identified wetlands are proposed to be filled to facilitate the construction of the 5,000-foot long runway, the parallel taxiway, aircraft parking apron, and associated connectors between the runway and the taxiway.

The 40.28 acres of impacted Jurisdictional Wetlands consist of approximately 22.40 acres of forested wetlands and approximately 17.88 acres of scrub shrub wetlands, based on the Cowardin classification. In addition to the identified wetlands, there were a total of nine (9) identified jurisdictional tributaries on airport property, for a total length of 12,650 feet. Eight (8) of the nine (9) streams, for a total length of 5,850 feet would be directly impacted by the proposed construction activities. Two of the eight streams have been identified as relatively permanent waterways [RPW] for a total length of 1,100 feet. The remaining six (6) streams proposed to be impacted have been determined to be non-relatively permanent waterways (NRPW). BWSC proposes that the 6,800 feet of non-impacted streams onsite would be utilized for mitigation

A Mitigation Plan Checklist is included as Table 1 of the Executive Summary indicating the areas addressed and included within the Preliminary Mitigation Plan.

TABLE 1

MITIGATION PLAN CHECKLIST

Included	Omitted	
[X]		**Executive summary** *
		Project description
[X]		Project location, maps *
[X]		Responsible parties *
[X]		Description of Project *
[X]		Impacts and extent of disturbance to wetlands *
[X]		Existing and proposed land uses *
[X]		Wetland delineation *
		Ecological assessment of impact site
[X]	[ ]	Existing vegetation
[X]	[ ]	Existing water regime
[X]	[ ]	Existing soils
[X]	[ ]	Existing fauna
[X]	[ ]	Functions and values
[X]	[ ]	Water quality
[X]	[ ]	Buffers
[X]	[ ]	Wetland rating
[X]	[ ]	Position of wetland in landscape
		Mitigation goals, objectives & performance standards
[X]		Mitigation sequencing followed *
[X]		Goals (wetlands functions to be restored, created, enhanced) *
		Objectives
[X]	[ ]	Water regime to be restored
[X]	[ ]	Vegetation structure to be restored, created, enhanced
[X]	[ ]	Habitat attributes to be restored, created, enhanced
[X]	[ ]	Performance standards to assess each objective
		Proposed mitigation site
[X]		Site description (location, size, maps) *
[X]		Ownership *
[]	[X]	Rational for choice
[]	[X]	Ecological assessment of mitigation site
[]	[X]	Site constraints
		Preliminary site plan
[X]	[ ]	Changes in topography
[X]	[ ]	Hydrologic structures
[X]	[ ]	Soils
[X]	[ ]	Vegetation distributions
[X]	[ ]	Habitat attributes

Included	Omitted	
[X]	[ ]	Buffers
[X]	[ ]	Section drawings showing relationship of topography to vegetation
		Monitoring Plan
[X]	[ ]	Vegetation
[X]	[ ]	Water regime
[X]	[ ]	Soils
[X]	[ ]	Fauna
[X]	[ ]	Functions and values
[X]	[ ]	Development of habitat structure
[X]	[ ]	Water quality
[X]	[ ]	Buffers
[X]		**Site protection** *

SECTION 2
PROJECT DESCRIPTION

2.1 Project Location

The Guntersville Municipal – Joe Starnes Field site is located on 7.5 minute USGS topographic quadrangle, Mt. Carmel, Alabama, in Sections 25 and 30, Township 7 South and Ranges 3 East and 4 East and is illustrated on Figure 1, Area Vicinity Map.

2.2 Responsible Parties

The City of Guntersville maintains the ultimate responsibility for the development and coordination of the airport improvement program at the Guntersville Municipal – Joe Starnes Field. The City of Guntersville selected Barge Waggoner Sumner & Cannon, Inc. as their airport consultant to assist with the overall airport planning, design, and construction of the proposed airport improvements.

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Wetland Sciences, Inc.
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Pensacola, FL 32507
(850) 453-4700
Craig D. Martin, M.S.
(Wetland Delineation & Ecological / Functional Assessment)

2.3 Description of Overall Project

The proposed airport expansion program at the Guntersville Municipal – Joe Starnes Field will consist of the following airport improvements:

- Acquire approximately 203 acres of land
- Construct a new 5,000 foot by 100 foot runway and install runway lights
- Improve the Runway Safety Area (RSA) for the proposed runway. The RSA is a graded, grassed overrun that will be 150 feet wide and extend 300 feet beyond each runway end
- Construct a full-length parallel taxiway to serve the proposed runway and install lighting
- Construct a new terminal building
- Construct a new access road and automobile parking area
- Construct T-hangars and corporate or private hangars
- Relocate the fuel farm
- Install Automated Weather Observing System (AWOS)
- Install perimeter fencing

BWSC anticipates that the proposed airport improvements at Guntersville Municipal – Joe Starnes Field will be implemented over a three to five year period beginning in 2009. The timing and phasing of the proposed airport improvements will be contingent upon the availability of funding assistance from the FAA and the Alabama Department of Transportation (ALDOT), Bureau of Aeronautics.

Based on the proposed 40.28 acres of direct wetland impact and a mitigation ratio of 2:1 for off-site compensatory mitigation, BWSC is proposing to mitigate the impacts with a total of 80.56 credits. BWSC proposes to mitigate the wetland impacts off-site through the use of USACE approved wetland mitigation banks or compensatory mitigation sites. BWSC has identified the Robinson Spring Wetland Mitigation Bank, Jackson County, Alabama, as potential for compensatory mitigation options for the proposed wetland impacts at the Guntersville Municipal Airport – Joe Starnes Field

2.4 Wetland Delineation of Impact Area

The wetland delineation of the proposed impact area was conducted in February 2003 by BWSC and Wetland Sciences, Inc. personnel. The wetland delineation initially identified a total of approximately 83.54 acres of wetlands on the proposed airport improvement site. Of the 83.54 acres of total wetlands, BWSC projects a direct impact to approximately 40.28 acres of wetlands

(Figure 2). It should be noted that the proposed location of the AWOS has changed. Therefore, there will be no wetland impacts associated with the installation of the Automated Weather Observing System (AWOS).

The identified wetlands consisted of forested bottomland and scrub shrub wetlands. In addition, there were a total of nine (9) identified jurisdictional tributaries on airport property. Eight (8) of the nine (9) streams will be directly impacted by the proposed construction activities. Two (2) of the eight (8) streams have been identified as relatively permanent waterways [RPW] and the remaining six (6) are non-relatively permanent waterways [NRPW]. In March 2003, a U.S. Army Corps of Engineers representative from the Decatur, Alabama, USACE Western Field Office conducted a Jurisdictional Determination of the proposed impact site. Based on correspondence received from the USACE, they are in concurrence with the total wetland acreage identified and delineated by the BWSC and WSI team. The USACE has determined that the wetlands identified on the proposed site are considered Jurisdictional Wetlands and are therefore "waters of the United States," requiring a Joint USACE Section 404 and TVA 26 (a) permit.

2.5 Analysis of Culverts and Detention Pond Design

BWSC transportation engineers performed a detailed hydraulic analysis of the watersheds which comprise the hydrologic regime of the wetlands identified on the proposed project site. The information obtained from the hydraulic modeling study was utilized to determine the most cost efficient means of directing the drainage from each of the existing streams beneath the proposed runway and insure that the necessary hydrologic conditions are maintained to support the existing wetlands located on the north side of the proposed project site.

The "rational method" was determined to be the method of choice for the estimation of flows to be used in the design of the drainage structures to be located beneath the proposed runway. The rational method is the preferred method of runoff calculation used by ALDOT for small watersheds less than 200 acres.

The detailed study is included in Appendix A, Hydraulic Analysis and Conceptual Design of Drainage Structures for Runway 6/24.

SECTION 3
ECOLOGICAL ASSESSMENT OF IMPACT SITE

3.1 Existing Vegetation

During the wetland delineation of the proposed project site in February 2003, representatives from BWSC and Wetland Sciences, Inc. identified a palustrine forested, wetland represented by poplar *(Liriodendron sp.)*, maple *(Acer rubrum)*, hickory *(Carya sp.)*, sweet gum *(Liquidambar styraciflua)*, willow *(Salix nigra)*, and black gum *(Nyssa sylvatica)*, with a dense coverage of Japanese privet *(Ligustrum sp.)*. Few herbaceous plants were noted within the groundcover, likely resulting from the opportunistic privet. Dominant species within the uplands section of the subject parcel included loblolly pine *(Pinus taeda)*, southern red cedar (*Juniperus virginiana)*, oaks *(Quercus spp.)*, and American beech (*Fagus grandifolia*).

3.2 Existing Water Regime

The watersheds for the area of the proposed airport improvements were identified using the USGS topographic quadrangle, Mount Carmel, Alabama (1948, photo revised 1983). There were eight (8) drainage basins identified in the project area, three of which are blue line streams, located in watersheds 1 and 6 as identified on the USGS quadrangle. Each of the basins drains from the southeast to the northwest from higher elevation of Buck Island to the relatively flat areas along the shoreline of Lake Guntersville. The delineated watersheds are noted on Figure 1 Watershed Map.

3.3 Existing Soils

The soil types identified in the area of the proposed airport improvements were evaluated utilizing the Soil Survey of Marshall County, Alabama, June 1959 prepared by the United States Department of Agriculture, Soil Conservation Service and supplemented with the Natural Resource Conservation Service (NRCS) Web Soil Survey. There were several different soil types identified within the project area. The primary soil types identified on the project site are summarized, as follows:

Lowlands:

Captina Silt Loam (CaB2) - composed primarily of clay and silt loam, moderately well drained, surface runoff is medium to moderately rapid.

Taft Silt Loam (TaB2) - clay and silt loam, somewhat poorly drained, runoff is slow to moderately rapid.

Tellico and Upshur Soils (TdB2) - clay and silt loam, generally well drained, runoff is rapid.

Captina-Colbert Soils (CcB) - clay and silt loam, moderately well drained, runoff is rapid.

Colbert Silty Clay Loam (CeB2) - clay and silt loam, moderately well drained, runoff is rapid.

Uplands:

Tellico and Upshur Soils (TbD2) - clay and silt loam, well drained, runoff is rapid.

Captina Silty Clay Loam (CbB3) - clay and silt loam, moderately well drained, runoff is rapid.

The information contained in the soil survey was used to determine the primary soil group classification. The soil types have been divided into four groups based on their minimum infiltration rates. The following is a listing of the soil groups and their definitions:

Group A — Soils having a high infiltration rate. They are chiefly deep, well drained sands or gravels, deep loess, or aggregated silts. They have a low runoff potential.

Group B — Soils having a moderate infiltration rate when thoroughly wet. They are chiefly moderately deep, well drained soils of moderately fine to moderately coarse texture, such as loess and sandy loam.

Group C — Soils having a slow infiltration rate when wet. They are soils with a layer that impedes downward movement of water and soils of moderately fine to fine texture, such as, clay loams, shallow sandy loam, soils low in organic content, and soils high in clay content.

Group D Soils having a very slow infiltration rate. They are chiefly clay soil with a high swelling potential, soils with a permanent high water table, soils with a claypan at or near the surface, shallow soils over nearly impervious material, heavy plastic clays, and certain saline soils. They have a high runoff potential.

The soils within the project area are identified within Group C due to their high clay content and rapid runoff potential.

3.4 Existing Fauna

Utilization of the subject wetlands by wildlife was the first variable assessed as part of the ecological / functional assessment. While there were no direct wildlife observations made during the December 2002, March 2003, June 2004 and October 2007 site visits, signs of wildlife presence (including scat, tracks, rubs, and other indirect evidence) were evaluated. The presence of adjacent food sources, suitable habitat, foraging ranges, nesting and roosting sites, and protective cover was evaluated for potential wildlife utilization. From the indirect evidence, common mammals such as whitetail deer *(Odocoileus virginianus)*, raccoon *(Procyon luter*), and opossum *(Didelphus virginiana*) certainly utilize the site. Diving, dabbling ducks, and wading birds utilize the open water and marsh fringe in the project vicinity. Various reptiles and amphibians such as the eastern box turtle *(Terrapene Carolina triunguis*), leopard frog *(Rana pipiens),* and green tree frog *(Hyla* sp.) which are cosmopolitan and adapted to the region are also expected to occur within the project limits. Notably, there was no evidence of beaver use identified within any of the noted stream channels. Aquatic species identified as the mosquito fish *(Gambusia affinis)* and sunfish *(Lepomis sp.)* were noted along the shoreline of Guntersville Lake near the existing approach end of RW 21.

3.5 Functions and Values

The wetlands within the parcel have generally been impacted by anthropomorphic actions such as ditching and timbering activities over time. Most of the natural drainage courses have been excavated and straightened, thus altering the hydrologic regimen favoring less water dependant species. This is noted by the invasive privet, which has become a dominant component of the sub-canopy. The clear-cut logging of portions of the site has also made conditions more favorable for opportunistic species such as the privet to become established.

3.6 Water Quality

Water quality associated with the wetlands on-site is affected by a number of variables that detract from the prescribed benefits associated with wetlands and water quality improvement. Water quality associated with the existing drainage ways is negatively impacted physically by the historic ditching activities. The typical positive attributes which wetland areas provide in relation to water quality include the storage of storm and flood waters with resultant moderation of flow extremes to the receiving waterways, in this case Lake Guntersville.

3.7 Buffers

Natural undeveloped buffers associated with the parcel are marginal except for the areas immediately adjacent to Lake Guntersville. In general the site is bordered by low density residential, scattered livestock grazing and the general aviation airport. The site currently maintains a privately operated, 4-acre facultative wastewater treatment lagoon in its central portion. The existing wastewater treatment lagoon will be closed following the land acquisition process and the connection of current customers of the treatment lagoon to an alternative treatment facility operated by the City of Guntersville.

3.8 Wetland Rating

The Nashville District of the U.S. Army Corps of Engineers utilizes the "ratio" method to determine the appropriate compensatory mitigation requirements for a specific project site's wetland impacts. During the site visits to conduct the U.S. Fish and Wildlife Service Threatened and Endangered Species Assessments, BWSC personnel evaluated the project's delineated wetlands to determine their overall functional status. The wetland areas were evaluated utilizing the Wetland Rapid Assessment Protocol (WRAP) a widely accepted quantitative tool to assess the functionality of the natural wetlands and mitigation activities (Miller and Gunsalus, 1997). The WRAP evaluates the basic wetland health variables, including wildlife utilization, vegetative cover (overstory, shrub, and ground cover), wetland hydrologic indicators, and basic water quality characteristics. A functional score is calculated based on the findings of the WRAP evaluation. A total WRAP score of 1.0 represents a wetland system functioning at the highest possible level and a score of zero represents a system that is severely impacted and exhibits only negligible attributes of a functioning wetland.

The WRAP was completed for the various components of the project and the results generally indicated that many of the existing wetlands were functioning at between 50-60 percent of their functional capacity generally due to the continued alterations to a majority of the hydrologic and invasive floristic components of the systems. The wetlands associated with the northeast section of the project scored in the 80-95 percent functional capacity due to the mature canopy and limited or absent invasive species. Whereas the remainder of the wetlands scored generally low due to historical and recent hydrologic alterations in the form of ditching, water quality degradation from upgradient agricultural and municipal sources, clear-cut timber operations, and the natural secession and establishment of invasive and exotic species.

3.9 Position and Function of Wetland in the Landscape

The value and functions provided by an assessment area to fish and wildlife are influenced by the landscape position of the area and its relationship with surrounding areas. The geographic location of the assessment area does not change, while the ecological relationship between the assessment areas and surrounding landscape may vary from the current condition to the "with impact" and "with mitigation" conditions. Many species that nest, feed, or find cover in a specific habitat or habitat type are also dependant, to varying degrees upon other habitats, including upland buffer, wetland, and other surface waters that are present within the local landscape.

In this case, the position of the wetlands in the landscape is sub-optimal due to the plant composition consisting of invasive species, wildlife access is limited by surrounding development, and the opportunity for the area to provide benefits to downstream areas is limited by significant hydrologic alterations.

SECTION 4
MITIGATION APPROACH

4.1 Mitigation Sequencing

Both a Federal permit issued by the U.S. Army Corps of Engineers (USACE) under Section 404 of the Clean Water Act and a TVA 26(a) permit will be required for any wetland fill activities. These separate permitting processes will require that the applicant address the following issues during the regulatory review to receive favorable review of the 404 and 26(a) permit applications.

4.1.1 Avoidance/Minimization: This section is to satisfy the presumption that an alternative exists that meets the aforementioned weighting criterion and which will have less environmental impact to a special aquatic site. The applicant undertook an evaluation examining the availability of parcels with the zoning that would allow for development of the proposed facility. The applicant must successfully demonstrate to the satisfaction of the regulatory entities that sufficient avoidance and minimization to wetland impacts have been undertaken prior to consideration of any mitigation to offset wetland impacts. This makes it difficult to justify the elimination of all of the wetlands through dredge-and-fill activities located within any particular parcel. Since there are no alternative sites that would satisfy the project's purpose and would result in less impact to special aquatic sites, the only criteria to satisfy prior to initiating mitigation are the strategies of avoidance and minimization within the parcel proposed for development. Based upon the size and irregular shape of the total parcels, the avoidance and minimization of wetland impacts was significantly limited. The avoidance and minimization of the impacted wetlands would have severely restricted the overall scope of aviation related development at this location.

4.1.2 Alternative Analysis: The USACE requires that a practicable alternative analysis be accomplished in which the applicant must demonstrate that there does not exist alternative sites that could meet the stated project purpose and that would result in less impacts to aquatic resources such as wetlands. Certainly, the projects purpose will dictate certain weighting criteria (i.e. geographical market area, impact to aquatic resources, and economic factors). Therefore, a project purpose could be construed in a manner which only permits the use of the subject parcel and eliminates the possibility of alternative sites. Alternative sites were evaluated as part of the Environmental Assessment process and it has been determined that the current proposed location offers the least amount of impact with respect to environmental, financial, cultural, social and historical issues. The Environmental Assessment for this proposed action was conducted and completed in accordance with the National Environmental Policy Act of 1969 (NEPA) and FAA 5050.4B.

4.1.3 Compensatory Mitigation – Wetlands & Streams: Following the avoidance/minimization and alternative analysis portions of the agency review have been satisfied, the applicant must provide some form of compensatory mitigation to offset wetland losses associated with the proposed dredge-and-fill activity. The mitigation efforts are proposed to be compensated via the purchase of 80.56 wetland mitigation credits (based on an impact of 40.28 acres) from the Robinson Spring Wetland Mitigation Bank located within the same watershed as the project site. Based on the conditions of the delineated wetlands, as previously discussed, BWSC would like to propose a compensatory mitigation ratio of 2:1 for the identified wetland impacts.

