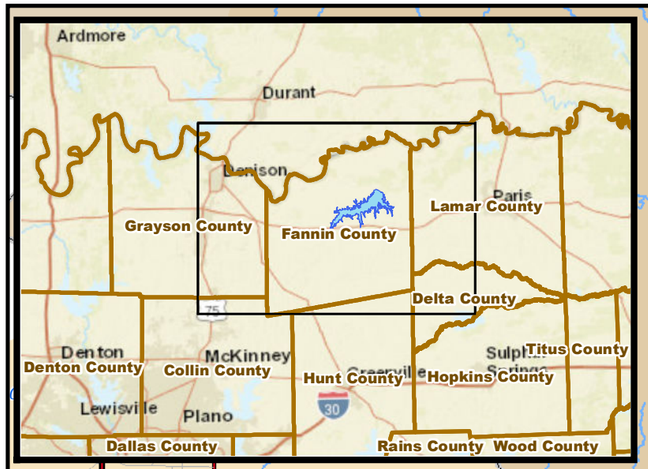
Appendix A

Figures



Lake
Boatner Lake
Bryan
Oklahoma
Choctaw
Oberlin Lake
Pat Mays Lake
Lake Fannin
Red River
Bois d' Arc Creek
Coffee Mill Lake
Lake Crockett
Lake Quail Haven
FANNIN
LAMAR
Lake Gibbons
Proposed Pump Station and Electrical Substation
Waterloo Lake
Loy Lake
Lake Bonham
Red River Basin
Bonham
Dodd City
Honey Grove
City Lake
Windom
Sulphur River Basin
Trinity River Basin
Proposed Terminal Storage Reservoir, Reservoir Outfall, Rail Spur, and Water Treatment Plant
Leonard
Wolfe City Reservoirs

91
75
82
69
78
56
121
11
160
5
34
50

0 10,000 20,000
Feet

- Creeks
- Bois d'Arc Creek
- Proclamation Boundary
- Proposed Raw Water Pipeline
- Proposed Lower Bois d'Arc Creek Reservoir
- Proposed Mitigation Sites
- Bois d'Arc Creek Watershed
- Lakes and Ponds
- Caddo National Grasslands
- Counties
- Red River Basin
- Sulphur River Basin
- Trinity River Basin
- Urban Areas

APPENDIX A

F&N JOB NO. NTD06128
DATE: Nov 2016
SCALE: 1:130,000
DESIGNED: HHM
DRAFTED: HHM
FILE: 1_GenLocation_11x17.mxd

North Texas Municipal Water District

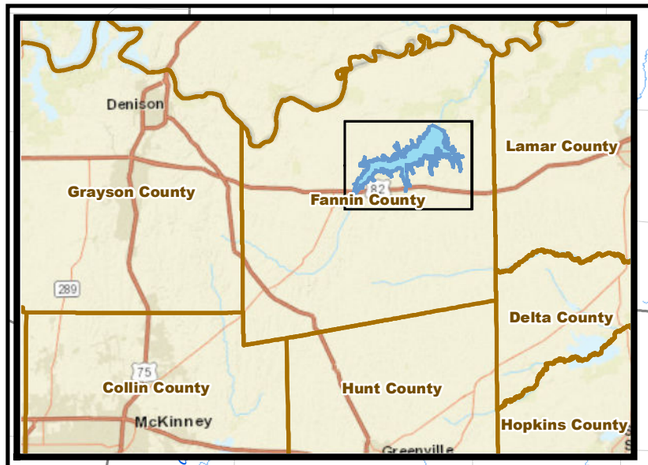
General Location Map - Proposed Reservoir Project Site and the Proposed Mitigation Sites

N
W E
S

Freese and Nichols
4055 International Plaza Suite 200
Fort Worth, Texas 76109-4895
817-735-7300

1
FIGURE

Document Path: H:\ENVIRONMENTAL\FINAL_EXHIBITS\Mitigation\Revisions\Mitigation_Plan\1_GenLocation_11x17.mxd



Briscoe Branch
FM-2029
Lake Quail Haven
Coffee Mill Lake
Spoonamore Creek
Sandy Creek
Dixon Creek
Sandy Creek
FM-100
West Oakland Branch
East Oakland
Thomas Branch
Timber Creek
Lake Bonham
Bois d'Arc Creek
Fox Creek
Yoakum Creek
Allens Creek
FM 898
Pettigrew Branch
Honey Grove Creek
Onstott Branch
Cottonwood Creek
Spring Branch
Sloans Creek
Bonham
Dodd City
Powder Creek
Win

0 1 2 3
Miles

Evergreen Forest
Upland / Deciduous Forest
Riperian Woodland / Bottomland Hardwood
Shrubland
Shrub Wetland
Grassland / Old Field
Emergent / Herbaceous Wetland
Cropland
Riverine
Lacustrine
Tree Savanna
Forested Wetland
Caddo National Grasslands
Proposed Lower Bois d'Arc Creek Reservoir
Lakes and Ponds
Streams

APPENDIX A

Document Path: H:\ENVIRONMENTAL\FINAL_EXHIBITS\Mitigation\Revisions\Mitigation_Plan\2_LBCR_ExistCoverTypes_11x17.mxd

F&N JOB NO: NTD06128
DATE: Nov 2016
SCALE: 1:65,000
DESIGNED: HHM
DRAFTED: HHM
FILE: 2_LBCR_ExistCoverTypes_11x17.mxd

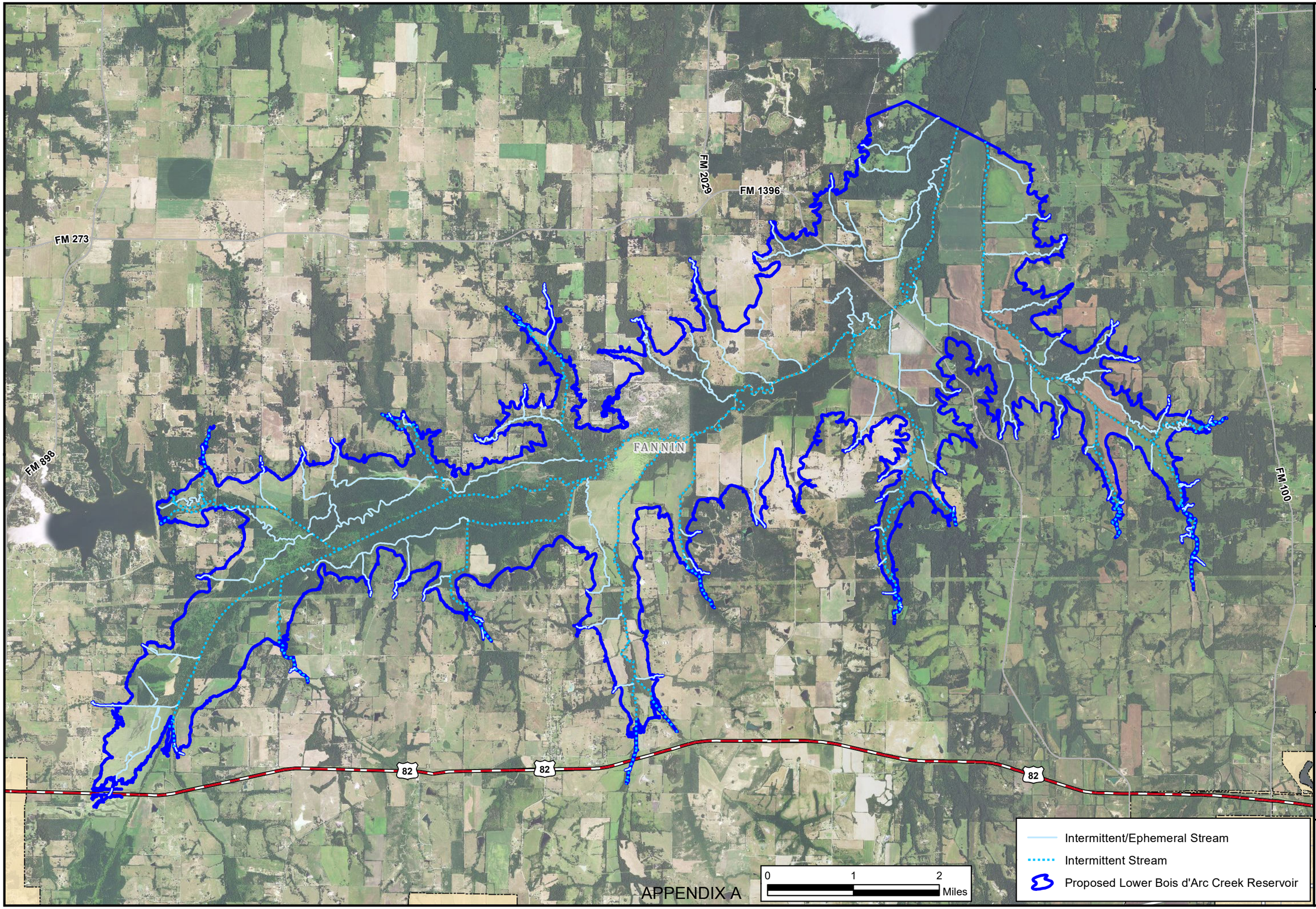
North Texas Municipal Water District

Existing Cover Types
Proposed Lower Bois d'Arc Creek Reservoir Site

N
W E
S

Freese and Nichols
4055 International Plaza Suite 200
Fort Worth, Texas 76109-4895
817-735-7300

2
FIGURE



APPENDIX A

North Texas Municipal Water District

Proposed Lower Bois d'Arc Creek Reservoir Site
LBCR Streams

F&N JOB NO: NTD06128
DATE: Nov 2016
SCALE: 1:63,360
DESIGNED: HHM
DRAFTED: HHM
FILE: 3_LBCR_Streams_11x17.mxd

N
W E
S

Freese and Nichols
4055 International Plaza, Suite 200
Fort Worth, Texas 76109-4895
817-735-7300

3
FIGURE

Document Path: H:\ENVIRONMENTAL\FINAL_EXHIBITS\Mitigation\Revisions\Mitigation_Plan\3_LBCR_Streams_11x17.mxd

INSET MAP

N

0 1,500 3,000 6,000 Feet

Bullard Creek

Cottonwood Creek

Tanbark Creek

Briscoe Branch

FM 2029

Spoonamore Creek

Sandy Creek

FM 1396

Sandy Branch

Thomas Branch

Dixon Creek

FM 898

Timber Creek

Bois d'Arc Creek

Bullard Creek

Burns Branch

FANNIN

Ward Creek

Honey Grove Creek

Yoakum Creek

Pertigrew Branch

Allens Creek

INSET MAP

82

Onstott Branch

Cottonwood Creek

Spring Branch

Burnett Creek

Pig Branch

Bonham

Powder Creek

Long Branch

Dodd City

0 1 2 Miles

APPENDIX A

Littoral Zone Wetland Areas

Proposed Lower Bois d'Arc Creek Reservoir

534' - 541' Pool Elevation

Lakes and Ponds

Caddo National Grasslands

NHD Streams

Target Streams

Intermittent/Ephemeral Stream

Intermittent Stream

F&N JOB NO: NTD06128

DATE: Nov 2016

SCALE: 1:63,360

DESIGNED: HHM

DRAFTED: HHM

FILE: 4_Lit_Zone_Tribs_11x17.mxd

North Texas Municipal Water District

Littoral Zone Wetlands and On-Site Tributary Streams
Proposed Lower Bois d'Arc Creek Reservoir Site

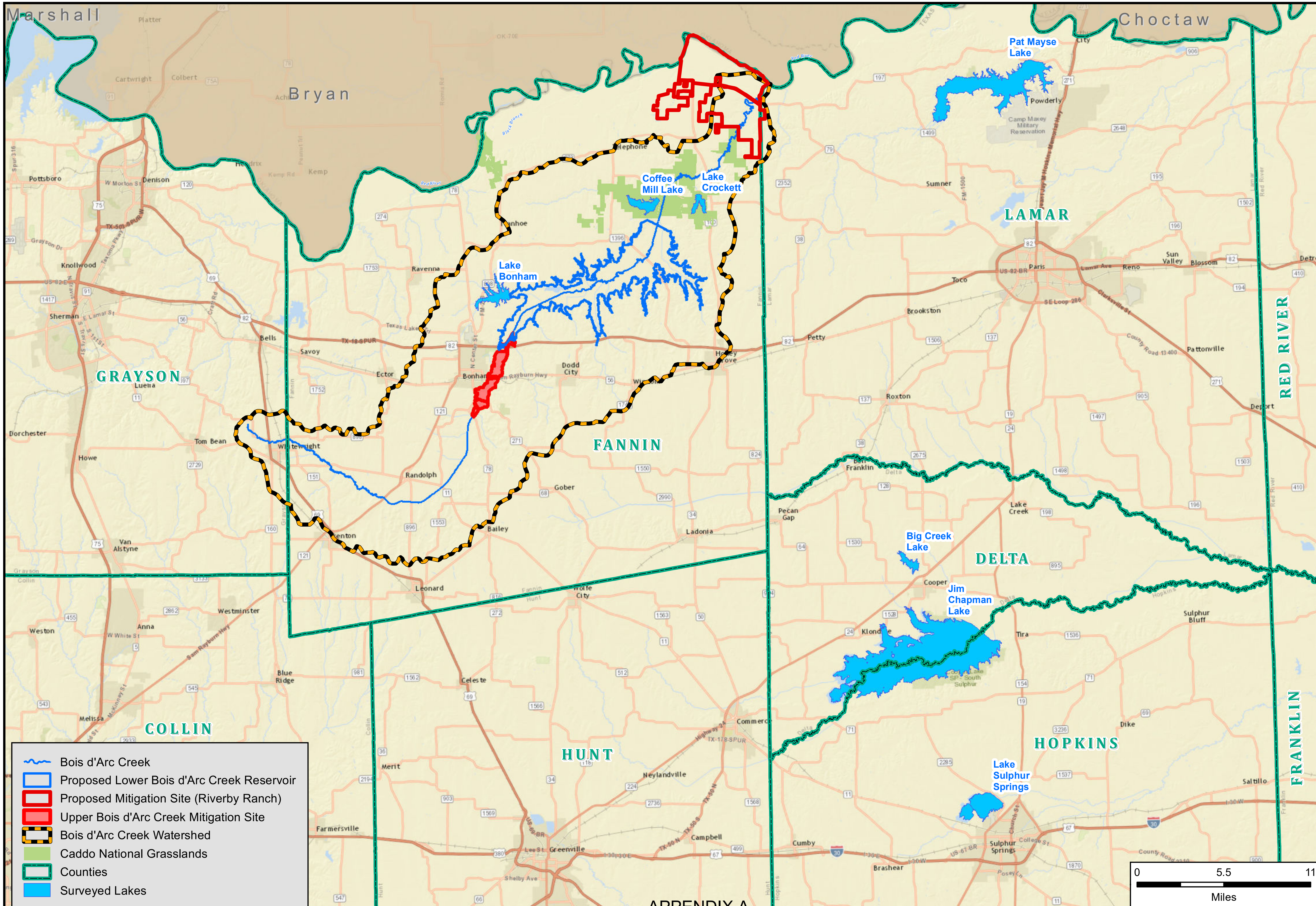
N W E S

Freese and Nichols
4055 International Plaza Suite 200
Fort Worth, Texas 76109-4895
817-735-7300

4

FIGURE

Document Path: H:\ENVIRONMENTAL\FINAL_EXHIBITS\Mitigation\Revisions\Mitigation_Plan\4_Lit_Zone_Tribs_11x17.mxd



F&N JOB NO. NTD06128
DATE: Nov 2016
SCALE: 1:130,000
DESIGNED: HHM
DRAFTED: HHM
FILE: 5_LocalReservoirs_11x17.mxd

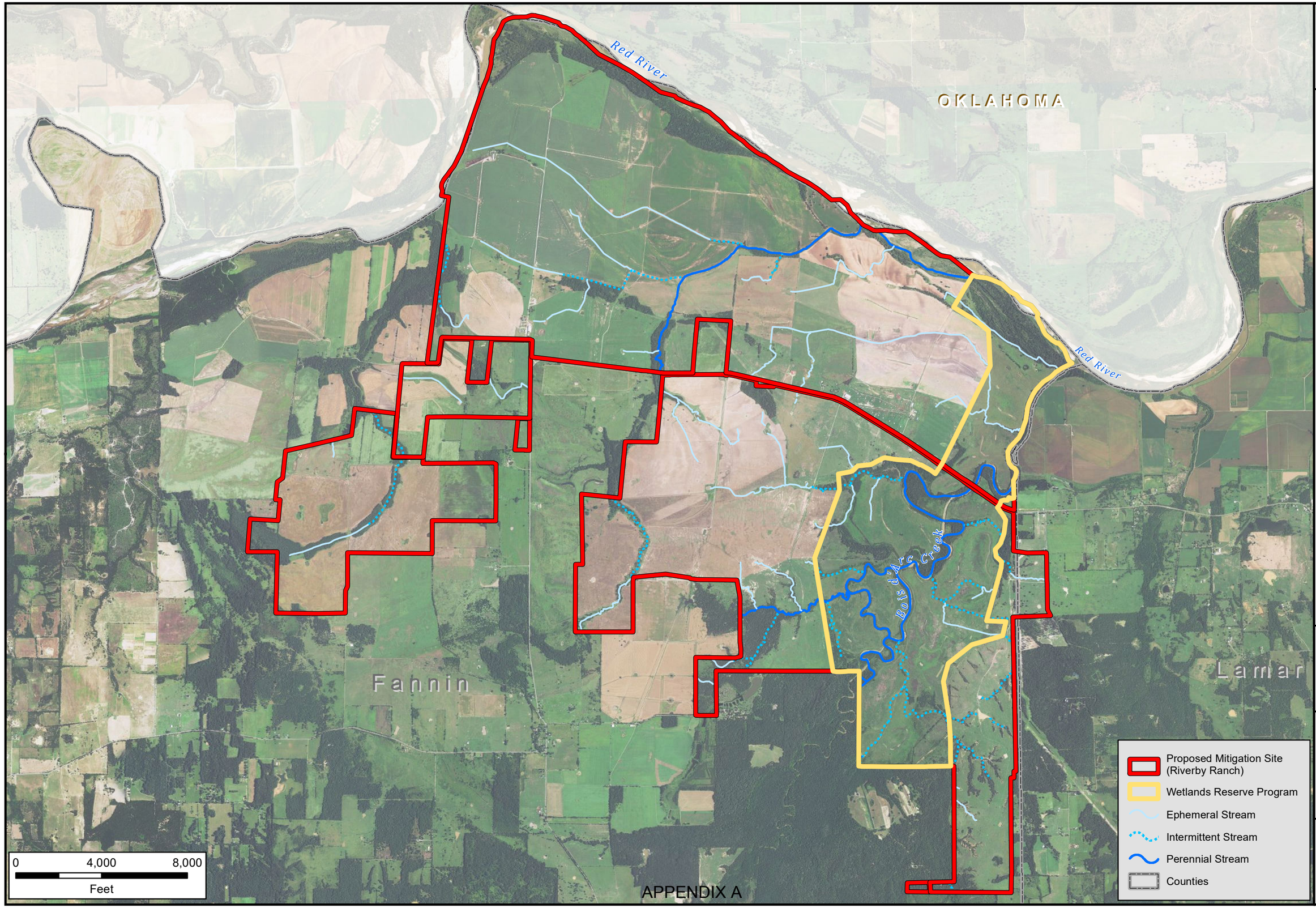
North Texas Municipal Water District

Location of Area Reservoirs Surveyed by the Texas Parks and Wildlife Department

Freese and Nichols
4055 International Plaza Suite 200
Fort Worth, Texas 76109-4895
817-735-7300

FIGURE 5

Document Path: H:\ENVIRONMENTAL\FINAL_EXHIBITS\Mitigation\Revisions\Mitigation_Plan\5_LocalReservoirs_11x17.mxd



APPENDIX A

F&N JOB NO: NTD06128
DATE: Nov 2016
SCALE: 1:48,000
DESIGNED: HHM
DRAFTED: HHM
FILE: 6_RiverbyRanchAerial_11x17.mxd

North Texas Municipal Water District

Riverby Ranch Aerial Imagery

N
W E
S

Freese and Nichols
4055 International Plaza Suite 200
Fort Worth, Texas 76109-4895
817-735-7300

6
FIGURE

Document Path: H:\ENVIRONMENTAL\FINAL_EXHIBITS\Mitigation\Revisions\Mitigation_Plan\6_RiverbyRanchAerial_11x17.mxd

Proposed Upper Bois d'Arc Creek Mitigation Site
Aerial Imagery

North Texas Municipal Water District

F&N JOB NO:	NTD06128
DATE:	Nov 2016
SCALE:	1:36,000
DESIGNED:	HHM
DRAFTED:	HHM
FILE:	7_UBDCMS_Aerial_11x17.mxd

Freese and Nichols
4055 International Plaza, Suite 200
Fort Worth, Texas 76109-4895
817-735-7300

N
W E
S

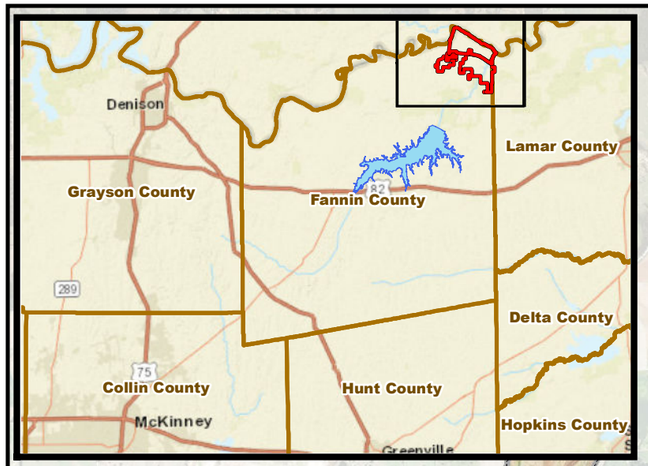
Intermittent/Ephemeral Stream
Intermittent Stream
Proposed Lower Bois d'Arc Creek Reservoir

