Hydraulic Connectivity to Riparian Habitats in the Colorado and Lavaca Basins

August 11, 2023

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Performed for:

Texas Parks and Wildlife Department, Austin, TX

and

Texas Water Development Board, Austin, TX

Texas Parks and Wildlife Department Contract No. CA-0001260

Texas Water Development Board Contract No. 2000012438

Pursuant to House Bill 1 as approved by the 86th Texas Legislature, this study report was funded for the purpose of studying environmental flow needs for Texas rivers and estuaries as part of the adaptive management phase of the Senate Bill 3 process for environmental flows established by the 80th Texas Legislature. The views and conclusions expressed herein are those of the author(s) and do not necessarily reflect the views of the Texas Water Development Board.

Acknowledgments:

The following staff at the Texas Parks and Wildlife Department
and the Texas Water Development Board provided invaluable assistance for this project:

Daniel J. Daugherty, PhD, and Kevin Mayes
Inland Fisheries Division, Texas Parks and Wildlife Department, Austin

Mark Wentzel, Texas Water Development Board, Austin

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1 Introduction

In 2007, the passage of Senate Bill 3 (SB3) of the 80th Texas Legislature amended the Texas water code (Section 11.0235) and established a stakeholder-driven process for identifying and quantifying flow regimes needed to maintain sound ecological environments in Texas rivers and estuaries. Environmental flow recommendations for the Colorado and Lavaca rivers were made in 2011 and used to develop environmental flow (e-flow) standards by the Texas Commission on Environmental Quality (TCEQ) in 2012. The SB3 process includes an adaptive management component wherein a Basin and Bay Area Stakeholder Committee can recommend changes as new data and information become available within their areas. This study is one of several studies conducted since 2011 whose results could help guide refinement of e-flow standards for the Colorado and Lavaca rivers.

Since 2009, the nonprofit Texas Conservation Science, Inc., (TCS) has quantified the river discharge requirements of riparian habitats in Texas, with an emphasis on declining riparian forests. The current assessment of river discharge-riparian habitat connectivity within the Colorado and Lavaca River basins is a cooperative effort of the Texas Parks and Wildlife Department (TPWD), the Texas Water Development Board (TWDB), and TCS. The project extends our shared efforts to implement long-term riparian planning mostly on private ranches and farms in the Guadalupe, Brazos, Trinity, Cypress, and other Texas river basins. With additional funding from the Caddo Lake Institute, the Sustainable Rivers Program (U.S. Army Corps of Engineers [USACE]), and The Nature Conservancy, TCS helps to establish riparian research sites across Texas. In this manner, over three dozen long-term riparian research sites have been established by TCS and its partners in multiple Texas river basins. The sites utilize comparable methods for quantifying the efficacy of environmental flows and other river discharge for sustaining riparian resources.

This report investigates the applicability of a new remote-sensing approach to evaluate the relationship between mean daily discharge (MDD), as measured in units of cubic feet per second (cfs), and riparian habitat connectivity at 10 study sites along the Colorado and Lavaca rivers in Texas. The study sites are centered upon streamflow gages, where TCEQ e-flow standards have been adopted for each stream segment. Standards consist of flow regime components that typically include subsistence, base flow, and high flow pulses. Flow regimes that vary through time, are defined by hydrologic characteristics, that support water quality, geomorphology, connectivity, and the biology of riverine and floodplain systems including riparian habitats. The standards for seasonal base flows and seasonal small pulse triggers at each site are the focus of the current investigation to determine habitat connectivity for riparian areas, including prime backwater habitat. This exploratory study will help inform validation, adjustment, and refinement of e-flow standards for these sites and potentially other basins.

Interest in the management and conservation of the Alligator Gar (*Atractosteus spatula)* has greatly expanded in recent decades following listing of the species as vulnerable by both Jelks et al. (2008) and Smith et al. (2020). Due to reductions in connectivity to floodplain spawning habitats, historical eradication efforts, and overharvest, populations of Alligator Gar have declined in the Mississippi River basin and many Gulf Coast systems (Kluender et al. 2017; Lochmann et al. 2021). This, combined with a growing popularity of Alligator Gar as a trophy angling species in Texas (Binion et al. 2015; Buckmeier et al. 2017; Smith et al. 2018) has necessitated fisheries managers to gain a better understanding of recruitment dynamics in relation to flow regimes, to effectively manage populations. Thus, this study provides informative data for the study of Alligator Gar year class strength as well as other floodplain-adapted fishes.

1.1 Project Area

Figure 1 maps the locations of the ten study sites on the Colorado and Lavaca Rivers in Texas. Table 1 provides more detailed information regarding the study site locations, including U.S. Geological Survey (USGS) steamflow gage identification numbers and coordinates. Table 2 includes the mean daily discharge rates (MDD, cfs) for TCEQ e-flow standards applicable to each study site. The 2x10-mile sites are centered on the USGS stream gages where TCEQ has adopted e-flow standards for each relevant stream segment.

2 Riparian Habitats

The hydraulic connectivity of riparian habitats with adjacent rivers is critical for the restoration and conservation of floodplain habitats (King et al. 2009). Nilsson and Svedmark (2002) present riparian areas as complex non-equilibrium ecosystems functioning as multi-level floodplain networks extending down to the low-water mark of stream channels. Their literature review identifies three fundamental approaches for understanding riparian systems: (1) flow-regime control of plant productivity and ecological function, (2) riparian-corridor connectivity for material transport, and (3) species-rich linkages of land and water processes. The current research combines remote sensing and hydrology to quantify the essential linkage between the river and its floodplain.

In undisturbed floodplains, habitats are dominated by a diversity of swamp and riparian forests, along with shrub and herbaceous wetlands, and both lentic and lotic aquatic habitats. More than any other factor, the sustainability of ecosystem processes within floodplains depends upon connectivity among these different habitat patches via water level fluctuations (Thoms et al. 2005, Junk et al. 1989).

When the amount of accessible floodplain expands, fish production increases greatly (Junk et al. 1989). Fish spawning is often coordinated with rising floodwater, with spring spawners targeting the seasonal coincidence of rising floodwaters and warmer temperature. Similar to the effect on tree recruitment following spring floods, fish recruitment depends on the gradual retreat of flood waters during the warm growing season (Junk et al. 1989). A slow drop in water levels also allows invertebrate prey populations, which increase due to coincidental nutrient runoff, to reach higher densities. Bayley (1995) documented that the earlier and more brief overbank events in recent decades, largely due to anthropogenic floodplain disturbance, disrupt the evolutionarily synchronized timing of fish spawning and invertebrate prey availability. Similarly, waterfowl are adversely impacted by decreased flood frequency, due to decreases in habitat accessibility, food availability, and nutritional quality (Heitmeyer 2006).

The exchange of organic matter and nutrients among different habitats starts with variable river levels that trigger switches between biological production and transfer phases within floodplain habitats (Amoros and Bornette 2002). Flood pulsing causes successive oxic and anoxic soil conditions within floodplain riparian forests, which drive nutrient processing. Hunter et al. (2008) document positive linear correlations of soil moisture in riparian forests with heterotrophic microbial activity, readily mineralizable carbon, and soluble organic carbon.

2.1 Riparian Connectivity

As discussed by King et al. (2009), impacts to riparian habitats and connectivity on both public and private lands pose serious threats to downstream resources, including the quantity and quality of stream flow, and the maintenance of lotic, lentic, and adjacent terrestrial habitats. Species composition varies among these habitats primarily due to different species tolerances to site-specific regimes of inundation and soil saturation. When researching connections between tree growth and inundation, Smith et al. (2013) showed that river flow variables impacted riparian tree growth more than climate. A higher frequency of floods either directly increases riparian forest growth rates or indirectly does so by impeding less flood-adapted competitors. In addition to hydrology, the location of riparian forest stands within the diverse floodplain mosaic of geomorphology, soils, and available plant species also causes variation in species composition and structural characteristics across floodplains. A consequence of the interplay among these factors is that the biodiversity of riparian forests is usually double that of nearby upland forests (Gosselink et al. 1981).

Seasonal inundation is the driving force for the maintenance of floodplain habitat. The site-specific combination of duration, frequency, timing, and depth of flooding is called the “hydroperiod.” The hydroperiod is the determining factor for species composition of both plants and animals in riparian forests, due to the evolutionary matching of species distributions and hydrologic cycles (Bedinger 1981, King and Allen 1996). In east Texas riparian habitats, flood duration is the most important influence of the hydroperiod on plant species composition (Dewey et al. 2006). The competitive sorting of species during annual recruitment is mostly determined by the spring hydroperiod, which exerts a disproportionate influence on seedling establishment and the early stages of succession.