As previously discussed, there are nine (9) identified RPW and NRPW streams located on the site. Eight (8) of the nine streams will be directly impacted by the proposed runway construction activities. BWSC personnel have estimated (through field measurements and map review) the total length of the streams at 12,650 feet with an estimated 5,850 feet to be directly impacted. BWSC would like to propose that the approximate 6,800 feet of non-impacted stream be utilized to offset the mitigation of the 5,850 feet of stream impacts. BWSC would propose to enhance and restore the original stream characteristics, i.e., natural sinuosity, addition of riffle pool complexes, removal of invasive species currently present in and along the stream channels and the incorporation of natural limestone identified onsite into the mitigation efforts.

STREAM	TYPE	TOTAL APPROXIMATE LENGTH OF STREAM	TOTAL APPROXIMATE IMPACT LENGTH OF STREAM
A	NRPW	~1,750 FT	NO IMPACT TO THIS STREAM
B	NRPW	~1,950 FT	~1,550 FT
C	NRPW	~2,050 FT	~1,050 FT
D	NRPW	~1,450 FT	~600 FT
E	NRPW	~1,100 FT	~600 FT
F	NRPW	~800 FT	~350 FT
G	NRPW	~1,100 FT	~600 FT
H	RPW	~1,500 FT	~600 FT
I	RPW	~950 FT	~500 FT
		~12,650 FT TOTAL STREAM	~5,850 FT IMPACTED STREAM

The FAA guidelines require that the land identified for the proposed project be purchased prior to the execution of any contractual instrument for the purchase of offsite compensatory mitigation credits. In the event that mitigation credits are not available at the Robinson Spring Wetland Mitigation Bank, an alternative offsite mitigation site will be identified. BWSC anticipates that the purchase of the mitigation credits will occur in 2008 and 2009, concurrently with the Land Acquisition phase of the proposed project.

As previously mentioned, BWSC proposes to mitigate the stream impacts through onsite compensatory mitigation. This onsite stream mitigation will be required to conform to the latest promulgated regulation as part of Title 33, Navigation and Navigable Waters, Part 332, Compensatory Mitigation for Losses of Aquatic Resources. This will require the development of a detailed mitigation plan following the final engineering design of the ultimate runway. The mitigation plan for the stream impacts will include a proposed channel design for each area proposed for mitigation. The channel design will include the reintroduction of sinuosity as well as construction of riffle-pool complexes throughout the length of streams proposed to be used for the mitigation offset. BWSC recommends the review of the final mitigation plan with a

Registered Landscape Architect or Landscape Designer for identifying suitable plant species for the area.

As part of compliance with Title 33, Part 332, the Airport will be responsible for conducting periodic assessments and regulatory reporting for a period of approximately 5 years or for a period to be determined by the USACE – Nashville District. This is part of the new mitigation guidelines in Title 33, Part 332, which requires that onsite mitigation efforts be monitored as closely as those of a Compensatory Wetland Mitigation Bank.

4.2 Goals and Objectives

The goals and objectives of the off-site as well as on-site mitigation efforts are to provide a net gain in overall wetland function and area by the proper planning, implementation, and monitoring by the owners of the mitigation banks and on-site mitigation areas. BWSC looks forward to the development of the on-site stream mitigation effort as a positive enhancement/restoration of the on-site stream channels thereby increasing the visual appeal of the overall site.

SECTION 5
PROPOSED MITIGATION SITE

5.1 Site Description

BWSC is proposing to utilize the Robinson Spring Wetlands Mitigation Bank (RSWMB) for compensatory mitigation of the proposed wetland impacts. The RSWMB is located within the Guntersville watershed near Hollywood, Jackson County, Alabama and it consists of approximately 308 acres. The RSWMB consists of old catfish ponds that are being reforested with bottomland hardwood species, as well as farm/pasture land that have been drained and has been converted back into a bottomland forest wetland habitat.

5.2 Ownership

The RSWMB is owned and managed by Robinson Spring, LLC, with Mr. Charles Oligee as the point of contact for the bank.

5.3 Rationale for Choice

The offsite compensatory mitigation option was selected for the Guntersville project site due to the Federal Aviation Administration Advisory circular, AC No. 150/5200-33B, *Hazardous Wildlife Attractants on or Near Airports.* This Advisory Circular was last revised on August 28, 2007.

5.4 Ecological Assessment of Mitigation Site

Since the offsite compensatory mitigation option has been selected for the proposed wetland impacts at the Guntersville Municipal Airport an ecological assessment of the mitigation site is outside the scope of the development of this Mitigation Plan.

5.5 Constraints

Since the offsite compensatory mitigation option has been selected for the proposed wetland impacts at the Guntersville Municipal Airport, based on the latest FAA AC 150/5200-33B, an assessment of the constraints to performing onsite wetland mitigation is outside the scope of the development of this Mitigation Plan.

As previously discussed, the FAA has indicated that the on-site mitigation of the proposed stream impacts would not present any issues with respect to the aforementioned FAA Advisory Circular, AC 150/5200-33B.

SECTION 6
PRELIMINARY SITE PLAN

6.1 Conceptual Design of Airport Drainage

The detailed conceptual design of the drainage patterns at the proposed runway and taxiway are included in Appendix A, BWSC Hydrological Study and Drainage Design Report. The following subsections highlight the overall design of the runway, taxiway and detention ponds as well as the culverts.

6.1.1 Runway Typical Section: In order to develop an overall conceptual design of the drainage structures, it was necessary to prepare a grading plan for the proposed runway and taxiway. As noted on the Airport Layout Plan (ALP), the proposed runway will maintain a consistent elevation of 605.00 feet above sea level. The runway will be designed with a crown in the center and a cross slope of 1.0 percent. In order to limit the overall impact to existing topography, the proposed taxiway will be situated 3 feet higher than the runway at a constant elevation of 608.00 feet above sea level and will be crowned with a 1.0 percent cross slope. Cross section details are included on Figure 3, *Runway 6/24 and Parallel Taxiway Typical Section*, of Appendix A, Hydraulic Analysis and Conceptual Design of Drainage Structures for Runway 6/24.

6.1.2 Detention Ponds: The use of detention ponds on the southwest side of Runway 6/24 was determined to be the most effective means of reducing the volume of water which must be transmitted under the runway. The use of detention basins allowed the use of culverts smaller than what would otherwise be required. Additionally, there were height concerns with the areas beneath the proposed runway and the existing drainage features. These height limitations restricted the size of the drainage structures to 24 inches or less. In the event that detention basins had not been specified in the design, multiple arch pipe structures would be required at each stream crossing. The use of detention basins also allows for enhanced benefit to the wetlands by slowing the flow of water and allowing an increased resonance time. This will allow the wetlands to have a somewhat metered flow during storm events which will serve to enhance the overall hydraulic regime.

The location of the detention basins was determined both by topography and by future plans for development as indicated on the ALP. It should be noted that stormwater detention was not feasible at all locations due to constraints imposed by topography and future aviation development. Detention pond details are included on Table 5, *Detention Ponds*, of Appendix A, Hydraulic Analysis and Conceptual Design of Drainage Structures for Runway 6/24.

6.1.3 Culvert Design: Two culverts were designed at each stream crossing, one under the taxiway (Structure A) and one under the runway (Structure B). Structures 1A, 4A, 5A, and 6A were designed using HydroFlow Hydrographs detention pond modeling, while Culverts 2A and 3A were designed using Haestad Method's Culvertmaster. The design assumed a maximum headwater elevation of 607.00 feet in order to prevent overtopping the proposed parallel taxiway.

In order to design the B structures, additional calculations were required to compensate for the additional run-off collected between the centerline of the taxiway and the centerline of the runway. This additional run-off was added to that from the A Structures in order to properly size the B Structures. The additional flows are identified in Table 6, *Runoff from Centerline of Runway to Centerline of Taxiway,* of Appendix A, BWSC Hydrological Study and Drainage Design Report. Additionally, the B structures were designed using Haestad Method's Culvertmaster. The design assumed a maximum headwater elevation of 604.00 feet in order to prevent overtopping the proposed runway.

The detailed profile drawings of each culvert crossing (Basins 1-6) are included in Appendix A, Hydraulic Analysis and Conceptual Design of Drainage Structures for Runway 6/24. In addition, Appendix A also includes a plan view showing the proposed contours for Runway 6/24 and the parallel taxiway as well as the proposed drainage structures and detention pond locations.

SECTION 7
MITIGATION MONITORING PLAN

Since the offsite mitigation option has been selected for the proposed wetland impacts at the Guntersville Municipal – Joe Starnes Field a Mitigation Monitoring Plan of the mitigation site is outside the scope of the development of this Mitigation Plan.

A mitigation monitoring plan will be developed for the proposed on-site mitigation of the stream impacts. This monitoring plan will be developed following authorization by the USACE to mitigate the impacts to the streams onsite. The mitigation monitoring plan will follow guidance from Title 33, Part 332, as previously discussed. As a part of the mitigation monitoring plan an invasive species management and revegetation schedule will be developed along with conceptual stream bed enhancements.

SECTION 8
SITE PROTECTION

Since the offsite mitigation option has been selected for the proposed wetland impacts at the Guntersville Municipal – Joe Starnes Field the site protection of the mitigation site is outside the scope of the development of this Mitigation Plan.

Upon authorization by the USACE to mitigate the stream impacts onsite, a site protection plan will be developed as a part of the mitigation monitoring program for the site.

FIGURE 1

AREA VICINITY & WATERSHED MAP

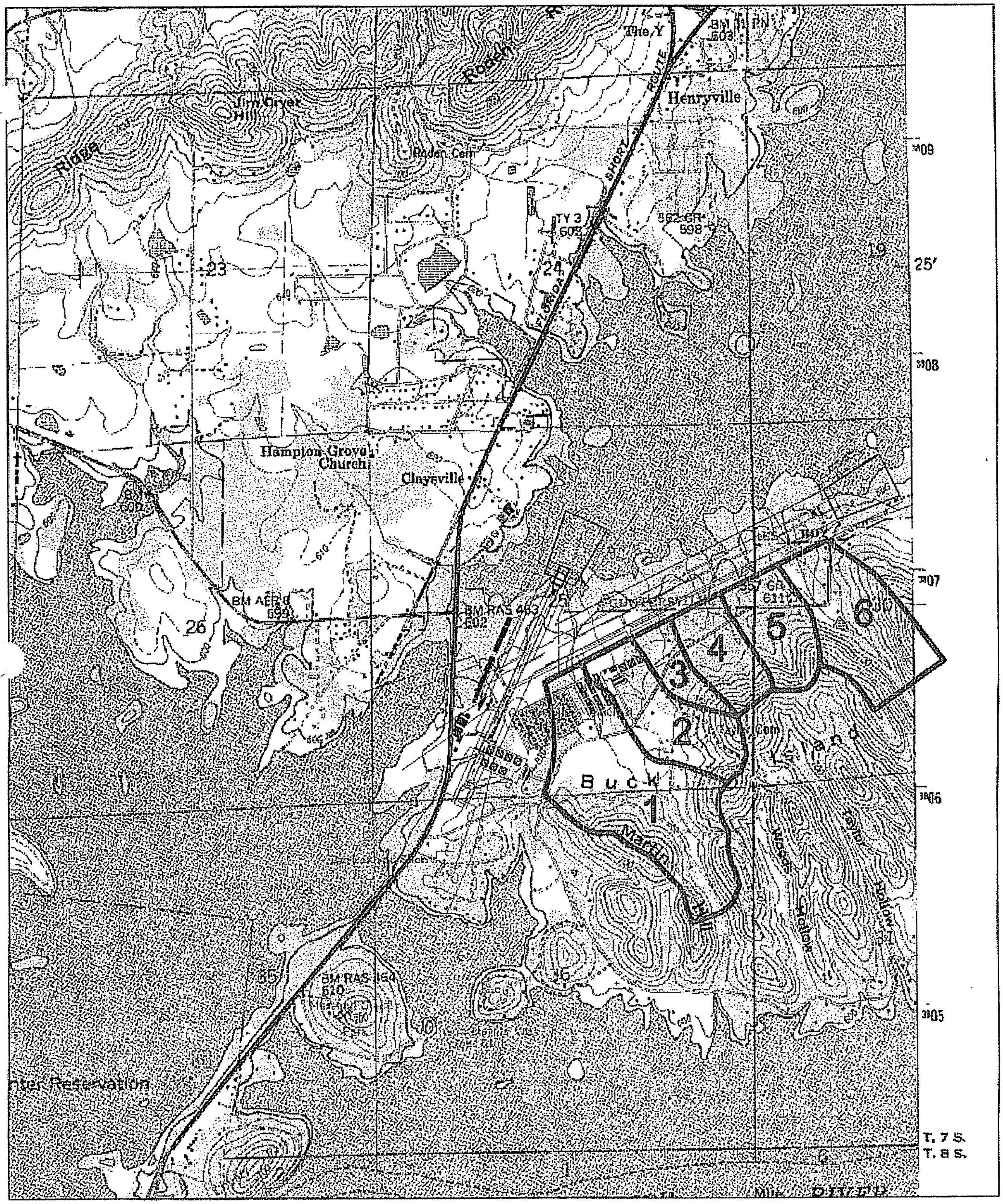


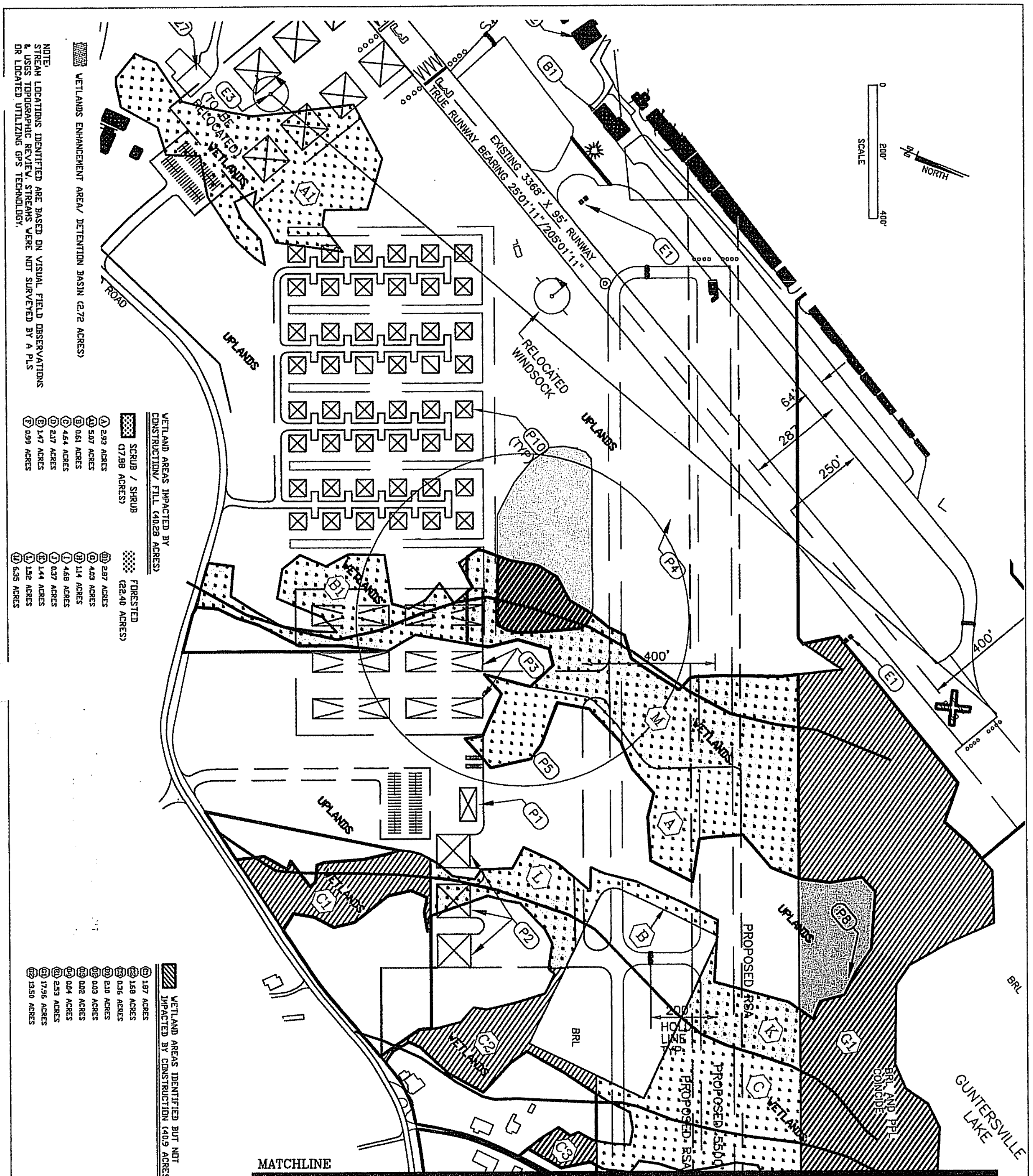
FIGURE 1

AREA VICINITY AND WATERSHED MAP
Guntersville, Alabama
Scale: 1" = 200'

Source: USGS Topographic Map, Mt Carmel, Alabama (1948, photorevised 1983)

FIGURE 2

SITE MAP WITH WETLANDS DELINEATION & WETLAND IMPACTS



BWSC Barge Waggoner Sumner & Cannon, Inc. Engineers Planners and Surveyors	SITE MAP ~ WITH WETLAND DELINEATION & WETLAND IMPACT	FIGURE 2
	GUNTERSVILLE MUNICIPAL – JOE STARNES FIELD GUNTERSVILLE, ALABAMA	