0 3,000 6,000
Feet

APPENDIX A

7
FIGURE

Document Path: H:\ENVIRONMENTAL\FINAL_EXHIBITS\Mitigation\Revisions\Mitigation_Plan\7_UBDCMS_Aerial_11x17.mxd



Bryan

Choctaw

OKLAHOMA

Red River

Red River

FM 79

FM 197

Bois d'Arc Creek

County Road 2155

Fannin

FM 100

FM 273

FM 273

FM 2029

Lamar

FM 197

0 1 2 3 4

Miles

Proposed Mitigation Site (Riverby Ranch)

Wetlands Reserve Program

Caddo National Grasslands

Pintail Farms (WRP)

Counties

Ephemeral Stream

Intermittent Stream

Perennial Stream

N

W E

S

F&N JOB NO: NTD06128

DATE: Nov 2016

SCALE: 1:63,360

DESIGNED: HHM

DRAFTED: HHM

FILE: R:\Riverby\Vicinity_11x17.mxd

North Texas Municipal Water District

Riverby Ranch Vicinity Map

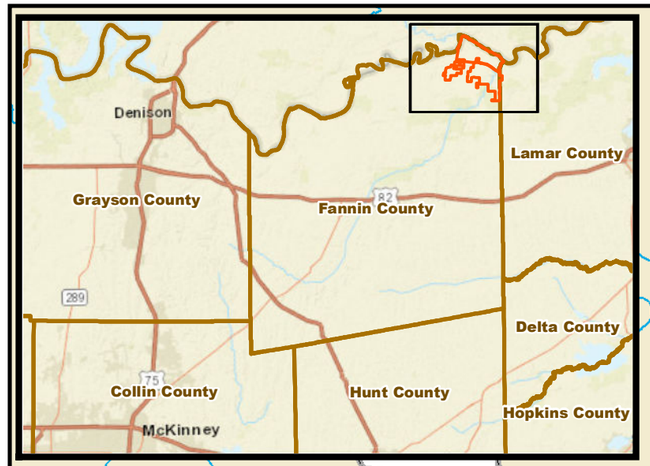
Freese and Nichols
4055 International Plaza Suite 200
Fort Worth, Texas 76109-4895
817-735-7300

8

FIGURE

APPENDIX A

Document Path: H:\ENVIRONMENTAL\FINAL_EXHIBITS\Mitigation\Revisions\Mitigation_Plan\8_RiverbyVicinity_11x17.mxd



Bryan

Choctaw

Blue River

Red River

Red River

Juret Branch

Mud Branch

Dry Creek

Whitegrass Creek

Oberlin Lake

FM 79

FM 100

FM 197

FM 273

FM 2029

Black Branch

Slough

Fannin

Bois d' Arc Creek

0 1 2
Miles

APPENDIX A

Legend

- Wetlands Reserve Program
- Proposed Mitigation Site (Riverby Ranch)
- Caddo National Grasslands
- Streams
- Pipeline Easement
- Counties

Existing Cover Types

- Shrub Wetland
- Lacustrine
- Forested Wetland
- Cropland
- Grassland/Old Field
- Herbaceous Wetland
- Riparian/Bottomland Hardwood Forest
- Upland Deciduous Forest

N
W E
S

F&N JOB NO: NTD06128
DATE: May 2011
SCALE: 1:65,000
DESIGNED: HHM
DRAFTED: HHM
FILE: G:\RiverbyCoverType_11x17.mxd

North Texas Municipal Water District

Existing Cover Types at Proposed Mitigation Site

Freese and Nichols
4055 International Plaza Suite 200
Fort Worth, Texas 76109-4895
817-735-7300

9
FIGURE

Document Path: H:\ENVIRONMENTAL\FINAL_EXHIBITS\Mitigation\Revisions\Mitigation_Plan\9_RiverbyCoverType_11x17.mxd

Soil Symbol	Soil Unit Name	Acres
15, DrA	Derly-Raino complex, 0 to 1 percent slopes	1745.95
DgA	Derly silt loam, 0 to 1 percent slopes	189.54
FhB	Freestone-Hicota complex, 0 to 2 percent slopes	5.43
IvA	Ivanhoe silt loam, 0 to 1 percent slopes	62.75
KaA	Karma loam, 0 to 2 percent slopes	2381.04
Mu	Muldrow clay loam, rarely flooded	847.76
Se	Severn silt loam, 0 to 1 percent slopes, rarely flooded	570.14
Tc	Tinn clay, 0 to 1 percent slopes, occasionally flooded	790.55
Tf	Tinn clay, 0 to 1 percent slopes, frequently flooded	76.38
WaA	Waskom silt loam, 0 to 1 percent slopes	1925.42
	Total:	**8594.96**

F&N JOB NO: NTD06128
DATE: 11/8/2016
SCALE: 1:50,000
DESIGNED: HHM
DRAFTED: HHM
FILE: 10 Riverbyranches Soils 11x17.mxd

North Texas Municipal Water District

Location of Hydric Soils at the Proposed Mitigation Site

N
W E
S

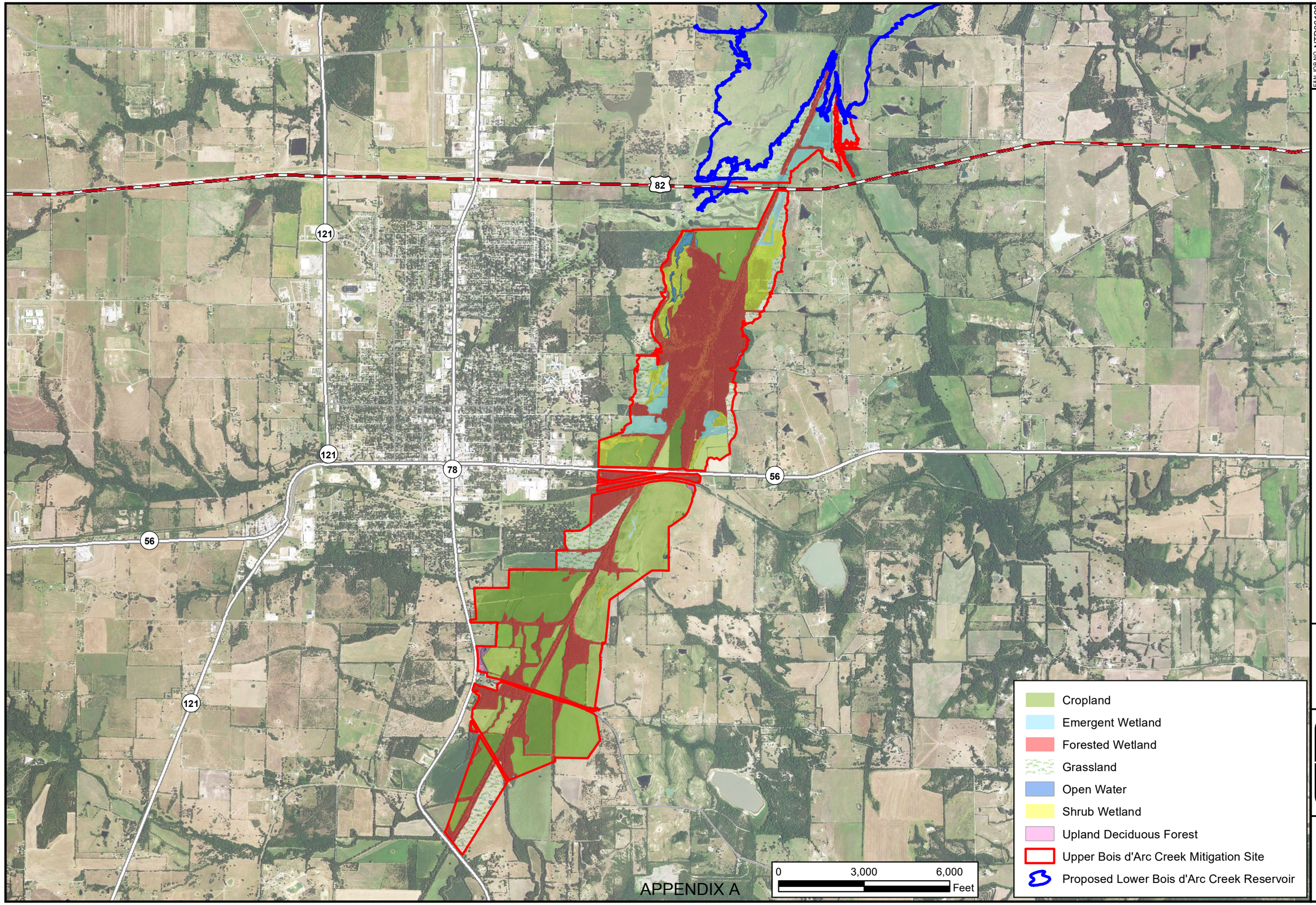
Freese and Nichols
4055 International Plaza Suite 200
Fort Worth, Texas 76109-4895
817-735-7300

10
FIGURE

Legend
- Non - Hydric Soils
- Hydric Soils
- Proposed Mitigation Site (Riverby Ranch)

0 4,000 8,000 Feet

APPENDIX A



F&N JOB NO: NTD06128
DATE: Nov 2016
SCALE: 1:36,000
DESIGNED: HHM
DRAFTED: HHM
FILE: E:\...\UBDCMS_ExistCoverTypes_11x17.mxd

North Texas Municipal Water District

Proposed Upper Bois d'Arc Creek Mitigation Site
Existing Cover Types

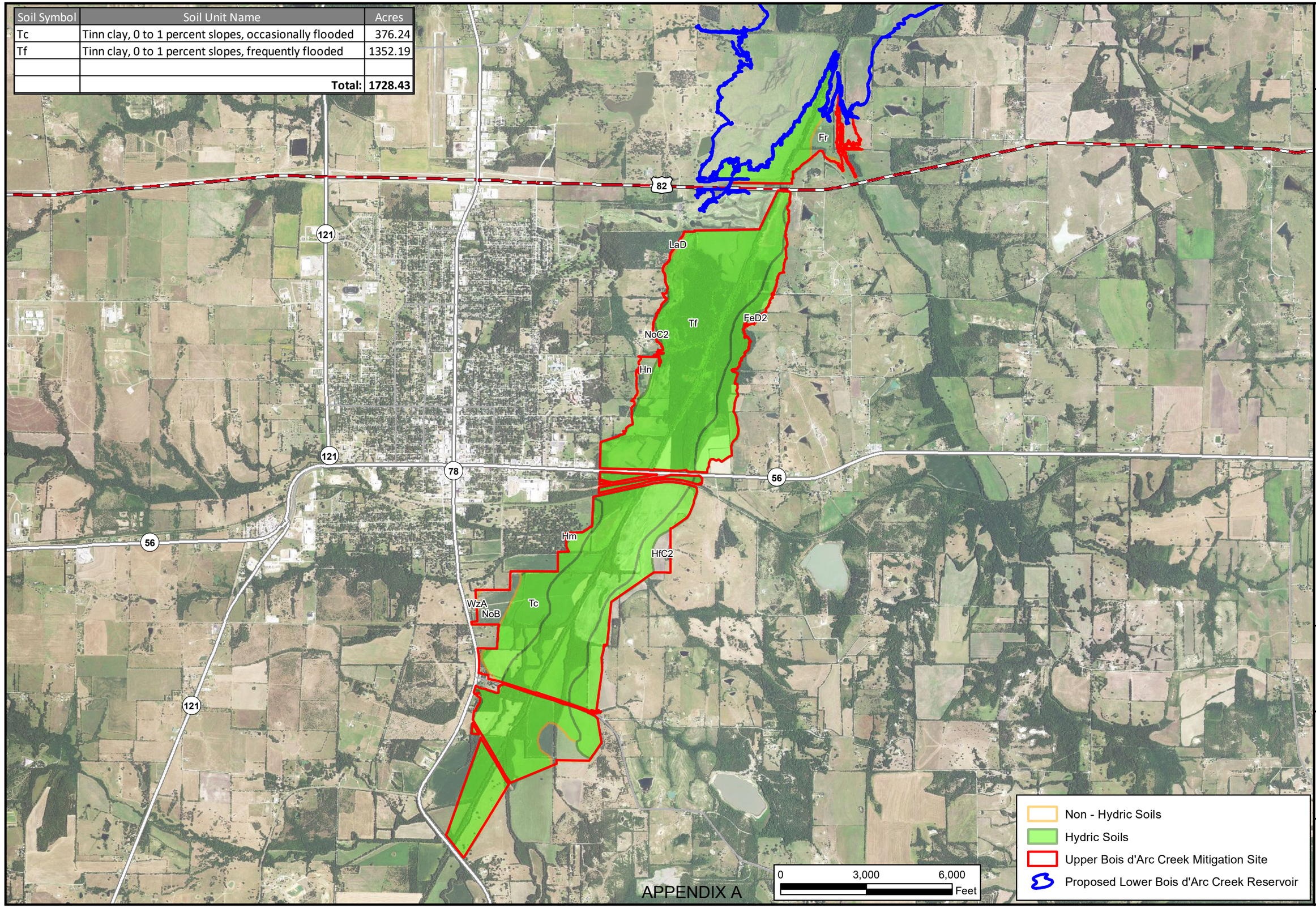
N
W E
S

Freese and Nichols
4055 International Plaza Suite 200
Fort Worth, Texas 76109-4895
817-735-7300

11
FIGURE

Document Path: H:\ENVIRONMENTAL\FINAL_EXHIBITS\Mitigation\Revisions\Mitigation_Plan\11_UBDCMS_ExistCoverTypes_11x17.mxd

Soil Symbol	Soil Unit Name	Acres
Tc	Tinn clay, 0 to 1 percent slopes, occasionally flooded	376.24
Tf	Tinn clay, 0 to 1 percent slopes, frequently flooded	1352.19
	Total:	**1728.43**



APPENDIX A

F&N JOB NO: NTD06128
DATE: Nov 2016
SCALE: 1:36,000
DESIGNED: HHM
DRAFTED: HHM
FILE: V:\...\UBDCMS_HydricSoils_11x17.mxd

North Texas Municipal Water District

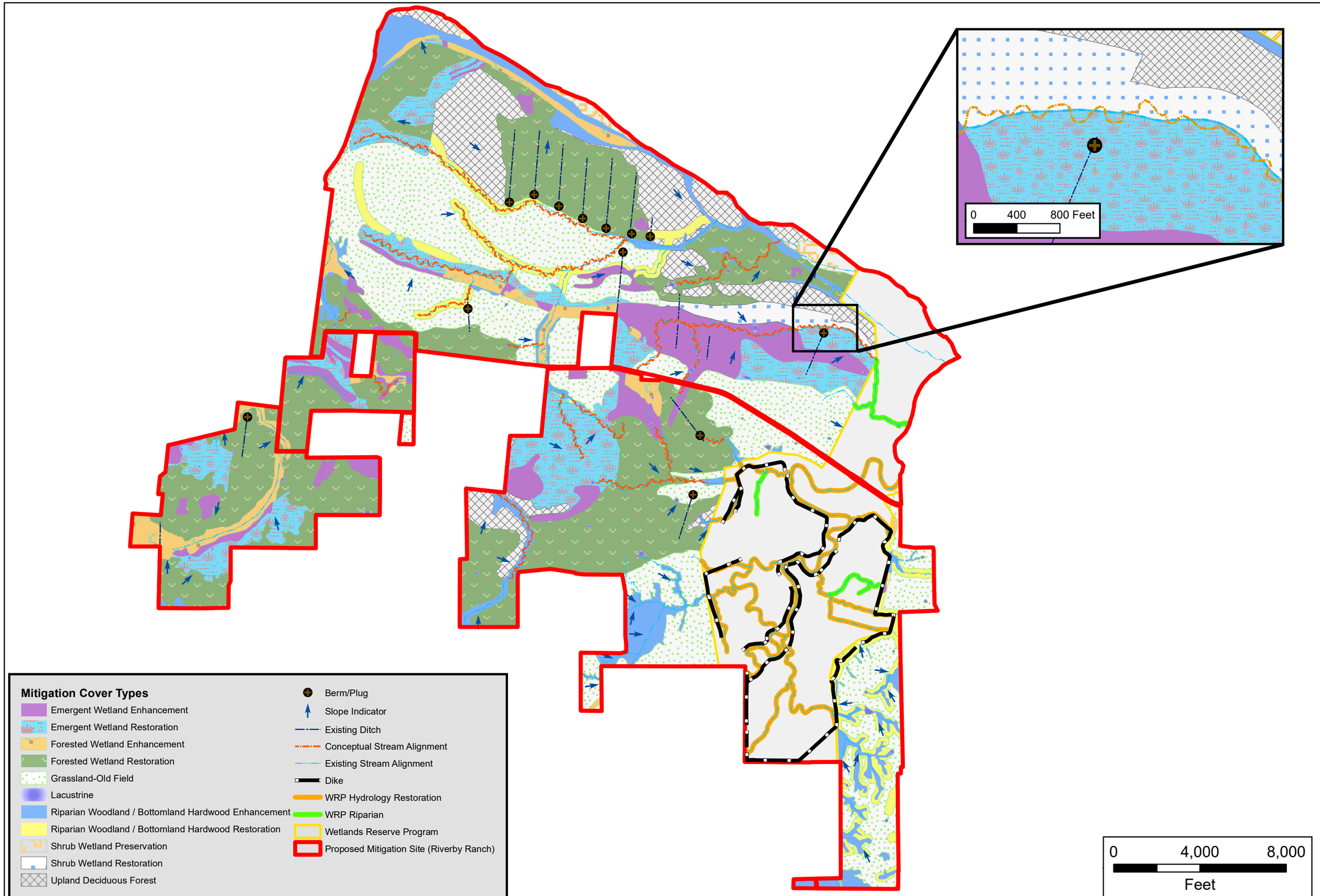
Proposed Upper Bois d'Arc Creek Mitigation Site
Hydric Soils

N
W E
S

Freese and Nichols
4055 International Plaza Suite 200
Fort Worth, Texas 76109-4895
817-735-7300

12
FIGURE

Document Path: H:\ENVIRONMENTAL\FINAL_EXHIBITS\Mitigation\Revisions\Mitigation_Plan\12_UBDCMS_HydricSoils_11x17.mxd



F&N JOB NO: NTD06128
DATE: May, 2011
SCALE: 1:48,000
DESIGNED: HHM
DRAFTED: HHM
FILE: 13_RiverbyConceptualmodel_11x17.mxd

North Texas Municipal Water District

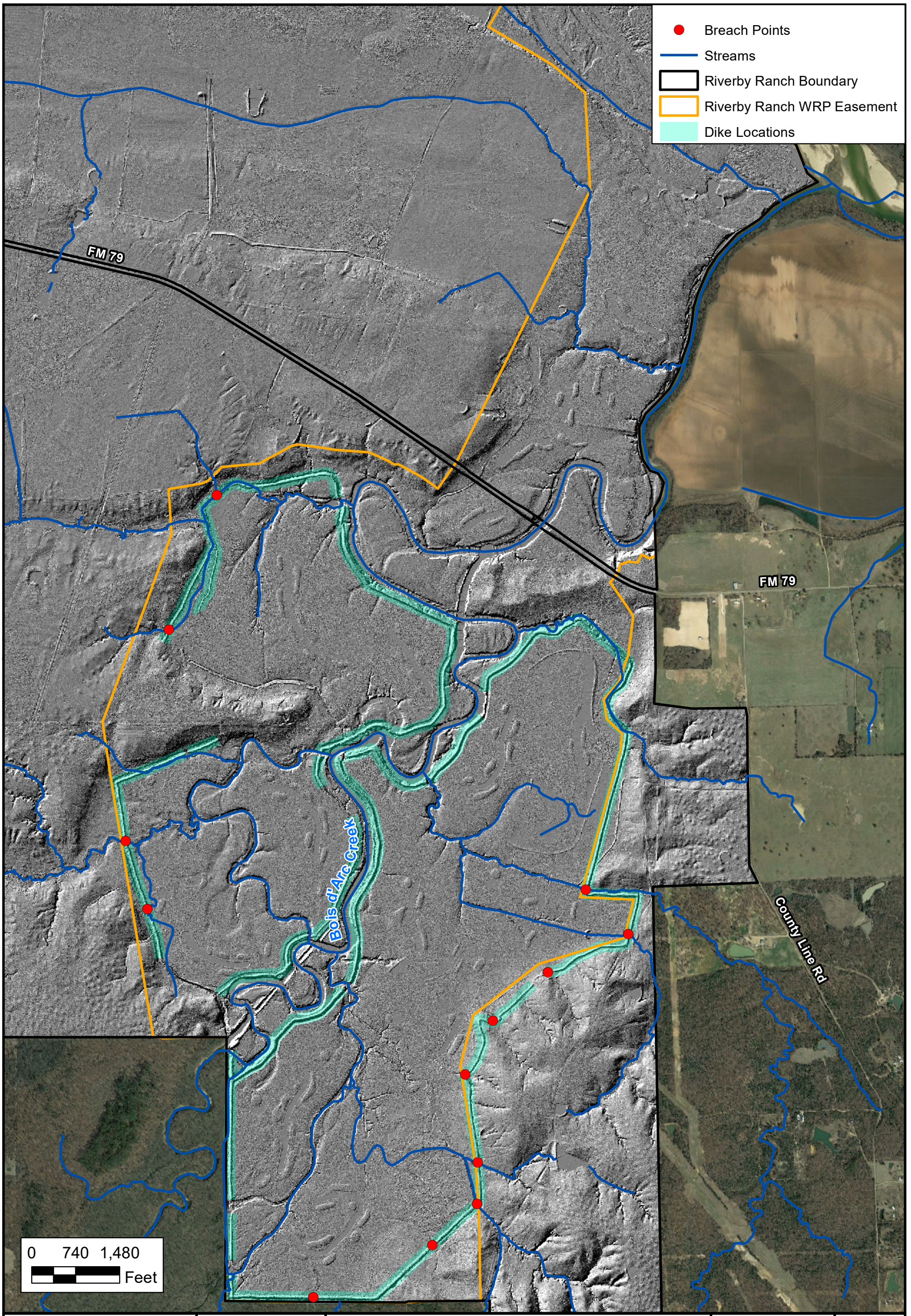
Conceptual Plan For Stream and Hydrology Restoration