Annual or nearly annual flooding is the defining feature of riparian forests. Annual flooding maximizes the increasingly valuable ecosystem and related economic benefits of riparian areas, including primary production, plant diversity, animal habitat use, organic matter export, and improved water quality (Gosselink et al. 1981, Hunter et al. 2008, Opperman et al. 2010). For example, a reduction in overbank flows results in the loss of backwater areas that comprise a primary source of labile carbon, which forms an essential foundation of riverine and downstream estuarine food chains (Thoms et al. 2005). In this manner, the maintenance of river-floodplain connections results in consistently higher freshwater fishery yields (Bayley 1995).

2.2 Riparian Productivity

Junk et al. (1989) show that the predictable seasonal timing of long-duration floods allows biotic adaptations to more efficiently utilize resources, allowing floodplain water flux to foster rapid recycling of organic matter and nutrients. As with seedling establishment, drawdown following a flood is likely more important to production than rising water levels in many temperate systems (Bayley 1995). In addition to the rate of rise and fall, the timing of overbank flows relative to rising temperatures influences annual productivity. Since most floods in the southeastern United States occur in winter or spring, water temperatures are more conducive to high biotic productivity during drawdown, as opposed to the rising phase of the hydrograph.

Overbank flows sustain the high productivity of riparian forests by elevating rates of annual litterfall and nutrient turnover, increasing decomposition rates, and flushing of accumulated detritus and metabolic waste products (Conner et al. 1990, Hunter et al. (2008). The temporal distribution of overbank flows is the primary determinant of not only habitat types, but also regulates biogeochemical processes in bottomland soils, such as decomposition, sedimentation, and Nitrogen (N) cycling (Hunter et al. 2008).

2.3 Prime Backwater Habitat

Prime backwater habitat includes terrestrial vegetation inundated to relatively shallow depth of (<1-m), often extending beyond the mainstream channel. Such habitat promotes foraging by both fish and wildlife, along with fish spawning. Within its range, which in the study area includes the Colorado River basin below Austin and the Lavaca River basin, prime backwater habitats provide critical spawning and nursery habitats for the Alligator Gar, which is a focal point of the current study.

Alligator Gar rely on seasonal connectivity to floodplain and backwater habitats for reproduction and recruitment (Buckmeier et al. 2017; Smith et al. 2020). Spawning success is tied to overbank flooding during spring and summer months at water temperatures greater than about 20°C (Smith et al. 2020). Pre-spawn fish enter the floodplain as water levels rise, and aggregations of multiple individuals can be found in shallow areas associated with inundated terrestrial vegetation under open canopies (Inebnit 2009; Allen et al. 2014; Kimmel et al. 2014; Sakaris et al. 2014). Female Alligator Gar are joined by multiple males, typically numbering from two to eight fish, who compete to fertilize the eggs as they are broadcast over vegetation (Mendoza et al. 2008). As a result of such observations, Buckmeier et al.(2017) proposed habitat suitability criteria for water temperature (20 to 30 °C, coinciding with spring and summer months), hydrology (inundation of floodplain habitats to a depth of at least 1 m (1 meter = 3.28 feet) for a minimum of 5 days), and habitat characteristics (open canopy with herbaceous or small woody vegetation within 0.5 m of the water surface where there is little or no flow).

Robertson et al. (2018) found that Alligator Gar recruitment mostly coincides with available spawning habitat during May through July. They found discharge and temperature variables to be less important than the availability of spawning habitat as defined above. Strong recruitment is also correlated with proximity to permanent open water and major floods during the spawning season (Smith et al 2020). Late-season (June-July) inundation produces the strongest recruitment, as confirmed by Buckmeier et al. (2017) and Robertson et al. (2018).

3 Methods

3.1 Flow Event Selection

Historical USGS daily stream flow records (1982-present) were analyzed to select flow-event dates for wetted-surface classification. To avoid imagery obscured by canopy cover, only flow events during the leaf-off period of December 15 and March 15 were considered for wetted-surface analysis. To avoid error due to previous inundation lingering on the floodplain, none of the selected event days had higher flows in the preceding three days. In this manner, the selected days were limited to rising or stable discharge periods. No dates were selected during a period of declining flows.

3.2 Wetted-Surface Classification

3.2.1 Multispectral Imagery

For multispectral imagery, the inundation classification is derived using the normalized difference water index (NDWI), which effectively measures the wetted surface. The NDWI is a band-ratio water index that is derived from the near infrared band and the green band of the remote sensing imagery. NDWI is calculated using the following formula:

NDWI = (Green – Near-Infrared) / (Green + Near-Infrared)

NDWI calculation according to imagery source:

- NAIP: *NDWI* = (Band 2 – Band 4) / (Band 2 + Band 4)
- TOP: *NDWI* = (Band 1 – Band 3) / (Band 1 + Band 3)
- Landsat 4, Landsat5, and Landsat7: *NDWI* = (Band 2 – Band 4) / (Band 2 + Band 4)
- Landsat 8: *NDWI* = (Band 3 – Band 5) / (Band 3 + Band 5)

3.2.2 NAPP Aerial Photographs

Where usable multispectral imagery is unavailable, NAPP aerial photographs are employed after being first geo-rectified by adding ground control points (GCPs). The closest available high-resolution multispectral imagery is then used as the reference image, with the GCPs added where a landmark can be observed both in the NAPP image and its reference image. Since NAPP aerial photographs lack the multispectral information, the inundation classification was created based on a band ratio derived from R channel and G channel of the georeferenced aerial photograph images. The band ratio is calculated using the formula below:

Band Ratio = (R – G) / (R + G)

3.2.3 LIDAR DEM Imagery

For the LiDAR DEM imagery, the density slicing method is applied to prepare the imagery for the inundation classification using a threshold value. The threshold value is observed at the pixels where the boundary of the wetted surface is located. The tool used to conduct this density slicing method is called Density Slices available in the ENVI 5.6 software package.

3.3 Detailed Classification Methodology

ENVI 5.6 and ESRI ArcGIS pro 3.0 software are used to map the wetted-surface based on the available imagery. All classifications follow the same step-wise methodology, as described below.

Wetted-Surface Mapping:

1. Download the acquired scenes for specified dates.
2. Mask the study reaches. The mask is created from a 2X10-mile buffer of the study reaches and saved as a shapefile via ESRI ArcGIS pro.
3. The images covering the study-site reaches are classified into two thematic classes based on the NDWI image used. The threshold value is observed at the pixels where the boundary of the wetted surface is located. The ENVI color slicing process is used to clearly separate wetted-surface class and non-wetted-surface class. The two-class thematic image is converted into shapefile format via ESRI ArcGIS.

4. The two thematic classes are then assigned to either wetted-surface class or non-wetted-surface class by visual interpretation using the raw image.
5. The resulting two-class image is re-coded using ESRI ArcGIS Raster Editor tool. The ESRI ArcGIS Eliminate tool is then run on the two-class image. The ESRI ArcGIS Eliminate tool is used to remove all groups of pixels less than one hectare in area, those areas smaller than one hectare are assigned the value of the nearest larger class.

Quality Control:

1. Create a set of random points within the thematic classified area and assign the two-class code to each individual point via visual interpretation for referencing.
2. ESRI ArcGIS Spatial Selection is run on the random points using the wetted-surface and non-wetted-surface polygons separately. Assign the class information to the set of random points above.
3. The accuracy estimate is the ratio between the number of errors wetted-surface (non-wetted-surface) points and the actual wetted-surface (non-wetted-surface) points.

3.4 Geographical Information System

ArcGIS pro 3.0 was used to calculate inundation acreages for each TPWD Texas Ecological System (TES) type (Elliott, L.F., et al. 2014, Elliot, L.F. 2009) within the specified study reaches by overlaying final wetted-surface shapefiles based on suitable scenes. TES types are also called habitat types in this study. Therefore, the first step was to acquire suitable TPWD TES shapefiles for each study site (https://tpwd.texas.gov/gis/data/downloads), prepare study-reach shapefiles, and acquire wetted-surface shapefiles for specified dates.

In order to measure area of inundation, first TES data was clipped into the study-reach area polygon. To tabulate acreages, an attribute field (double) in the TES attribute table named “area” was created and set to calculate area in hectares. Using shapefiles created from the 2X10-mile buffer extending from the river centerline located within the study reach, the Clip tool was used to apply TES data to each study site. The “Zonal Statistics as Table” tool was used to determine which habitat types were located in the same position as the wetted-surface data for that increment, as well as for the summarized area data. Using the “Zonal Statistics as Table” tool, the newly formed intersects’ Statistics field was set to the previously created area attribute and the Case field to Common Name. Summary results were opened and acreages transferred from ArcGIS table into an Excel spreadsheet. Summary Statistics were also utilized when tabulating total habitat areas for study sites by using the previously clipped TES data as input with no wetted-surface intersect.