DR.	CHK.	DATE	DESCRIPTION
GS	WFM	2-28-03	ORIGINAL ISSUE
TAH	GKB	12-22-04	REVISED
JEM	GKB	6-30-08	REVISED

1 OF 2

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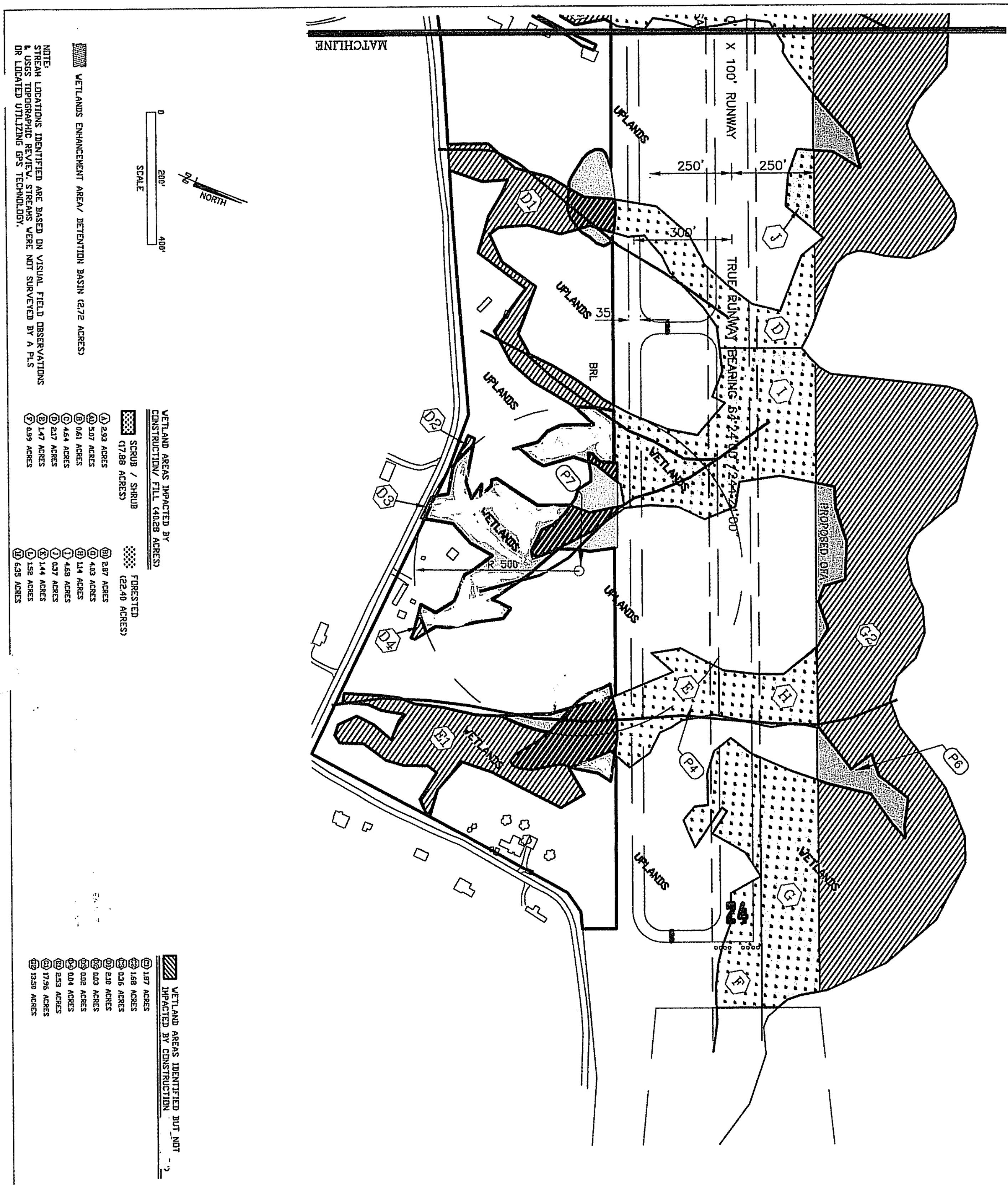

BWSC Barge Waggoner Sumner & Cannon, Inc. Engineers Planners and Surveyors	SITE MAP ~ WITH WETLAND DELINEATION & WETLAND IMPACT	FIGURE 2
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GS	WFM	2-28-03	ORIGINAL ISSUE
TAH	GKB	12-22-04	REVISED
JEH	GKB	6-30-08	REVISED

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APPENDIX A
HYDRAULIC ANALYSIS AND CONCEPTUAL DESIGN OF DRAINAGE STRUCTURES FOR RUNWAY 6/24

Hydraulic Analysis and Conceptual Design of Drainage Structures for Runway 6/24

Guntersville Municipal Airport, Joe Starnes Field
Guntersville, Alabama

October 2004

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1.0 Introduction

The purpose of this report is to perform a detailed hydraulic analysis of the watersheds which contribute to the hydrologic regime of the existing wetlands within the limits of the proposed runway project at Joe Starnes Field in Guntersville, Alabama. This information was used to determine the most cost efficient method of conveying the drainage from each of the existing streams beneath the proposed runway and insuring that flows are maintained to the existing wetlands north of the proposed project. This report includes conceptual drawings in both plan and profile of the proposed structures to be used and design data for each.

2.0 Methodology

2.1 Rational Method

The rational method was selected for the estimation of flows to be used in the design of the drainage structures beneath the proposed runway. The rational method is a well established method used in calculating the peak runoff for the selected frequency in small watersheds (less than 200 acres). It is the preferred method of runoff calculation used by the Alabama Department of Transportation (ALDOT), and has thus been selected to be the most logical method to be used for this analysis.

The Rational Method is represented by the following formula:

$$Q = CIA$$

Where

Q = maximum rate of runoff (cfs)

C = runoff coefficient (dimensionless)

I = Average range rainfall intensity for a duration equal to the time of concentration (inches per hour)

A = drainage area (acres)

2.2 Runoff Coefficients

The runoff coefficient "C" is the most subjective variable in the equation, meaning it is the least likely to be determined precisely. This coefficient is a measure of the amount of rainfall that "runs-off" or eventually finds it's way into a stream, channel, or other water body. It attempts to account for ground infiltration, vegetation type, land use, degree of development, and other factors. Engineering judgment is needed in selecting the best runoff coefficient for a specific situation. The higher the C value selected, the higher the runoff calculated.

2.3 Rainfall Intensity

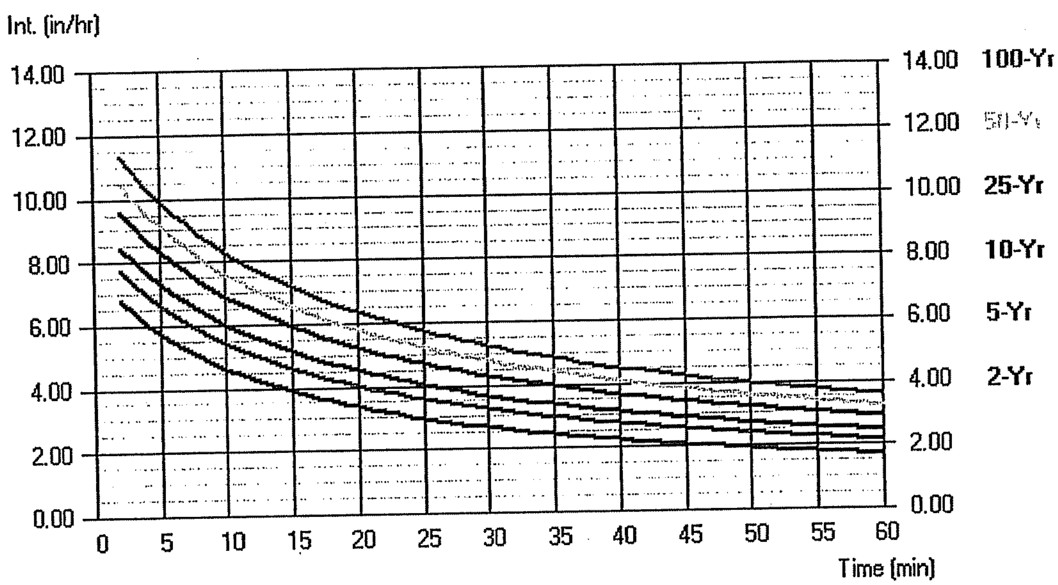
The average rainfall intensity was determined using maps provided in the National Weather Service Report, HYDRO-35. The following data was obtained for the Guntersville Area:

Table 1: Rainfall Intensities for Guntersville Alabama from Hydro 35 Eastern/ Central Rainfall Data (inches per hour)

	5 minute	15 minute	60 minute
2 year	5.77	3.90	1.70
100 year	9.94	7.17	3.57

Using this data, the following intensity-duration-frequency curve was developed:

Figure 1: Intensity-Duration-Frequency (IDF) Curve for Guntersville, Alabama



This figure shows the length of time that a storm can continue at a given intensity relative to selected recurrence intervals. The horizontal axis represents the time that a given storm lasts. The vertical axis represents the intensity of rainfall in inches per hour. The shorter the duration, the higher the intensity. The engineer must attempt to identify the shortest reasonable duration for the affected drainage area. This duration is determined by calculating the Time of Concentration (Tc).

2.4 Time of Concentration

There are several methods which are commonly used in calculation of the time of concentration (Tc). These include the Kirpich Method, The US DOT equation, the SCS overland flow method, the Kirby method, and the Kinematic Wave.

The Kirpich method was selected for use in this study. The Kirpich Equation was developed from data obtained in seven rural watersheds in Tennessee. The watersheds had well-defined channels and steep slopes of 3-10% and areas of 1 to 112 acres. This method is widely used in urban areas for both overland flow and channel flow; and it is used for agricultural watersheds up to 200 acres in size.

In the Kirpich method, the time of concentration is directly dependent upon the length of the watershed (L). This is defined as the distance from the farthest point in the drainage basin along a flow path to the discharge point. It is also directly dependent on the difference in elevation between these two points (H). The following formula represents the equation:

$$Tc = 0.0078 \; (L^{1.5} / H^{0.5})^{0.77}$$

Once the time of concentration was calculated, the IDF curve was used to determine the intensity (inches/hour) to be used in the Rational Method equation.

Computer Software Used for Flow Calculations

The flows were calculated using Hydroflow Hydrographs 2004, Version 8.0.0.0 by Intelisolve. This computer program allows input of the various variables discussed above for computation of runoff by the Rational Method. In addition, the software models storm water storage facilities such as detention and/or retention ponds.

2.5 Culvert and Detention Pond Design

The objective of this study was to prepare a preliminary design that would show how flows will be maintained to the wetlands on the north side of the proposed runway. The primary means of transferring the flows beneath the runway is by using culverts. The term culvert generally refers to any drainage structure crossing beneath a roadway, embankment, or in this case, a runway. Several variables are used in the design of the culvert. These include, but are not limited to, the slope of the existing drainage way, the proposed grades of the runway, the calculated volume of water to be transported, the maximum allowable headwater on the upstream end of the culvert, and the tailwater elevation.

In order to reduce the required size and number of culverts beneath the runway and thus reduce the infrastructure cost, detention ponds were proposed to detain storm water and release it at a slower rate. Detention ponds were oriented and sized based upon the future capital improvements shown on the Airport Layout Plan (ALP) and the site topography. Detention ponds were not feasible for all stream crossings.

2.6 Computer Software Used for Culvert Design

CulvertMaster V3.0 by Haestad Methods, Inc. was used for design and analysis of various culvert options. This software allows input of known variables discussed above to provide the required size for the culvert.

3.0 Site Characteristics and Hydrology

3.1 Site Topography and Natural Features

Joe Starnes Field is located on Buck Island within Guntersville Lake. The topography of Buck Island is very hilly with the exception of the western section which is relatively level. The elevation of the project area ranges from 520 to 640 feet above mean sea level. Runway 6/24 is proposed to have a constant elevation 605 feet above mean sea level while the parallel taxiway is proposed to have an elevation 608 feet above mean sea level.

Land use in the vicinity of the airport generally consists of residential and commercial uses with areas of vacant/undeveloped land and land managed by the Tennessee Valley Authority (TVA). Several single family residences are located along Buck Island Road and U.S. Highway 431. A maintenance/storage facility operated by TVA is located just west of the airport across U.S. Highway 431. A golf course is located south of the airport along Gunter's Landing Road.

Watersheds were identified using the USGS Topographic Map, Mount Carmel, AL (1948, photorevised 1983). There are six (6) primary drainage basins identified in the project area, two of which contain blue line streams as identified on the quad map. Each of these basins drain generally from the southeast to the northwest from the higher elevations of Buck Island to the relatively flat areas around the periphery of Guntersville Lake. The delineated watersheds are shown in **Figure 2**.

3.2 Soil Types and Runoff Characteristics

Soil types in the area were researched using the Soil Survey of Marshall County, Alabama, June 1959 by the United States Department of Agriculture, Soil Conservation Service. There were several soils identified in the project area. Following is a summary of the primary soil types found:

Lowlands:

CaB2 Captina Silt Loam: primarily clay and silt loam, moderately well drained, surface runoff is medium to moderately rapid.

TaB2 Taft Silt Loam: clay and silt loam, somewhat poorly drained, runoff is slow to moderately rapid.

TdB2 Tellico and Upshur Soils: clay and silt loam, generally well drained, runoff is rapid.

CcB Captina – Colbert Soils: clay and silt loam, moderately well drained, runoff is rapid.

CeB2 Colbert Silty Clay Loam: clay and silt loam, moderately well drained, runoff is rapid.

Highlands:

TbD2 Tellico and Upshur Soils: clay and silt loam, well drained, runoff is rapid.

CbB3 Captina Silty Clay Loam: clay and silt loam, moderately well drained, runoff is medium to moderately rapid.

The information provided by the soil survey was used to identify the primary soil group classification. Soils are divided into four groups based upon their minimum infiltration rates. Following is a listing of the soil groups and their definitions:

Group A — Soils having a high infiltration rate. They are chiefly deep, well drained sands or gravels, deep loess, or aggregated silts. The have low runoff potential.

Group B — Soils having a moderate infiltration rate when thoroughly wet. They are chiefly moderately deep, well drained soils of moderately fine to moderately coarse texture such as shallow loess and sandy loam.

Group C — Soils having a slow infiltration rate when wet. They are soils with a layer that impedes downward movement of water and soils of moderately fine to fine texture such as clay loams, shallow sandy loam, soils low in organic content, and soils high in clay content.

Group D — Soils having a very slow infiltration rate. They are chiefly clay soil with a high swelling potential, soils with a permanent high water table, soils with a claypan at or near the surface, shallow soils over nearly impervious material, heavy plastic clays, and certain saline soils. They have high runoff potential.

The soils in the project area fall into Group C due to their high clay content and rapid runoff potential.

3.3 Selection of Runoff Coefficient

After determining the runoff potential of the soils in the area, runoff coefficients (C) were selected for use in the Rational Equation. Runoff coefficients were selected from table 7-9 of Design and Construction of Sanitary Sewer and Storm Sewers, American Society of Civil Engineers, New York, p.332, 1969. This table presents runoff coefficients for various land uses by soil type and slope. Each basin was divided into sub-basins based upon predominant land use and assigned a C value. The land use was determined by analyzing aerial photography. The composite C for the drainage basin was then determined by averaging the values over the respective area. **Table 2** presents the runoff coefficients selected for each sub-area and the composite C used.

Table 2: Runoff Coefficients – Soil Group C

AREA	LAND USE	SLOPE	ACRES	C
BASIN 1				
Sub-area A	Forrest	0-2%	14.49	0.12
Sub-area B	Meadow	0-2%	26.45	0.26
Sub-area C	Forrest	2-6%	30.22	0.16
Sub-area D	Golf Course	0-2%	44.31	0.30
Sub-area E	Future Hangars	0-2%	8.86	0.86
COMPOSITE			***124.33***	***0.28***
BASIN 2				
Sub-area A	Meadow	0-2%	3.04	0.26
Sub-area B	Forrest	0-2%	29.94	0.12
Sub-area C	Meadow	0-2%	14.92	0.26
Sub-area D	Future Apron	0-2%	6.96	0.95
COMPOSITE			***54.86***	***0.27***
BASIN 3				
Sub-area A	Meadow	0-2%	3.17	0.26
Sub-area B	Forrest	0-2%	15.72	0.12
COMPOSITE			***18.89***	***0.14***
BASIN 4				
Sub-area A	Forrest	2-6%	17.00	0.16
Sub-area B	Forrest	6%+	17.00	0.20
COMPOSITE			***34.00***	***0.18***
BASIN 5				
Sub-area A	Forrest	2-6%	19.5	0.16
Sub-area B	Forrest	6%+	19.5	0.20
COMPOSITE			***39.00***	***0.18***
BASIN 6				
	Forrest	6%+	***71.00***	***0.20***

3.4 Time of Concentration

As discussed previously, the Time of Concentration (Tc) for each watershed was calculated using the Kirpich Method. Each watershed was analyzed to determine the length of the longest watercourse and the change in elevation between the upstream and downstream ends of the watershed. The downstream point of the watershed was taken to be the point where the flow would enter a culvert beneath the taxiway. Inputting this data into the Kirpich equation yielded a Tc for each of the basins. **Table 3** Presents this data:

Table 3: Time of Concentration for Basins (Kirpich Equation)

BASIN	LENGTH (ft)	SLOPE (ft/ft)	Tc (min)
1	4592	.0058	37
2	3032	.0521	12
3	1959	.1174	6
4	1947	.1187	6
5	2147	.0745	8
6	2695	.0223	15

3.5 Calculation of Flows

The storm with a recurrence interval of 25 years was selected as the design storm for this analysis. The 100 year storm was checked to insure that the runway and taxiway would not be overtopped in a 100 year event. The basin area, runoff coefficient, and time of concentration were entered into Hydroflow Hydrographs 2004 by Intellisolve for each of the delineated basins. The runoff in cubic feet per second was automatically calculated for the 2, 5, 10, 25, 50, and 100 year storms. **Table 4** presents the calculated 25 and 100 year flows:

Table 4 Computed Runoff for the 25 Year and 100 Year Storm Events

BASIN	AREA (Acres)	25 yr (cfs)	100 yr (cfs)
1	124.33	133.39	163.48
2	54.89	95.82	115.42
3	18.89	21.14	25.25
4	34.00	48.91	58.42
5	39.00	51.92	62.22
6	71.00	84.24	101.81

4.0 Conceptual Design of Airport Drainage

4.1 Runway Typical Section

In order to design the drainage structures, it was necessary to prepare a conceptual design which included a grading plan for the proposed runway and taxiway. As indicated on the Airport Layout Plan (ALP), the proposed runway will sit at a constant elevation of 605.00 ft above sea level. The runway will be crowned in the center with a cross slope of 1.0%. In working with the existing topography, the proposed parallel taxiway will sit 3' higher than the runway at a constant elevation of 608.00 ft above sea level and be crowned in the center with a cross slope of 1.0%. **Figure 3** shows the proposed cross section for the runway and taxiway.