N
W E
S

Freese and Nichols
4055 International Plaza Suite 200
Fort Worth, Texas 76109-4895
817-735-7300

13
FIGURE

Document Path: H:\ENVIRONMENTAL\FINAL_EXHIBITS\Mitigation\Revisions\Mitigation_Plan\13_RiverbyConceptualmodel_11x17.mxd



Freese and Nichols

4055 International Plaza Suite 200
Fort Worth, Texas 76109-4895
817-735-7300

NORTH TEXAS MUNICIPAL WATER DISTRICT
Wetlands Reserve Program Relief

Proposed Dike Breach Locations

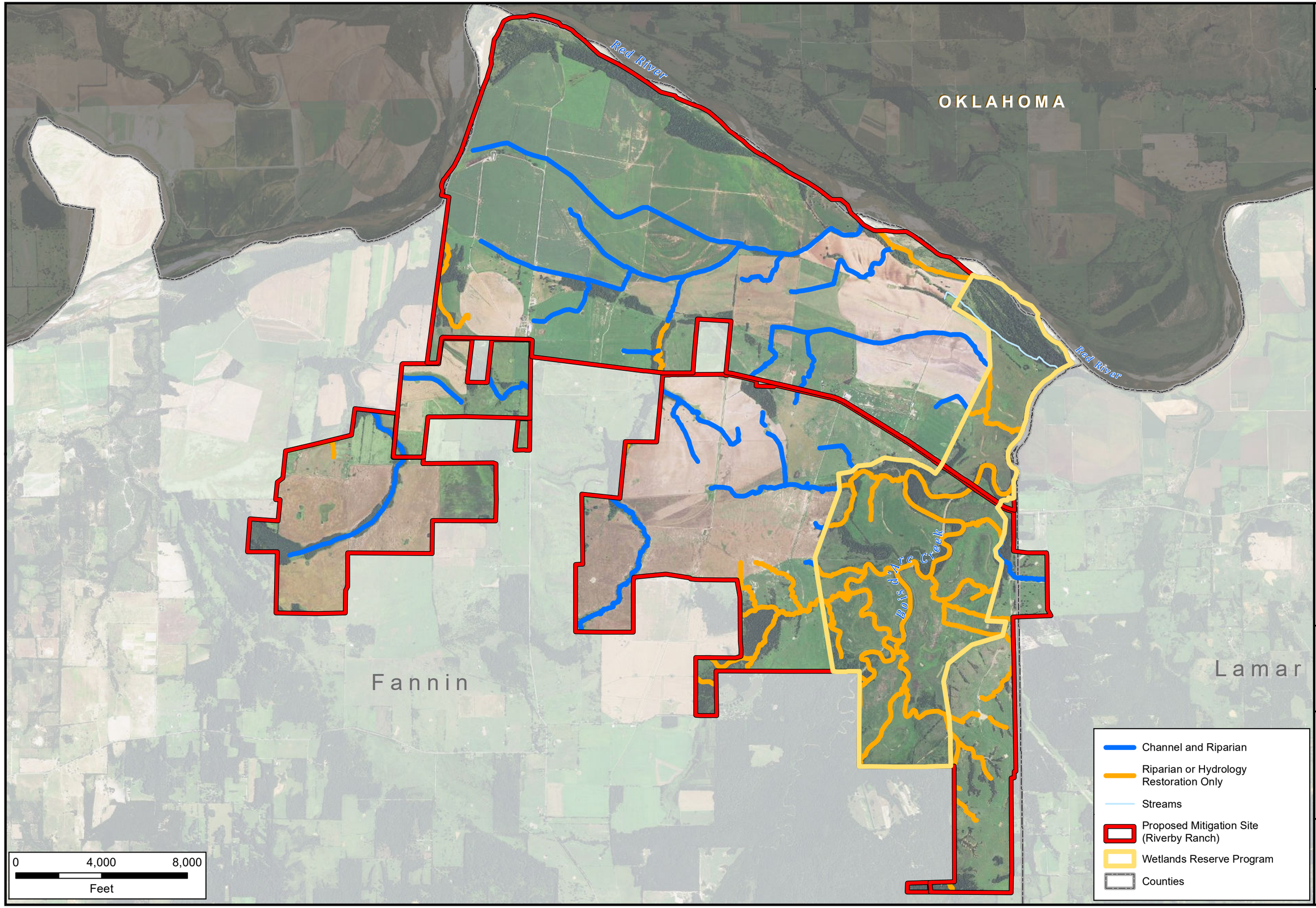
FN JOB NO	NTD06128
FILE	14_Dikes_11x17
DATE	2/9/2017
SCALE	1:24,000
DESIGNED	RH
DRAFTED	HHM

14

Figure

Document Name: H:\ENVIRONMENTAL\FINAL_EXHIBITS\Mitigation\Revisions\Mitigation_Plan\14_Dikes_11x17.mxd

Coordinate System: NAD 1983 StatePlane Texas North Central FIPS 4202 Feet



F&N JOB NO: NTD06128
DATE: Jan 2017
SCALE: 1:48,000
DESIGNED: HHM
DRAFTED: HHM
FILE: S:\...\15_RiverbyWork_Type11x17.mxd

North Texas Municipal Water District

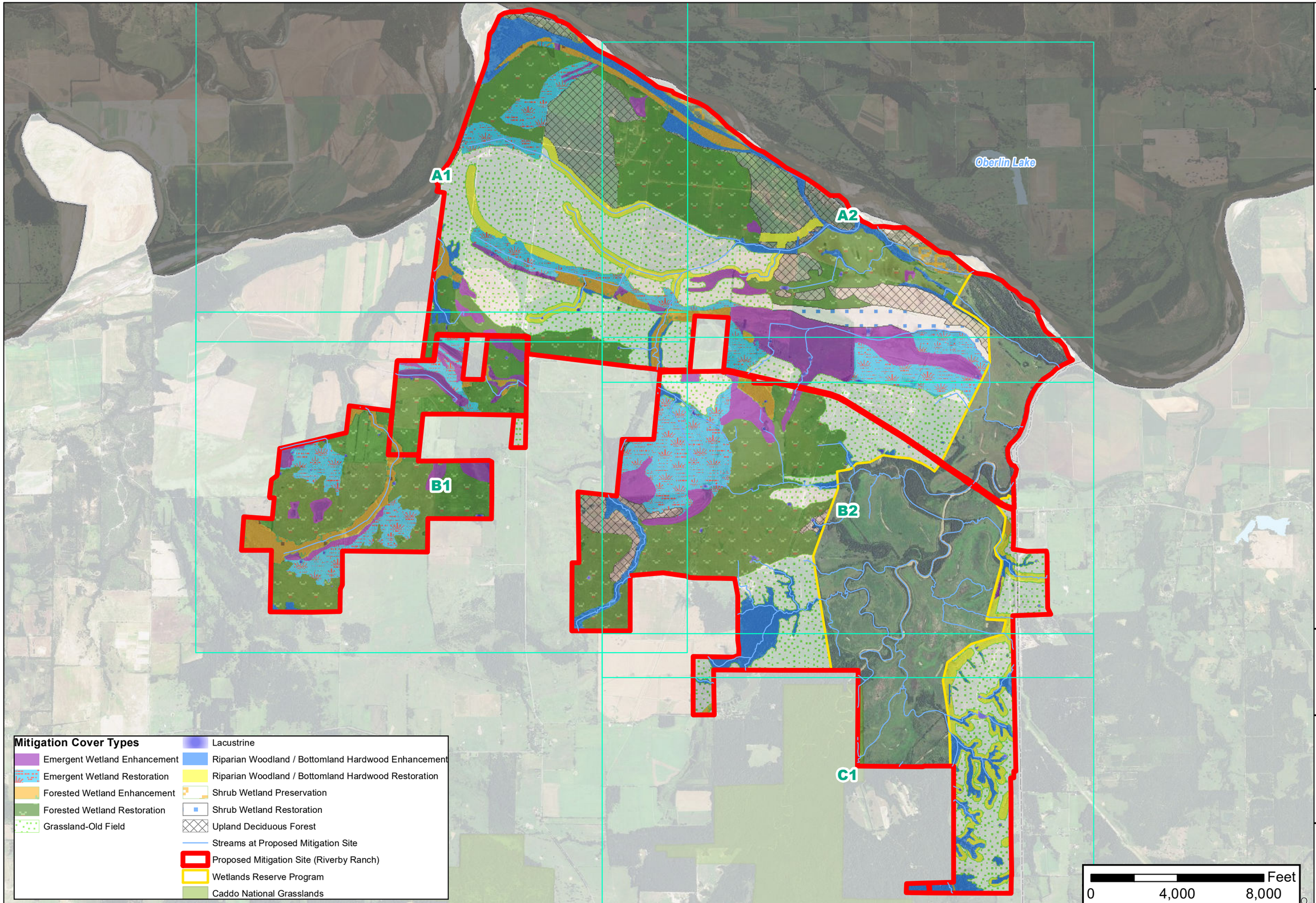
Riverby Ranch Stream Work Type

N
W E
S

Freese and Nichols
4055 International Plaza Suite 200
Fort Worth, Texas 76109-4895
817-735-7300

15
FIGURE

Document Path: H:\ENVIRONMENTAL\FINAL_EXHIBITS\Mitigation\Revisions\Mitigation_Plan\15_RiverbyWork_Type11x17.mxd



F&N JOB NO. NTD06128
DATE: Jan 2017
SCALE: 1:48,000
DESIGNED: HHM
DRAFTED: HHM
FILE: 16_RiverbyIndex_11x17.mxd

North Texas Municipal Water District

Index for Aquatic and Terrestrial Mitigation Area Maps

N
W E
S

Freese and Nichols
4055 International Plaza Suite 200
Fort Worth, Texas 76109-4895
817-735-7300

16
FIGURE

Document Path: H:\ENVIRONMENTAL\FINAL_EXHIBITS\Mitigation\Revisions\Mitigation_Plan\16_RiverbyIndex_11x17.mxd

Mitigation Cover Types

- Emergent Wetland Enhancement
- Emergent Wetland Restoration
- Forested Wetland Enhancement
- Forested Wetland Restoration
- Grassland-Old Field
- Lacustrine
- Riparian Woodland / Bottomland Hardwood Enhancement
- Riparian Woodland / Bottomland Hardwood Restoration
- Shrub Wetland Preservation
- Upland Deciduous Forest

0 1,500 3,000
Feet

F&N JOB NO. NTD06128
DATE: Jan 2017
SCALE: 1:15,000
DESIGNED: HHM
DRAFTED: HHM
FILE: 16_RiverbyProp_Mitigation_MB_11x17.mxd

North Texas Municipal Water District

Aquatic and Terrestrial Mitigation Area Maps

N
W E
S

Freese and Nichols
4055 International Plaza Suite 200
Fort Worth, Texas 76109-4895
817-735-7300

16A-1

FIGURE

Document Path: H:\ENVIRONMENTAL\FINAL_EXHIBITS\Mitigation\Revisions\Mitigation_Plan\16_RiverbyProp_Mitigation_MB_11x17.mxd

Mitigation Cover Types

- Emergent Wetland Enhancement
- Emergent Wetland Restoration
- Forested Wetland Enhancement
- Forested Wetland Restoration
- Grassland-Old Field
- Lacustrine
- Riparian Woodland / Bottomland Hardwood Enhancement
- Riparian Woodland / Bottomland Hardwood Restoration
- Shrub Wetland Preservation
- Shrub Wetland Restoration
- Upland Deciduous Forest

Oberlin Lake

0 1,500 3,000
Feet

F&N JOB NO. NTD06128
DATE: Jan 2017
SCALE: 1:15,000
DESIGNED: HHM
DRAFTED: HHM
FILE: 16_RiverbyProp_Mitigation_MB_11x17.mxd

North Texas Municipal Water District

Aquatic and Terrestrial Mitigation Area Maps

N
W E
S

Freese and Nichols
4055 International Plaza Suite 200
Fort Worth, Texas 76109-4895
817-735-7300

16A-2

FIGURE

Document Path: H:\ENVIRONMENTAL\FINAL_EXHIBITS\Mitigation\Revisions\Mitigation_Plan\16_RiverbyProp_Mitigation_MB_11x17.mxd

Mitigation Cover Types

- Emergent Wetland Enhancement
- Emergent Wetland Restoration
- Forested Wetland Enhancement
- Forested Wetland Restoration
- Grassland-Old Field
- Lacustrine
- Riparian Woodland / Bottomland Hardwood Enhancement
- Riparian Woodland / Bottomland Hardwood Restoration
- Upland Deciduous Forest

0 1,500 3,000
Feet

F&N JOB NO. NTD06128
DATE: Jan 2017
SCALE: 1:15,000
DESIGNED: HHM
DRAFTED: HHM
FILE: 16_RiverbyProp_Mitigation_MB_11x17.mxd

North Texas Municipal Water District

Aquatic and Terrestrial Mitigation Area Maps

N
W E
S

Freese and Nichols
4055 International Plaza Suite 200
Fort Worth, Texas 76109-4895
817-735-7300

16B-1

FIGURE

Document Path: H:\ENVIRONMENTAL\FINAL_EXHIBITS\Mitigation\Revisions\Mitigation_Plan\16_RiverbyProp_Mitigation_MB_11x17.mxd

Mitigation Cover Types

- Emergent Wetland Enhancement
- Emergent Wetland Restoration
- Forested Wetland Enhancement
- Forested Wetland Restoration
- Grassland-Old Field
- Lacustrine
- Riparian Woodland / Bottomland Hardwood Enhancement
- Riparian Woodland / Bottomland Hardwood Restoration
- Shrub Wetland Restoration
- Upland Deciduous Forest

0 1,500 3,000
Feet

F&N JOB NO. NTD06128
DATE: Jan 2017
SCALE: 1:15,000
DESIGNED: HHM
DRAFTED: HHM
FILE: 16_RiverbyProp_Mitigation_MB_11x17.mxd

North Texas Municipal Water District

Aquatic and Terrestrial Mitigation Area Maps

N
W E
S

Freese and Nichols
4055 International Plaza Suite 200
Fort Worth, Texas 76109-4895
817-735-7300

16B-2

FIGURE

Document Path: H:\ENVIRONMENTAL\FINAL_EXHIBITS\Mitigation\Revisions\Mitigation_Plan\16_RiverbyProp_Mitigation_MB_11x17.mxd

Mitigation Cover Types

- Forested Wetland Enhancement
- Grassland-Old Field
- Lacustrine
- Riparian Woodland / Bottomland Hardwood Enhancement
- Riparian Woodland / Bottomland Hardwood Restoration

0 1,500 3,000
Feet

F&N JOB NO. NTD06128
DATE: Jan 2017
SCALE: 1:15,000
DESIGNED: HHM
DRAFTED: HHM
FILE: 16_RiverbyProp_Mitigation_MB_11x17.mxd

North Texas Municipal Water District

Aquatic and Terrestrial Mitigation Area Maps

N
W E
S

Freese and Nichols
4055 International Plaza Suite 200
Fort Worth, Texas 76109-4895
817-735-7300

16C-1

FIGURE

Document Path: H:\ENVIRONMENTAL\FINAL_EXHIBITS\Mitigation\Revisions\Mitigation_Plan\16_RiverbyProp_Mitigation_MB_11x17.mxd

82
121
121
78
56
56
121

Forested Wetland Enhancement
Forested Wetland Restoration
Riparian
Upland Deciduous Forest
Open Water
Upper Bois d'Arc Creek Mitigation Site
Proposed Lower Bois d'Arc Creek Reservoir

0 3,000 6,000 Feet

N
W E
S

Proposed Upper Bois d'Arc Creek Mitigation Site
Proposed Cover Types

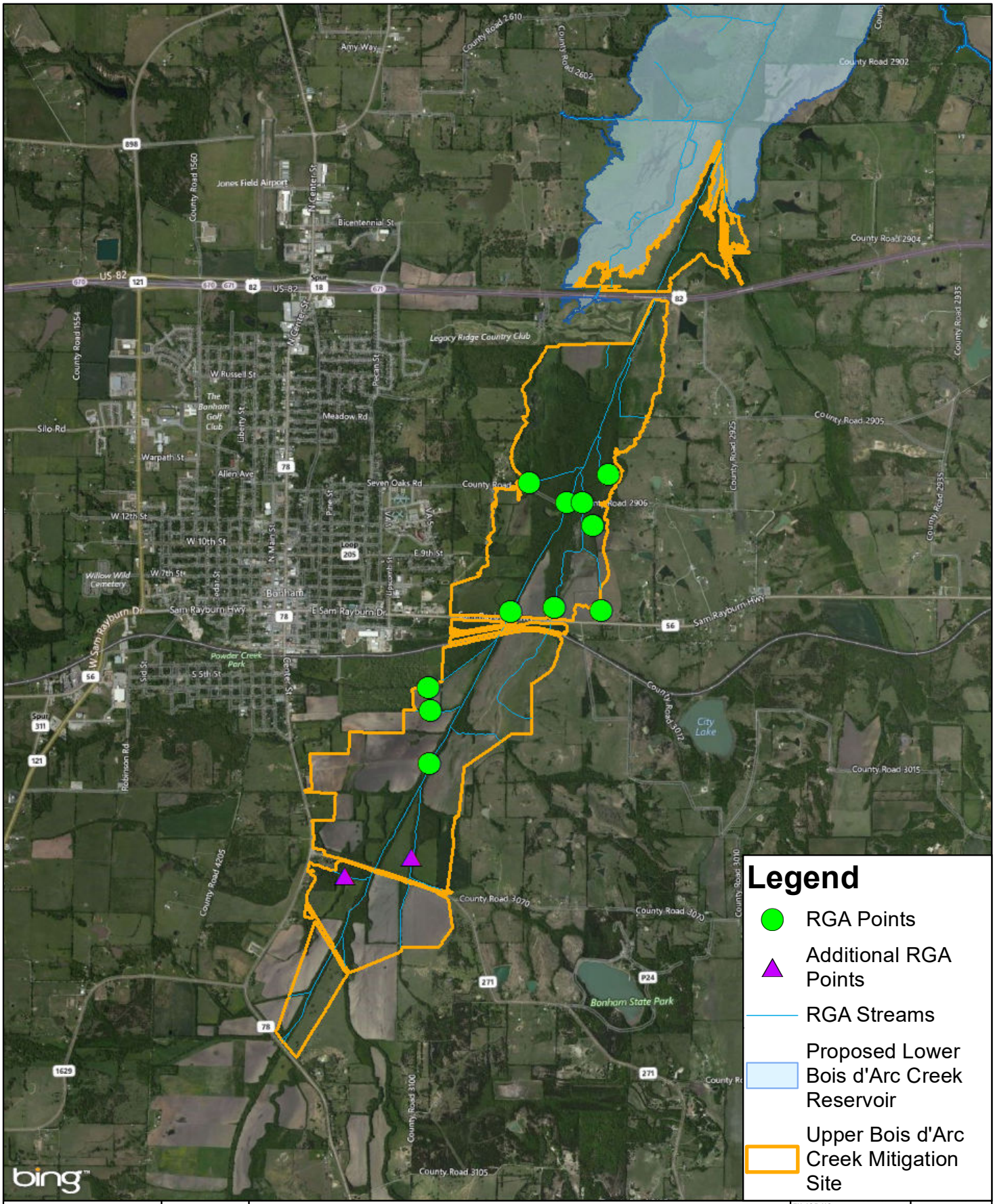
North Texas Municipal Water District

F&N JOB NO: NTD06128
DATE: Jan 2017
SCALE: 1:36,000
DESIGNED: HHM
DRAFTED: HHM
FILE: E:\ENVIRONMENTAL\FINAL_EXHIBITS\Mitigation\Revisions\Mitigation_Plan\17_UBDCMS_PropCoverTypes_11x17.mxd

Freese and Nichols
4055 International Plaza Suite 200
Fort Worth, Texas 76109-4895
817-735-7300

17
FIGURE

Document Path: H:\ENVIRONMENTAL\FINAL_EXHIBITS\Mitigation\Revisions\Mitigation_Plan\17_UBDCMS_PropCoverTypes_11x17.mxd



FREESE AND NICHOLS
Freese and Nichols, Inc.
4055 International Plaza Suite 200
Fort Worth, Texas 76109-4895
817-735-7300

NORTH TEXAS MUNICPAL WATER DISTRICT

Upper Bois d'Arc Creek Mitigation Site

Proposed RGA Monitoring Sites

0 4,000 8,000 Feet

FN JOB NO	NTD06128
FILE NAME	18_Upper_BDC_MA_RGA_8x11.mxd
DATE	1/26/2017
SCALE	1:48,000
DESIGNED	SSJ
DRAFTED	02405

18

FIGURE

Path: H:\ENVIRONMENTAL\FINAL_EXHIBITS\Mitigation\Revisions\Mitigation_Plan\18_Upper_BDC_MA_RGA_8x11.mxd

NAD 1983 StatePlane Texas North Central FIPS 4202 Feet

INSET MAP

N

0 1,500 3,000 6,000 Feet

Bullard Creek
Spring Branch
Cottonwood Creek

Tanbark Creek
Sandy Creek
Thomas Branch
Sandy Branch
Wolf Creek
Timber Creek
Bois d'Arc Creek
UT of Thomas Branch
Burns Branch
UT of Burns Branch
Bullard Creek
FANNIN
FM 2029
Spoonamore Creek
FM 1396
Dixon Creek
FM 100
UT of Bois d'Arc Creek
Ward Creek
Honey Grove Creek
Yoakum Creek
Allens Creek
Pettigrew Branch
FM 898
Onstott Branch
82
82
INSET MAP
Cottonwood Creek
Spring Branch
Pig Branch
Sloans Creek
Powder Creek
Bonham
Dodd City
1743