Zonal Statistical Analysis:

1. Export the wetted-surface class only, as a new image.
2. Mask the TES classification shapefile. The mask is derived in Step#2 of wetted-surface mapping.
3. Conduct zonal statistical analysis to measure the total area in hectares and percentage of wetted surface in each TES class. The Zonal Statistics as Table tool is used, while the wetted-surface image and TES classification are used as inputs.

3.5 Modeling Habitat Inundation Relative to TCEQ E-Flow Standards

The following methods were applied in Excel by pairing site-specific empirical data for USGS MDD data and remote-sensing habitat-inundation data (Tables 3-22) for each site. In the current study, frequently flooded open-canopy grasslands, croplands, and woodlands are together mapped as prime backwater habitats, based on criteria listed in Robertson et al (2018). for the evaluation assessed the following habitat categories:

- Prime backwater habitats: Herbaceous
- Prime backwater habitats: Open Woody Non-Forest
- Prime backwater habitats: Open water
- Total prime backwater habitats
- Total habitat Inundation

The resulting site-specific statistical extrapolation models were then utilized to produce the above habitat inundation values (ha) corresponding to the TCEQ e-flow standards (Table 2) for each site. Comparison of modeled data values in both linear and exponential regressions using respective values showed exponential regression to be the best fit statistically for the observed habitat-inundation data with a higher coefficient of determination (R^2) value. R^2 is commonly used to describe the strength of modeled relationships being the proportion of total variability explained by the regression line (Helsel et al., 2018). This strength explains overall fitness of a relationship and when comparing linear and exponential fitness exponential was drastically higher, formulations were then created for respective habitats (Helsel et al., 2018). The statistical extrapolation of data was conducted based upon site-specific exponential formulations created by the regression line.

Extrapolated hectare values were completed in Microsoft Excel by using site specific formulas in Goal Seek Forecast, which is a type of "what if analysis" tool that calculates a variable with respect to the desired outcome. In this case, the variable is hectare, and our desired outcome are the MDD flow values using the formulated equations. Goal Seek needs 3 parameters to function a set cell (reference site-specific formula), to value (desired output – MDD Flow) and the Excel cell that will create and tabulate hectare values (Goal Seek Tool). The forecast for this project was conducted on all sites and habitat specific formulations respective to TCEQ e-flow standards.While we explored regression analyses to quantitatively model habitat inundation in relation to flow, low data density and distribution (i.e., few useable event dates across a wide range of flows) for many sites limited inferences. Therefore, we elected to forgo quantitative modeling approaches in favor of providing scatter plots.

4 Results: Habitat Inundation

Figure 1 maps the locations of each of the ten study sites. Detailed location information is listed in Table 1 for all study sites, including river basin, USGS stream-gage name and number, and coordinates. Table 2 presents additional study-site information, such as discharge rates for the seasonal TCEQ e-flow standards for based flows and small pulse triggers. Figures for low-flow events are included primarily to establish a visual baseline for delineating site-wide plant cover and existing open-water resources, prior to applying the wetted-surface mask to inundation-event figures.

4.1 Field Validation

The following field validations were performed at sites 2, 3, and 9. Only low-flow events were available during the work period. However, important data were acquired concerning site conditions, including the effectiveness of remote-sensing.

4.1.1 Site 2: Navidad River at Strane Park near Edna, TX:

Dates: 02/16/23 & 05/03/23 **Personnel**: **Tom Hayes**

Location: Strane Park, small open-access roadside parking spot on CR 401 off highway 111.

Survey Location: Surveyed area extends 1 mile downstream of Strane Park.

GPS: N 29.06407, W 096.67987

Average Depths and Widths of Discharge:

(1 centimeter (cm) = 0.394 inch, cfs = cubic feet per second, 1 meter (m) = 3.28 feet)

02/16/23: MDD: 14.2 cfs Depth: 20 cm (15-27 cm) Width: 16 m (15-17.5 m)

05/03/23: MDD: 52.7 cfs Depth: 50 cm (35-80 cm) Width: 22 m (18-30 m)

Overstory canopy openness: 10% (0-50%) **Ground cover:** 95% (90-100%), *Chasmanthium latifolia*, catbrier, poison oak,

Density and height: In-Channel

Herb layer: density: 2%, height: 35 cm, dominant: sedge, baby blues, Panicum,

Shrub layer: density: 2% (0-3%), height: 55 cm, dominant: black willow, Virginia creeper

Tree layer: over-channel density: 100-85 %, height: 15-25 m, dominant: pecan, sycamore, boxelder

General: The sandy streambed was without large rocks, under a closed overstory canopy. Several Alligator Gar up to 6 feet long were observed feeding near the park during both site visits. Nearly 100% closed canopy mostly prevented observation of the river channel during remote-sensing.

4.1.2 Site 3: Colorado River near Ballinger, TX:

Date: 02/14/23 **Personnel**: Tom Hayes

Location: private property near Ballinger, TX

Survey Location: Surveyed area extends 3 miles downstream from CR 288 bridge

GPS: N 31.71502, W 100.02654

Average Depths and Widths of Discharge:

MDD: 0.56 cfs Depth: 5-10 cm Width: 1-2 m

Overstory canopy openness: 100% **Ground cover:** 100-40%

Density and height: In-Channel

Herb layer: 60% density, height: 10-100 cm, switchgrass dominant with bulrush and narrow-leaf cattail

Shrub layer: 0-5% density, height: saltcedar, Baccharis

Tree layer: adjacent to channel: 5-10% density, soapberry dominant with Celtis,

General: The 10-18 m wide riverbed consists of long pools hundreds of feet long, separated by 100-200 m long in-channel marsh with dense plant cover that finely disperses flow that is not detectable in imagery.

4.1.3 Site 9: Pedernales River near Johnson City, TX:

Date: 02/15/23 **Personnel**: Tom Hayes

Location: Pedernales River Nature Park, LCRA, Johnson City, TX.

Survey Location: Surveyed area extended 1 mile downstream from dam in park.

GPS: N 30.284295, W 98.398370

Average Depths and Widths of Discharge:

MDD: 16.4 cfs Depth: 5-30cm deep with dispersed pools 50 cm deep
Width: 15-25 m

Overstory canopy openness: 90% (20-100%) **Ground cover:** 15% (8-50%)

Density and height: In-Channel

Herb layer: 8-50% density, height: 50 cm, switchgrass & Sesbania dominant

Shrub layer: 0-5% density, height: 1-3 m, roughleaf dogwood, mesquite

Tree layer: adjacent to channel: 5% (0-30%) density, pecan

General: Below the park dam, rapids with medium-sized rocks separate 200-300 m long shallow pools, which dominate the river channel. Between pools, thick marsh and shallow rapids distribute flow into small channels (20-30 cm wide) undetectable in imagery.

4.2 Wetted-Surface Classifications:

Due to the lack of imagery particularly for high discharge events, TCS performed a regression analysis for each site to derive habitat inundation hectares for the TCEQ e-flow standards, including seasonal average base and seasonal small pulse triggers. Most regressions resulted in high R^2 values. However, the trend lines did not fit the data well due to too few data points. Therefore, a decision was made to only include scatter plots of flow versus habitat inundation for the report (Figures 32-41).

4.2.1 Site 1. Lavaca River near Edna, TX

Low and High Flow Dates & MDD: 02/18/15: 3.52 cfs, 01/01/03: 1,880.00 cfs

Figures 2-4 present the wetted-surface classifications of satellite imagery for the above event dates at Site 1. Tables 3 (summary) and 13 (details) list the inundated hectare data by TES habitat type and prime backwater suitability for the 8 analyzed flow events at Site 1. In this report, river discharge (cfs) is measured as MDD (mean daily discharge, cfs).

Figure 32 presents scatter plots for flow versus habitat inundation for Site 1. At an MDD of 1,880 cfs, extensive areas of the floodplain are inundated up to the upland transition. In this manner, contiguous wetted areas of prairies and cropland are created. Out of the total flooded area of 1,644.16 hectares (ha) on 01/01/03, 1,304.12 ha (1 hectare [ha] = 2.47 acres) of prime backwater habitat are potentially provided, depending on flood duration, water temperature, etc. (Tables 3 & 13). At Site 1, satellite imagery indicates that backwater inundation begins at 250 cfs (Table 23).