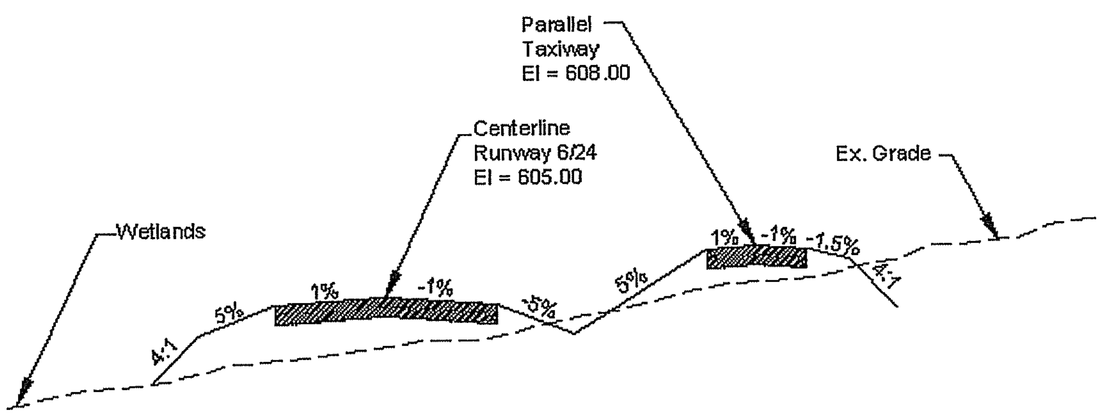


Figure 3: Runway 6/24 and Parallel Taxiway Typical Section

4.2 Detention Ponds

As previously discussed, the use of detention ponds on the south-west side of Runway 6/24 was determined to be a good way to reduce the volume of water which must be transported under the runway. This enabled the size of the culverts to be considerably smaller than what would otherwise be required. In addition, there is limited height beneath the proposed runway and the existing drainage features. This limits the height of any drainage structures to 24" or less. In order to transport these large flows without detention, multiple arch pipe structures would be needed at each stream crossing.

The use of detention further enhances benefits to the wetlands by slowing the flow of water and allowing it to be maintained for greater lengths of time rather than having it be released quickly at a higher volume. This will allow the wetlands to have a somewhat more measured flow during storm events which should enhance the hydraulic regime.

The location of detention ponds was determined both by topography and by future plans for development indicated on the ALP. In some locations, stormwater detention was not feasible due to these constraints. Detention ponds are proposed for basins 1, 4, 5, and 6. Table 5 presents the data for each of the four detention ponds:

Table 5: Detention Ponds

	STORAGE VOLUME (CuFt)	DEPTH (ft)	BOTTOM ELEV. (ft)	100 YR ELEV. (ft)	OUTLET SIZE
POND 1 (BASIN 1) Culvert 1A	132,533	4.0	603.00	605.63	28 ½" X 18" Arch Pipe
POND 2 (BASIN 4) Culvert 4A	22,438	3.0	604.00	605.15	18" RCP
POND 3 (BASIN 5) Culvert 5A	40,767	3.0	604.00	604.86	18" RCP
POND 4 (BASIN 6) Culvert 6A	47,245	3.0	604.00	606.12	18" RCP

It should be noted that this is a conceptual design only. Actual size of detention ponds may vary upon final design.

Stormwater detention for Basin 2 was not feasible due to a proposed GA Apron shown on the ALP. Due to the low flow of Basin 3, no detention was provided.

4.3 Culvert Design

Two culverts were designed for each stream crossing. One beneath the taxiway (Structure A) and one beneath the runway (Structure B). Structures 1A, 4A, 5A, and 6A were designed using HydroFlow Hydrographs detention pond modeling (see Table 5, above). Culverts 2A and 3A were designed using Haestad Method's Culvertmaster. The design assumed a maximum headwater elevation of 607.00 ft in order to prevent overtopping of the proposed parallel taxiway. The resulting culvert sizes were double 36 ¼" x 22 ½" concrete arch pipes and a 28 ½" x 18" concrete arch pipe for Structures 2A and 3A respectively.

In order to design the B structures, it was necessary to calculate the additional runoff which would be collected between the centerline of the runway and the centerline of the taxiway. The runoffs were added to those from the A Structures in order to size the B structures. **Table 6** presents the additional flows calculated:

Table 6: Runoff from Centerline of Runway to Centerline of Taxiway

BASIN	AREA (Acres)	C*	Tc	25 yr (cfs)	100 yr (cfs)
1B	9.55	0.21	17	17.80	20.04
2B	4.94	0.35	6	95.82	115.42
3B	5.78	0.35	6	37.30	44.56
4B	5.27	0.35	6	14.98	17.94
5B	5.14	0.35	6	14.62	17.92
6B	6.89	0.35	6	19.30	23.06

* Weighted C values were calculated for each watershed based on the proportion of pavement (C=0.85) and grassed area (C = 0.20).

The B structures were also designed using Haestad Method's Culvertmaster. The design assumed a maximum headwater elevation of 604.00 ft in order to prevent overtopping of the proposed runway. **Table 7** presents the resulting culvert sizes:

Table 7: Sizes of B Culverts

	SIZE
CULVERT 1B	28 ½" X 18" RCAP
CULVERT 2B	TRPL 36 ¼" X 221/2" RCAP
CULVERT 3B	DBL 28 ½" X 18" RCAP
CULVERT 4B	28 ½" X 18" RCAP
CULVERT 5B	28 ½" X 18" RCAP
CULVERT 6B	28 ½" X 18" RCAP

Profile drawings of each culvert crossing (Basins 1-6) are provided in the appendix to this report. The appendix to this report also contains a plan view showing the proposed contours for Runway 6/24 and the parallel taxiway as well as the proposed drainage structures and detention pond locations.

5.0 REFERENCES

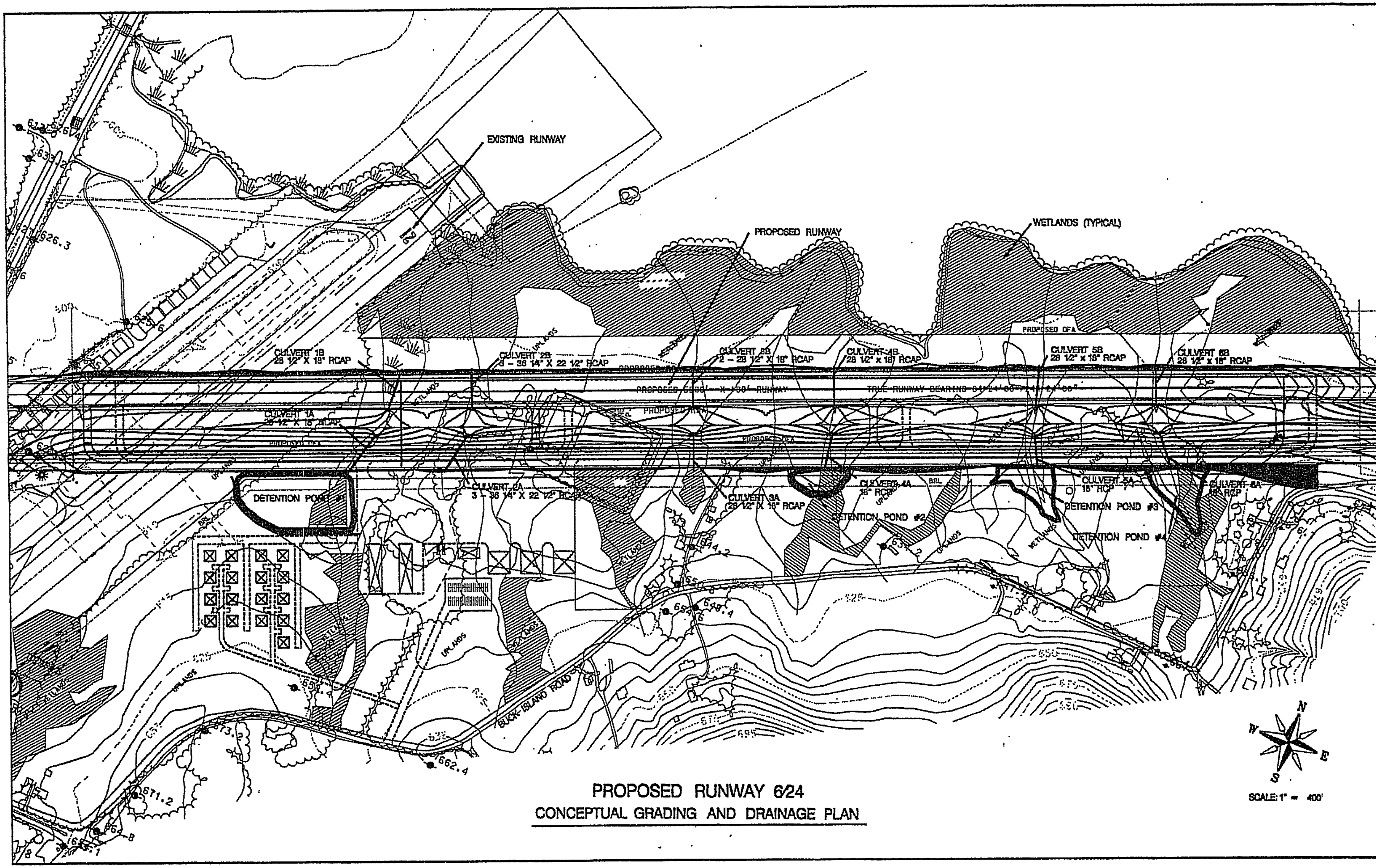
Alabama Department of Transportation. (1990). Hydraulic Manual.

American Society of Civil Engineers. (1969). Design and Construction of Sanitary Sewer and Storm Sewers. New York, pp.332

Frederick, et al. (1977). National Weather Service Report – HYDRO-35, "Five to 60 minute precipitation frequency for the Eastern and Central United States".

United States Department of Agriculture, Soil Conservation Service. (1959). Soil Survey of Marshall County, Alabama.

United States Department of Transportation, Federal Aviation Administration. (1989). Advisory Circular AC 150/5300-13 Airport Design.



PROPOSED RUNWAY 6/24

CONCEPTUAL GRADING AND DRAINAGE PLAN

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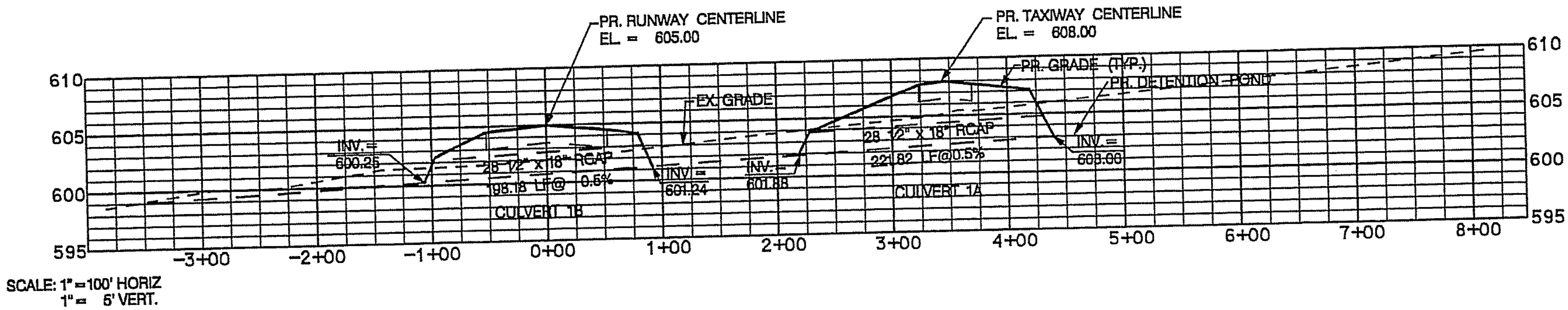
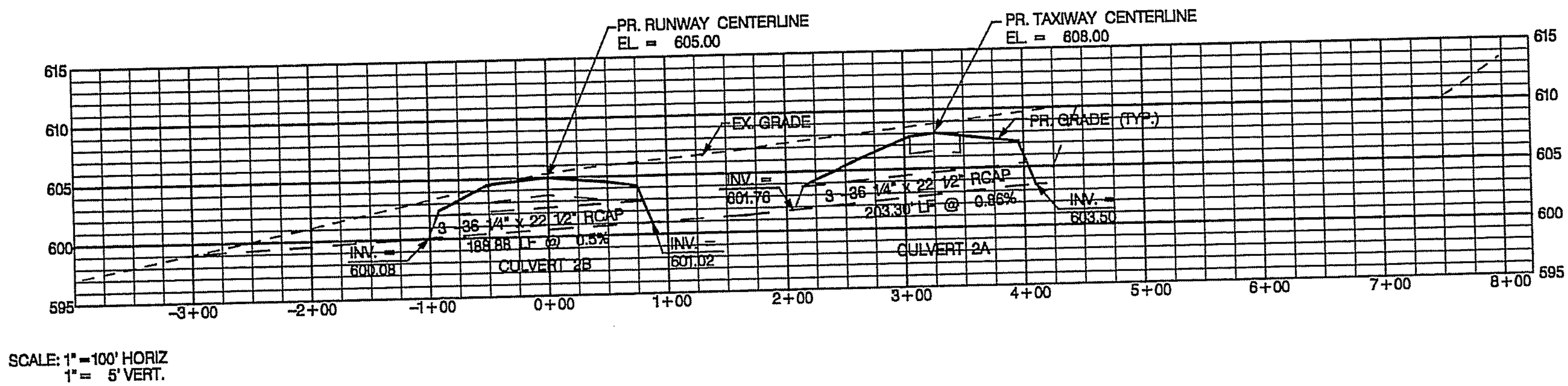
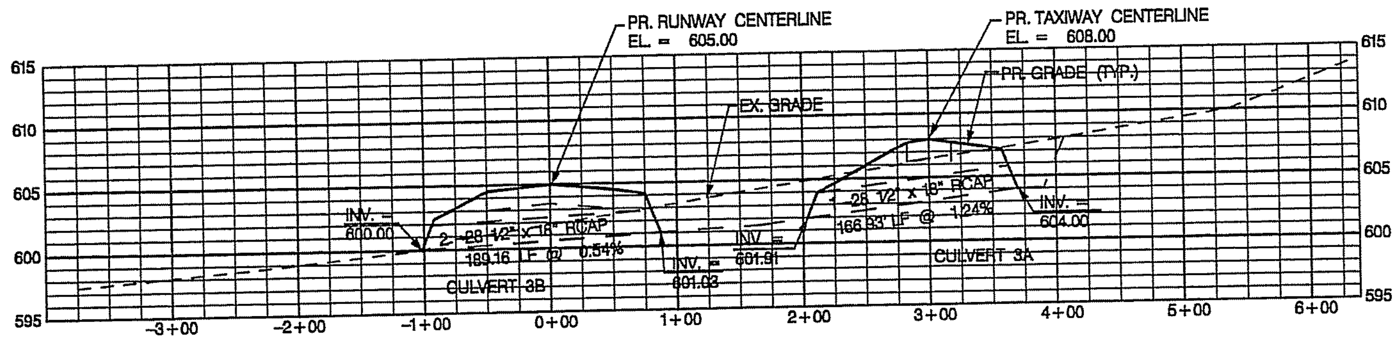


CULVERT 1
STA 12+84

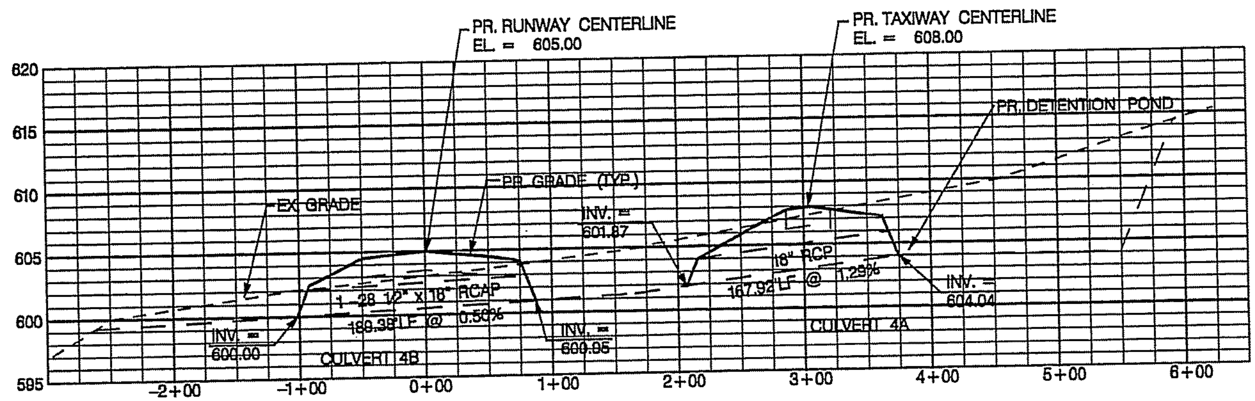


CULVERT 2
STA 16+41



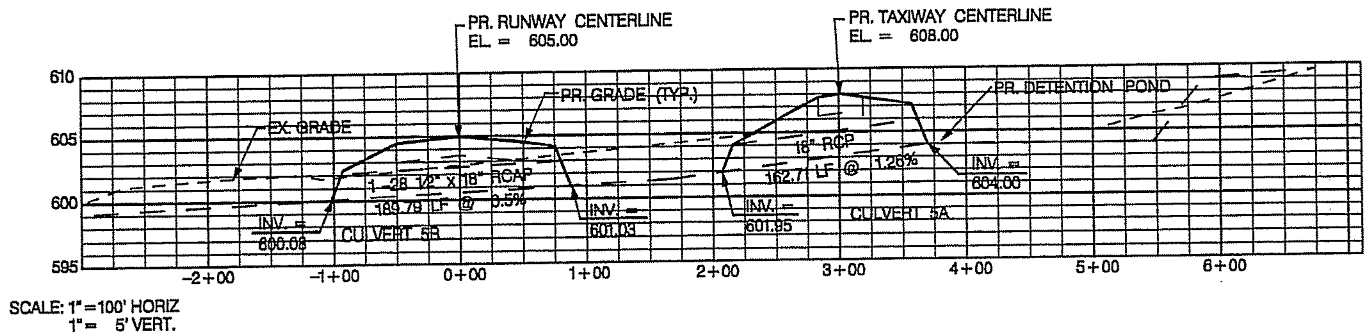
SCALE: 1"=100' HORIZ
1"= 5' VERT.

CULVERT 3
STA 26+57

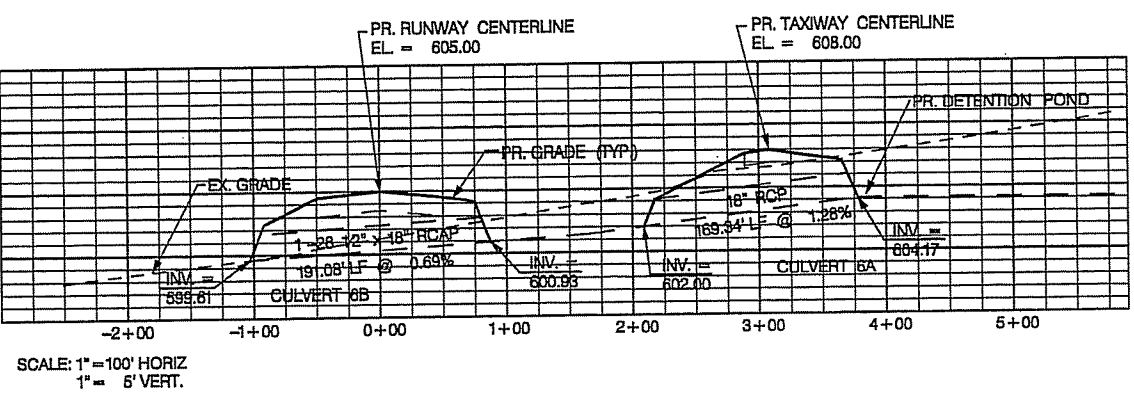


SCALE: 1"=100' HORIZ
1"= 5' VERT.