0 1 2 Miles

- RGA Points
- Littoral Zone Wetland Areas
- Proposed Lower Bois d'Arc Creek Reservoir
- 534' - 541' Pool Elevation
- Lakes and Ponds
- Caddo National Grasslands
- NHD Streams

Target Streams

- Intermittent/Ephemeral Stream
- Intermittent Stream

F&N JOB NO: NTD06128
DATE: Jan 2017
SCALE: 1:63,360
DESIGNED: HHM
DRAFTED: HHM
FILE: 19_OnSite_Tribs_RGA_11x17.mxd

North Texas Municipal Water District

Proposed Lower Bois d'Arc Creek Reservoir Site

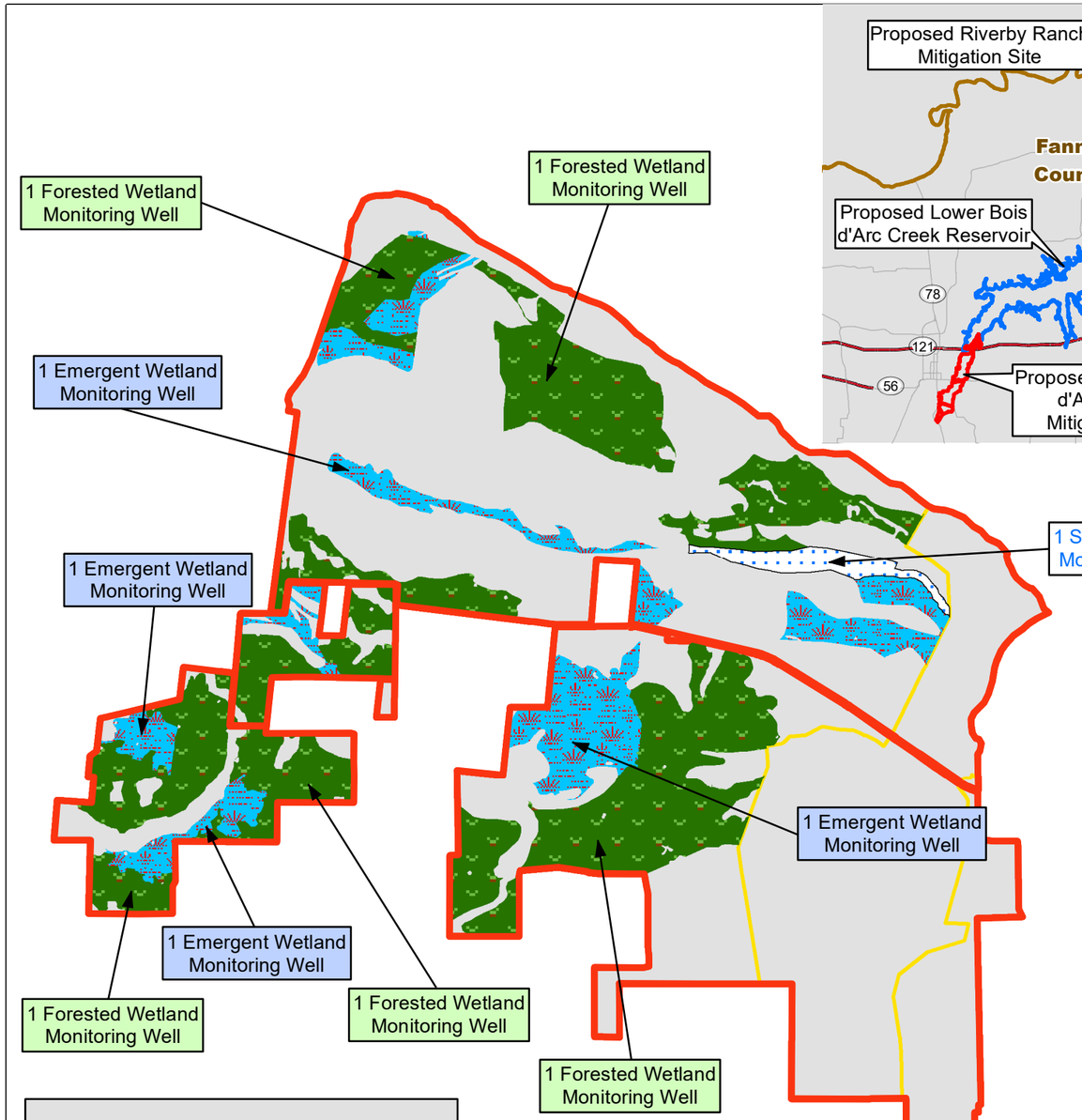
Littoral Zone Wetlands and On-Site Tributary Streams
Proposed RGA Monitoring Sites

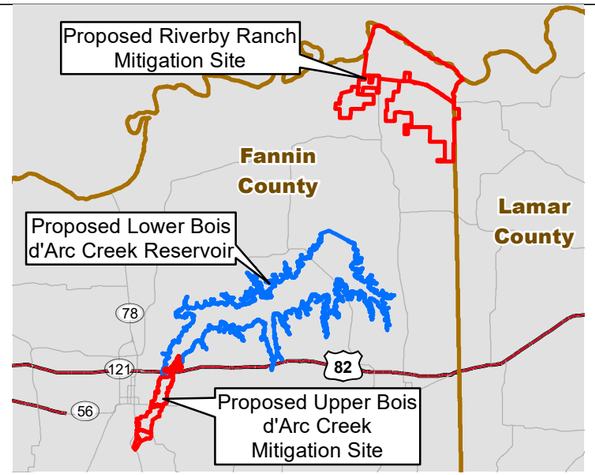
N
W E
S

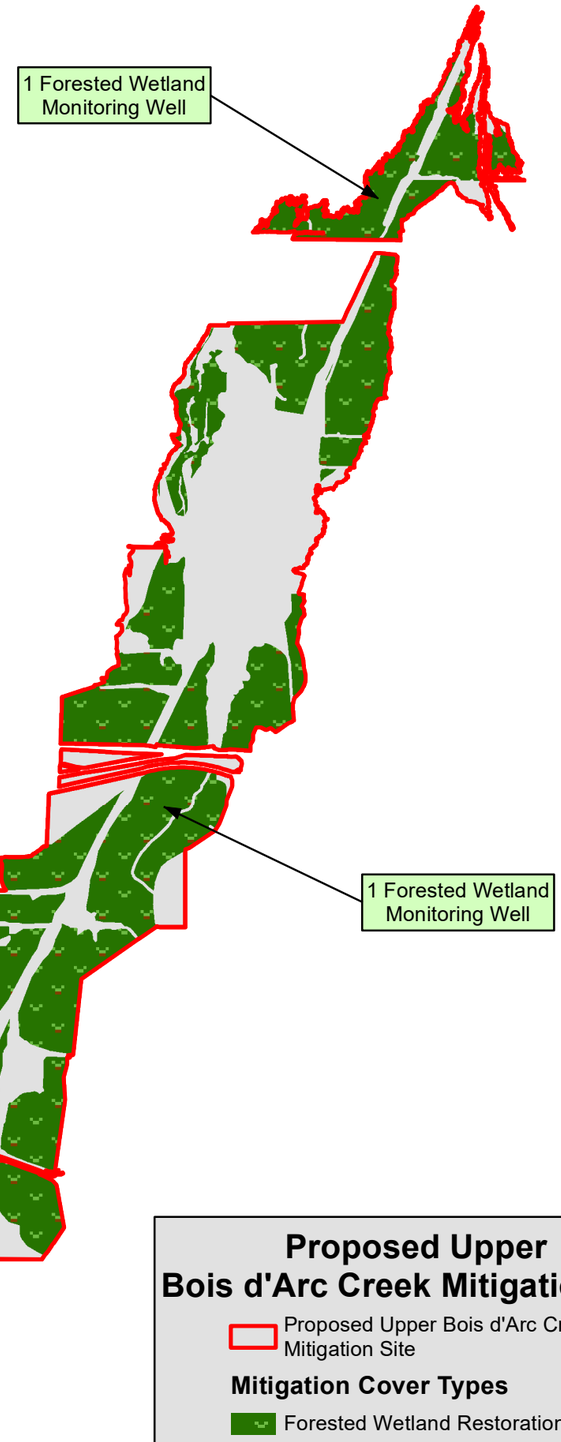
Freese and Nichols
4055 International Plaza Suite 200
Fort Worth, Texas 76109-4895
817-735-7300

19
FIGURE

Document Path: H:\ENVIRONMENTAL\FINAL_EXHIBITS\Mitigation\Revisions\Mitigation_Plan\19_OnSite_Tribs_RGA_11x17.mxd







Proposed Riverby Ranch Mitigation Site

- Proposed Riverby Ranch Mitigation Site
- Wetlands Reserve Program

Mitigation Cover Types

- Emergent Wetland Restoration
- Forested Wetland Restoration
- Shrub Wetland Restoration

0 5,500 11,000

Feet

Proposed Upper Bois d'Arc Creek Mitigation Site

- Proposed Upper Bois d'Arc Creek Mitigation Site

Mitigation Cover Types

- Forested Wetland Restoration

0 3,000 6,000

Feet

F&N JOB NO: NTD06128
DATE: May, 2011
SCALE: 1:48,000
DESIGNED: HHM
DRAFTED: HHM
FILE: P:\20 Wetland Monitoring Wells 11x17.mxd

North Texas Municipal Water District

Potential Wetland Hydrology Monitoring Wells

N W E S

Freese and Nichols
4055 International Plaza Suite 200
Fort Worth, Texas 76109-4895
817.735.7300

20
FIGURE

Document Path: H:\ENVIRONMENTAL\FINAL_EXHIBITS\Mitigation\Revisions\Mitigation_Plan\20_Wetland_Monitoring_Wells_11x17.mxd

Appendix B

Common and Scientific Names (Existing)

Organisms Identified within Mitigation Plan

Common Name	Scientific Name
Birds	
American crow	*Corvus brachyrhynchos*
Barred owl	*Strix varia*
Canada goose	*Branta canadensis*
Carolina chickadee	*Poecile carolinensis*
Carolina wren	*Thryothorus ludovicianus*
Common yellowthroat	*Geothylpis trichas*
Ducks	Family: *Anatidae*
Great blue heron	*Ardea Herodias*
Great egret	*Ardea alba*
Indigo bunting	*Passerina cyanea*
Northern cardinal	*Cardinalis*
Northern harrier	*Circus cyaneus*
Painted bunting	*Passerina ciris*
Red-tailed hawk	*Buteo jamaicensis*
Solitary warbler	Family: *Parulidae*
Tufted titmouse	*Baeolophus bicolor*
White-eyed vireo	*Vireo griseus*
White-fronted goose (greater)	*Anser albifrons*
Forbs	
American lotus	*Nelumbo lutea*
Arrowhead	*Sagittaria* spp.
Balloon vine	*Cardiospermum halicacabum*
Black-eyed susan	*Rudbeckia hirta*
Buttercup	*Ranunculus* spp.
Clasping coneflower	*Dracopis amplexicaulis*
Dock	*Rumex* spp.
Drummond phlox	*Phlox drummondii*
Eared redstem	*Ammannia auriculata*
Evening primrose (pink)	*Oenothera speciosa*
Frogfruit	*Phyla* spp.
Goldenrod	*Solidago* spp.
Illinois bundleflower	*Desmanthus illinoensis*
Indian blanket	*Gaillardia pulchella*
Ironweed	*Vernonia* spp.
Lazy daisy	*Aphanostephus* sp.
Lemon mint	*Monarda citriodora*
Mockbishop weed	*Ptilimnium nuttallii*
Partridge pea	*Chamaecrista fasciculata*
Pennsylvania smartweed	*Polygonum pensylvanicum*
Plains coreopsis	*Coreopsis tinctoria*
Ragweed	*Ambrosia* spp.
Redstems	*Ammannia* spp.

Common Name	Scientific Name
Roundleaf groundsel	*Packera obouta*
Smartweeds	*Polygonum* spp.
Sumpweed	*Iva annua*
Water primrose	*Ludwigia* spp.
Wild pea	*Lathyrus* spp.
Grasses	
Barnyardgrass	*Echinochloa crus-galli*
Broomsedge bluestem	*Andropogon virginicus*
Bushy bluestem	*Andropogon glomeratus*
Crowngrass	*Paspalum* sp.
Eastern gamagrass	*Tripsacum dactyloides*
Indiangrass	*Sorghastrum nutans*
Little bluestem	*Schizachyrium scoparium*
Prairie wildrye	*Elymus canadensis*
Purpletop	*Tridens flavus*
Sand dropseed	*Sporobolus cryptandrus*
Sand lovegrass	*Eragrostis trichodes*
Sideoats grama	*Bouteloua curtipendula*
Switchgrass	*Panicum virgatum*
Virginia wildrye	*Elymus virginicus*
Insects	
Butterflies	Order: *Lepidoptera*
Mosquitoes	Family: *Culicidae*
Bees	Order: *Hymenoptera*
Dragonflies	Order: *Odonata*
Mammals	
Raccoon	*Procyon lotor*
American Beaver	*Castor canadensis*
River otter	*Lutra canadensis*
Feral hog	*Sus scrofa*
White-tailed deer	*Odocoileus virginianus*
Reptiles	
Ornate box turtle	*Terrapene ornata*
Cottonmouth water moccasin	*Agkistrodon piscivorus*
Copperhead	*Agkistrodon contortrix*
Amphibians	
Frogs	Order: *Anura*
Southern Leopard frog	*Rana sphenocephala*
Rushes and Sedges	
Blue sedge	*Carex glaucodea*
Cherokee sedge	*Carex cherokeensis*
Flatsedge	*Cyperus* spp.
Flatstem spikerush	*Eleocharis compressa*

Common Name	Scientific Name
Grassleaf rush	*Juncus marginatus*
Green flatsedge	*Cyperus virens*
Horned beakrush	*Rhynchospora corniculata*
Slimpod rush	*Juncus diffusissimus*
Spikerush	*Eleocharis* spp.
Shrubs and Vines	
American beautyberry	*Callicarpa americana*
Baccharis	*Baccharis* spp.
Buttonbush	*Cephalanthus occidentalis*
Coralberry	*Symphoricarpos orbiculatus*
Deciduous holly	*Ilex decidua*
Hydrolea	*Hydrolea ovata*
Poison ivy	*Toxicodendron radicans*
Salt cedar	*Tamarix chinensis*
Sandbar willow	*Salix exigua*
Swamp privet	*Forestiera acuminata*
Virginia creeper	*Parthenocissus quinquefolia*
Trees	
American sycamore	*Platanus occidentalis*
Black cherry	*Prunus serotina*
Black hickory	*Carya texana*
Black oak	*Quercus velutina*
Black walnut	*Juglans nigra*
Black willow	*Salix nigra*
Bois d'Arc	*Maclura pomifera*
Box elder	*Acer negundo*
Bur oak	*Quercus macrocarpa*
Cedar elm	*Ulmus crassifolia*
Cherrybark oak	*Quercus pagoda*
Chinkapin oak	*Quercus muehlenbergii*
Dogwood	*Cornus spp.*
Eastern cottonwood	*Populus deltoides*
Eastern redbud	*Cercis canadensis*
Eastern red cedar	*Juniperus virginiana*
Elm	*Ulmus* spp.
Green ash	*Fraxinus pennsylvanica*
Hackberry	*Celtis occidentalis*
Hawthorn	*Crataegus spp.*
Hickory	*Carya spp.*
Honey locust	*Gleditsia triacanthos*
Overcup oak	*Quercus lyrata*
Pecan	*Carya illinoinensis*
Post oak	*Quercus stellata*
Persimmon	*Diospyros spp.*
Red maple	*Acer rubrum*

Common Name	Scientific Name
Red mulberry	*Morus rubra*
Shumard oak	*Quercus shumardii*
Soapberry	*Sapindus spp.*
Southern red oak	*Quercus falcata*
Sugarberry	*Celtis laevigata*
Water oak	*Quercus nigra*
White oak	*Quercus alba*
Willow oak	*Quercus phellos*
Other	
Crayfish	Family: *Cambaridae*
Mussels	Family: *Unionidae*
Mosquitofish	*Gambusia affinis*
Land snails	Class: *Gastropoda*

Appendix C

Habitat Evaluation Procedures

Estimation of Future Wetland Habitat Unit Production at Riverby Ranch

The purpose of this memo is to describe the methods used to estimate the Habitat Units (HU) values at the near-site mitigation property Riverby Ranch. Baseline and future HU values were estimated for three wetland cover type categories. *Existing Emergent Wetlands* refer to the acreage of land at Riverby Ranch designated as these cover types in the July 2009 field evaluations. *Restored Shrub Wetlands* and *Restored Emergent Wetlands* are those acreages expected to be converted from existing *Cropland* or *Grassland* acreage.

Baseline (year 0) HU values for *Existing Emergent Wetlands* were calculated using Habitat Evaluation Procedures (HEP) analysis of habitat variables measured in the field in September and October 2010. No baseline (year 0) HU calculations for Existing Shrub Wetlands was performed, as discussed in the Mitigation Plan. Baseline HU values for *Restored Shrub Wetlands* and *Restored Emergent Wetlands* and expected future HU values for all cover type categories were calculated from predicted values for each habitat variable used in the HEP analysis.

The following sections describe the planned enhancement and/or restoration actions that were predicted to affect a change in future habitat variable values. Other mitigation efforts may be proposed in the Mitigation Plan, but are not included in the following discussion.

Restored Shrub Wetlands

The Mitigation Plan proposes to construct 150 acres of *Restored Shrub Wetlands* from existing *Cropland* and *Grassland* areas of Riverby Ranch. The baseline HSI value for this cover type category was calculated from the predicted values of *Shrub Wetland* habitat variables if measured in a *Cropland* or *Grassland* area, resulting in a Year 0 value of 0 HUs. The Mitigation Plan proposes the following preservation, enhancement, and restoration efforts at these sites:

- Establishment of a deed restriction
- Cessation of land clearing
- Cattle removal/control of herbivores
- Invasive species removal/control
- Restoration of vegetation, particularly the planting of native shrub wetland species
- Restoration of wetland hydrology

These efforts, along with a 5-year time period of vegetative growth, were predicted to result in positive changes to habitat variables for this cover type. These changes, described in the table below, would produce an expected gain of 103.5 HUs.

Habitat Variable Affected	Predicted Values	
	Year 0	Year 5
Distance to water (mi.) *(Raccoon)*	0	0.1
Water regime: A) Permanent water; B) Semi-permanent water; C) None or ephemeral flooding *(Raccoon and Green Heron)*	0	B
Water regime: 1) Permanent; 2) Intermittently exposed; 3) Semi-permanent; 4) Seasonally flooded; 5) None or ephemeral *(Swamp Rabbit)*	0	4
Water current: A) Still or slow; B) Moderately slow; C) Moderately fast; D) Fast *(Green Heron)*	A	A
Number per acre of refuge sites *(Raccoon)*	0	1
Percent water area <10" deep *(Green Heron)*	0	100
Percent emergent herbaceous cover in littoral zone *(Green Heron)*	0	50
Percent water area covered by logs, trees limbs, shrub cover or herbaceous vegetation in summer *(Wood duck)*	0	50
Percent water surface covered by logs, tree or shrub overhangs, etc. in winter *(Wood duck)*	0	50
Aquatic substrate composition: A) Muddy; B) Sandy; C) Rocky *(Green Heron)*	A	A
Number per acre of potential nest cavities *(Wood Duck)*	0	1
Percent shrub crown closure *(Swamp Rabbit)*	0	50
Percent herbaceous canopy cover *(Swamp Rabbit)*	0	75

Existing Emergent Wetlands

Riverby Ranch contains 1,377 acres of *Existing Emergent Wetlands*. The baseline HSI value of this covertype was calculated from field data to be 0.23, which equates to 316.7 HUs. The Mitigation Plan proposes the following preservation and enhancement efforts at the site:

- Establishment of a deed restriction
- Cattle removal/control of herbivores
- Invasive species removal/control

These efforts along with a 5-year time period of vegetative regeneration are predicted to result in positive changes to the habitat variables for this cover type. These changes, described in the table below, would produce a expected gain of 275.4 HUs in 5 years.

Habitat Variable Affected	Predicted Change in Value (Year 5)
Percent cover of emergent herbaceous in littoral zone *(Green heron)*	Increase from 0% to 80%
Percent of water area covered by logs, trees limbs, shrub cover or herbaceous vegetation in summer (live or dead & overhanging within 1 m of surface) (*Green heron)*	Increase from 0% to 30%
Percent of water surface covered by logs, tree or shrub overhangs, etc. in winter (persistent) (*Wood duck)*	Increase from 0% to 10%

Restored Emergent Wetlands

The Mitigation Plan proposes to construct 1,100 acres of *Restored Emergent Wetlands* from existing *Cropland* and *Grassland* areas of Riverby Ranch. The baseline HSI value for this cover type category was calculated from the predicted values of *Emergent Wetland* habitat variables if measured in a *Cropland* or *Grassland* area, resulting in a Year 0 value of 0 HUs. The Mitigation Plan proposes the following preservation, enhancement, and restoration efforts at these sites:

- Establishment of a deed restriction
- Cattle removal/control of herbivores
- Invasive species removal/control
- Restoration of wetland hydrology
- Restoration of vegetation

Over the 5-year period, the above actions are expected to result in positive changes to the habitat variables for this cover type. These changes, described in the table below, would produce an expected gain of 440 HUs.