4.2.2 Site 2. Navidad River at Strane Park near Edna, TX

Low and High Flow Dates & MDD: 02/18/15: 1.25 cfs, 01/01/21: 710.00 cfs

Wetted-surface classification results are mapped in Figures 5-7 for the above event dates at site 2. Inundation hectares are tallied by habitat type and prime backwater suitability for a total of 9 inundation events in Tables 4 (summary) and 14 (details). At a high-flow MDD of 710.00 cfs on 01/01/21, 647.2 ha, out of an inundated total of 945.4 ha, consisted of prime backwater habitat. Scatter plots for flow versus habitat inundation are provided in Figure 33 for Site 2. Similar to Site 1, a MDD of 250 cfs initiates backwater inundation at Site 2 (Table 23).

4.2.3 Site 3. Colorado River near Ballinger, TX

Low and High Flow Dates & MDD: 02/11/18: 1.96 cfs, 02/25/92: 2,860.0 cfs

For the available event dates, Site-3 wetted-surface classification results are shown in Figures 8-10. Inundation hectares are tallied by habitat type and prime backwater suitability for a total of 9 events in Tables 5 (summary) and 15 (details), which list the inundated hectare data by TES habitat type and prime backwater suitability during flow events at Site 3. Within the 10-mile study reach, the 02/25/92 high-flow event (2,860.0 cfs) flooded 647.2 ha of herbaceous and open-woody prime backwater habitats highly valuable to Alligator Gar and other fish and wildlife species. Figure 34 includes the scatter plots for flow versus habitat inundation at Site 3. At Site 3, backwater habitats begin to fill at a discharge rate of 200 cfs (Table 23).

4.2.4 Site 4. Colorado River above Silver, TX

Low and High Flow Dates & MDD: 02/08/96: 3.20 cfs, 12/23/91: 748 cfs

Figures 11-13 map the wetted-surface results for Site 4, based on classified satellite imagery for the above event dates. The 12/23/91 imagery revels widespread flooding in the middle portion of the reach above Silver, TX., at an MDD of 748.0 cfs. Tables 6 (summary) and 16 (details) list the inundated hectare data by TES habitat type for the 8 analyzed flow events at Site 1. The tables list 748.0 ha of prime backwater habitat available at a MDD of 652.7 cfs on 12/23/91. Scatter plots for flow versus habitat inundation in Figure 35, show essentially all event inundation at Site

4 benefits prime backwater habitats. On the upper Colorado River at Site 4, remote sensing shows that backwater inundation commences at about 125 cfs (Table 23).

4.2.5 Site 5. Colorado River near San Saba, TX

Low and High Flow Dates & MDD: 01/02/07: 64.50 cfs, 03/03/97: 7,410 cfs

Figures 14-16 show wetted-surface classification results for the satellite imagery on the above event dates at Site 5. Tables 7 (summary) and 17 (details) list the inundated hectare data by TES habitat type for the 7 available flow events at Site 5. Despite a high MDD of 7,410 cfs on 03/03/97, only 162.35 ha of available prime backwater habitat is inundated, due to the narrow floodplain. The inundated total for prime backwater habitat includes 71.8 ha of open water, primarily in and immediately adjacent to the main channel, a relatively high percentage. This channel-driven distribution of augmented open water (Figure 14) increases access to productive riparian habitat for both fish and wildlife. However, scatter plots of total event inundation and prime backwater habitat availability (Figure 36) reveal a relatively small proportion of inundation within prime backwater habitats at Site 5. At this site on the middle Colorado River, backwater habitats begin to fill at an MDD of 850 cfs (Table 23), based on available satellite imagery (Table 23).

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4.2.6 Site 6. Concho River at Paint Rock, TX

Low and High Flow Dates & MDD: 03/14/18: 6.22 cfs, 02/25/92: 2,220 cfs

Wetted-surface classifications are mapped in Figures 17-19 for the above dates at Site 6. Inundation hectares are tallied by habitat type for a total of 11 events in Tables 8 (summary) and 18 (details). Similar to Site 5, this Site encompasses a fairly narrow western floodplain. Again, the bulk of inundation is immediately along and connected to the main river channel, leading to increased connectivity with riparian resources. At the same time, compared to Site 5, a higher proportion of flooding connects with areas farther from the river channel. The 02/25/92 high-flow event (2,220 cfs) inundates only 359.83 ha (3.1%) of potential prime backwater habitat (162.94 ha) within the 10-mile study reach. The scatter plots in Figure 37 show a relatively large proportion of flows benefiting prime backwater habitats at Site 6. At this study site on the

Concho River, backwater habitats first connect to the main river channel at an MDD of approximately 30 cfs (Table 23).

4.2.7 Site 9. Pedernales River near Johnson City, TX

Low and High Flow Dates & MDD: 12/26/01: 13.10 cfs, 01/28/19: 01/18/19: 319.00 cfs

Figures 20-22 map the wetted surface on the above dates. As seen in Figure 20, the moderately high MDD of 319.00 cfs on 01/18/18 fills the meander belt and immediately adjacent reaches of the tributary creeks. However, this discharge is insufficient to connect to the large majority of riparian habitats. Inundation hectares are tallied by habitat type for a total of 8 events in Tables 9 (summary) and 19 (details). Figure 38 scatter plots reveal a sharp increase in inundated habitat area above 50 cfs. At this site on the upper Pedernales River, backwater habitats begin to fill at a MDD of 30 cfs (Table 23).

4.2.8 Site 11. Sandy Creek near Ganado, TX

Low and High Flow Dates & MDD:12/01/18: 33.50 cfs, 01/01/03: 1,130.50 cfs

Figures 23-25 depict wetted-surface classifications of satellite imagery for the above event dates at Site 11. Tables 10 (summary) and 20 (details) list the inundated hectare data by TES habitat type for the 6 flow events at Site 11 available for remote-sensing analysis. During the 01/01/03 high-flow event (1,130.5 cfs), the large majority of the 294.67 ha of inundated prime backwater habitat consisted of prime herbaceous habitats (243.30 ha). During the observed high-flow event, Figure 23 documents significant inundation within the meander belt that is widely separated from other inundated habitats in the outer floodplain. As illustrated in Figure 39 scatter plots, only about 50% of flows above 50 cfs inundate prime backwater habitats. At site 11 on Sandy Creek, backwater inundation begins at approximately 165 cfs (Table 23).

4.2.9 Site 13. E. Mustang Ck near Louise, TX

Low and High Flow Dates & MDD: 01/26/90: 2.40 cfs, 03/08/95: 351.00 cfs

Wetted-surface classification results are mapped in Figures 26-28 for the above dates at Site 13. Inundation hectares are tallied by habitat type at this site for a total of 6 events in Tables 13 (summary) and 23 (details). Similar to other sites during a medium high MDD, Figure 26 shows two-part inundation including contiguous areas throughout the meander belt and disjunct wetted surfaces largely in the outer floodplain. This pattern reflects the lower elevations along the main channel and in the more distant floodplain receiving relatively less sediment input. Figure 40 documents the high proportion of flows that sustain prime backwater habitats at Site 13. Remote sensing at Site 13 shows a MDD of approximately 95 cfs to initiate backwater filling (Table 23).

4.2.10 Site 14. Tres Palacios River near Midfield, TX

Low and High Flow Dates & MDD: 03/10/89: 6.70 cfs, 12/07/09: 700 cfs

Figures 29-31 map habitat inundation, based on classified satellite imagery for the above event dates. Inundation hectares are tallied by habitat type for a total of 8 flow events in Tables 12 (summary) and 22 (details). The tables include inundated hectare data by TES habitat type. Figure 29 shows very limited flooding within the meander belt at the medium-high discharge of 700.00 cfs, although significant off-channel inundation is evident mostly in the middle of this 10-mile reach. At this discharge value, a total of 371.00 ha is inundated out of a total of 397.7 ha of potential prime backwater habitat at Site 14. Relative to Site 13, an even higher percentage of discharge at Site 14 sustains prime backwater habitats (Figure 41). At study site 14 on the Tres Palacios River, backwater habitats first connect to the main river channel at an MDD of approximately 125 cfs (Table 23).

5 Discussion

This project explores the use of remote sensing to help determine the efficacy of TCEQ e-flow standards, for average base discharge and small-pulse trigger flows, for connecting riparian habitats. Connectivity between riparian and riverine habitat is critical, since almost all animal biomass within riverine systems is produced within floodplains (Junk et al. 1989). For instance, even for smaller streams, 67-95 percent of invertebrate production takes place in the floodplain rather than the stream channel (Smock et al. 1992). Consequently, many researchers find that bird, mammal, and fish populations decline in riparian ecosystems when flood frequency decreases (Gosselink et al. 1981).