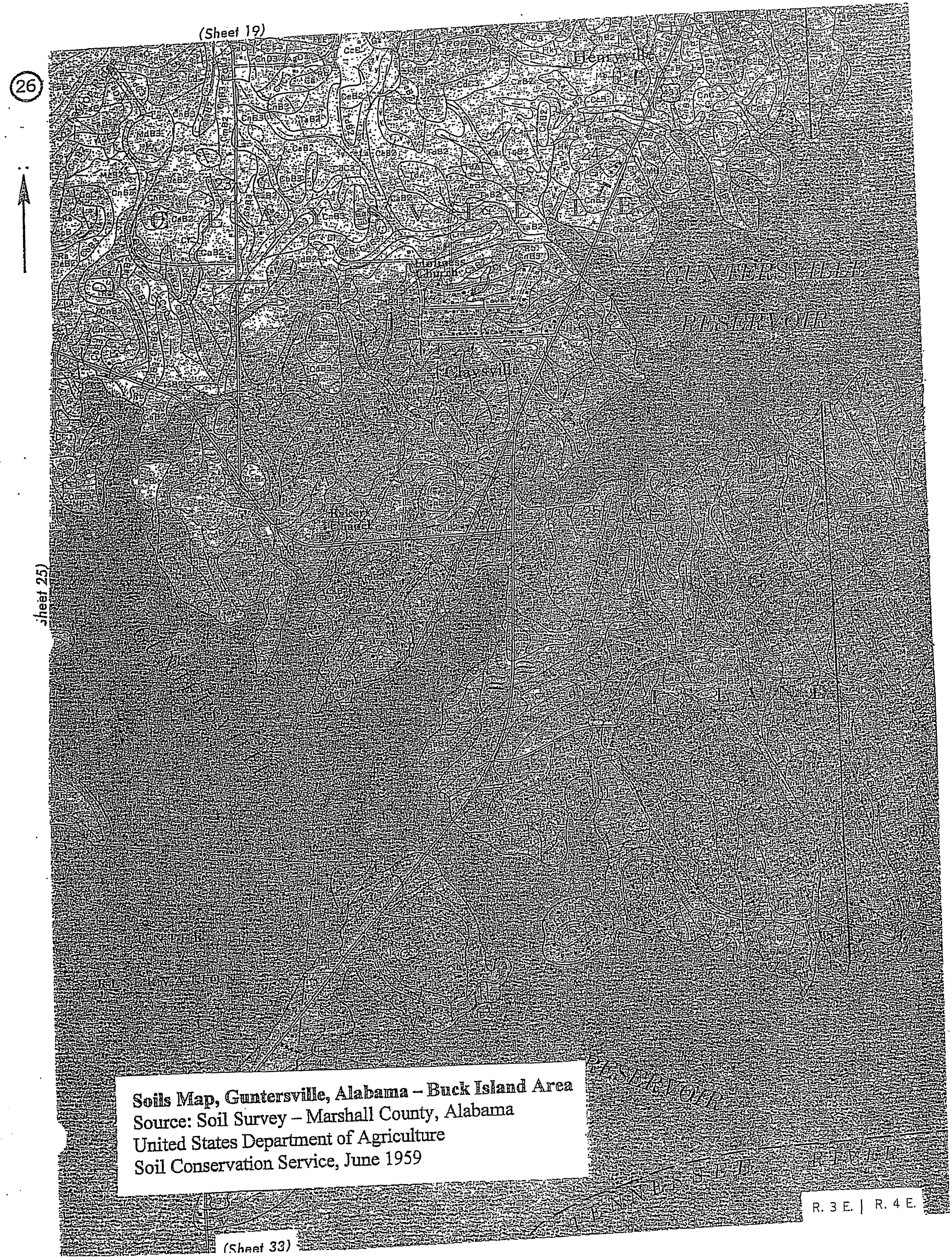
CULVERT 4
STA 33+13



CULVERT 5
STA 42+34



CULVERT 6
STA 47+67



Soils Map, Guntersville, Alabama – Buck Island Area
Source: Soil Survey – Marshall County, Alabama
United States Department of Agriculture
Soil Conservation Service, June 1959

Hydrograph Summary Report

d. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to peak (min)	Volume (cuft)	Inflow hyd(s)	Maximum elevation (ft)	Maximum storage (cuft)	Hydrograph description
1	Rational	133.39	1	37	296,115	—	——	——	Watershed 1
2	Rational	95.82	1	12	68,988	—	——	——	Watershed 2
3	Rational	21.14	1	6	7,609	—	——	——	Watershed 3
4	Rational	48.91	1	6	17,608	—	——	——	Watershed 4
5	Rational	51.92	1	8	24,922	—	——	——	Watershed 5
6	Rational	84.24	1	15	75,820	—	——	——	Watershed 6
7	Reservoir	17.80	1	69	294,778	1	605.16	256,305	Pond 1
8	Reservoir	0.72	1	12	16,056	4	604.98	17,388	Pond 2
9	Reservoir	2.46	1	16	24,474	5	604.72	23,954	Pond 3
10	Reservoir	3.46	1	29	67,253	6	605.79	73,829	Pond 4
11	Rational	11.29	1	17	11,516	—	——	——	Watershed 1B
12	Rational	13.82	1	6	4,975	—	——	——	Watershed 2B
13	Rational	16.17	1	6	5,821	—	——	——	Watershed 3B
14	Rational	14.74	1	6	5,307	—	——	——	Watershed 4B
	Rational	14.38	1	6	5,176	—	——	——	Waterhsed 5B
	Rational	19.27	1	6	6,938	—	——	——	Watershed 6B
17	Combine	17.80	1	69	306,293	7, 11,	——	——	Total 1B
18	Combine	95.82	1	12	73,963	2, 12,	——	——	Total 2B
19	Combine	37.30	1	6	13,429	3, 13,	——	——	Total 3B
20	Combine	14.98	1	6	21,363	8, 14,	——	——	Total 4B
21	Combine	14.62	1	6	29,650	9, 15,	——	——	Total 5B
22	Combine	19.30	1	6	74,191	10, 16,	——	——	Total 6B

Hydrograph Summary Report

No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to peak (min)	Volume (cuft)	Inflow hyd(s)	Maximum elevation (ft)	Maximum storage (cuft)	Hydrograph description
1	Rational	163.48	1	37	362,915	——	——	——	Watershed 1
2	Rational	115.42	1	12	83,105	——	——	——	Watershed 2
3	Rational	25.25	1	6	9,089	——	——	——	Watershed 3
4	Rational	58.42	1	6	21,033	——	——	——	Watershed 4
5	Rational	62.22	1	8	29,866	——	——	——	Watershed 5
6	Rational	101.81	1	15	91,625	——	——	——	Watershed 6
7	Reservoir	20.04	1	69	361,480	1	605.63	316,284	Pond 1
8	Reservoir	0.87	1	12	19,442	4	605.15	20,752	Pond 2
9	Reservoir	3.34	1	16	29,405	5	604.86	28,534	Pond 3
10	Reservoir	4.93	1	29	82,877	6	606.12	88,425	Pond 4
11	Rational	13.67	1	17	13,942	——	——	——	Watershed 1B
12	Rational	16.51	1	6	5,942	——	——	——	Watershed 2B
13	Rational	19.31	1	6	6,953	——	——	——	Watershed 3B
14	Rational	17.61	1	6	6,339	——	——	——	Watershed 4B
[illegible]	Rational	17.17	1	6	6,183	——	——	——	Waterhsed 5B
[illegible]	Rational	23.02	1	6	8,288	——	——	——	Watershed 6B
17	Combine	20.04	1	69	375,422	7, 11,	——	——	Total 1B
18	Combine	115.42	1	12	89,047	2, 12,	——	——	Total 2B
19	Combine	44.56	1	6	16,041	3, 13,	——	——	Total 3B
20	Combine	17.94	1	6	25,781	8, 14,	——	——	Total 4B
21	Combine	17.52	1	6	35,588	9, 15,	——	——	Total 5B
22	Combine	23.06	1	6	91,164	10, 16,	——	——	Total 6B

flow-rat.gpw	Return Period: 100 Year	Friday, May 29 2009, 1:02 PM

Hydrograph Return Period Recap

d. No.	Hydrograph type (origin)	Inflow Hyd(s)	Peak Outflow (cfs)								Hydrograph description
			1-Yr	2-Yr	3-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	
1	Rational	------	------	81.91	------	100.60	113.91	133.39	148.55	163.48	Watershed 1
2	Rational	------	------	63.72	------	74.93	83.46	95.82	105.74	115.42	Watershed 2
3	Rational	------	------	14.52	------	16.79	18.54	21.14	23.20	25.25	Watershed 3
4	Rational	------	------	33.59	------	38.87	42.91	48.91	53.69	58.42	Watershed 4
5	Rational	------	------	35.24	------	41.01	45.44	51.92	57.12	62.22	Watershed 5
6	Rational	------	------	55.29	------	65.47	73.16	84.24	93.14	101.81	Watershed 6
7	Reservoir	1	------	12.66	------	14.93	16.17	17.80	18.96	20.04	Pond 1
8	Reservoir	4	------	0.41	------	0.52	0.60	0.72	0.80	0.87	Pond 2
9	Reservoir	5	------	1.23	------	1.62	1.95	2.46	2.89	3.34	Pond 3
10	Reservoir	6	------	0.93	------	1.02	1.94	3.46	4.29	4.93	Pond 4
11	Rational	------	------	7.35	------	8.74	9.79	11.29	12.49	13.67	Watershed 1B
12	Rational	------	------	9.49	------	10.98	12.12	13.82	15.17	16.51	Watershed 2B
13	Rational	------	------	11.10	------	12.85	14.19	16.17	17.75	19.31	Watershed 3B
14	Rational	------	------	10.12	------	11.71	12.93	14.74	16.18	17.61	Watershed 4B
	Rational	------	------	9.87	------	11.42	12.61	14.38	15.78	17.17	Waterhsed 5B
	Rational	------	------	13.24	------	15.31	16.91	19.27	21.16	23.02	Watershed 6B
17	Combine	7, 11,	------	12.66	------	14.93	16.17	17.80	18.96	20.04	Total 1B
18	Combine	2, 12,	------	63.72	------	74.93	83.46	95.82	105.74	115.42	Total 2B
19	Combine	3, 13,	------	25.62	------	29.64	32.73	37.30	40.95	44.56	Total 3B
20	Combine	8, 14,	------	10.25	------	11.87	13.13	14.98	16.47	17.94	Total 4B
21	Combine	9, 15,	------	10.00	------	11.59	12.80	14.62	16.08	17.52	Total 5B
22	Combine	10, 16,	------	13.25	------	15.33	16.93	19.30	21.19	23.06	Total 6B

Pond Report

Hydraflow Hydrographs by Intelisolve

Tuesday, Oct 19 2004, 9:41 AM

Pond No. 1 - Pond 1

Pond Data

Pond storage is based on known contour areas. Average end area method used.

Stage / Storage Table

Stage (ft)	Elevation (ft)	Contour area (sqft)	Incr. Storage (cuft)	Total storage (cuft)
0.00	603.00	112,599	0	0
1.00	604.00	118,160	115,380	115,380
2.00	605.00	123,826	120,993	236,373
3.00	606.00	129,596	126,711	363,084
4.00	607.00	135,469	132,533	495,616

Culvert / Orifice Structures

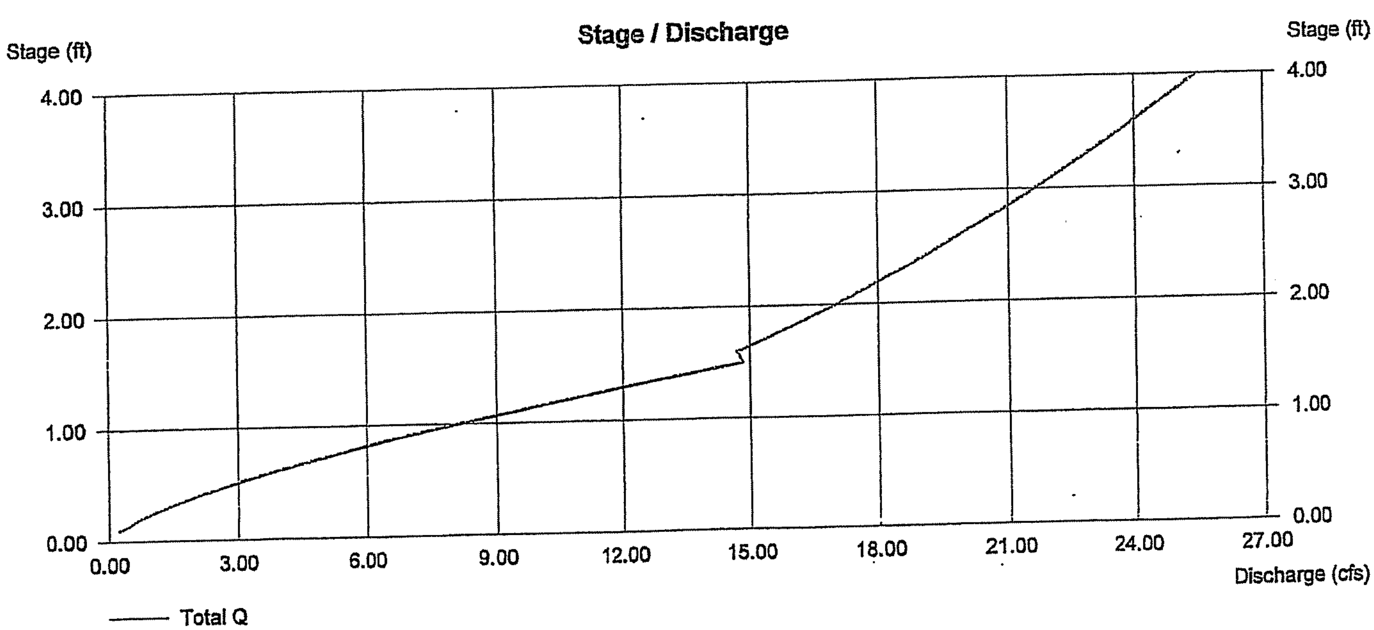
	[A]	[B]	[C]	[D]
Rise (in)	= 18.00	0.00	0.00	0.00
Span (in)	= 28.50	0.00	0.00	0.00
No. Barrels	= 1	0	0	0
Invert El. (ft)	= 603.00	0.00	0.00	0.00
Length (ft)	= 221.82	0.00	0.00	0.00
Slope (%)	= 0.50	0.00	0.00	0.00
N-Value	= .013	.000	.000	.000
Orif. Coeff.	= 0.60	0.00	0.00	0.00
Multi-Stage	= n/a	No	No	No

Weir Structures

	[A]	[B]	[C]	[D]
Crest Len (ft)	= 0.00	0.00	0.00	0.00
Crest El. (ft)	= 0.00	0.00	0.00	0.00
Weir Coeff.	= 0.00	0.00	0.00	0.00
Weir Type	= —	—	—	—
Multi-Stage	= No	No	No	No

Exfiltration = 0.000 in/hr (Contour) Tailwater Elev. = 0.00 ft

Note: Culvert/Orifice outflows have been analyzed under inlet and outlet control.



Pond Report

Hydraflow Hydrographs by Intelisolve | Tuesday, Oct 19 2004, 9:41 AM

Pond No. 1 - Pond 1

Pond Data

Pond storage is based on known contour areas. Average end area method used.

Stage / Storage Table

Stage (ft)	Elevation (ft)	Contour area (sqft)	Incr. Storage (cuft)	Total storage (cuft)
0.00	603.00	112,599	0	0
1.00	604.00	118,160	115,380	115,380
2.00	605.00	123,826	120,993	236,373
3.00	606.00	129,596	126,711	363,084
4.00	607.00	135,469	132,533	495,616

Culvert / Orifice Structures

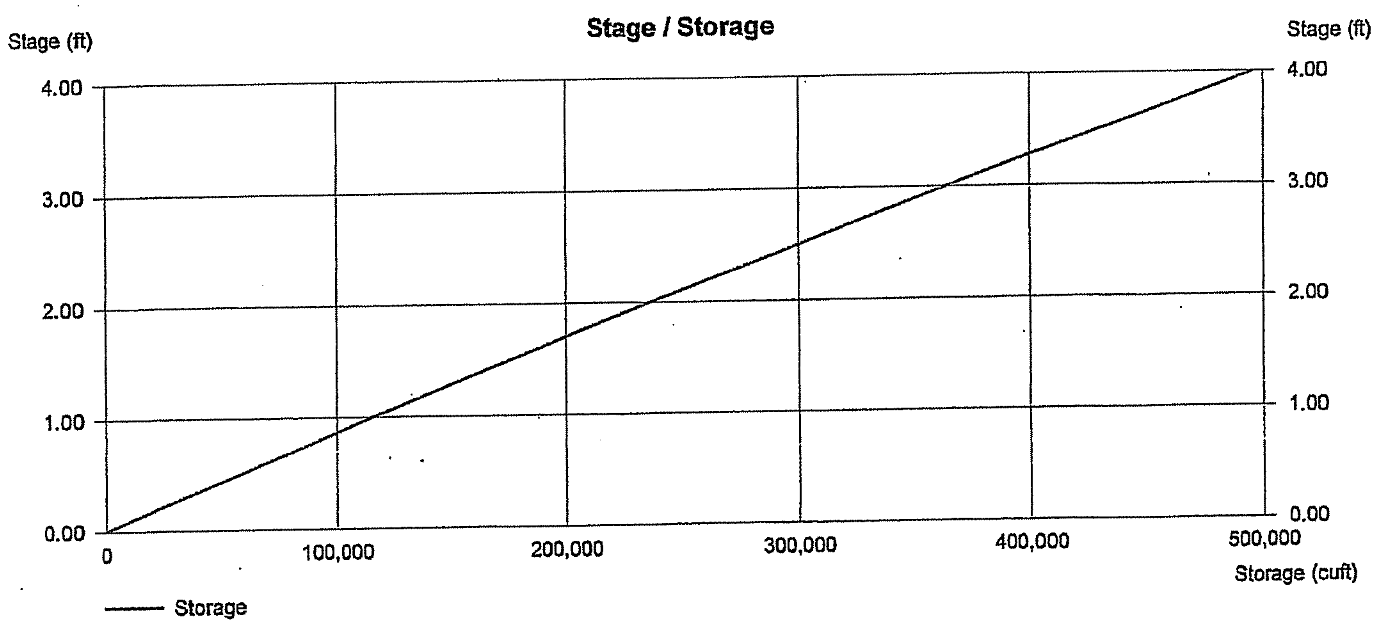
	[A]	[B]	[C]	[D]
Rise (in)	= 18.00	0.00	0.00	0.00
Span (in)	= 28.50	0.00	0.00	0.00
No. Barrels	= 1	0	0	0
Invert El. (ft)	= 603.00	0.00	0.00	0.00
Length (ft)	= 221.82	0.00	0.00	0.00
Slope (%)	= 0.50	0.00	0.00	0.00
N-Value	= .013	.000	.000	.000
Orif. Coeff.	= 0.60	0.00	0.00	0.00
Multi-Stage	= n/a	No	No	No

Weir Structures

	[A]	[B]	[C]	[D]
Crest Len (ft)	= 0.00	0.00	0.00	0.00
Crest El. (ft)	= 0.00	0.00	0.00	0.00
Weir Coeff.	= 0.00	0.00	0.00	0.00
Weir Type	= —	—	—	—
Multi-Stage	= No	No	No	No

Exfiltration = 0.000 in/hr (Contour) Tailwater Elev. = 0.00 ft

Note: Culvert/Orifice outflows have been analyzed under inlet and outlet control.