Habitat Variable Affected	Predicted Change in Value (Year 5)
Distance to water (*Raccoon)*	Decrease from ~500 yd. to 0 yd.
Water regime category (Permanent, Semi-permanent, or None/Ephemeral) (*Raccoon, Green heron)*	Change from "None/Ephemeral" to "Permanent"
Percent of water area less than 10 in. deep in average summer conditions (*Green heron)*	Increase from 0% to 50%
Percent cover of emergent herbaceous in littoral zone *(Green heron)*	Increase from 0% to 80%
Percent of water area covered by logs, trees limbs, shrub cover or herbaceous vegetation in summer (live or dead & overhanging within 1 m of surface) (*Green heron)*	Increase from 0% to 30%

Percent of water surface covered by logs, tree or shrub overhangs, etc. in winter (persistent) (*Wood duck)*	Increase from 0% to 10%

Appendix D

Hydrogeomorphic Method (HGM) for Forested Wetlands

Technical Memorandum on Functional Assessment of Forested Wetlands at the Lower Bois d'Arc Creek Reservoir Site using the Modified East Texas HGM

MEMORANDUM

FREESE AND NICHOLS

Innovative approaches
Practical results
Outstanding service

4055 International Plaza, Suite 200 • Fort Worth, Texas 76109 • 817-735-7300 • fax 817-735-7492 www.freese.com

TO: Robert McCarthy, North Texas Municipal Water District

CC: Simone Kiel, P.E., Steve Watters, PWS

FROM: Michael Votaw, PWS, CWB

SUBJECT: Functional Assessment of Forested Wetlands at the Lower Bois d'Arc Creek Reservoir Site using the Modified East Texas HGM

DATE: 6/22/2016

PROJECT: NTD06128 - Lower Bois d'Arc Creek Reservoir

INTRODUCTION

At the request of the Tulsa District U.S. Army Corps of Engineers (USACE), the North Texas Municipal Water District (NTMWD) has completed a functional assessment of forested wetlands located within the footprint of the proposed Lower Bois d'Arc Creek Reservoir project (Figure 1). The functional assessment method utilized is a modification of the *Regional Guidebook for Applying the Hydrogeomorphic Approach to the Functional Assessment of Forested Wetlands in Alluvial Valleys of East Texas* (Regional Guidebook) (Williams, et al., 2010). Modifications to the guidebook were completed as a joint effort between the Tulsa District USACE, the U.S. Army Corps of Engineers Research and Development Center (ERDC), and Stephen F. Austin State University (SFA). Documentation of how the guidebook was modified can be found in *Modifying the East Texas Regional HydroGeoMorphic Guidebook for Use in Fannin County, TX, in the Lower Bois D'Arc Creek Reservoir Project* (Camp et al., 2016). The purpose of conducting the functional assessment was to develop indices for the wetland functions being performed by the forested wetlands within the proposed reservoir site and to estimate potential impacts to those forested wetlands resulting from reservoir construction. The six functions assessed using the modified hydrogeomorphic (HGM) assessment method include, Detain Floodwater, Detain Precipitation, Cycle Nutrients, Export Organic Carbon, Maintain Plant Communities, and Provide Habitat for Fish and Wildlife. The following information describes the application of the modified HGM method and the results from this effort.

METHODS

The methods used for this assessment followed the protocol as described in the *Regional Guidebook for Applying the Hydrogeomorphic Approach to the Functional Assessment of Forested Wetlands in Alluvial Valleys of East Texas* (Regional Guidebook) (Williams, et al. 2010) and from *Modifying the East Texas Regional HydroGeoMorphic Guidebook for Use in Fannin County, TX, in the Lower Bois D'Arc Creek Reservoir Project* (Camp et al., 2016).

The 4,602 acres (1,862 hectares) of forested wetlands within the footprint of the proposed Lower Bois d'Arc Creek Reservoir site would be classified as riverine wetlands according to the Regional Guidebook. Riverine wetlands are a class of wetlands that occur within the 5-year floodplains and riparian corridors associated with stream channels. Their primary source of water comes from overbank or backwater flow from the channel. Other sources of

hydrology include interflow, overland flow from adjacent uplands, tributary inflow, and direct precipitation. The forested wetlands within the proposed reservoir site and associated 5-year floodplain are shown on Figure 2.

Following the HGM methodology, riverine wetlands are further refined into two sub-classes: low-gradient riverine, and mid-gradient riverine. Low-gradient riverine wetlands occur within the floodplains of major rivers. The floodplains can be very wide even along relatively narrow channels, a common feature of modern coastal plain river systems (Bridge 2003). Typically, these systems have large, distinctive geomorphic features and often receive both backwater and overbank flooding. Their typical hydrogeomorphic setting includes point bars, backswamps, and natural levee deposits associated with meandering streams within the 5-year floodplain (Williams et al. 2010). Based on these characteristics, it was determined that the forested wetlands within the footprint of the proposed reservoir would fall within the sub-class, low-gradient riverine.

The Wetland Assessment Area (WAA) utilized for this functional assessment includes all of the forested wetlands identified within the footprint of the proposed reservoir (4,602 acres/1,862 hectares). According to the Regional Guidebook, each WAA belongs to a single regional wetland sub-class and is relatively homogenous with respect to the criteria used to assess wetland functions (i.e., hydrologic regime, vegetation structure, topography, soils, successional stage). All of the forested wetlands within the footprint of the proposed reservoir were identified as sub-class low-gradient riverine, are contiguous, and are located within the 5-year floodplain of Bois d'Arc Creek (Figure 2). Additionally, these wetlands are strongly associated with the Tinn Clay, 0-1 percent slopes, frequently flooded and Tinn Clay, 0-1 percent slopes, occasionally flooded soil map units (Figure 3) and all are dominated by three primary tree species including, green ash (*Fraxinus pennsylvanica*), sugarberry (*Celtis laevigata*), and cedar elm (*Ulmus crassifolia*). Based on these data, one WAA was identified that included all forested wetlands within the project area.

Following the identification of the WAA to designate the project boundary, sample plot locations were identified to collect field data. The plot locations were reviewed by all cooperating agencies involved in the project prior to data collection efforts. From December 15 through 17, 2015, FNI environmental scientists, regulatory staff from the Tulsa District USACE, and NTMWD representatives collected field data at 12 sample plot locations within the footprint of the proposed Lower Bois d'Arc Creek Reservoir site (Figure 4). Data collection was performed utilizing the modified low-gradient riverine data collection form and following the protocol described in the Regional Guidebook. At each sample plot location, data forms were completed, GPS coordinates were recorded, and photographs were taken. Photographs from each sample plot are located in Attachment A.

Field data collected during the December 2015 field efforts at the proposed Lower Bois d'Arc Creek Reservoir site were entered into the modified East TX HGM calculator provided by ERDC. Once data were entered, the calculator provided an average measure for each variable and its associated sub-index score. The average measure and sub-index scores for each variable evaluated for the forested wetlands at the proposed Lower Bois d'Arc Creek Reservoir site are summarized in Table 1. The sub-index scores for each variable were then utilized in the formulas (assessment models) for each of the six functions assessed to calculate a functional capacity index (FCI) value for each function. The FCI value represents the ability of a wetland to perform a specific function relative to the ability of reference standard wetlands to perform the same function. The theoretical FCI value ranges from 0.0 to 1.0, where wetlands with an FCI of 1.0 perform the assessed function at a level that is characteristic of reference standard wetlands. A lower FCI indicates that the wetland is performing a function at a level below that characteristic of reference standard wetlands. The FCI values for each function were then multiplied by the area (hectares) of forested wetlands in the WAA to determine functional capacity units (FCU) for each function, as shown in the following equation:

Functional Capacity Unit (FCU) = Functional Capacity Index (FCI) x Area (hectares)

RESULTS

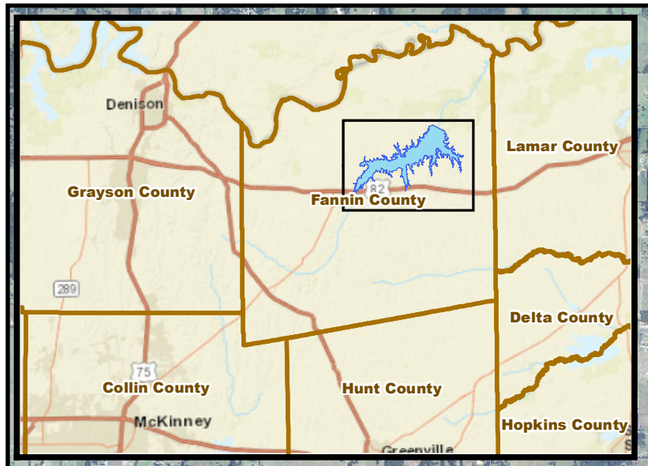
In the case of the proposed reservoir site, the WAA was determined to be the total acreage of forested wetlands within the footprint of the reservoir, which was 4,602 acres (1,862 hectares). The FCI values and resulting FCU's for each function are summarized in Table 2. Output from the modified East TX HGM calculator, including the FCI calculator and Data Summary by Plot tabs, are located in Attachment B.

Table 1. Average Measure and Sub-Index Values of the Forested Wetlands within the Proposed Lower Bois d'Arc Creek Reservoir Site.

Variable	Name	Average Measure	Sub-Index
V_{PATCH}	Forest Patch Size (ha)	2,500	1.00
V_{FREQ}	Change in Frequency of Flooding (years change)	0	1.00
V_{DUR}	Change in Growing Season Flood Duration (weeks change)	0	1.00
V_{POND}	Total Ponded Area (%)	30	1.00
V_{STRATA}	Number of Vegetation Strata	4	1.00
V_{SOIL}	Soil Integrity (%)	0	1.00
V_{TBA}	Tree Basal Area (m^3/ha)	29	1.00
V_{TDEN}	Tree Density (stems/ha)	690	0.81
V_{SNAG}	Snag Density (stems/ha)	79	1.00
V_{OHOR}	O Horizon Accumulation (cm)	0	0.20
V_{COMP}	Composition of Tallest Woody Stratum (%)	0.70	0.70
V_{TCOMP}	Tree Composition (%)	0.70	0.70
V_{SSD}	Shrub-Sapling Density (stems/ha)	875	0.88
V_{GVC}	Ground Vegetation Cover (%)	29	1.00
V_{LITTER}	Litter Cover (%)	57	0.92
V_{LOG}	Log Biomass (m^3/ha)	29	1.00
V_{WD}	Woody Debris Biomass (m^3/ha)	51	1.00

Table 2. Functional Capacity Index (FCI) Values and Functional Capacity Units (FCU) of the Forested Wetlands within the Proposed Lower Bois d'Arc Creek Reservoir Site.

Function	Functional Capacity Index (FCI)	Functional Capacity Units (FCU)
Detain Floodwater	0.92	1,713.04
Detain Precipitation	0.78	1,452.36
Cycle Nutrients	0.85	1,582.70
Export Organic Carbon	0.87	1,619.94
Maintain Plant Communities	0.90	1,675.80
Provide Habitat for Fish and Wildlife	0.86	1,601.32



FM 2029

FM 1396

FM 100

FM 898

82

Bonham

Dodd City

FM 1743

Windom

Honey Grove

0 1 2 3 4
Miles

Caddo National Grasslands

Proposed Lower Bois d'Arc Creek Reservoir

APPENDIX D

F&N JOB NO: NTD06128
DATE: June, 2016
SCALE: 1:65,000
DESIGNED: HHM
DRAFTED: HHM
FILE: Location_Map_11x17.mxd

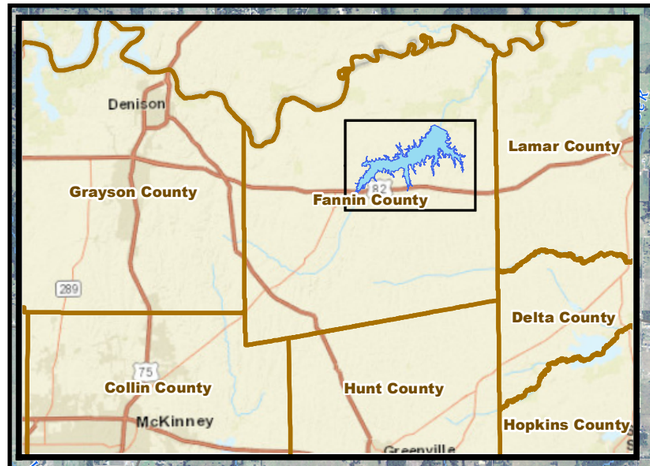
North Texas Municipal Water District

Proposed Lower Bois d'Arc Reservoir Site
Location Map

N
W E
S

Freese and Nichols
4055 International Plaza Suite 200
Fort Worth, Texas 76109-4895
817-735-7300

1
FIGURE



FM 2029
Briscoe Branch
Spoonamore Creek
Sandy Creek
FM 1396
Dixon Creek
Sandy Creek
FM 100
Honey Grove Creek
Fox Creek
West Oakland Branch
Thomas Branch
Timber Creek
Stallhouse Branch
Bois d'Arc Creek
Bullard Creek
Ward Creek
Yoakum Creek
Allens Creek
FM 898
Pettigrew Branch
Onstott Branch
82
Cottonwood Creek
Spring Branch
Sloans Creek
Pig Branch
Moss Creek
FM 1743

0 1 2 3 4
Miles

Proposed Lower Bois d'Arc Creek Reservoir
Streams
Forested Wetland
5yr Existing Floodplain

APPENDIX D

F&N JOB NO: NTD06128
DATE: June, 2016
SCALE: 1:65,000
DESIGNED: HHM
DRAFTED: HHM
FILE: Exist_FP_1147.mxd

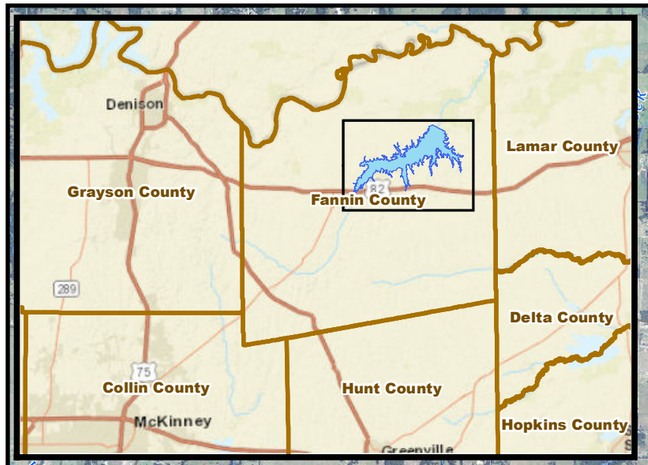
North Texas Municipal Water District

Proposed Lower Bois d'Arc Reservoir Site
Existing 5-Yr Floodplain

N
W E
S

Freese and Nichols
4055 International Plaza Suite 200
Fort Worth, Texas 76109-4895
817-735-7300

2
FIGURE



FM 2029
Briscoe Branch
Spoonamore Creek
Sandy Creek
FM 1396
Dixon Creek
Sandy Creek
West Oakland Branch
Thomas Branch
Honey Grove Creek
FM 100
Fox Creek
Timber Creek
Smithhouse Branch
Bois d'Arc Creek
Bullard Creek
Ward Creek
Yoakum Creek
Allens Creek
FM 898
Pettigrew Branch
Onstott Branch
82
Cottonwood Creek
Sloans Creek
Spring Branch
Pig Branch
FM 1743
Moss Creek

0 1 2 3 4
Miles

Proposed Lower Bois d'Arc Creek Reservoir
Streams
Forested Wetland
Tinn clay, 0 to 1 percent slopes, frequently & occasionally flooded

N
W E
S

APPENDIX D

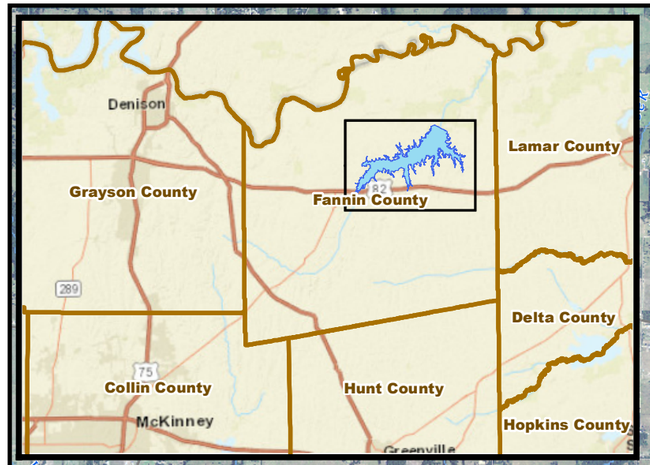
F&N JOB NO: NTD06128
DATE: June, 2016
SCALE: 1:65,000
DESIGNED: HHM
DRAFTED: HHM
FILE: Soils_11x17_192.mxd

North Texas Municipal Water District

Proposed Lower Bois d'Arc Reservoir Site
Hydric Soils

Freese and Nichols
4055 International Plaza Suite 200
Fort Worth, Texas 76109-4895
817-735-7300

3
FIGURE



FM 2029
Brixoe Branch
Spoonamore Creek
Sandy Creek
FM 1396
Dixon Creek
Sandy Creek
FM 100
West Oakland Branch
Thomas Branch
Honey Grove Creek
Fox Creek
Timber Creek
Stallhouse Branch
Bois d'Arc Creek
Bullard Creek
Ward Creek
Yoakum Creek
Allens Creek
FM 898
Pettigrew Branch
Onstott Branch
Slocums Creek
Cottonwood Creek
Spring Branch
Pig Branch
Moss Creek
82
FM 1743

12a
11a
10a
9
8a
7a
5a
4a
6
3a
2
1a

0 1 2 3 4
Miles

HGM Sample Plot Locations
Proposed Lower Bois d'Arc Creek Reservoir
Streams
Forested Wetland

APPENDIX D

F&N JOB NO: NTD06128
DATE: June, 2016
SCALE: 1:65,000
DESIGNED: HHM
DRAFTED: HHM
FILE: HGM_Points_11x17.mxd

North Texas Municipal Water District

Proposed Lower Bois d'Arc Reservoir Site
HGM Sample Plot Locations

N
W E
S

Freese and Nichols
4055 International Plaza Suite 200
Fort Worth, Texas 76109-4895
817-735-7300

4
FIGURE

ATTACHMENT A
Photographs

Photo 1. Site 1A, view looking north

Photo 2. Site 1A, view looking south

Photo 3. Site 1A, view looking east

Photo 4. Site 1A, view looking west

Photo 5. Site 2, view looking north

Photo 6. Site 2, view looking south

Photo 7. Site 2, view looking east

Photo 8. Site 2, view looking west

Photo 9. Site 3A, view looking north

Photo 10. Site 3A, view looking south

Photo 11. Site 3A, view looking east

Photo 12. Site 3A, view looking west

Photo 13. Site 4A, view looking north

Photo 14. Site 4A, view looking south

Photo 15. Site 4A, view looking east

Photo 16. Site 4A, view looking west

Photo 17. Site 5A, view looking north

Photo 18. Site 5A, view looking south

Photo 19. Site 5A, view looking east

Photo 20. Site 5A, view looking west

Photo 21. Site 6, view looking north

Photo 22. Site 6, view looking south

Photo 23. Site 6, view looking east

Photo 24. Site 6, view looking west

Photo 25. Site 7A, view looking north

Photo 26. Site 7A, view looking south

Photo 27. Site 7A, view looking east

Photo 28. Site 7A, view looking west

Photo 29. Site 8A, view looking north

Photo 30. Site 8A, view looking south

Photo 31. Site 8A, view looking east

Photo 32. Site 8A, view looking west

Photo 33. Site 9, view looking north

Photo 34. Site 9, view looking south

Photo 35. Site 9, view looking east

Photo 36. Site 9, view looking west

Photo 37. Site 10A, view looking north

Photo 38. Site 10A, view looking south

Photo 39. Site 10A, view looking east

Photo 40. Site 10A, view looking west

Photo 41. Site 11A, view looking north

Photo 42. Site 11A, view looking south

Photo 43. Site 11A, view looking east

Photo 44. Site 11A, view looking west

Photo 45. Site 12A, view looking north

Photo 46. Site 12A, view looking south

Photo 47. Site 12A, view looking east

Photo 48. Site 12A, view looking west

ATTACHMENT B
Modified East TX HGM Calculator Output

FCI/FCU Calculator for the Fannin County, Texas Adaptation of the East Texas HGM Guidebook

Start with the Project Level Data Entry below. Enter in the yellow cells the number and size of the Wetland Assessment Area (WAA) being sampled, the project name, and location. Use the drop down menus to indicate whether this WAA represents the Project Site or Mitigation Site, before project or after project. Then go to the Data Entry tabs to enter individual field measurements for the tract and each plot. For information on determining how to split a project into WAAs, see A Regional Guidebook for Applying the Hydrogeomorphic Approach to the Functional Assessment of Forested Wetlands in Alluvial Valleys of East Texas (Williams *et al.* 2010). This spreadsheet calculator only allows for ten plots per WAA. If the WAA merits more plots, it must be subdivided to use this tool. Functional Results are automatically calculated based on the data entered into the Data Entry sheets. If the analysis includes mitigation sufficiency assessment, you may enter the functional results into the sufficiency calculator at http://el.erdc.usace.army.mil/wetlands/datanal.html.

Project Level Data Entry

Enter information in yellow cells, and select HGM Subclass and Site information from dropdown menus. A Subclass must be selected prior to printing out data sheets.

Project Name: Lower Bois d'Arc Creek Modified HGM Functional Assessment
Location: Proposed Lower Bois d'Arc Creek Reservoir Site
Sampling Dates: 4/28/16 through 4/29/16

HGM Subclass present at this WAA: Low Gradient Riverine

WAA number: 1

Project Site: Project Site

Project Timing: Before Project

WAA size (ha): 1862

Final Summaries

All summaries of results are automatically calculated based on data entered into the individual plot entry data sheets.