Examination of the above site-specific results from the wetted-surface classifications and the habitat inundation results provides estimates of the minimum discharge levels that provide surface-water connections with slough, side channel, and other backwater habitats. Connectivity of riparian habitats with the river is most important to sustain productivity. Long-duration inundation events in prime backwater habitats during April through July are necessary for the productivity of Alligator Gar (Buckmeier et al. 2017, Robertson et al. 2018), and many other fish and wildlife species. Adjacent areas of permanent open water, such as floodplain ponds, are also important (Allen et al. 2020), possibly as staging areas or temporary refugia during variable backwater flooding. Although habitat structure is a precondition, the annual suitability of prime backwater habitats is highly variable according to temperature and hydrology (Allen et al 2020). Strong Alligator Gar recruitment depends upon major floods during the April-July spawning season (Smith et al 2020), with late-season inundation (June-July) responsible for the strongest reproduction, as confirmed by year-class sampling (Buckmeier et al. 2017, Robertson et al. 2018).,

The study's habitat inundation results include inundated areas for 30-40 TES habitat types, depending on the selected study site. Initiation of flooding is defined as when approximately 1.0-1.2% of prime backwater habitats are inundated, since low-lying backwater habitats would be inundated first.

5.1 Deviations from the Original Scope of Work

- At all study sites, the area for wetted-surface classification was extended to cover a 10-river-mile reach centered on the TCEQ Environmental Flows Measurement Point (USGS gage), for all classifications, including hi-resolution and LANDSAT imagery. Originally, the contract SOW only required a 5-river-mile reach for LANDSAT classification.
- Due to the limited number of usable hi-resolution images, additional LANDSAT classifications were completed for events coinciding with TCEQ e-flow standards.
- Due to georeferencing and other technical issues with high-resolution (NAPP, LIDAR, etc.) imagery relative to the wetted-surface classifications, fewer event dates were included in the study than anticipated.

- Only a few inundation maps could be created for the selected event dates that have NAPP imagery coverage, due to poor quality and/or incorrect georeferencing. Due to the very high NAPP resolution, multiple images are needed to cover one study site. The inundation map may fail due to the poor quality existing of one or more of the multiple NAPP images for a given site and date. Some inundated habitat data were later derived for a limited number of NAPP dates by adjusting the threshold values slightly. The classifications require multiple layers of high-quality multispectral imagery for each frame, which meant that some imagery was discarded.
- Due to technical issues, the delineation of connected vs unconnected wetted surface was determined to be inaccurate, so that only total wetted surface was used in in final classifications. In the imagery, tree, shrub, and herbaceous cover all masked hydrologic connections at different discharge rates. High-resolution imagery did not alleviate the problem, partly due to the wide scale of classifications, However, both connected and unconnected classification datasets were retained. TCS will tabulate or otherwise provide these datasets, if desired.
- A large effort was required to develop and implement new classification methods for the different imagery types and resolve their individual data quality issues. This indicated that modeling habitat inundation versus discharge was the more effective course to address the impact of TCEQ e-flow standards, compared to flow statistics.

5.2 Recommendations

The lack of usable imagery for the study sites limited development of statistical tools such as habitat inundation regression equations. Models would be more accurate if more imagery were available for wetted-surface classification. The most important requirement to effectively apply the methods developed in this study is the acquisition of additional high-quality multispectral imagery for the study sites, including more high-discharge events in the range of the e-flow standards. To the extent possible, days with rising discharge during storm events should be targeted during the leaf-off period of December 15 through March 15. A more immediate alternative may be upfront hydrological assessments, in order to select study sites with sufficient high-quality imagery for a range of discharge, including multiple high-discharge events during the leaf-off timeframe.

6 Conclusion

This remote-sensing research directly links riparian connectivity to river discharge. The sustainability of riparian wetlands is important to maintain buffers to absorb sediments and nutrients transported by rivers and lessen agricultural inflows (King et al. 2009). Study results quantify the discharge rates needed to inundate important riparian and riverine habitats within the study sites and associated river reaches, including sloughs and other backwater environments. Even if their triggers are implemented, these research results indicate the TCEQ seasonal small pulse standards do not sufficiently restore a naturally variable flow regime. For example, a comparison of Tables 2 (Site-specific e-flow standards) and 23 (Discharge rates initiating backwater connectivity) demonstrates that across the ten study sites, almost one-third (13/40) of the seasonal pulse standards, if triggered, do not initiate even minimal inundation of prime spawning and other backwater habitats. This is especially true during the summer.

7 Citations

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Figure 1. Hydraulic Connectivity Study Site Locations

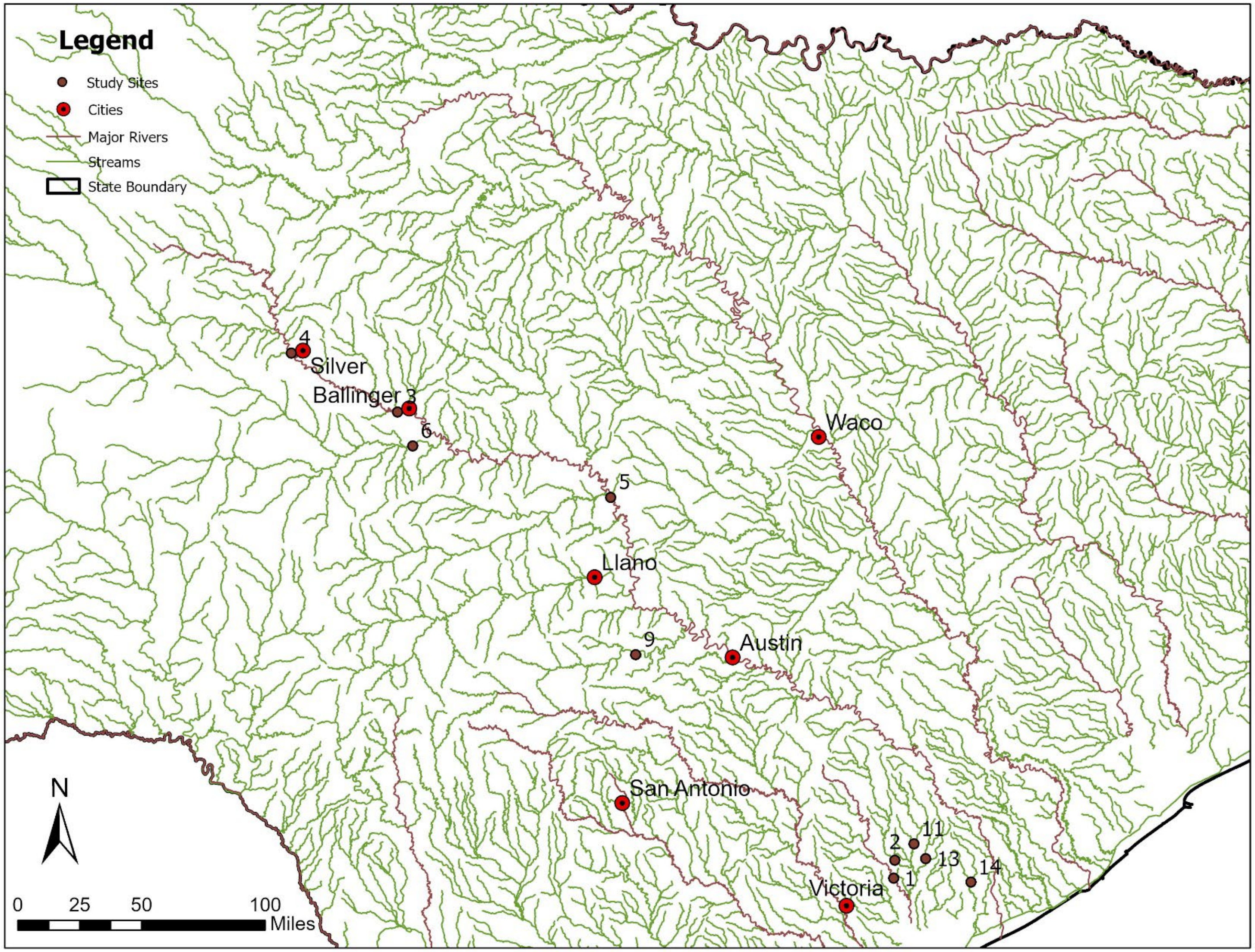


Figure 2. Site 1: Lavaca River near Edna, TX, 01/01/03
Habitat Inundation, MDD: 1,880 cfs