Pond Report

Hydraflow Hydrographs by Intelisolve — Tuesday, Oct 19 2004, 9:42 AM

Pond No. 1 - Pond 1

Pond Data

Pond storage is based on known contour areas. Average end area method used.

Stage / Storage Table

Stage (ft)	Elevation (ft)	Contour area (sqft)	Incr. Storage (cuft)	Total storage (cuft)
0.00	603.00	112,599	0	0
1.00	604.00	118,160	115,380	115,380
2.00	605.00	123,826	120,993	236,373
3.00	606.00	129,596	126,711	363,084
4.00	607.00	135,469	132,533	495,616

Culvert / Orifice Structures

	[A]	[B]	[C]	[D]
Rise (in)	= 18.00	0.00	0.00	0.00
Span (in)	= 28.50	0.00	0.00	0.00
No. Barrels	= 1	0	0	0
Invert El. (ft)	= 603.00	0.00	0.00	0.00
Length (ft)	= 221.82	0.00	0.00	0.00
Slope (%)	= 0.50	0.00	0.00	0.00
N-Value	= .013	.000	.000	.000
Orif. Coeff.	= 0.60	0.00	0.00	0.00
Multi-Stage	= n/a	No	No	No

Weir Structures

	[A]	[B]	[C]	[D]
Crest Len (ft)	= 0.00	0.00	0.00	0.00
Crest El. (ft)	= 0.00	0.00	0.00	0.00
Weir Coeff.	= 0.00	0.00	0.00	0.00
Weir Type	= —	—	—	—
Multi-Stage	= No	No	No	No

Exfiltration = 0.000 in/hr (Contour) Tailwater Elev. = 0.00 ft

Note: Culvert/Orifice outflows have been analyzed under inlet and outlet control.

Stage / Storage / Discharge Table

Stage ft	Storage cuft	Elevation ft	Clv A cfs	Clv B cfs	Clv C cfs	Clv D cfs	Wr A cfs	Wr B cfs	Wr C cfs	Wr D cfs	Exfil cfs	Total cfs
0.00	0	603.00	0.00	—	—	—	—	—	—	—	—	0.00
1.00	115,380	604.00	8.09	—	—	—	—	—	—	—	—	8.09
2.00	236,373	605.00	16.99	—	—	—	—	—	—	—	—	16.99
3.00	363,084	606.00	21.63	—	—	—	—	—	—	—	—	21.63
4.00	495,616	607.00	25.44	—	—	—	—	—	—	—	—	25.44

Pond Report

Hydraflow Hydrographs by Intelisolve

Tuesday, Oct 19 2004, 9:42 AM

Pond No. 2 - Pond 2

Pond Data

Pond storage is based on known contour areas. Average end area method used.

Stage / Storage Table

Stage (ft)	Elevation (ft)	Contour area (sqft)	Incr. Storage (cuft)	Total storage (cuft)
0.00	604.00	16,634	0	0
1.00	605.00	18,874	17,754	17,754
2.00	606.00	21,216	20,045	37,799
3.00	607.00	23,660	22,438	60,237

Culvert / Orifice Structures

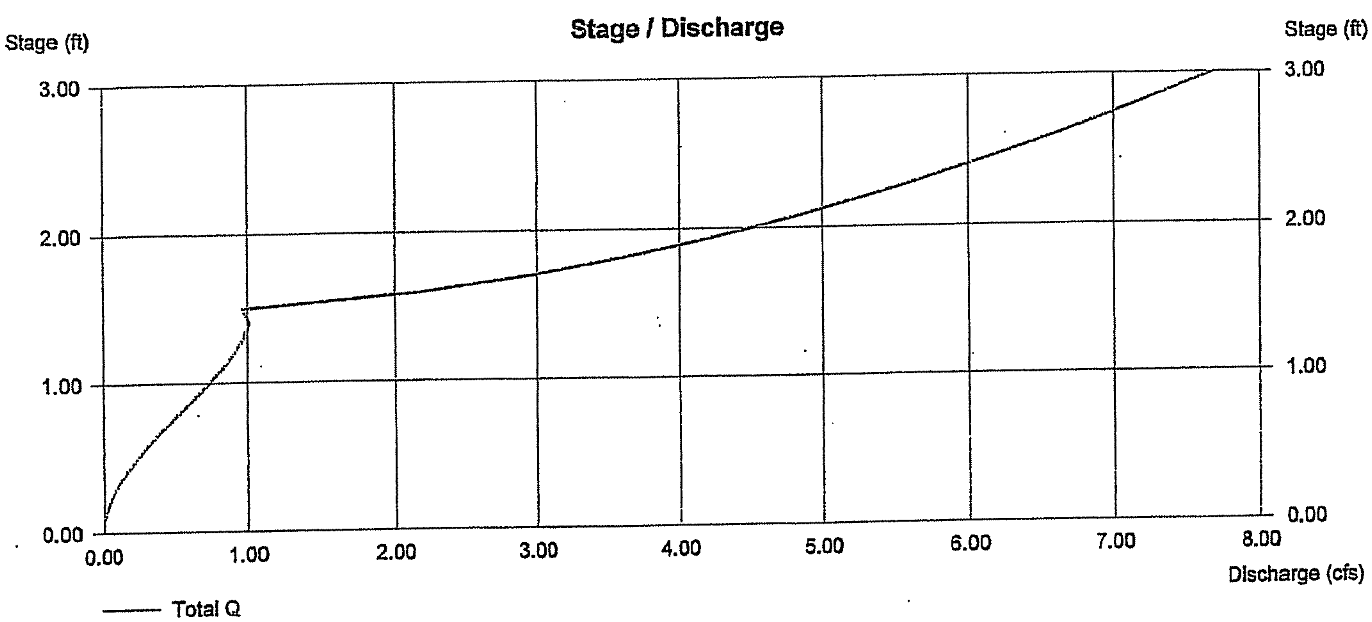
	[A]	[B]	[C]	[D]
Rise (in)	= 18.00	0.00	0.00	0.00
Span (in)	= 18.00	0.00	0.00	0.00
No. Barrels	= 1	0	0	0
Invert El. (ft)	= 604.00	0.00	0.00	0.00
Length (ft)	= 205.47	0.00	0.00	0.00
Slope (%)	= 0.01	0.00	0.00	0.00
N-Value	= .013	.000	.000	.000
Orif. Coeff.	= 0.60	0.00	0.00	0.00
Multi-Stage	= n/a	No	No	No

Weir Structures

	[A]	[B]	[C]	[D]
Crest Len (ft)	= 0.00	0.00	0.00	0.00
Crest El. (ft)	= 0.00	0.00	0.00	0.00
Weir Coeff.	= 0.00	0.00	0.00	0.00
Weir Type	= —	—	—	—
Multi-Stage	= No	No	No	No

Exfiltration = 0.000 in/hr (Contour) Tailwater Elev. = 0.00 ft

Note: Culvert/Orifice outflows have been analyzed under inlet and outlet control.



Pond Report

Hydraflow Hydrographs by Intelisolve Tuesday, Oct 19 2004, 9:42 AM

Pond No. 2 - Pond 2

Pond Data

Pond storage is based on known contour areas. Average end area method used.

Stage / Storage Table

Stage (ft)	Elevation (ft)	Contour area (sqft)	Incr. Storage (cuft)	Total storage (cuft)
0.00	604.00	16,634	0	0
1.00	605.00	18,874	17,754	17,754
2.00	606.00	21,216	20,045	37,799
3.00	607.00	23,660	22,438	60,237

Culvert / Orifice Structures

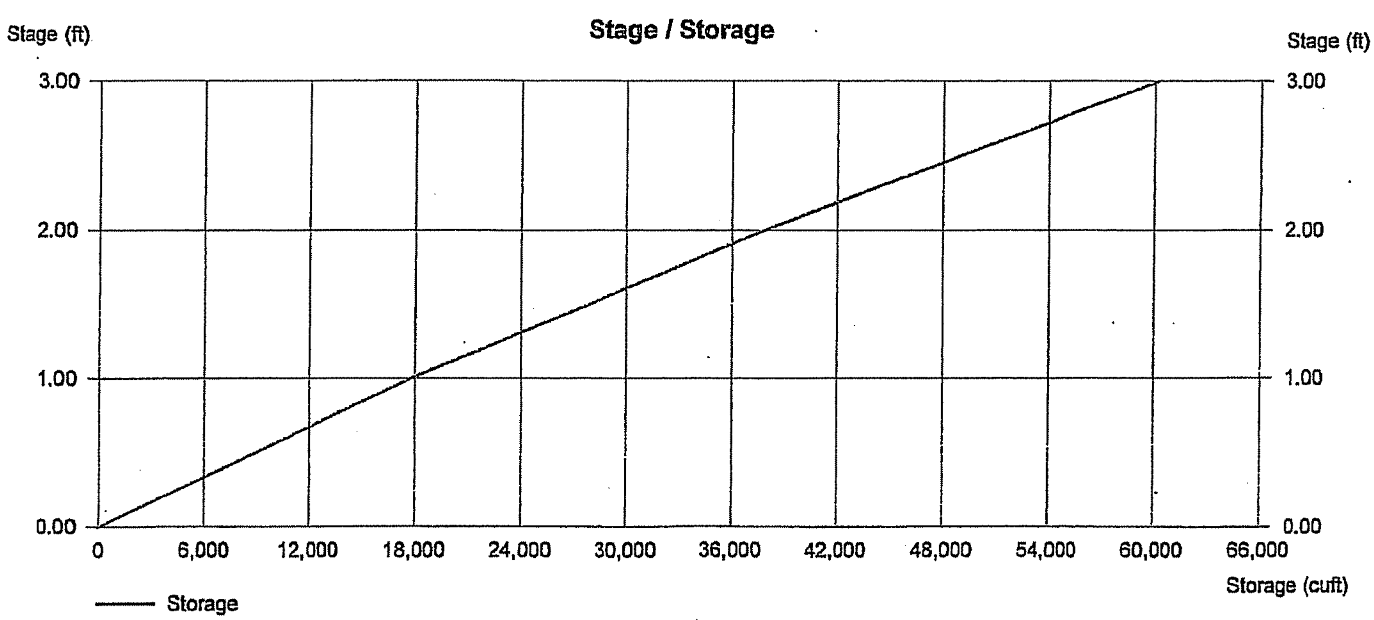
	[A]	[B]	[C]	[D]
Rise (in)	= 18.00	0.00	0.00	0.00
Span (in)	= 18.00	0.00	0.00	0.00
No. Barrels	= 1	0	0	0
Invert El. (ft)	= 604.00	0.00	0.00	0.00
Length (ft)	= 205.47	0.00	0.00	0.00
Slope (%)	= 0.01	0.00	0.00	0.00
N-Value	= .013	.000	.000	.000
Orif. Coeff.	= 0.60	0.00	0.00	0.00
Multi-Stage	= n/a	No	No	No

Weir Structures

	[A]	[B]	[C]	[D]
Crest Len (ft)	= 0.00	0.00	0.00	0.00
Crest El. (ft)	= 0.00	0.00	0.00	0.00
Weir Coeff.	= 0.00	0.00	0.00	0.00
Weir Type	= —	—	—	—
Multi-Stage	= No	No	No	No

Exfiltration = 0.000 in/hr (Contour) Tailwater Elev. = 0.00 ft

Note: Culvert/Orifice outflows have been analyzed under inlet and outlet control.



Pond Report

Hydraflow Hydrographs by Intelisolve — Tuesday, Oct 19 2004, 9:42 AM

Pond No. 2 - Pond 2

Pond Data

Pond storage is based on known contour areas. Average end area method used.

Stage / Storage Table

Stage (ft)	Elevation (ft)	Contour area (sqft)	Incr. Storage (cuft)	Total storage (cuft)
0.00	604.00	16,634	0	0
1.00	605.00	18,874	17,754	17,754
2.00	606.00	21,216	20,045	37,799
3.00	607.00	23,660	22,438	60,237

Culvert / Orifice Structures

	[A]	[B]	[C]	[D]
Rise (in)	= 18.00	0.00	0.00	0.00
Span (in)	= 18.00	0.00	0.00	0.00
No. Barrels	= 1	0	0	0
Invert El. (ft)	= 604.00	0.00	0.00	0.00
Length (ft)	= 205.47	0.00	0.00	0.00
Slope (%)	= 0.01	0.00	0.00	0.00
N-Value	= .013	.000	.000	.000
Orif. Coeff.	= 0.60	0.00	0.00	0.00
Multi-Stage	= n/a	No	No	No

Weir Structures

	[A]	[B]	[C]	[D]
Crest Len (ft)	= 0.00	0.00	0.00	0.00
Crest El. (ft)	= 0.00	0.00	0.00	0.00
Weir Coeff.	= 0.00	0.00	0.00	0.00
Weir Type	= —	—	—	—
Multi-Stage	= No	No	No	No

Exfiltration = 0.000 in/hr (Contour) Tailwater Elev. = 0.00 ft

Note: Culvert/Orifice outflows have been analyzed under inlet and outlet control.

Stage / Storage / Discharge Table

Stage ft	Storage cuft	Elevation ft	Clv A cfs	Clv B cfs	Clv C cfs	Clv D cfs	Wr A cfs	Wr B cfs	Wr C cfs	Wr D cfs	Exfil cfs	Total cfs
0.00	0	604.00	0.00	—	—	—	—	—	—	—	—	0.00
1.00	17,754	605.00	0.74	—	—	—	—	—	—	—	—	0.74
2.00	37,799	606.00	4.50	—	—	—	—	—	—	—	—	4.50
3.00	60,237	607.00	7.67	—	—	—	—	—	—	—	—	7.67

Pond Report

Pond No. 3 - Pond 3

Pond Data

Pond storage is based on known contour areas. Average end area method used.

Stage / Storage Table

Stage (ft)	Elevation (ft)	Contour area (sqft)	Incr. Storage (cuft)	Total storage (cuft)
0.00	604.00	31,191	0	0
1.00	605.00	34,897	33,044	33,044
2.00	606.00	38,766	36,832	69,876
3.00	607.00	42,768	40,767	110,643

Culvert / Orifice Structures

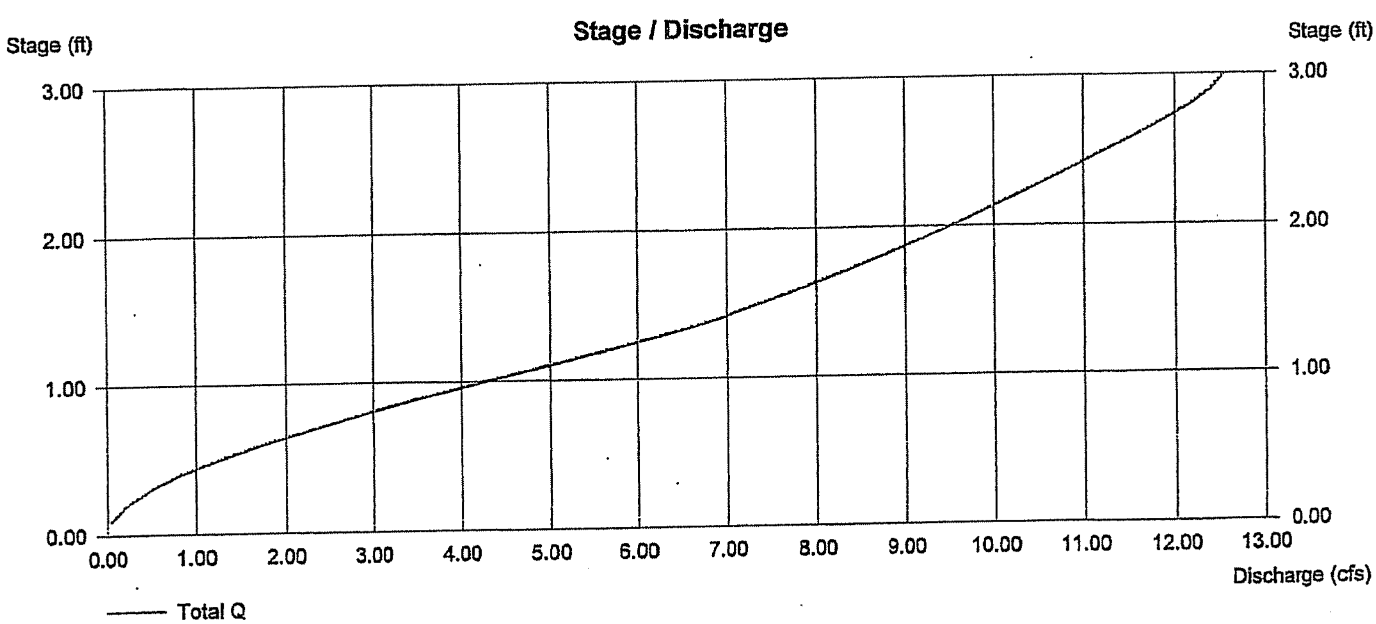
	[A]	[B]	[C]	[D]
Rise (in)	= 18.00	0.00	0.00	0.00
Span (in)	= 18.00	0.00	0.00	0.00
No. Barrels	= 1	0	0	0
Invert El. (ft)	= 604.00	0.00	0.00	0.00
Length (ft)	= 203.31	0.00	0.00	0.00
Slope (%)	= 1.26	0.00	0.00	0.00
N-Value	= .013	.000	.000	.000
Orif. Coeff.	= 0.60	0.00	0.00	0.00
Multi-Stage	= n/a	No	No	No

Weir Structures

	[A]	[B]	[C]	[D]
Crest Len (ft)	= 0.00	0.00	0.00	0.00
Crest El. (ft)	= 0.00	0.00	0.00	0.00
Weir Coeff.	= 0.00	0.00	0.00	0.00
Weir Type	= ---	---	---	---
Multi-Stage	= No	No	No	No

Exfiltration = 0.000 in/hr (Contour) Tailwater Elev. = 0.00 ft

Note: Culvert/Orifice outflows have been analyzed under inlet and outlet control.