Functional Results Summary:

Enter Results in Section A of the Mitigation Sufficiency Calculator

Function	Functional Capacity Index	Functional Capacity Units
Detain Floodwater	0.92	1713.04
Detain Precipitation	0.78	1452.36
Cycle Nutrients	0.85	1582.70
Export Organic Carbon	0.87	1619.94
Maintain Plant Communities	0.90	1675.80
Provide Habitat for Fish and Wildlife	0.86	1601.32

Variable Measure and Subindex Summary:

Variable	Name	Average Measure	Subindex
V_{PATCH}	Forested Patch Size (ha)	2500	1.00
V_{FREQ}	Change in Frequency of Flooding (years change)	0	1.00
V_{DUR}	Change in Growing Season Flood Duration (weeks change)	0	1.00
V_{POND}	Total Ponded Area (%)	30	1.00
V_{STRATA}	Number of Vegetation Strata	4	1.00
V_{SOIL}	Soil Integrity (%)	0	1.00
V_{TBA}	Tree Basal Area (m^3/ha)	29	1.00
V_{TDEN}	Tree Density (stems/ha)	690	0.81
V_{SNAG}	Snag Density (stems/ha)	79	1.00
V_{OHOR}	O Horizon Organic Accumulation (cm)	0	0.20
V_{COMP}	Composition of Tallest Woody Vegetation Stratum (%)	0.70	0.70
V_{TCOMP}	Tree Composition (%)	0.70	0.70
V_{SSD}	Shrub-Sapling Density (stems/ha)	875	0.88
V_{GVC}	Ground Vegetation Cover (%)	29	1.00
V_{LITTER}	Litter Cover (%)	57	0.92
V_{LOG}	Log Biomass (m^3/ha)	29	1.00
V_{WD}	Woody Debris Biomass (m^3/ha)	51	1.00

WAA Data Summary: **WAA Number : 1** **Low-Gradient Riverine**

Variable	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6	Plot 7	Plot 8	Plot 9	Plot 10	Plot 11	Plot 12	Number of Plots Used	Average Measure
1 V_{PATCH}	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500	12	2500
2 V_{FREQ}	0	0	0	0	0	0	0	0	0	0	0	0	12	0
3 V_{DUR}	0	0	0	0	0	0	0	0	0	0	0	0	12	0
4 V_{POND}	30	30	30	30	30	30	30	30	30	30	30	30	12	30
5 V_{STRATA}	4	4	4	4	4	4	4	4	4	4	4	4	12	4
6 V_{SOIL}	0	0	0	0	0	0	0	0	0	0	0	0	12	0
7 V_{TBA}	36.8	20.7	25.3	36.8	23.0	23.0	25.3	23.0	23.0	36.8	37	32	12	28.6
8 V_{TDEN}	550	725	1075	675	550	700	625	850	650	575	625	675	12	690
9 V_{SNAG}	50	100	125	75	25	100	50	75	100	75	125	50	12	79
10 V_{OHOR}	0	0	0	0	0	0	0	0	0	0	0	0	12	0
11 V_{COMP}	0.51	0.66	0.55	1.00	0.72	0.66	1.00	0.51	1.00	0.44	1	1	12	0.70
12 V_{TCOMP}	0.51	0.66	0.55	1.00	0.72	0.66	1.00	0.51	1.00	0.44	1	1	12	0.70
13 V_{SSD}	625.0	750.0	1375.0	875.0	2875.0	375.0	875.0	375.0	750.0	750.0	625	250	12	875.0
14 V_{GVC}	42.5	22.5	18.8	52.5	3.8	27.5	17.5	37.5	53.8	33.8	13	21	12	28.6
15 V_{LITTER}	61.3	57.5	15.0	60.0	70.0	20.0	67.5	47.5	83.8	22.5	89	90	12	57.0
16 V_{LOG}	21.9	20.9	0.0	0.0	2.9	47.7	10.9	92.7	13.3	6.5	62	71	12	29.2
17 V_{WD}	72.3	83.3	17.3	24.9	13.3	56.8	63.6	96.1	35.4	10.7	64	78	12	51.3

Technical Memorandum on Lower Bois d'Arc Creek Reservoir – Additional Forested Wetland Mitigation Proposal Based on the Modified East TX HGM Functional Assessment

MEMORANDUM

FREESE AND NICHOLS

Innovative approaches
Practical results
Outstanding service

4055 International Plaza, Suite 200 • Fort Worth, Texas 76109 • 817-735-7300 • fax 817-735-7492 www.freese.com

TO: Robert McCarthy, North Texas Municipal Water District

CC: Simone Kiel, P.E., Steve Watters, PWS

FROM: Michael Votaw, PWS, CWB

SUBJECT: Lower Bois d'Arc Creek Reservoir – Additional Forested Wetland Mitigation Proposal Based on the Modified East TX HGM Functional Assessment

DATE: 9/30/2016

PROJECT: NTD06128 - Lower Bois d'Arc Creek Reservoir

BACKGROUND

In 2007, the North Texas Municipal Water District (NTMWD) assessed the wildlife habitat value of the cover types, including forested wetlands, within the proposed Lower Bois d'Arc Creek Reservoir site utilizing the Habitat Evaluation Procedures (HEP), developed by the U.S. Fish and Wildlife Service (USFWS). This study was conducted by an interagency team that included personnel from USFWS, U.S. Army Corps of Engineers (USACE), U.S. Environmental Protection Agency (EPA), U.S. Forest Service (USFS), Texas Parks and Wildlife Department (TPWD), Texas Water Development Board (TWDB), Texas Commission on Environmental Quality (TCEQ), NTMWD, and Freese and Nichols, Inc. (FNI). The results of this study showed that the forested wetlands within the footprint of the proposed reservoir obtained a habitat suitability index (HSI) score of 0.25 on a scale that ranges between 0.0 (poorest quality habitat) and 1.0 (highest quality habitat). Following the HEP protocol, the HSI score was multiplied by the number of acres (4,602) (1,862 hectares) of affected forested wetlands to quantify impacts to the forested wetlands, in terms of HEP habitat units (HU) and to determine what would be required as mitigation to offset those impacts. Results of the HEP evaluation for forested wetlands show that 1,150.5 HUs (0.25 HSI x 4,602 acres) would be impacted.

In February 2010, NTMWD purchased the approximately 15,000-acre Riverby Land and Cattle Company, LLC property (Riverby Ranch) located downstream of the proposed reservoir site to serve as a mitigation site. A separate interagency HEP study was conducted at Riverby Ranch in October 2010 to establish baseline conditions for the forested wetlands and other cover types located on the ranch. A subsequent HEP analysis was conducted to determine the number of habitat units that could be generated from the enhancement of existing forested wetlands and restoration of forested wetlands from existing grassland and cropland areas on the ranch. Results of this analysis showed that by enhancing 452 acres (182.9 hectares) of existing forested wetlands and restoring an additional 3,500 acres (1,416 hectares) of forested wetlands, the ranch could provide 2,266.1 HUs of forested wetland, resulting in an overall net gain of 1,115.6 HUs above what is expected to be impacted at the proposed reservoir site. This information was provided to the USACE in the December 2014 *Proposed Lower Bois d'Arc Creek Reservoir Mitigation Plan*.

In 2015, NTMWD was required to conduct an additional study utilizing the Hydrogeomorphic Methodology (HGM) to further assess the potential impacts to the forested wetlands within the footprint of the proposed reservoir site.

The functional assessment method utilized is a modification of the *Regional Guidebook for Applying the Hydrogeomorphic Approach to the Functional Assessment of Forested Wetlands in Alluvial Valleys of East Texas* (Regional Guidebook) (Williams, et al., 2010). Documentation of how the guidebook was modified can be found in *Modifying the East Texas Regional HydroGeoMorphic Guidebook for Use in Fannin County, TX, in the Lower Bois D'Arc Creek Reservoir Project* (Camp et al., 2016). As directed by the USACE, both impacts and mitigation would be determined using an average of the FCI scores from the HGM Calculator Tool for the modeled functions. The average FCI score for the forested wetland functions assessed within the footprint of the proposed reservoir was calculated to be 0.86 (Table 1). To estimate impacts, the average FCI score (0.86) is multiplied by the area (1,862 hectares) of forested wetlands located within the footprint of the proposed reservoir. This results in 1,601.32 functional capacity units (FCUs) of impacts to forested wetlands (Table 2).

Table 1. Average Functional Capacity Index (FCI) Value for the Forested Wetlands within the Proposed Lower Bois d'Arc Creek Reservoir Site.

Function	Functional Capacity Index (FCI)
Detain Floodwater	0.92
Detain Precipitation	0.78
Cycle Nutrients	0.85
Export Organic Carbon	0.87
Maintain Plant Communities	0.90
Provide Habitat for Fish and Wildlife	0.86
AVERAGE	**0.86**

Table 2. Average Functional Capacity Index (FCI) Value and Functional Capacity Units (FCU) of the Forested Wetlands within the Proposed Lower Bois d'Arc Creek Reservoir Site.

Average Functional Capacity Index (FCI)	Wetland Assessment Area (WAA) (hectares)	Functional Capacity Units (FCU)
0.86	1,862	1,601.32

In February of 2016, NTMWD conducted an HGM study on the forested wetlands located on Riverby Ranch to establish existing conditions. Four separate wetland assessment areas (WAAs) were identified and were evaluated independently. The average FCI score for the forested wetland functions assessed within each WAA were: 0.82 (WAA#1); 0.74 (WAA#2); 0.79 (WAA#3); and 0.74 (WAA#4). To determine existing FCUs, the average FCI score for each WAA is multiplied by the area of forested wetlands located within its respective WAA (Table 3).

Table 3. Average Functional Capacity Index (FCI) Value and Functional Capacity Units (FCU) of the Existing Forested Wetlands at the Proposed Mitigation Site (Riverby Ranch).

WAA	Average Functional Capacity Index (FCI)	Wetland Assessment Area (WAA) (hectares)	Functional Capacity Units (FCU)
WAA#1	0.82	33.3	27.2
WAA#2	0.74	81	59.81
WAA#3	0.79	49.3	38.86
WAA#4	0.74	19.3	14.25
TOTAL	**N/A**	**182.9**	**140.12**

In order to determine mitigation requirements utilizing the Modified East TX HGM approach and averaging FCI scores, the future functional conditions of the existing and proposed forested wetland mitigation areas on Riverby Ranch were predicted by evaluating each of the HGM sub-index variables to predict achievable values in 20 years. The assumptions made and resulting sub-index variable scores have been documented and are included as Attachment A. Once all future sub-index variable scores were predicted, the scores were entered into the Modified East TX HGM Calculator provided by ERDC. It was assumed that the existing FCI scores for the areas identified for restoration (existing grassland and cropland) have a baseline score of 0.0. Results of this evaluation show that the average FCI score for the proposed restored forested wetland areas located on Riverby Ranch would be 0.95 and the enhanced forested wetland areas would range between 0.95 and 0.93, for the four WAAs being analyzed. Following the establishment of the average FCI scores, a separate analysis was conducted using the Mitigation Sufficiency Calculator, also provided by ERDC, to determine if the proposed restored and enhanced forested wetlands on Riverby Ranch would provide sufficient mitigation to offset impacts to the forested wetlands at the proposed reservoir site. Table 4 summarizes the results of this analysis.

Table 4. Summary of Impacts at the Proposed Lower Bois d'Arc Creek Reservoir Site and Proposed Mitigation at Riverby Ranch.

Impacts					
	Hectares	**Average Baseline Functional Capacity Index (FCI)**	**Average Future Functional Capacity Index (FCI)**	**Baseline Functional Capacity Units (FCU)**	**Future Functional Capacity Units (FCU)**
Proposed Reservoir Site	(-)1,862	0.86	0.0	1,601.32	0.0
Mitigation					
	Hectares	**Average Baseline Functional Capacity Index (FCI)**	**Average Future Functional Capacity Index (FCI)**	**Baseline Functional Capacity Units (FCU)**	**Future Functional Capacity Units (FCU) Uplift**
Riverby Restoration	1,487.2	0.0	0.95	0.0	1,412.8
Riverby Enhancement (WAA#1)*	33.3	0.82	0.95	27.2	4.38
Riverby Enhancement (WAA#2)*	81	0.74	0.93	59.81	15.39
Riverby Enhancement (WAA#3)*	49.3	0.79	0.93	38.86	6.90
Riverby Enhancement (WAA#4)*	19.3	0.74	0.93	14.25	3.73
Total	(+)1,670.1	N/A	N/A	140.12	(+)1,443.2
Net Gain/Net Loss	**(-)191.9**	N/A	N/A	**140.12**	**-158.12**

**Note-Future functional capacity units for forested wetland enhancement areas only reflect predicted uplift above existing conditions.*

Use of the Modified East TX HGM methodology now shows that the proposed mitigation (as described in the December 2014 *Proposed Lower Bois d'Arc Creek Reservoir Mitigation Plan*) for forested wetlands at Riverby Ranch is not sufficient to offset the impacts at the proposed reservoir site. To address this, NTMWD has started investigations of additional lands located upstream of the proposed reservoir site that could be used to provide additional forested wetland mitigation. The following paragraphs describe the methods used to identify potential additional mitigation property and the estimated mitigation amount (area and FCUs) that could be added to NTMWD's mitigation proposal to fully compensate for the forested wetland impacts at the proposed reservoir site.

METHODS AND RESULTS

Recognizing the USACE mandate to compensate for impacts as close to the impact site as practicable, NTMWD's additional mitigation property search focused on lands located along Bois d'Arc Creek upstream of the proposed reservoir site. The search was specifically focused on areas located within the 5-year floodplain and that were mapped as having hydric soils. Once these areas were identified, recent aerial photographs were used to identify sites that had been cleared for agricultural purposes, as these areas have the potential to produce the highest uplift (i.e., gain in FCUs). An additional objective during this process was to avoid fragmentation of the additional mitigation property and to create an area of contiguous forest to increase patch size. The additional mitigation area identified as a result of this search is depicted on Figure 1. This area includes approximately 1,900 acres of bottomlands along Bois d'Arc Creek.

Following the identification of potential additional mitigation property, NTMWD, FNI, and the USACE conducted site visits to verify site conditions and collect HGM data using the Modified East TX HGM protocol within existing forested wetland areas. Data were collected in three additional forested wetland plots (Figure 2) resulting in average FCI score of 0.78 (Table 5). Information collected during the site visits were also used to create a preliminary cover type map of the area being proposed for additional forested wetland mitigation (Figure 3).

Table 5. Average Functional Capacity Index (FCI) Value for the Existing Forested Wetlands along Bois d'Arc Creek Upstream of the Proposed Reservoir Site.

Function	Functional Capacity Index (FCI)
Detain Floodwater	0.76
Detain Precipitation	0.67
Cycle Nutrients	0.78
Export Organic Carbon	0.74
Maintain Plant Communities	0.86
Provide Habitat for Fish and Wildlife	0.86
Average	**0.78**

The final analysis conducted within the proposed additional mitigation area involved the use of the Modified East TX HGM Calculator Tool and Mitigation Sufficiency Calculator. It was assumed for the purposes of this analysis that the same sub-index variable scores could be achieved for the restored forested wetlands upstream of the proposed reservoir as at Riverby Ranch. Based on this assumption, the average FCI score (as calculated by the Calculator Tool) for the proposed restored forested wetland areas located upstream of the proposed reservoir would be 0.93. It was also assumed that the functions of the existing forested wetlands located upstream of the proposed reservoir would increase (i.e., be enhanced) the same as they are expected to at Riverby Ranch, resulting in an average FCI score of

Table 6. Summary of Additional Forested Wetland Mitigation that Could Be Provided Upstream of the Proposed Lower Bois d'Arc Creek Reservoir.

Mitigation					
	Hectares	**Average Baseline Functional Capacity Index (FCI)**	**Average Future Functional Capacity Index (FCI)**	**Baseline Functional Capacity Units (FCU)**	**Future Functional Capacity Units (FCU) Uplift**
Upstream Restoration	445.1	0.0	0.93	0.0	413.94
Upstream Enhancement*	232.2	0.78	0.93	181.12	34.83
Total	**677.3**	**N/A**	**N/A**	**181.12**	**448.77**

**Note-Functional capacity units for forested wetland enhancement areas only reflect predicted uplift above existing conditions.*

0.93. Based on these assumptions, the 232.2 hectares of existing forested wetlands within the additional mitigation area could provide 34.83 FCUs of uplift credit through protection and enhancement activities. Additionally, the existing cropland, grassland, shrub and emergent wetlands (445.1 hectares) within the additional mitigation area could be restored to forested wetlands to generate an additional 413.94 FCUs above a baseline of 0.0 in these non-forested areas. This would result in a net total of 448.77 FCUs that could be gained from the additional upstream mitigation area (Table 6).

If the total FCUs from the upstream mitigation site are combined with the total FCUs that would be generated at the Riverby Ranch mitigation site, this would result in a net gain in both area (485.4 hectares) and functions (290.65 FCUs) compared to what would be impacted at the proposed reservoir site (Table 7).

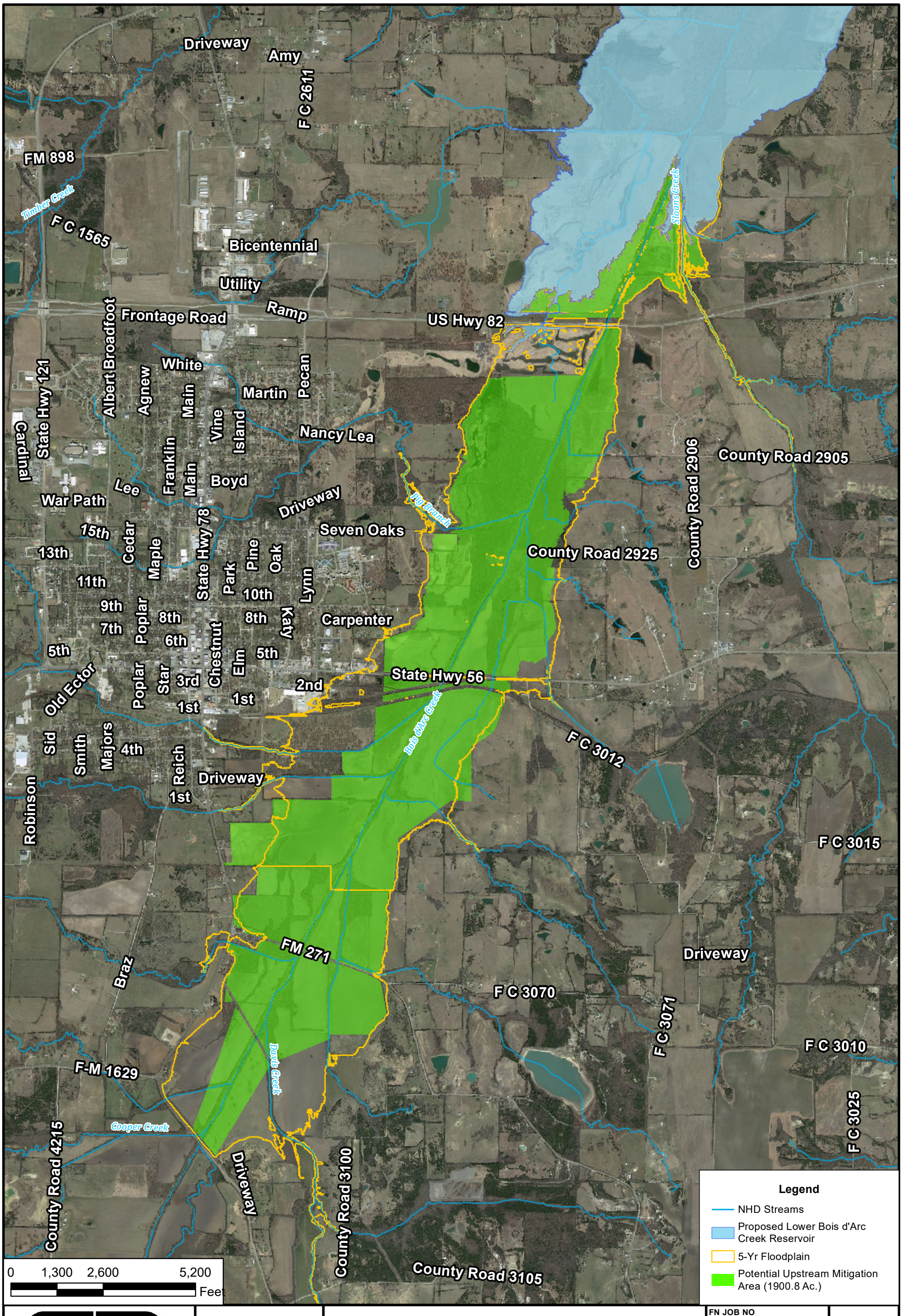
Table 7. Summary of Impacts at the Proposed Lower Bois d'Arc Creek Reservoir Site and Proposed Mitigation at Riverby Ranch and Upstream Mitigation Area.

Impacts			
	Hectares	**Average Functional Capacity Index (FCI)**	**Functional Capacity Units (FCU)**
Proposed Reservoir Site	(-)1,862	0.86	(-)1,601.32
Mitigation			
	Hectares	**Average Functional Capacity Index (FCI)**	**Functional Capacity Units (FCU) Uplift**
Riverby Restoration	1,487.2	0.95	1,412.8
Riverby Enhancement (WAA#1)*	33.3	0.95	4.38
Riverby Enhancement (WAA#2)*	81	0.93	15.39
Riverby Enhancement (WAA#3)*	49.3	0.93	6.90
Riverby Enhancement (WAA#4)*	19.3	0.93	3.73
Upstream Restoration	445.1	0.93	413.94
Upstream Enhancement	232.2	0.93	34.83
Total	2,347.4	N/A	1,891.97
Net Gain/Net Loss	**(+)485.4**	N/A	**(+)290.65**

REFERENCES CITED

Camp, A., J. Grogan, A. Urbanovsky, and H. Williams. 2016. Draft Report - Modifying the East Texas Regional HydroGeoMorphic Guidebook for Use in Fannin County, TX, in the Lower Bois D'Arc Creek Reservoir Project. Prepared for the U.S. Army Corps of Engineers, Tulsa District, by the Arthur Temple College of Forestry and Agriculture.