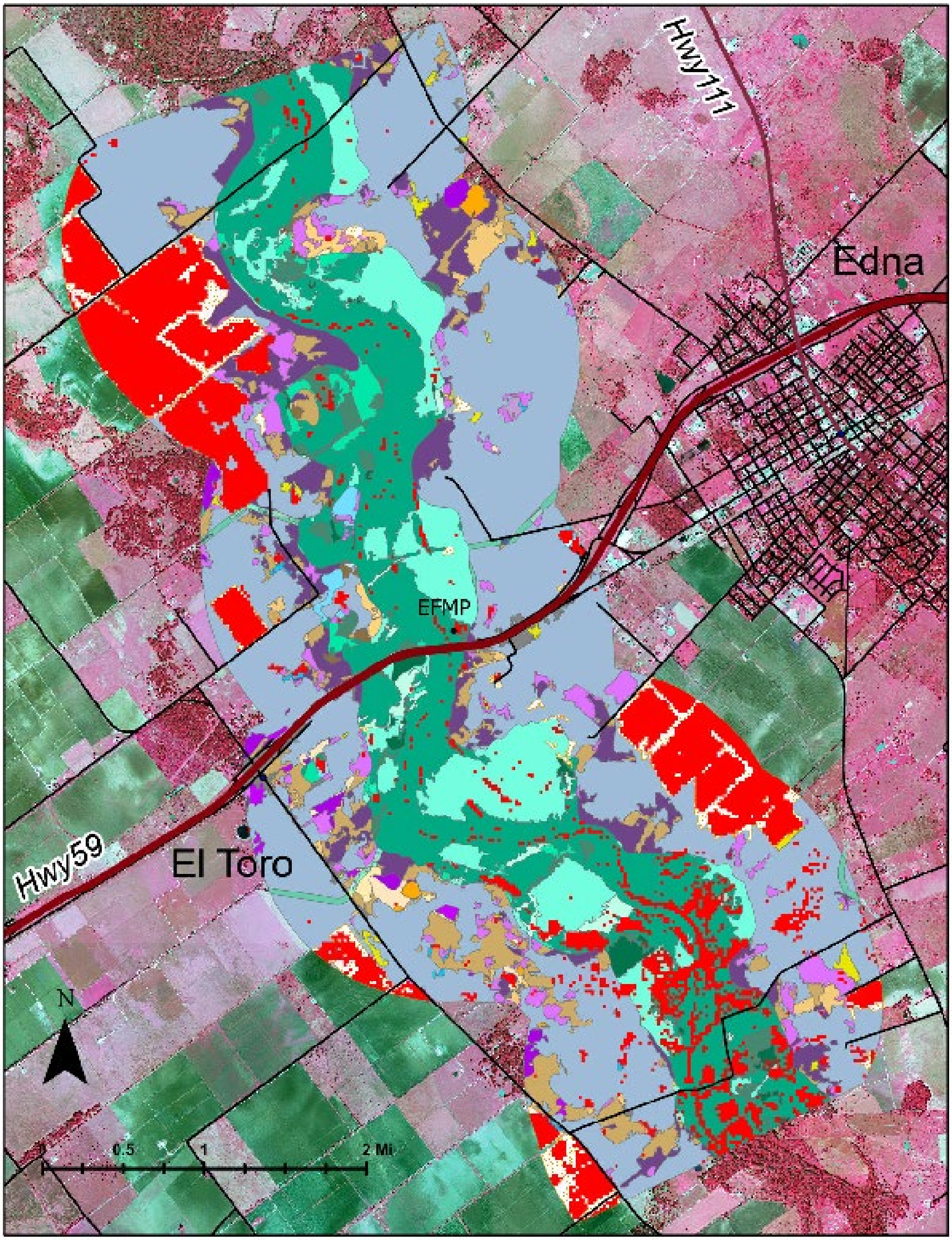


Figure 3. Site 1: Lavaca River near Edna, TX, 02/18/15
Habitat Inundation, MDD: 3.52 cfs

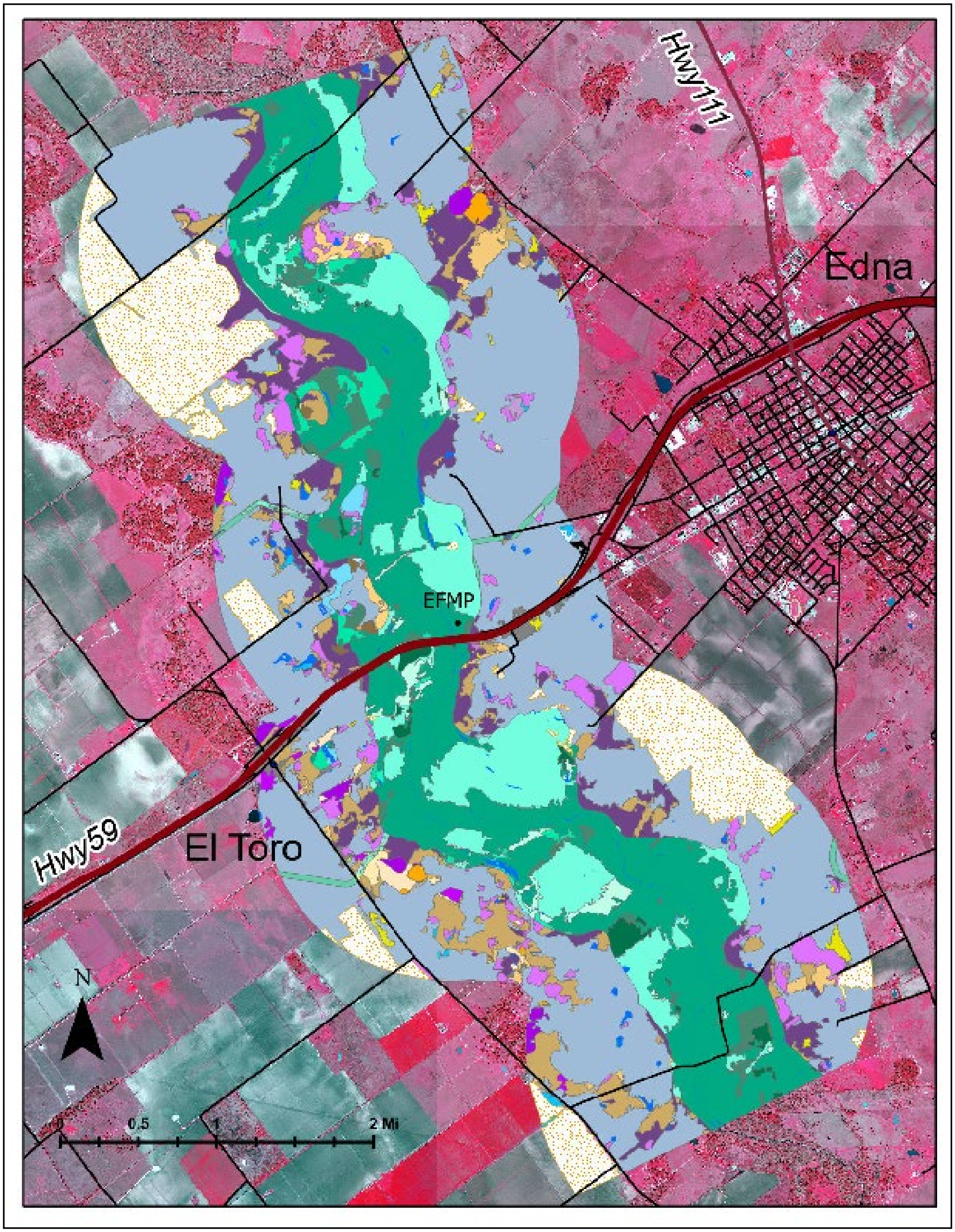


Figure 5. Site 2: Navidad River at Strane Park near Edna, TX, 01/01/21 Habitat Inundation, MDD: 710.00 cfs