Pond Report

Hydraflow Hydrographs by Intelisolve

Tuesday, Oct 19 2004, 9:43 AM

Pond No. 3 - Pond 3

Pond Data

Pond storage is based on known contour areas. Average end area method used.

Stage / Storage Table

Stage (ft)	Elevation (ft)	Contour area (sqft)	Incr. Storage (cuft)	Total storage (cuft)
0.00	604.00	31,191	0	0
1.00	605.00	34,897	33,044	33,044
2.00	606.00	38,766	36,832	69,876
3.00	607.00	42,768	40,767	110,643

Culvert / Orifice Structures

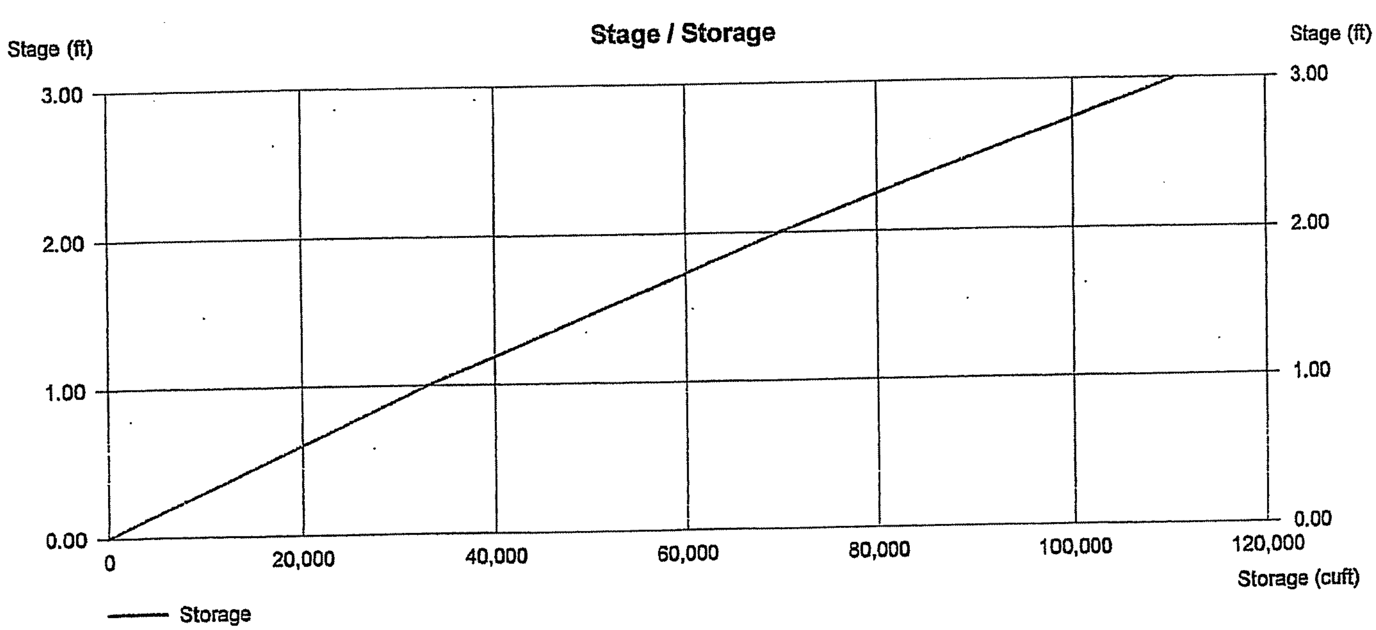
	[A]	[B]	[C]	[D]
Rise (in)	= 18.00	0.00	0.00	0.00
Span (in)	= 18.00	0.00	0.00	0.00
No. Barrels	= 1	0	0	0
Invert El. (ft)	= 604.00	0.00	0.00	0.00
Length (ft)	= 203.31	0.00	0.00	0.00
Slope (%)	= 1.26	0.00	0.00	0.00
N-Value	= .013	.000	.000	.000
Orif. Coeff.	= 0.60	0.00	0.00	0.00
Multi-Stage	= n/a	No	No	No

Weir Structures

	[A]	[B]	[C]	[D]
Crest Len (ft)	= 0.00	0.00	0.00	0.00
Crest El. (ft)	= 0.00	0.00	0.00	0.00
Weir Coeff.	= 0.00	0.00	0.00	0.00
Weir Type	= —	—	—	—
Multi-Stage	= No	No	No	No

Exfiltration = 0.000 in/hr (Contour) Tailwater Elev. = 0.00 ft

Note: Culvert/Orifice outflows have been analyzed under inlet and outlet control.



Pond Report

Hydraflow Hydrographs by Intelisolve

Tuesday, Oct 19 2004, 9:43 AM

Pond No. 3 - Pond 3

Pond Data

Pond storage is based on known contour areas. Average end area method used.

Stage / Storage Table

Stage (ft)	Elevation (ft)	Contour area (sqft)	Incr. Storage (cuft)	Total storage (cuft)
0.00	604.00	31,191	0	0
1.00	605.00	34,897	33,044	33,044
2.00	606.00	38,766	36,832	69,876
3.00	607.00	42,768	40,767	110,643

Culvert / Orifice Structures

	[A]	[B]	[C]	[D]
Rise (in)	= 18.00	0.00	0.00	0.00
Span (in)	= 18.00	0.00	0.00	0.00
No. Barrels	= 1	0	0	0
Invert El. (ft)	= 604.00	0.00	0.00	0.00
Length (ft)	= 203.31	0.00	0.00	0.00
Slope (%)	= 1.26	0.00	0.00	0.00
N-Value	= .013	.000	.000	.000
Orif. Coeff.	= 0.60	0.00	0.00	0.00
Multi-Stage	= n/a	No	No	No

Weir Structures

	[A]	[B]	[C]	[D]
Crest Len (ft)	= 0.00	0.00	0.00	0.00
Crest El. (ft)	= 0.00	0.00	0.00	0.00
Weir Coeff.	= 0.00	0.00	0.00	0.00
Weir Type	= —	—	—	—
Multi-Stage	= No	No	No	No

Exfiltration = 0.000 in/hr (Contour) Tailwater Elev. = 0.00 ft

Note: Culvert/Orifice outflows have been analyzed under inlet and outlet control.

Stage / Storage / Discharge Table

Stage ft	Storage cuft	Elevation ft	Clv A cfs	Clv B cfs	Clv C cfs	Clv D cfs	Wr A cfs	Wr B cfs	Wr C cfs	Wr D cfs	Exfil cfs	Total cfs
0.00	0	604.00	0.00	—	—	—	—	—	—	—	—	0.00
1.00	33,044	605.00	4.26	—	—	—	—	—	—	—	—	4.26
2.00	69,876	606.00	9.51	—	—	—	—	—	—	—	—	9.51
3.00	110,643	607.00	12.56	—	—	—	—	—	—	—	—	12.56

Pond Report

Hydraflow Hydrographs by Intelisolve — Tuesday, Oct 19 2004, 9:44 AM

Pond No. 4 - Pond 4

Pond Data

Pond storage is based on known contour areas. Average end area method used.

Stage / Storage Table

Stage (ft)	Elevation (ft)	Contour area (sqft)	Incr. Storage (cuft)	Total storage (cuft)
0.00	604.00	37,664	0	0
1.00	605.00	41,389	39,527	39,527
2.00	606.00	45,249	43,319	82,846
3.00	607.00	49,241	47,245	130,091

Culvert / Orifice Structures

	[A]	[B]	[C]	[D]
Rise (in)	= 18.00	0.00	0.00	0.00
Span (in)	= 18.00	0.00	0.00	0.00
No. Barrels	= 1	0	0	0
Invert El. (ft)	= 604.00	0.00	0.00	0.00
Length (ft)	= 211.49	0.00	0.00	0.00
Slope (%)	= 0.01	0.00	0.00	0.00
N-Value	= .013	.000	.000	.000
Orif. Coeff.	= 0.60	0.00	0.00	0.00
Multi-Stage	= n/a	No	No	No

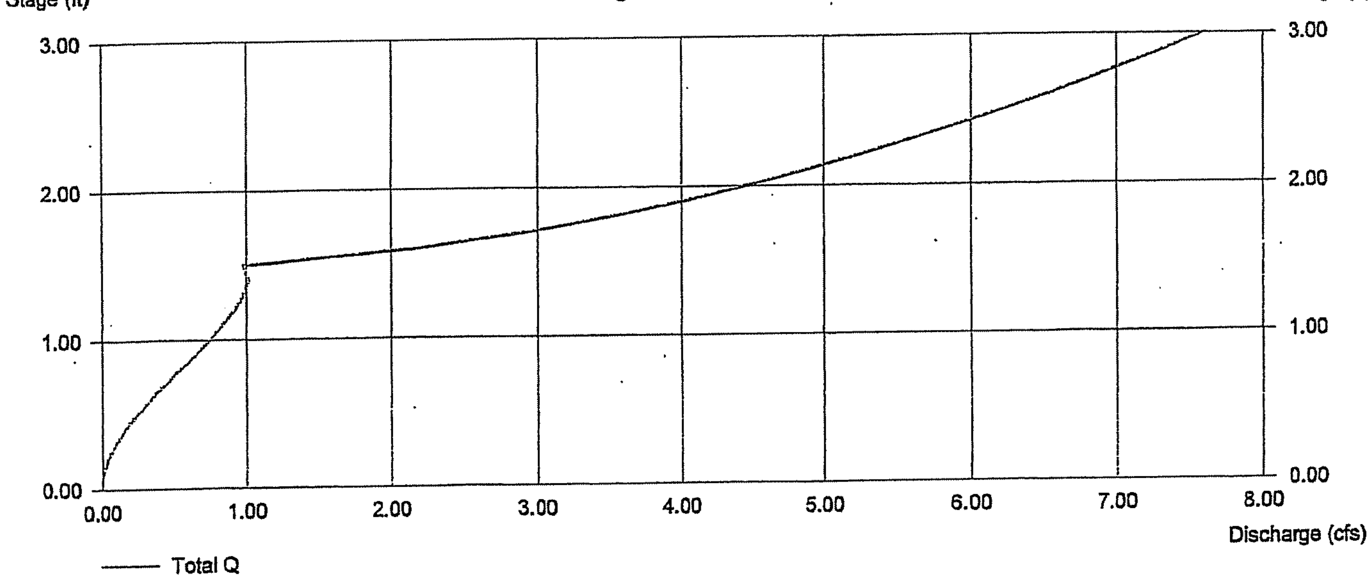
Weir Structures

	[A]	[B]	[C]	[D]
Crest Len (ft)	= 0.00	0.00	0.00	0.00
Crest El. (ft)	= 0.00	0.00	0.00	0.00
Weir Coeff.	= 0.00	0.00	0.00	0.00
Weir Type	= —	—	—	—
Multi-Stage	= No	No	No	No

Exfiltration = 0.000 in/hr (Contour) Tailwater Elev. = 0.00 ft

Note: Culvert/Orifice outflows have been analyzed under inlet and outlet control.

Stage / Discharge



Pond Report

Hydraflow Hydrographs by Intelisolve — Tuesday, Oct 19 2004, 9:44 AM

Pond No. 4 - Pond 4

Pond Data

Pond storage is based on known contour areas. Average end area method used.

Stage / Storage Table

Stage (ft)	Elevation (ft)	Contour area (sqft)	Incr. Storage (cuft)	Total storage (cuft)
0.00	604.00	37,664	0	0
1.00	605.00	41,389	39,527	39,527
2.00	606.00	45,249	43,319	82,846
3.00	607.00	49,241	47,245	130,091

Culvert / Orifice Structures

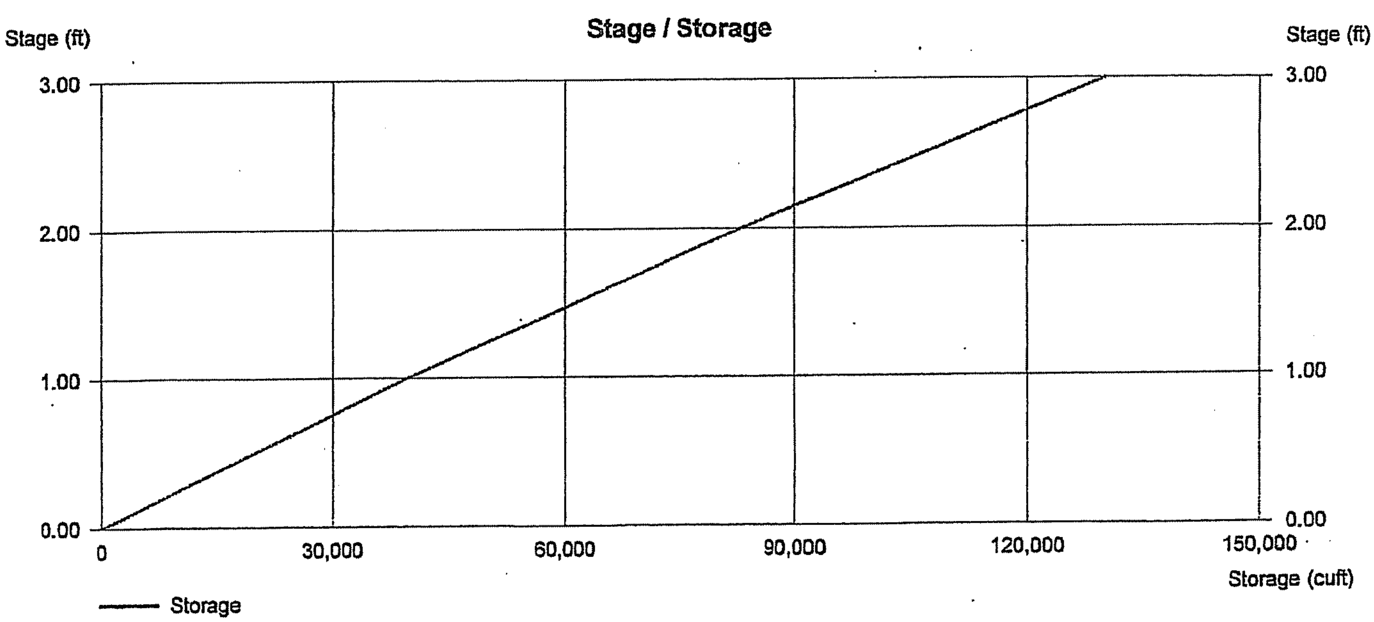
	[A]	[B]	[C]	[D]
Rise (in)	= 18.00	0.00	0.00	0.00
Span (in)	= 18.00	0.00	0.00	0.00
No. Barrels	= 1	0	0	0
Invert El. (ft)	= 604.00	0.00	0.00	0.00
Length (ft)	= 211.49	0.00	0.00	0.00
Slope (%)	= 0.01	0.00	0.00	0.00
N-Value	= .013	.000	.000	.000
Orif. Coeff.	= 0.60	0.00	0.00	0.00
Multi-Stage	= n/a	No	No	No

Weir Structures

	[A]	[B]	[C]	[D]
Crest Len (ft)	= 0.00	0.00	0.00	0.00
Crest El. (ft)	= 0.00	0.00	0.00	0.00
Weir Coeff.	= 0.00	0.00	0.00	0.00
Weir Type	= —	—	—	—
Multi-Stage	= No	No	No	No

Exfiltration = 0.000 in/hr (Contour) Tailwater Elev. = 0.00 ft

Note: Culvert/Orifice outflows have been analyzed under inlet and outlet control.



Pond Report

Hydraflow Hydrographs by Intelisolve

Tuesday, Oct 19 2004, 9:44 AM

Pond No. 4 - Pond 4

Pond Data

Pond storage is based on known contour areas. Average end area method used.

Stage / Storage Table

Stage (ft)	Elevation (ft)	Contour area (sqft)	Incr. Storage (cuft)	Total storage (cuft)
0.00	604.00	37,664	0	0
1.00	605.00	41,389	39,527	39,527
2.00	606.00	45,249	43,319	82,846
3.00	607.00	49,241	47,245	130,091

Culvert / Orifice Structures

	[A]	[B]	[C]	[D]
Rise (in)	= 18.00	0.00	0.00	0.00
Span (in)	= 18.00	0.00	0.00	0.00
No. Barrels	= 1	0	0	0
Invert El. (ft)	= 604.00	0.00	0.00	0.00
Length (ft)	= 211.49	0.00	0.00	0.00
Slope (%)	= 0.01	0.00	0.00	0.00
N-Value	= .013	.000	.000	.000
Orif. Coeff.	= 0.60	0.00	0.00	0.00
Multi-Stage	= n/a	No	No	No

Weir Structures

	[A]	[B]	[C]	[D]
Crest Len (ft)	= 0.00	0.00	0.00	0.00
Crest El. (ft)	= 0.00	0.00	0.00	0.00
Weir Coeff.	= 0.00	0.00	0.00	0.00
Weir Type	= —	—	—	—
Multi-Stage	= No	No	No	No

Exfiltration = 0.000 in/hr (Contour) Tailwater Elev. = 0.00 ft

Note: Culvert/Orifice outflows have been analyzed under inlet and outlet control.