Hans M. Williams, Adam J. Miller, Rachel S. McNamee, and Charles V. Klimas. 2010. A Regional Guidebook for Applying the Hydrogeomorphic Approach to the Functional Assessment of Forested Wetlands in Alluvial Valleys of East Texas. U.S. Army Engineer Research and Development Center.



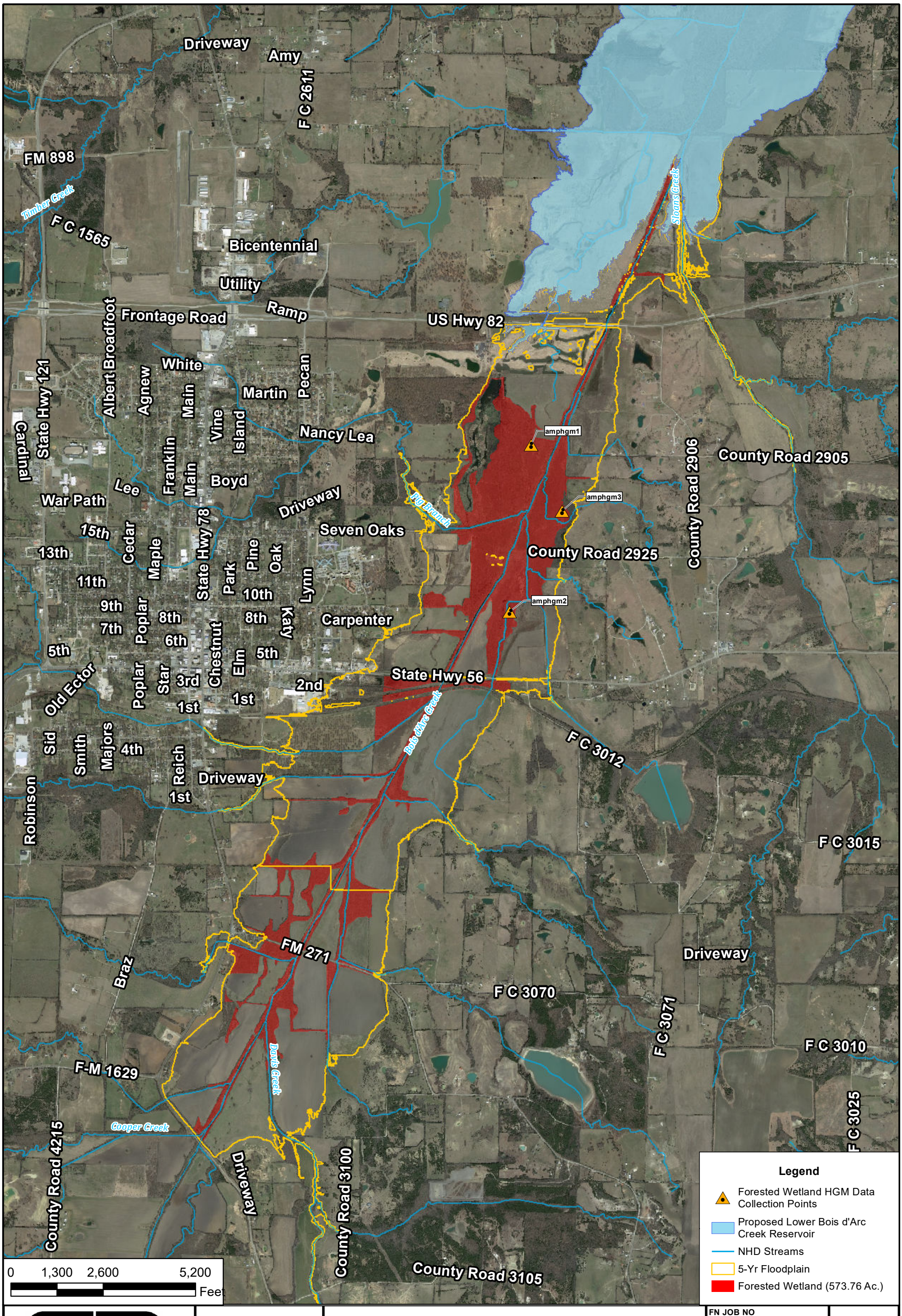
Freese and Nichols
4055 International Plaza Suite 200
Fort Worth, Texas 76109-4895
817-735-7300

North Texas Municipal Water District
Lower Bois d'Arc Creek Reservior

Prospective Upstream Mitigation Land

FN JOB NO	NTD06128
FILE	1_Upstream_Mitigation_Area.mxd
DATE	June 28, 2016
SCALE	1:20,000
DESIGNED	CJS
DRAFTED	HHM

1
Figure



Freese and Nichols
4055 International Plaza Suite 200
Fort Worth, Texas 76109-4895
817-735-7300

N W E S

North Texas Municipal Water District
Lower Bois d'Arc Creek Reservior

Prospective Upstream Mitigation Land-
Forested Wetland HGM Data Collection Points

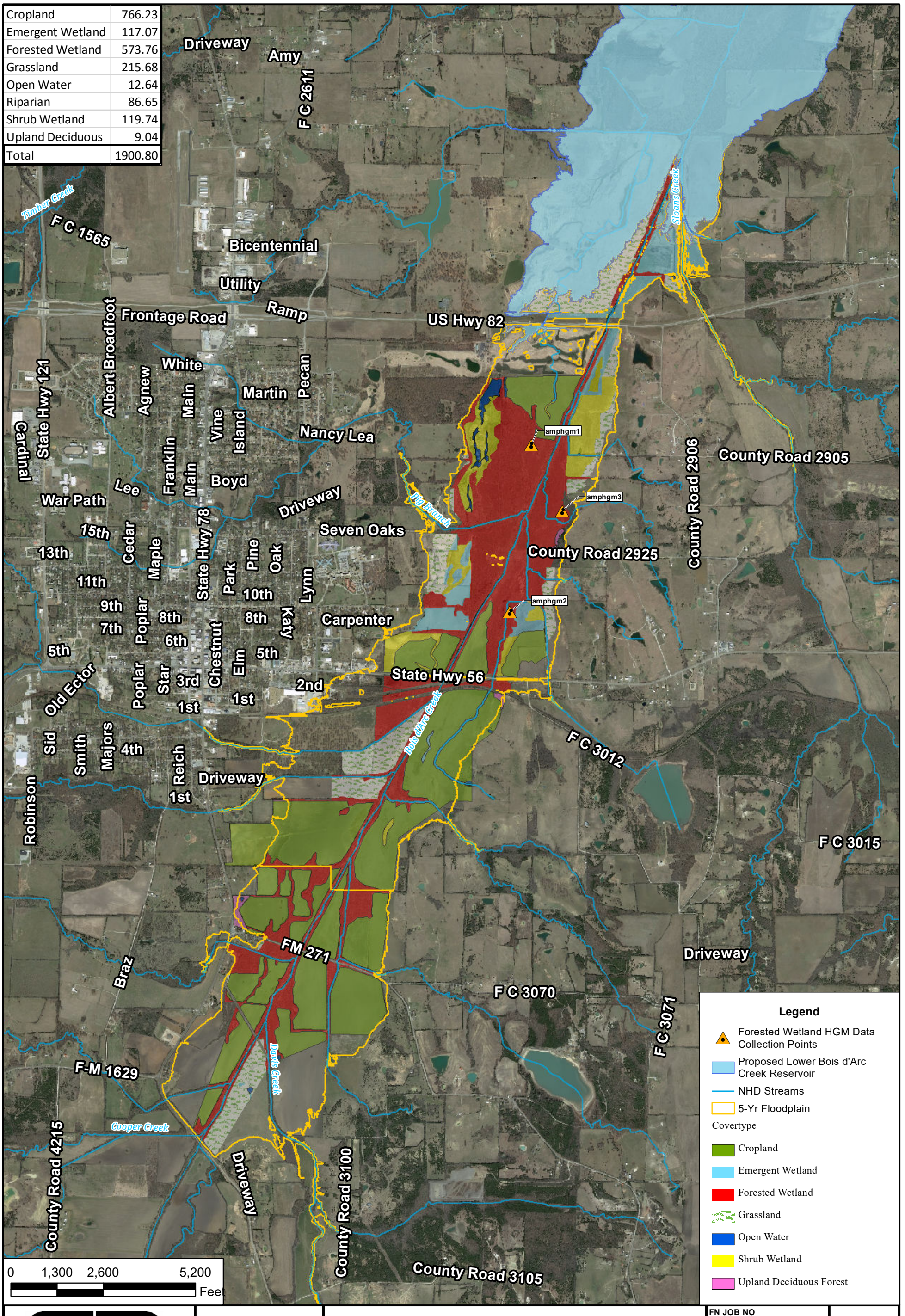
FN JOB NO	NTD06128
FILE	2_FW_HGM_Points.mxd
DATE	June 28, 2016
SCALE	1:20,000
DESIGNED	CJS
DRAFTED	HHM

2

Figure

APPENDIX D

Cropland	766.23
Emergent Wetland	117.07
Forested Wetland	573.76
Grassland	215.68
Open Water	12.64
Riparian	86.65
Shrub Wetland	119.74
Upland Deciduous	9.04
Total	1900.80



Freese and Nichols
4055 International Plaza Suite 200
Fort Worth, Texas 76109-4895
817-735-7300

N W E S

North Texas Municipal Water District
Lower Bois d'Arc Creek Reservior

Prospective Upstream Mitigation Land-Existing Cover Types

FN JOB NO	NTD06128
FILE	3_Exist_CoverTypes.mxd
DATE	June 28, 2016
SCALE	1:20,000
DESIGNED	CJS
DRAFTED	HHM

3

Figure

ATTACHMENT A

Projected Values of Forested Wetlands Sub-index Variables at Mitigation Sites for the Lower Bois d'Arc Creek Reservoir Site using the Modified East Texas HGM

Technical Memorandum on Projected Values of Forested Wetlands Sub-index Variables at Mitigation Sites for the Lower Bois d'Arc Creek Reservoir Site using the Modified East Texas HGM

MEMORANDUM

FREESE AND NICHOLS

Innovative approaches
Practical results
Outstanding service

4055 International Plaza, Suite 200 • Fort Worth, Texas 76109 • 817-735-7300 • fax 817-735-7492 www.freese.com

TO: Robert McCarthy, North Texas Municipal Water District

CC: Simone Kiel, P.E.

FROM: Steve Watters, PWS, and Michael Votaw, PWS, CWB

SUBJECT: Projected Values of Forested Wetlands Sub-index Variables at Mitigation Sites for the Lower Bois d'Arc Creek Reservoir Site using the Modified East Texas HGM

DATE: 6/24/2016

PROJECT: NTD06128 - Lower Bois d'Arc Creek Reservoir

INTRODUCTION

In order to predict future functional conditions of forested wetland mitigation areas using the Modified East Texas HGM (the "Modified HGM") calculator, FNI wetland scientists evaluated each of the HGM sub-index variables to predict achievable values in 20 years. It was assumed that restored forested wetland areas would grow into a forest stand by year 20 with the majority of dominant trees reaching a diameter at breast height (dbh) of at least 4 inches. The results of our evaluation of future sub-index variable scores are summarized in Table 1 (attached).

The first column of Table 1 lists the sub-index variables of the Modified HGM method developed by Camp et al. (2016). The second column describes the measurement thresholds within which each variable would be scored a value of 1.0 based on the revised sub-index variable curves for the Modified HGM (see Attachment A). For example, for the variable Total Ponded Area (VPOND), the revised curve indicates that VPOND would score a 1.0 in areas where the total ponded area is between 20 and 60 percent. The third column of Table 1 indicates whether or not each variable may be manipulated or controlled by mitigation construction, and if so, it provides a description as to how the variable might be manipulated. Finally, the fourth column of Table 1 identifies our projected value of each sub-index variable at 20 years, the age when restored forested areas are expected to develop into a forest stand. These projected sub-index values are proposed to be used in the Modified HGM models to calculate the expected value of each function for the forested wetland mitigation areas 20 years following planting.

Reference

Camp, A., J. Grogan, A. Urbanovsky, and H. Williams. 2016. Draft Report - Modifying the East Texas Regional HydroGeoMorphic Guidebook for Use in Fannin County, TX, in the Lower Bois D'Arc Creek Reservoir Project. Prepared for the U.S. Army Corps of Engineers, Tulsa District, by the Arthur Temple College of Forestry and Agriculture.

Table 1. Projected Values of Sub-index Variables for the Lower Bois d'Arc Creek Reservoir Forested Wetland Mitigation Areas 20 Years Following Planting

Sub-index Variables in the Modified East TX HGM Model	Index Curve Score of 1.0	Controllable/Constructible	Projected Score at 20 Years Post-Planting
Change in Growing Season Flood Duration (VDUR)	No change in growing season flood duration	This should automatically score 1.0 after construction.	1.00
Change in Frequency of Flooding (VFREQ)	No change in frequency of flooding	This should automatically score 1.0 after construction.	1.00
Total Ponded Area (VPOND)	20-60% of site capable of ponding	Yes - grade site to pond between 20-60% after heavy rain.	1.00
Composition of Overstory Vegetation (VTCOMP)	100% concurrence of overstory stratum	Yes - plant to achieve dominant spp. from Group 1. Non-dominant spp. planted from Group 2 or 3 to increase VTBA, VLOG, VSNAG, and VWD, e.g. cottonwood, black willow.	1.00
Number of Vegetation Strata (VSTRATA)	Site has all 4 vegetation strata	Yes - plant super-canopy species such as cottonwood, sub-canopy species such as ash, elm, sugarberry. It is expected that shrubs/groundcover will develop over time. ETx HGM Guidebook indicates 4 strata at 20 yr. Will plant cover crop - wheat, annual rye	1.00
Snag Density (VSNAG)	20-100 snags/ha (8-40 snags/ac)	Yes - plant species which grow quickly and are short lived. Examples include sugarberry, cottonwood, green ash, and black willow. Snags (min 6 ft. tall, 4 in dbh) installed min 4.5 ft. above ground, 18 in below ground at rate of min 10/acre.	1.00
Tree Basal Area (VTBA)	Anything above 18 square meters/ha (78 sq. ft./ac)	Yes - plant species which grow quickly. Examples include cottonwood, green ash, sugarberry. With proposed planting rate and species selected for planting, we anticipate a minimum of 100 sq. ft./ac. At 20-years. Reference young wetland sites within reservoir.	1.00

Table 1. Projected Values of Sub-index Variables for the Lower Bois d'Arc Creek Reservoir Forested Wetland Mitigation Areas 20 Years Following Planting (Continued)

Sub-index Variables in the Modified East TX HGM Model	Index Curve Score of 1.0	Controllable/Constructible	Projected Score at 20 Years Post-Planting
Log Volume (VLOG)	5-60 cubic meters/ha	Yes - plant species which grow quickly, short lived, and that are prone to producing dead fall. Examples include sugarberry, cottonwood, and black willow. ETx HGM Guidebook indicates 5 cubic meters at year 20 for typical hardwoods.	1.00
Forest Patch Size (VPATCH)	Anything greater than 6,178 ac	Yes - plant larger blocks/patches of forested wetlands and/or plant adjacent to existing forested areas. Plant wildlife corridors to connect to other patches of forested areas.	1.00
Ground Vegetation Cover (VGVC)	Ground vegetation cover (herbaceous and woody) less than or equal to 4.5-ft. in height between 0-40%.	ETx HGM Guidebook indicates 100% cover at year 20 for typical hardwoods.	0.50
Shrub-Sapling Density (VSSD)	Woody stems less than 4 inches dbh and greater than 4.5-ft. in height between 1000-4000 stems per hectare (405-1,620 stems per acre).	This should occur naturally over time. ETx HGM Guidebook indicates 5,000 stems/ha at year 20 for typical hardwoods. However, VSSD will be managed to maintain density to obtain 1,000-4,000 stems/ha.	1.00
Tree Density (VTDEN)	Density of the trees between 200-500 stems per hectare (81-202 stems per acre).	Yes - we are proposing to plant 435 trees/acre and anticipating with mortality at year 20, the tree density will be in the range of 100-200 trees/ac. This would achieve a score of 1.0.	1.00

Table 1. Projected Values of Sub-index Variables for the Lower Bois d'Arc Creek Reservoir Forested Wetland Mitigation Areas 20 Years Following Planting (Continued)

Sub-index Variables in the Modified East TX HGM Model	Index Curve Score of 1.0	Controllable/Constructible	Projected Score at 20 Years Post-Planting
O-Horizon Organic Accumulation (VOHOR)	Partially decomposed organic matter such as leaves, twigs, needles, or sticks less than 1/4-inch in diameter, flowers, fruits, insect frass, dead moss, or detached lichens on or near the surface of the ground. Anything over 1.25 cm (1/2-inch) thick.	No. This would occur/develop naturally over time. ETx HGM Guidebook indicates 1 cm O-horizon at year 20 for typical hardwoods.	0.84
Litter Cover (VLITTER)	Average percent of the ground surface covered by recognizable dead plant material between 60-100%.	ETx HGM Guidebook indicates approximately 80% litter cover at year 20 for typical hardwoods. Planting of cover crop will also contribute to litter cover.	1.00
Woody Debris Biomass (VWD)	20-90 cubic meters per hectare (706-3178 cubic feet per hectare).	Yes - plant species which grow quickly, short lived, and that are prone to producing dead fall. Examples include sugarberry, cottonwood, and black willow. ETx HGM Guidebook indicates 72 cubic meters/ha at year 20 for typical hardwoods.	1.00
Composition of Tallest Woody Stratum (VCOMP)	Composition and diversity concurrence of dominant woody stratum. 100% concurrence = 1.0.	Yes - plant to achieve dominant spp. from Group 1. Non-dominant spp. planted from Group 2 or 3 to increase VTBA, VLOG, VSNAG, and VWD, e.g. cottonwood, black willow.	1.00
Soil Integrity (VSOIL)	Percent of site with altered soils. 0% alteration = 1.0.	Yes - do not manipulate soils following initial restoration.	1.00

*A-horizon variable was omitted from the Modified East Texas HGM Model by Williams et al. (2016)

ATTACHMENT A

Modified East Texas HGM Models and Revised Sub-index Curves Developed by Camp et al. (2016)

Revised models for Fannin County application of East Texas HGM Low Gradient Riverine Models

a. Detain Floodwater.

$$FCI = V_{FREQ} \times \left[\frac{(V_{LOG} + V_{GVC} + V_{SSD} + V_{TDEN})}{4}\right]$$

b. Detain Precipitation.

$$FCI = \frac{\left[V_{POND} + \frac{(V_{OHOR} + V_{LITTER})}{2}\right]}{2}$$

c. Cycle Nutrients.

$$FCI = \frac{\left[\frac{(V_{TBA} + V_{SSD} + V_{GCV})}{3} + \frac{(V_{OHOR} + V_{WD} + V_{SNAG})}{3}\right]}{2}$$

d. Export Organic Carbon.

$$FCI = V_{FREQ} \times \frac{\left[\frac{(V_{LITTER} + V_{OHOR} + V_{WD} + V_{SNAG})}{4} + \frac{(V_{TBA} + V_{SSD} + V_{GVC})}{3}\right]}{2}$$

e. Maintain Plant Communities.

$$FCI = \left[\left\{\frac{\frac{[V_{TBA} + V_{TDEN}]}{2} + V_{COMP}}{2}\right\} \times \left[\frac{(V_{SOIL} + V_{DUR} + V_{POND})}{3}\right]\right]^{1/2}$$

f. Provide Habitat for Fish and Wildlife.

$$FCI = \left\{\left[\frac{(V_{FREQ} + V_{DUR} + V_{POND})}{3}\right] \times \left[\frac{(V_{TCOMP} + V_{STRATA} + V_{SNAG} + V_{TBA})}{4}\right] \times \left[\frac{(V_{LOG} + V_{OHOR})}{2}\right] \times V_{PATCH}\right\}^{1/4}$$

Revised models for Fannin County application of East Texas HGM in Mitigation Flats Wetlands

a. Detain Floodwater. **Not Assessed.**

b. Detain Precipitation.

$$FCI = \frac{\left[V_{POND} + \frac{(V_{OHOR} + V_{LITTER})}{2}\right]}{2}$$

c. Cycle Nutrients.

$$FCI = \frac{\left[\frac{(V_{TBA} + V_{SSD} + V_{GCV})}{3} + \frac{(V_{OHOR} + V_{WD} + V_{SNAG})}{3}\right]}{2}$$

d. Export Organic Carbon. **Not Assessed.**

e. Maintain Plant Communities.

$$FCI = \left[\left\{\frac{\frac{[V_{TBA} + V_{TDEN}]}{2} + V_{COMP}}{2}\right\} \times \left[\frac{(V_{SOIL} + V_{POND})}{2}\right]\right]^{1/2}$$

f. Provide Habitat for Fish and Wildlife.

$$FCI = \left\{V_{POND} \times \left[\frac{(V_{TCOMP} + V_{STRATA} + V_{SNAG} + V_{TBA})}{4}\right] \times \left[\frac{(V_{LOG} + V_{OHOR})}{2}\right] \times V_{PATCH}\right\}^{1/4}$$

Revised V_{COMP} for Fannin County application of East Texas HGM Low Gradient Riverine Models (including diversity factor).

Table 5A. Suggested HGM calculator tree species grouping based on field data and research on the reference domain.