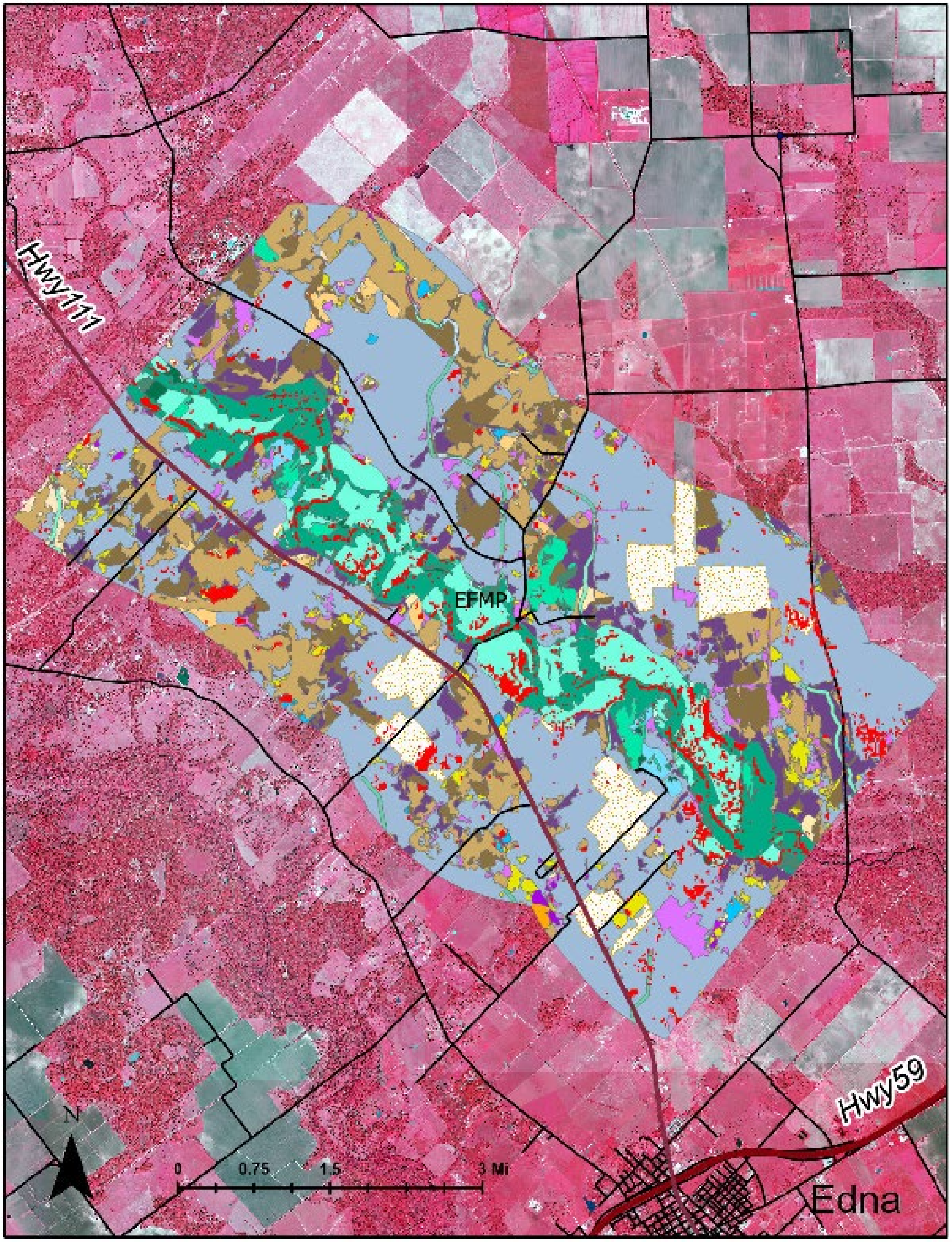


Figure 4. Site 1.
Inundation Map Legend: TES Habitat Types

Texas Ecological System (S1)

- Barren
- Coastal Bend: Floodplain Deciduous Shrubland
- Coastal Bend: Floodplain Evergreen Shrubland
- Coastal Bend: Floodplain Grassland
- Coastal Bend: Floodplain Hardwood Forest
- Coastal Bend: Floodplain Herbaceous Wetland
- Coastal Bend: Floodplain Live Oak - Hardwood Forest
- Coastal Bend: Floodplain Live Oak Forest
- Coastal Bend: Riparian Deciduous Shrubland
- Coastal Bend: Riparian Grassland
- Coastal Bend: Riparian Hardwood Forest
- Coastal Bend: Riparian Herbaceous Wetland
- Coastal Bend: Riparian Live Oak - Hardwood Forest
- Coastal Bend: Riparian Live Oak Forest
- Coastal Plain: Terrace Sandyland Grassland
- Gulf Coast: Coastal Prairie
- Gulf Coast: Coastal Prairie Pondshore
- Invasive: Evergreen Shrubland
- Marsh
- Native Invasive: Baccharis Shrubland
- Native Invasive: Common Reed
- Native Invasive: Deciduous Woodland
- Native Invasive: Huisache Woodland or Shrubland
- Native Invasive: Mesquite Shrubland
- Non-Native Invasive: Chinese Tallow Forest, Woodland, or Shrubland
- Open Water
- Post Oak Savanna: Live Oak Motte and Woodland
- Post Oak Savanna: Live Oak Shrubland
- Post Oak Savanna: Post Oak - Live Oak Motte and Woodland
- Post Oak Savanna: Post Oak - Yaupon Motte and Woodland
- Post Oak Savanna: Post Oak Motte and Woodland
- Post Oak Savanna: Savanna Grassland
- Row Crops
- Urban High Intensity
- Urban Low Intensity

Red Overlay in Maps Denotes Areas of Event Inundation

Figure 6. Site 2: Navidad River at Strane Park near Edna, TX, 02/18/15
Habitat Inundation, MDD: 1.25 cfs