Stage / Storage / Discharge Table

Stage ft	Storage cuft	Elevation ft	Clv A cfs	Clv B cfs	Clv C cfs	Clv D cfs	Wr A cfs	Wr B cfs	Wr C cfs	Wr D cfs	Exfil cfs	Total cfs
0.00	0	604.00	0.00	—	—	—	—	—	—	—	—	0.00
1.00	39,527	605.00	0.75	—	—	—	—	—	—	—	—	0.75
2.00	82,846	606.00	4.46	—	—	—	—	—	—	—	—	4.46
3.00	130,091	607.00	7.59	—	—	—	—	—	—	—	—	7.59

Culvert Designer/Analyzer Report
Culvert 1B

Peak Discharge Method: User-Specified			
Design Discharge	17.80 cfs	Check Discharge	20.04 cfs

Grades Model: Inverts			
Invert Upstream	601.24 ft	Invert Downstream	600.25 ft
Length	198.18 ft	Slope	0.004995 ft/ft
Drop	0.99 ft		

Headwater Model: Maximum Allowable HW	
Headwater Elevation	604.00 ft

Tailwater Conditions: Constant Tailwater	
Tailwater Elevation	N/A ft

Name	Description	Discharge	HW Elev.	Velocity
x Trial-1	1-28.5 x 18.0 inch Arch	17.80 cfs	604.11 ft	

Culvert Designer/Analyzer Report
Culvert 1B

Design:Trial-1

Solve For: Headwater Elevation

Culvert Summary

Allowable HW Elevation	604.00 ft	Storm Event	Design
Computed Headwater Eleva	604.11 ft	Discharge	17.80 cfs
Headwater Depth/Height	1.92	Tailwater Elevation	N/A ft
Inlet Control HW Elev.	603.56 ft	Control Type	Outlet Control
Outlet Control HW Elev.	604.11 ft		

Grades

Upstream Invert	601.24 ft	Downstream Invert	600.25 ft
Length	198.18 ft	Constructed Slope	0.004995 ft/ft

Hydraulic Profile

Profile	CompositeM2PressureProfile	Depth, Downstream	1.21 ft
Slope Type	Mild	Normal Depth	N/A ft
Flow Regime	Subcritical	Critical Depth	1.21 ft
Velocity Downstream	7.16 ft/s	Critical Slope	0.008509 ft/ft

Section

Section Shape	Arch	Mannings Coefficient	0.013
Section Material	Concrete	Span	2.37 ft
Section Size	28.5 x 18.0 inch	Rise	1.50 ft
Number Sections	1		

Outlet Control Properties

Outlet Control HW Elev.	604.11 ft	Upstream Velocity Head	0.63 ft
Ke	0.20	Entrance Loss	0.13 ft

Inlet Control Properties

Inlet Control HW Elev.	603.56 ft	Flow Control	N/A
Inlet Type	Groove end projecting (arch)	Area Full	2.8 ft²
K	0.00450	HDS 5 Chart	0
M	2.00000	HDS 5 Scale	0
C	0.03170	Equation Form	1
Y	0.69000		

Culvert Designer/Analyzer Report
Culvert 2A

Peak Discharge Method: User-Specified			
Design Discharge	95.82 cfs	Check Discharge	115.42 cfs

Grades Model: Inverts			
Invert Upstream	603.50 ft	Invert Downstream	601.76 ft
Length	203.30 ft	Slope	0.008559 ft/ft
Drop	1.74 ft		

Headwater Model: Maximum Allowable HW	
Headwater Elevation	607.00 ft

Tailwater Conditions: Constant Tailwater	
Tailwater Elevation	N/A ft

Name	Description	Discharge	HW Elev.	Velocity
x Trial-1	3-36.25 x 22.5 inch Arch	95.82 cfs	606.44 ft	

Culvert Designer/Analyzer Report
Culvert 2A

Design:Trial-1

Solve For: Headwater Elevation

Culvert Summary

Allowable HW Elevation	607.00 ft	Storm Event	Design
Computed Headwater Eleva	606.44 ft	Discharge	95.82 cfs
Headwater Depth/Height	1.57	Tailwater Elevation	N/A ft
Inlet Control HW Elev.	606.44 ft	Control Type	Inlet Control
Outlet Control HW Elev.	606.24 ft		

Grades

Upstream Invert	603.50 ft	Downstream Invert	601.76 ft
Length	203.30 ft	Constructed Slope	0.008559 ft/ft

Hydraulic Profile

Profile	S2	Depth, Downstream	1.48 ft
Slope Type	Steep	Normal Depth	1.48 ft
Flow Regime	Supercritical	Critical Depth	1.53 ft
Velocity Downstream	8.26 ft/s	Critical Slope	0.008167 ft/ft

Section

Section Shape	Arch	Mannings Coefficient	0.013
Section Material	Concrete	Span	3.02 ft
Section Size	36.25 x 22.5 inch	Rise	1.87 ft
Number Sections	3		

Outlet Control Properties

Outlet Control HW Elev.	606.24 ft	Upstream Velocity Head	1.01 ft
Ke	0.20	Entrance Loss	0.20 ft

Inlet Control Properties

Inlet Control HW Elev.	606.44 ft	Flow Control	Submerged
Inlet Type	Groove end projecting (arch)	Area Full	13.3 ft²
K	0.00450	HDS 5 Chart	0
M	2.00000	HDS 5 Scale	0
C	0.03170	Equation Form	1
Y	0.69000		

Culvert Designer/Analyzer Report
Culvert 2B

Peak Discharge Method: User-Specified

Design Discharge	95.82 cfs	Check Discharge	115.42 cfs

Grades Model: Inverts

Invert Upstream	601.02 ft	Invert Downstream	600.08 ft
Length	188.88 ft	Slope	0.004977 ft/ft
Drop	0.94 ft		

Headwater Model: Maximum Allowable HW

Headwater Elevation	604.00 ft

Tailwater Conditions: Constant Tailwater

Tailwater Elevation	N/A ft

Name	Description	Discharge	HW Elev.	Velocity
x Trial-1	3-36.25 x 22.5 inch Arch	95.82 cfs	604.35 ft	

Culvert Designer/Analyzer Report
Culvert 2B

Design:Trial-1

Solve For: Headwater Elevation

Culvert Summary

Allowable HW Elevation	604.00 ft	Storm Event	Design
Computed Headwater Eleva	604.35 ft	Discharge	95.82 cfs
Headwater Depth/Height	1.78	Tailwater Elevation	N/A ft
Inlet Control HW Elev.	603.96 ft	Control Type	Outlet Control
Outlet Control HW Elev.	604.35 ft		

Grades

Upstream Invert	601.02 ft	Downstream Invert	600.08 ft
Length	188.88 ft	Constructed Slope	0.004977 ft/ft

Hydraulic Profile

Profile	CompositeM2PressureProfile	Depth, Downstream	1.53 ft
Slope Type	Mild	Normal Depth	N/A ft
Flow Regime	Subcritical	Critical Depth	1.53 ft
Velocity Downstream	8.06 ft/s	Critical Slope	0.008167 ft/ft

Section

Section Shape	Arch	Mannings Coefficient	0.013
Section Material	Concrete	Span	3.02 ft
Section Size	36.25 x 22.5 inch	Rise	1.87 ft
Number Sections	3		

Outlet Control Properties

Outlet Control HW Elev.	604.35 ft	Upstream Velocity Head	0.81 ft
Ke	0.20	Entrance Loss	0.16 ft

Inlet Control Properties

Inlet Control HW Elev.	603.96 ft	Flow Control	Submerged
Inlet Type	Groove end projecting (arch)	Area Full	13.3 ft²
K	0.00450	HDS 5 Chart	0
M	2.00000	HDS 5 Scale	0
C	0.03170	Equation Form	1
Y	0.69000		

Culvert Designer/Analyzer Report
Culvert 3A

Peak Discharge Method: User-Specified			
Design Discharge	21.14 cfs	Check Discharge	25.25 cfs

Grades Model: Inverts			
Invert Upstream	604.00 ft	Invert Downstream	601.91 ft
Length	166.93 ft	Slope	0.012520 ft/ft
Drop	2.09 ft		

Headwater Model: Maximum Allowable HW	
Headwater Elevation	607.00 ft

Tailwater Conditions: Constant Tailwater	
Tailwater Elevation	N/A ft

	Name	Description	Discharge	HW Elev.	Velocity
x	Trial-1	1-28.5 x 18.0 inch Arch	21.14 cfs	606.84 ft	

Culvert Designer/Analyzer Report
Culvert 3A

Design:Trial-1

Solve For: Headwater Elevation

Culvert Summary

Allowable HW Elevation	607.00 ft	Storm Event	Design
Computed Headwater Eleva	606.84 ft	Discharge	21.14 cfs
Headwater Depth/Height	1.90	Tailwater Elevation	N/A ft
Inlet Control HW Elev.	606.84 ft	Control Type	Inlet Control
Outlet Control HW Elev.	606.52 ft		

Grades

Upstream Invert	604.00 ft	Downstream Invert	601.91 ft
Length	166.93 ft	Constructed Slope	0.012520 ft/ft

Hydraulic Profile

Profile	S2	Depth, Downstream	1.18 ft
Slope Type	Steep	Normal Depth	1.18 ft
Flow Regime	Supercritical	Critical Depth	1.31 ft
Velocity Downstream	8.69 ft/s	Critical Slope	0.011016 ft/ft

Section

Section Shape	Arch	Mannings Coefficient	0.013
Section Material	Concrete	Span	2.37 ft
Section Size	28.5 x 18.0 inch	Rise	1.50 ft
Number Sections	1		

Outlet Control Properties

Outlet Control HW Elev.	606.52 ft	Upstream Velocity Head	1.01 ft
Ke	0.20	Entrance Loss	0.20 ft

Inlet Control Properties

Inlet Control HW Elev.	606.84 ft	Flow Control	Submerged
Inlet Type Groove end projecting (arch)		Area Full	2.8 ft²
K	0.00450	HDS 5 Chart	0
M	2.00000	HDS 5 Scale	0
C	0.03170	Equation Form	1
Y	0.69000		

Culvert Designer/Analyzer Report
Culvert 3B

Peak Discharge Method: User-Specified

Design Discharge	37.30 cfs	Check Discharge	44.56 cfs

Grades Model: Inverts

Invert Upstream	601.03 ft	Invert Downstream	600.00 ft
Length	189.16 ft	Slope	0.005445 ft/ft
Drop	1.03 ft		

Headwater Model: Maximum Allowable HW

Headwater Elevation	604.00 ft

Tailwater Conditions: Constant Tailwater

Tailwater Elevation	N/A ft

Name	Description	Discharge	HW Elev.	Velocity
x Trial-1	2-28.5 x 18.0 inch Arch	37.30 cfs	604.04 ft	

Culvert Designer/Analyzer Report
Culvert 3B

Design:Trial-1

Solve For: Headwater Elevation

Culvert Summary

Allowable HW Elevation	604.00 ft	Storm Event	Design
Computed Headwater Eleva	604.04 ft	Discharge	37.30 cfs
Headwater Depth/Height	2.01	Tailwater Elevation	N/A ft
Inlet Control HW Elev.	603.48 ft	Control Type	Outlet Control
Outlet Control HW Elev.	604.04 ft		

Grades

Upstream Invert	601.03 ft	Downstream Invert	600.00 ft
Length	189.16 ft	Constructed Slope	0.005445 ft/ft

Hydraulic Profile

Profile	CompositeM2PressureProfile	Depth, Downstream	1.24 ft
Slope Type	Mild	Normal Depth	N/A ft
Flow Regime	Subcritical	Critical Depth	1.24 ft
Velocity Downstream	7.37 ft/s	Critical Slope	0.009069 ft/ft

Section

Section Shape	Arch	Mannings Coefficient	0.013
Section Material	Concrete	Span	2.37 ft
Section Size	28.5 x 18.0 inch	Rise	1.50 ft
Number Sections	2		

Outlet Control Properties

Outlet Control HW Elev.	604.04 ft	Upstream Velocity Head	0.69 ft
Ke	0.20	Entrance Loss	0.14 ft

Inlet Control Properties

Inlet Control HW Elev.	603.48 ft	Flow Control	Submerged
Inlet Type	Groove end projecting (arch)	Area Full	5.6 ft²
K	0.00450	HDS 5 Chart	0
M	2.00000	HDS 5 Scale	0
C	0.03170	Equation Form	1
Y	0.69000		

Culvert Designer/Analyzer Report
Culvert 4B

Peak Discharge Method: User-Specified			
Design Discharge	14.98 cfs	Check Discharge	17.94 cfs

Grades Model: Inverts			
Invert Upstream	600.95 ft	Invert Downstream	600.00 ft
Length	189.38 ft	Slope	0.005016 ft/ft
Drop	0.95 ft		

Headwater Model: Maximum Allowable HW	
Headwater Elevation	604.00 ft

Tailwater Conditions: Constant Tailwater	
Tailwater Elevation	N/A ft

Name	Description	Discharge	HW Elev.	Velocity
x Trial-1	1-28.5 x 18.0 inch Arch	14.98 cfs	602.91 ft	

Culvert Designer/Analyzer Report
Culvert 4B

Design:Trial-1

Solve For: Headwater Elevation

Culvert Summary

Allowable HW Elevation	604.00 ft	Storm Event	Design
Computed Headwater Eleva	602.91 ft	Discharge	14.98 cfs
Headwater Depth/Height	1.31	Tailwater Elevation	N/A ft
Inlet Control HW Elev.	602.89 ft	Control Type	Outlet Control
Outlet Control HW Elev.	602.91 ft		

Grades

Upstream Invert	600.95 ft	Downstream Invert	600.00 ft
Length	189.38 ft	Constructed Slope	0.005016 ft/ft

Hydraulic Profile

Profile	M2	Depth, Downstream	1.11 ft
Slope Type	Mild	Normal Depth	N/A ft
Flow Regime	Subcritical	Critical Depth	1.11 ft
Velocity Downstream	6.47 ft/s	Critical Slope	0.006981 ft/ft

Section

Section Shape	Arch	Mannings Coefficient	0.013
Section Material	Concrete	Span	2.37 ft
Section Size	28.5 x 18.0 inch	Rise	1.50 ft
Number Sections	1		

Outlet Control Properties

Outlet Control HW Elev.	602.91 ft	Upstream Velocity Head	0.47 ft
Ke	0.20	Entrance Loss	0.09 ft

Inlet Control Properties

Inlet Control HW Elev.	602.89 ft	Flow Control	Submerged
Inlet Type	Groove end projecting (arch)	Area Full	2.8 ft²
K	0.00450	HDS 5 Chart	0
M	2.00000	HDS 5 Scale	0
C	0.03170	Equation Form	1
Y	0.69000		

Culvert Designer/Analyzer Report
Culvert 5B

Peak Discharge Method: User-Specified			
Design Discharge	14.62 cfs	Check Discharge	17.92 cfs

Grades Model: Inverts			
Invert Upstream	601.03 ft	Invert Downstream	600.08 ft
Length	189.79 ft	Slope	0.005006 ft/ft
Drop	0.95 ft		

Headwater Model: Maximum Allowable HW	
Headwater Elevation	604.00 ft

Tailwater Conditions: Constant Tailwater	
Tailwater Elevation	N/A ft

Name	Description	Discharge	HW Elev.	Velocity
x Trial-1	1-28.5 x 18.0 inch Arch	14.62 cfs	602.94 ft	

Culvert Designer/Analyzer Report
Culvert 5B

Design:Trial-1

Solve For: Headwater Elevation

Culvert Summary

Allowable HW Elevation	604.00 ft	Storm Event	Design
Computed Headwater Eleva	602.94 ft	Discharge	14.62 cfs
Headwater Depth/Height	1.27	Tailwater Elevation	N/A ft
Inlet Control HW Elev.	602.93 ft	Control Type	Outlet Control
Outlet Control HW Elev.	602.94 ft		

Grades

Upstream Invert	601.03 ft	Downstream Invert	600.08 ft
Length	189.79 ft	Constructed Slope	0.005006 ft/ft

Hydraulic Profile

Profile	M2	Depth, Downstream	1.10 ft
Slope Type	Mild	Normal Depth	N/A ft
Flow Regime	Subcritical	Critical Depth	1.10 ft
Velocity Downstream	6.39 ft/s	Critical Slope	0.006817 ft/ft

Section

Section Shape	Arch	Mannings Coefficient	0.013
Section Material	Concrete	Span	2.37 ft
Section Size	28.5 x 18.0 inch	Rise	1.50 ft
Number Sections	1		

Outlet Control Properties

Outlet Control HW Elev.	602.94 ft	Upstream Velocity Head	0.47 ft
Ke	0.20	Entrance Loss	0.09 ft

Inlet Control Properties

Inlet Control HW Elev.	602.93 ft	Flow Control	Submerged
Inlet Type	Groove end projecting (arch)	Area Full	2.8 ft²
K	0.00450	HDS 5 Chart	0
M	2.00000	HDS 5 Scale	0
C	0.03170	Equation Form	1
Y	0.69000		

Culvert Designer/Analyzer Report
Culvert 6B

Peak Discharge Method: User-Specified			
Design Discharge	19.30 cfs	Check Discharge	23.06 cfs

Grades Model: Inverts			
Invert Upstream	600.93 ft	Invert Downstream	599.61 ft
Length	191.08 ft	Slope	0.006908 ft/ft
Drop	1.32 ft		

Headwater Model: Maximum Allowable HW	
Headwater Elevation	604.00 ft

Tailwater Conditions: Constant Tailwater	
Tailwater Elevation	N/A ft

Name	Description	Discharge	HW Elev.	Velocity
x Trial-1	1-28.5 x 18.0 inch Arch	19.30 cfs	603.86 ft	

Culvert Designer/Analyzer Report
Culvert 6B

Design:Trial-1

Solve For: Headwater Elevation

Culvert Summary

Allowable HW Elevation	604.00 ft	Storm Event	Design
Computed Headwater Eleva	603.86 ft	Discharge	19.30 cfs
Headwater Depth/Height	1.95	Tailwater Elevation	N/A ft
Inlet Control HW Elev.	603.47 ft	Control Type	Outlet Control
Outlet Control HW Elev.	603.86 ft		

Grades

Upstream Invert	600.93 ft	Downstream Invert	599.61 ft
Length	191.08 ft	Constructed Slope	0.006908 ft/ft

Hydraulic Profile

Profile	CompositeM2PressureProfile	Depth, Downstream	1.26 ft
Slope Type	Mild	Normal Depth	N/A ft
Flow Regime	Subcritical	Critical Depth	1.26 ft
Velocity Downstream	7.55 ft/s	Critical Slope	0.009533 ft/ft

Section

Section Shape	Arch	Mannings Coefficient	0.013
Section Material	Concrete	Span	2.37 ft
Section Size	28.5 x 18.0 inch	Rise	1.50 ft
Number Sections	1		

Outlet Control Properties

Outlet Control HW Elev.	603.86 ft	Upstream Velocity Head	0.74 ft
Ke	0.20	Entrance Loss	0.15 ft

Inlet Control Properties

Inlet Control HW Elev.	603.47 ft	Flow Control	Submerged
Inlet Type	Groove end projecting (arch)	Area Full	2.8 ft²
K	0.00450	HDS 5 Chart	0
M	2.00000	HDS 5 Scale	0
C	0.03170	Equation Form	1
Y	0.69000		