Group 1		Group 2		Group 3	
Ash	*Fraxinus spp.*	Black Walnut	*Juglans nigra*	Black Willow	*Salix nigra*
Bur Oak	*Quercus macrocarpa*	Box Elder	*Acer negundo*	Bois D'Arc	*Maclura pomifera*
Chinkapin Oak	*Quercus muehlenbergii*	Cherrybark Oak	*Quercus pagoda*	Eastern Cottonwood	*Populus deltoides*
Elm	*Ulmus spp.*	Dogwood	*Cornus spp.*	Eastern Redbud	*Cercis canadensis*
Pecan	*Carya illinoinensis*	Honey Locust	*Gleditsia triacanthos*	Hawthorn	*Crataegus spp.*
Shumard Oak	*Quercus shumardii*	Persimmon	*Diospyros spp.*	Soapberry	*Sapindus spp.*
Sugarberry	*Celtis laevigata*	Red Maple	*Acer rubrum*		
Water Oak	*Quercus nigra*	Sycamore	*Platanus occidentalis*		
Willow Oak	*Quercus phellos*	Hickory Spp.	*Carya spp.*		

Group 1 = Common dominants in reference standard sites
Group 2 = Species commonly present in reference standard sites, but dominance generally indicates man-made or natural disturbance
Group 3 = Uncommon, minor or shrub species in reference standard sites, but may dominate in degraded systems

$$\boldsymbol{Initial\ Quality\ Index} = \frac{\left[\begin{array}{c}(\#\ \boldsymbol{of\ dominants\ from\ Group\ 1}\ \times \mathbf{1.0}) + (\#\ \boldsymbol{of\ dominants\ from\ Group\ 2}\ \times \mathbf{0.66}) + \\ (\#\boldsymbol{of\ dominants\ from\ Group\ 3}\ \times \mathbf{0.33})\end{array}\right]}{\#\ \boldsymbol{of\ dominants\ from\ Groups\ 1, 2, and\ 3}}$$

$$\boldsymbol{VSI = Adjusted\ Quality\ Index}$$

Where if there are <u>3</u> or more dominants from Groups 1 and 2:

$$\boldsymbol{Adjusted\ Quality\ Index} = \mathbf{1.0}\ \times \boldsymbol{Initial\ Quality\ Index}$$

Where if there are <u>2</u> dominants from Groups 1 and 2:

$$\boldsymbol{Adjusted\ Quality\ Index} = \mathbf{0.66}\ \times \boldsymbol{Initial\ Quality\ Index}$$

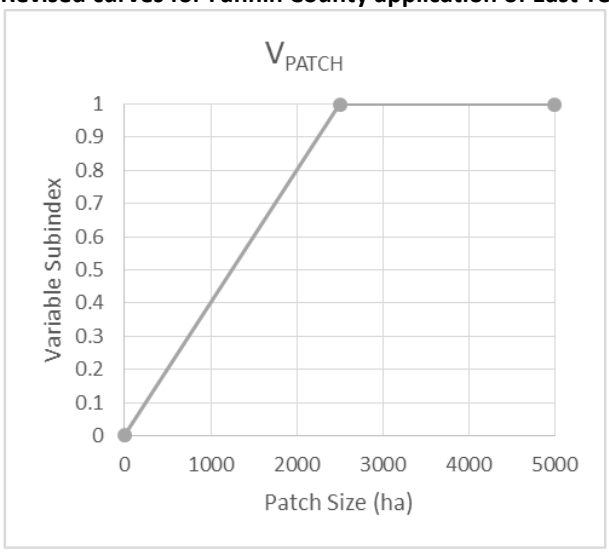
Where if there is <u>1</u> dominant from Groups 1 and 2:

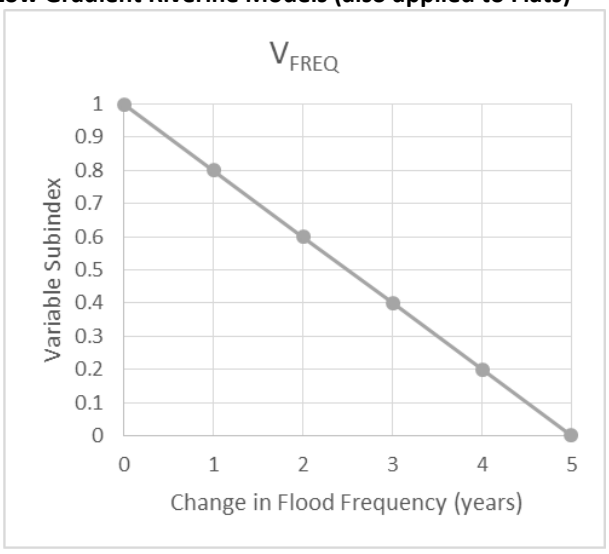
$$\boldsymbol{Adjusted\ Quality\ Index} = \mathbf{0.33}\ \times \boldsymbol{Initial\ Quality\ Index}$$

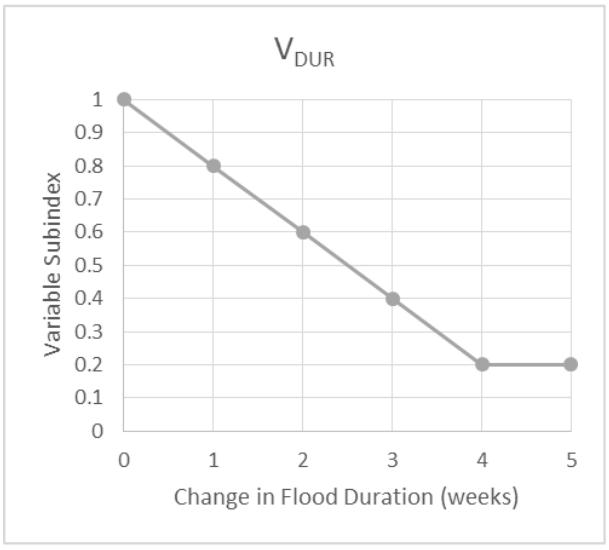
And if there are <u>0</u> dominants from Groups 1 and 2:

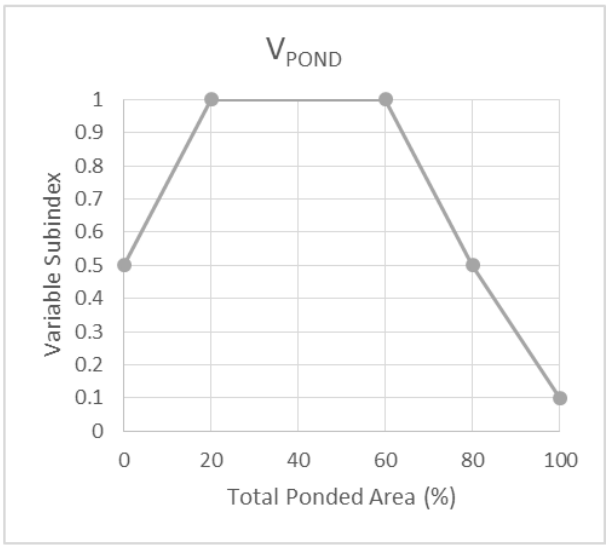
$$\boldsymbol{Adjusted\ Quality\ Index} = \mathbf{0.10}\ \times \boldsymbol{Initial\ Quality\ Index}$$

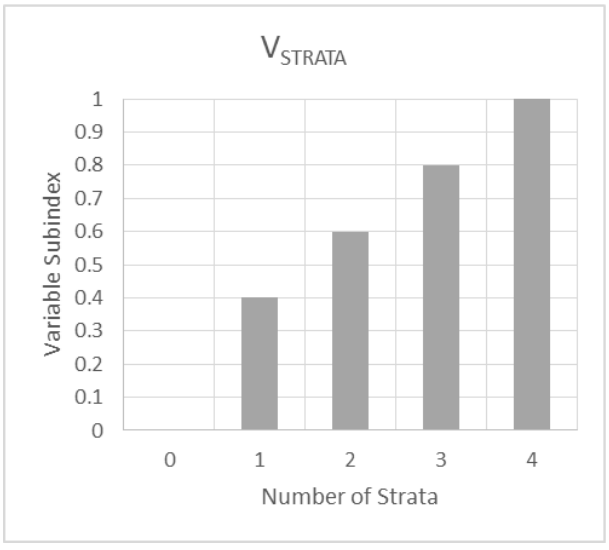
Revised curves for Fannin County application of East Texas HGM Low Gradient Riverine Models (also applied to Flats)

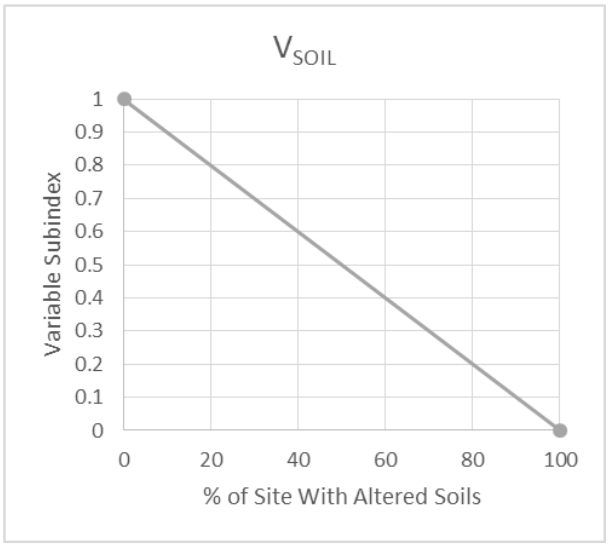


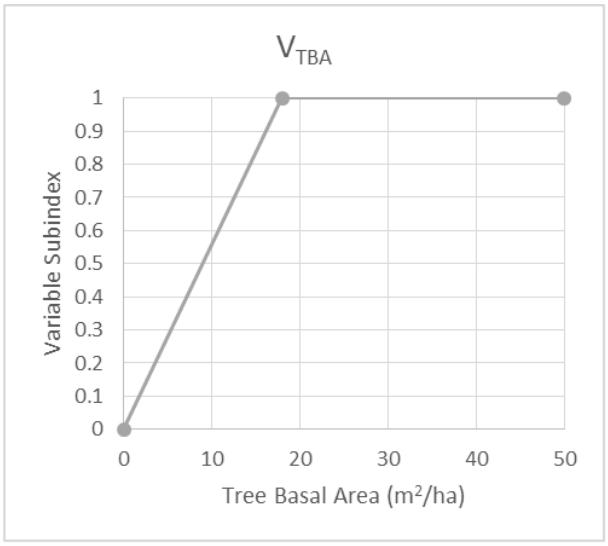


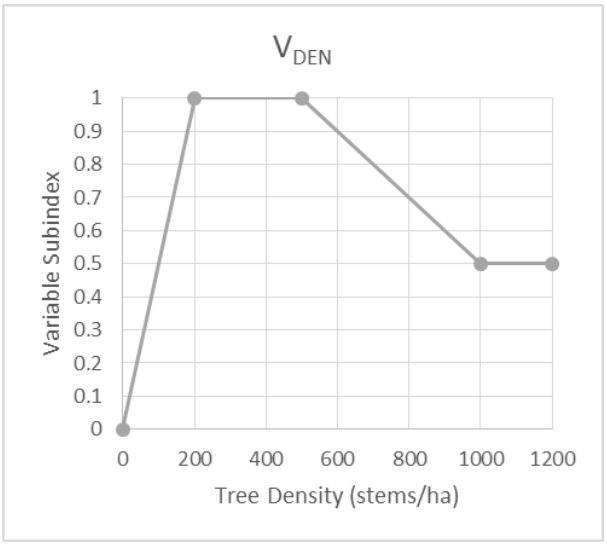


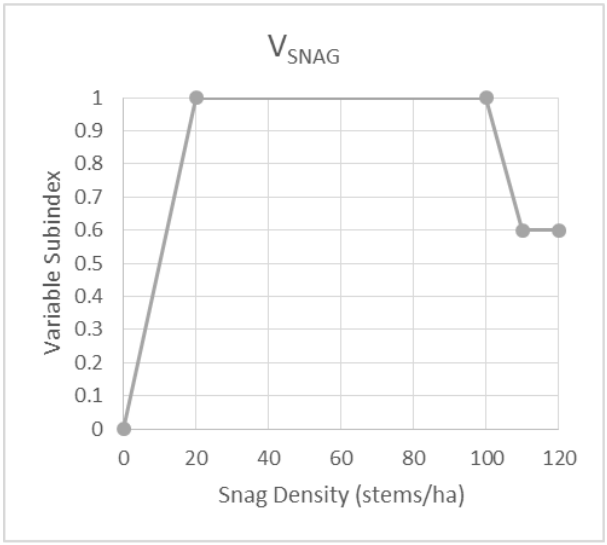


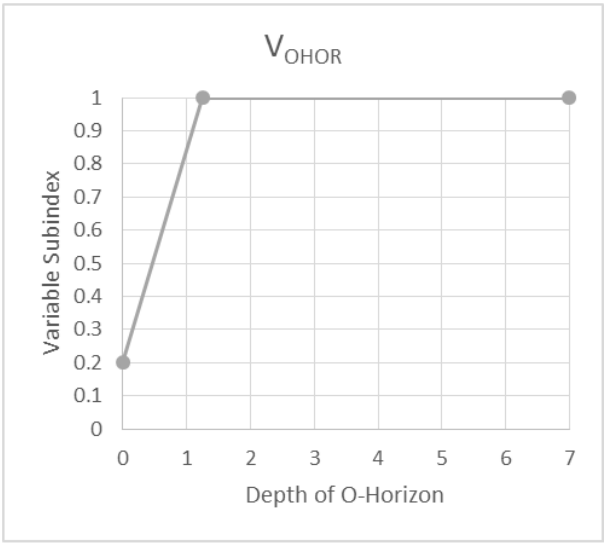


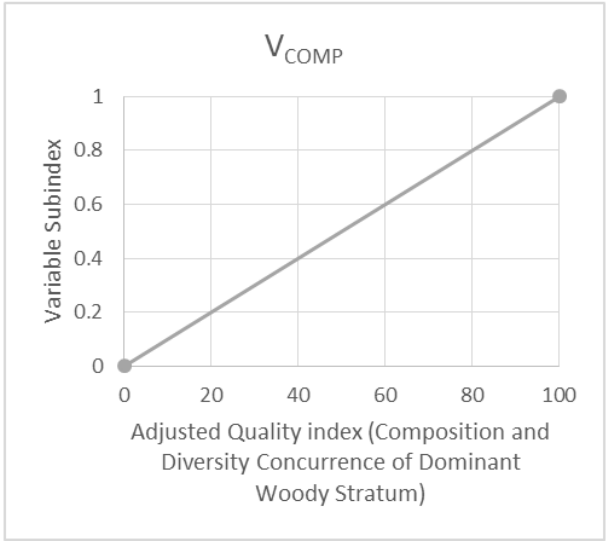



V_{TBA}
Variable Subindex
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
10
20
30
40
50
Tree Basal Area (m²/ha)

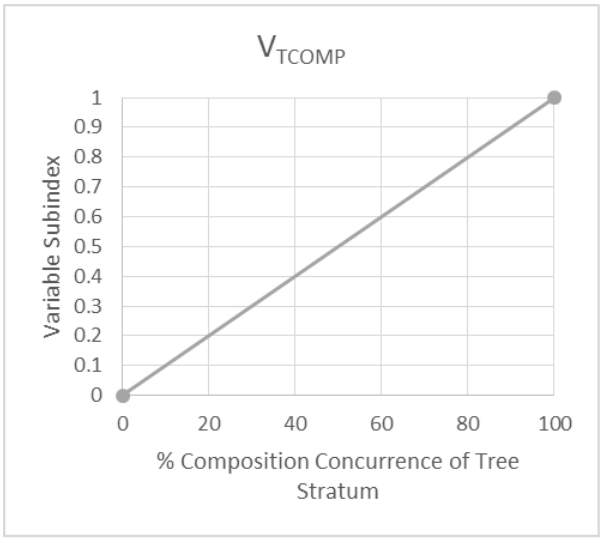

V_{DEN}
Variable Subindex
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
200
400
600
800
1000
1200
Tree Density (stems/ha)

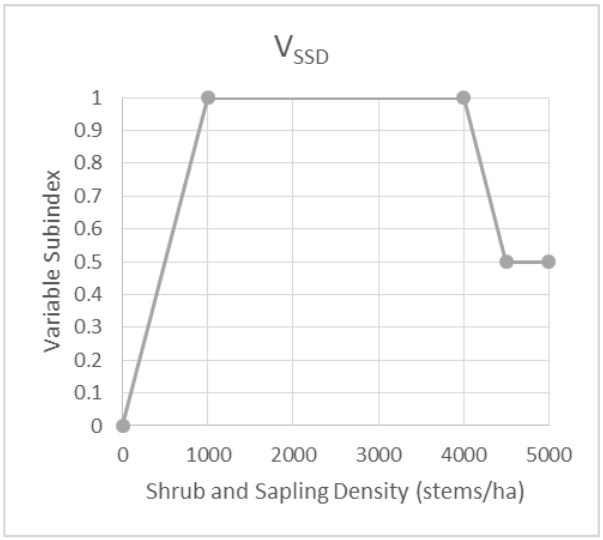

V_{SNAG}
Variable Subindex
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
20
40
60
80
100
120
Snag Density (stems/ha)

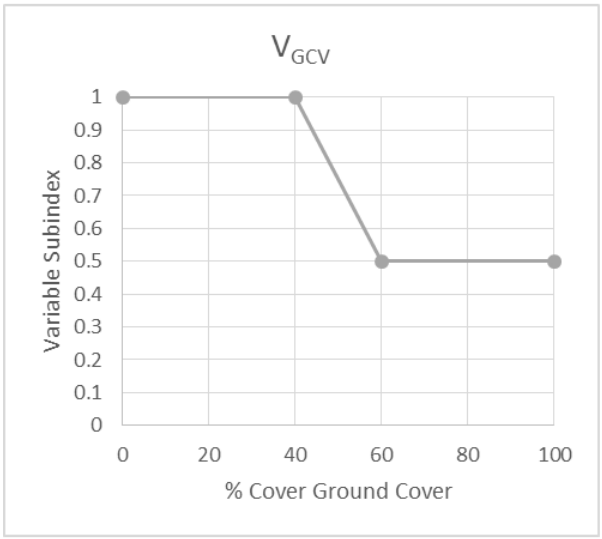

V_{OHOR}
Variable Subindex
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
1
2
3
4
5
6
7
Depth of O-Horizon

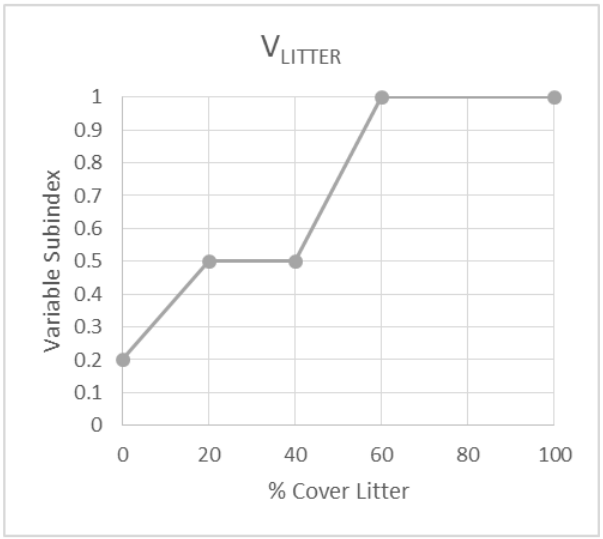

V_{COMP}
Variable Subindex
0
0.2
0.4
0.6
0.8
1
0
20
40
60
80
100
Adjusted Quality index (Composition and Diversity Concurrence of Dominant Woody Stratum)

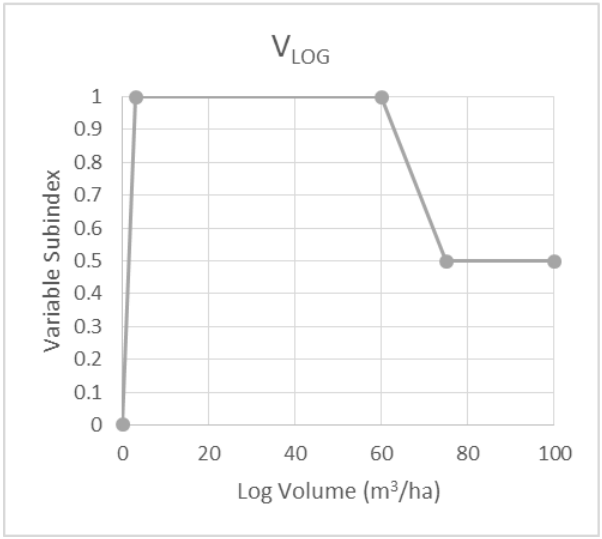
APPENDIX D

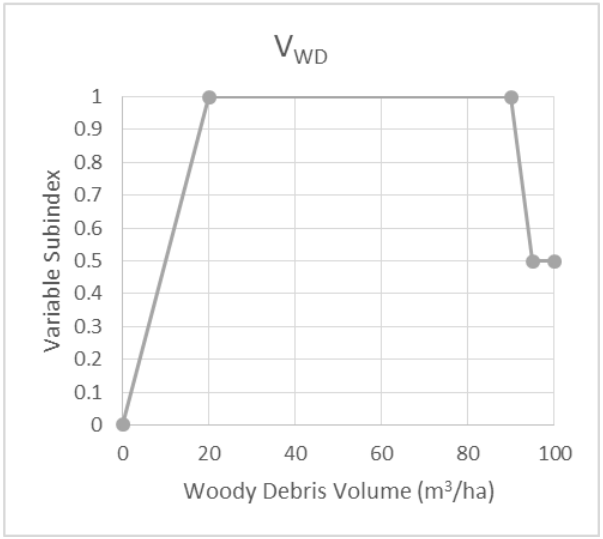

V_{TCOMP}
Variable Subindex
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
20
40
60
80
100
% Composition Concurrence of Tree Stratum


V_{SSD}
Variable Subindex
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
1000
2000
3000
4000
5000
Shrub and Sapling Density (stems/ha)


V_{GCV}
Variable Subindex
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
20
40
60
80
100
% Cover Ground Cover


V_{LITTER}
Variable Subindex
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
20
40
60
80
100
% Cover Litter


V_{LOG}
Variable Subindex
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
20
40
60
80
100
Log Volume (m^3/ha)


V_{WD}
Variable Subindex
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
20
40
60
80
100
Woody Debris Volume (m^3/ha)

APPENDIX D