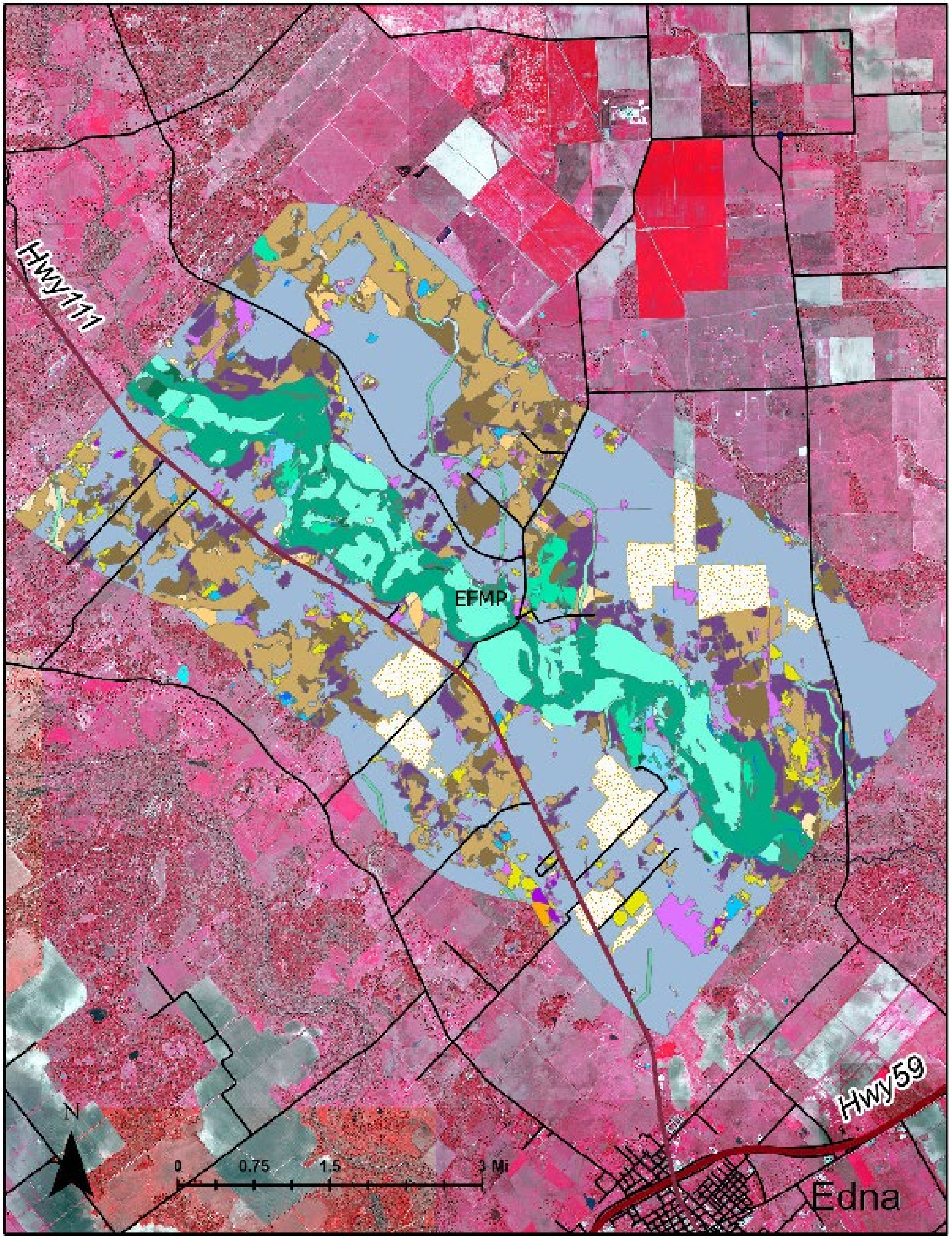
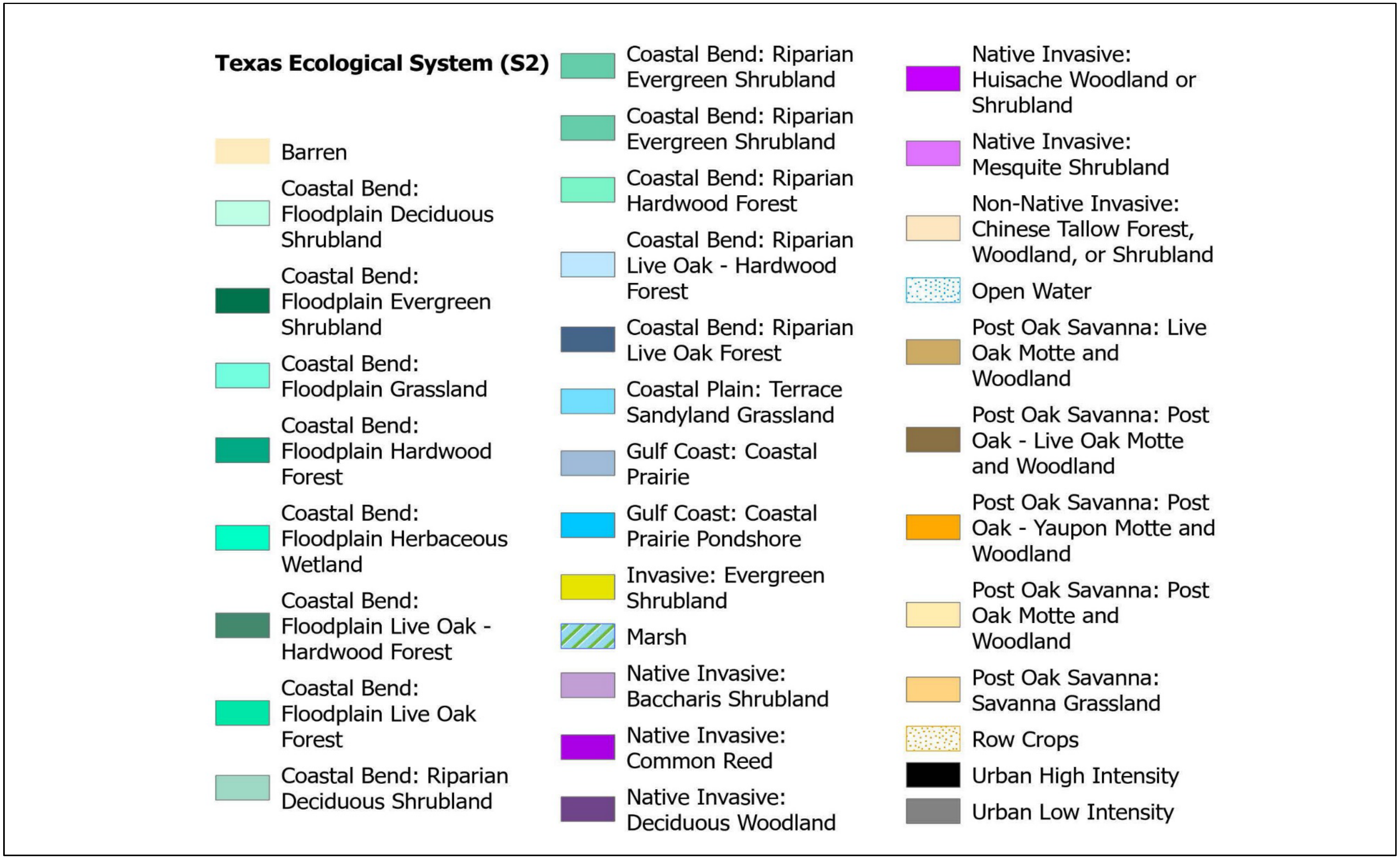


Figure 7. Site 2. Inundation Map Legend: TES Habitat Types



Red Overlay in Maps Denotes Areas of Event Inundation

Figure 8. Site 3: Colorado River near Ballinger, TX, 02/25/92
Habitat Inundation, MDD: 2,860.00 cfs

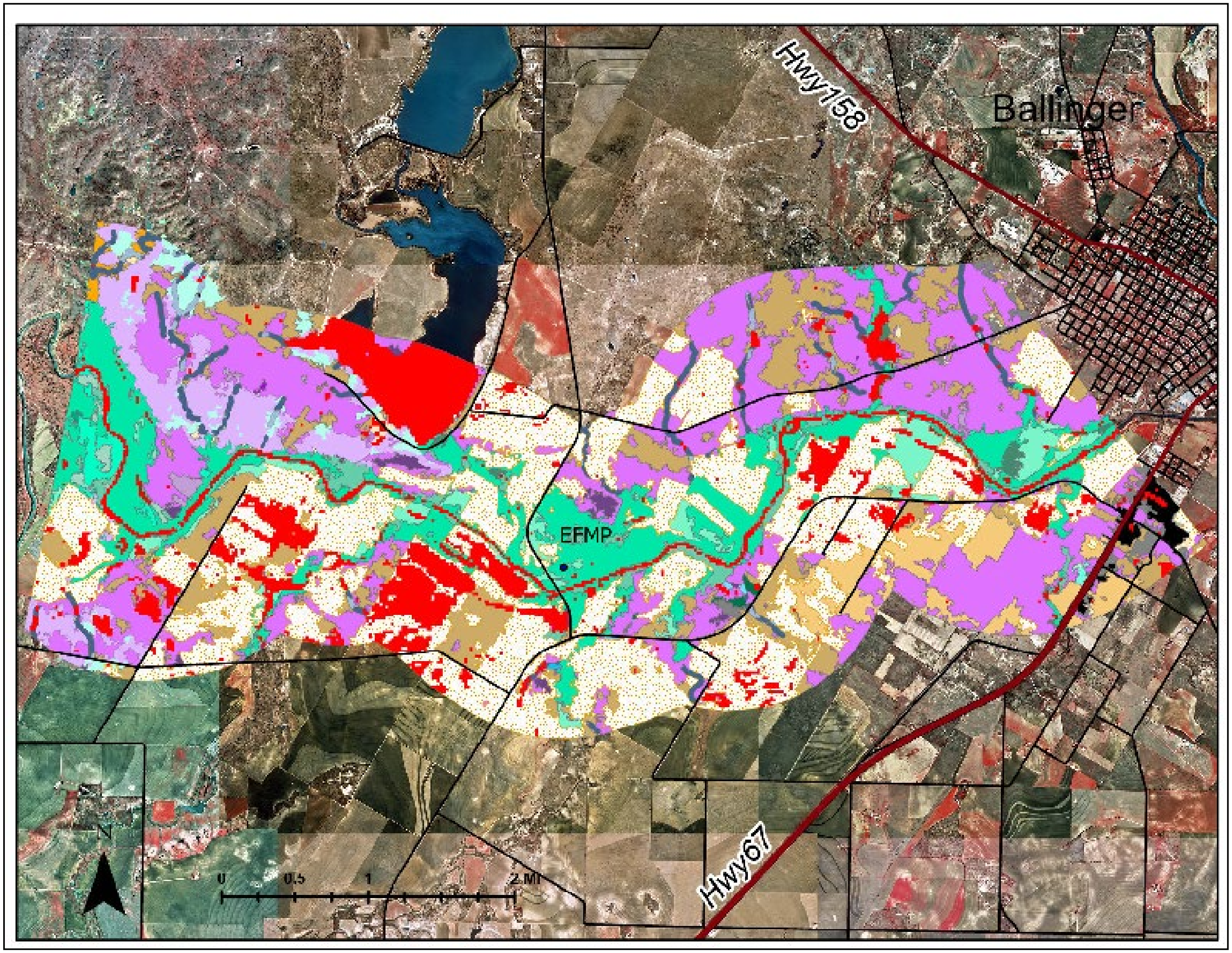


Figure 9. Site 3: Colorado River near Ballinger, TX, 02/11/18
Habitat Inundation, MDD: 1.96 cfs

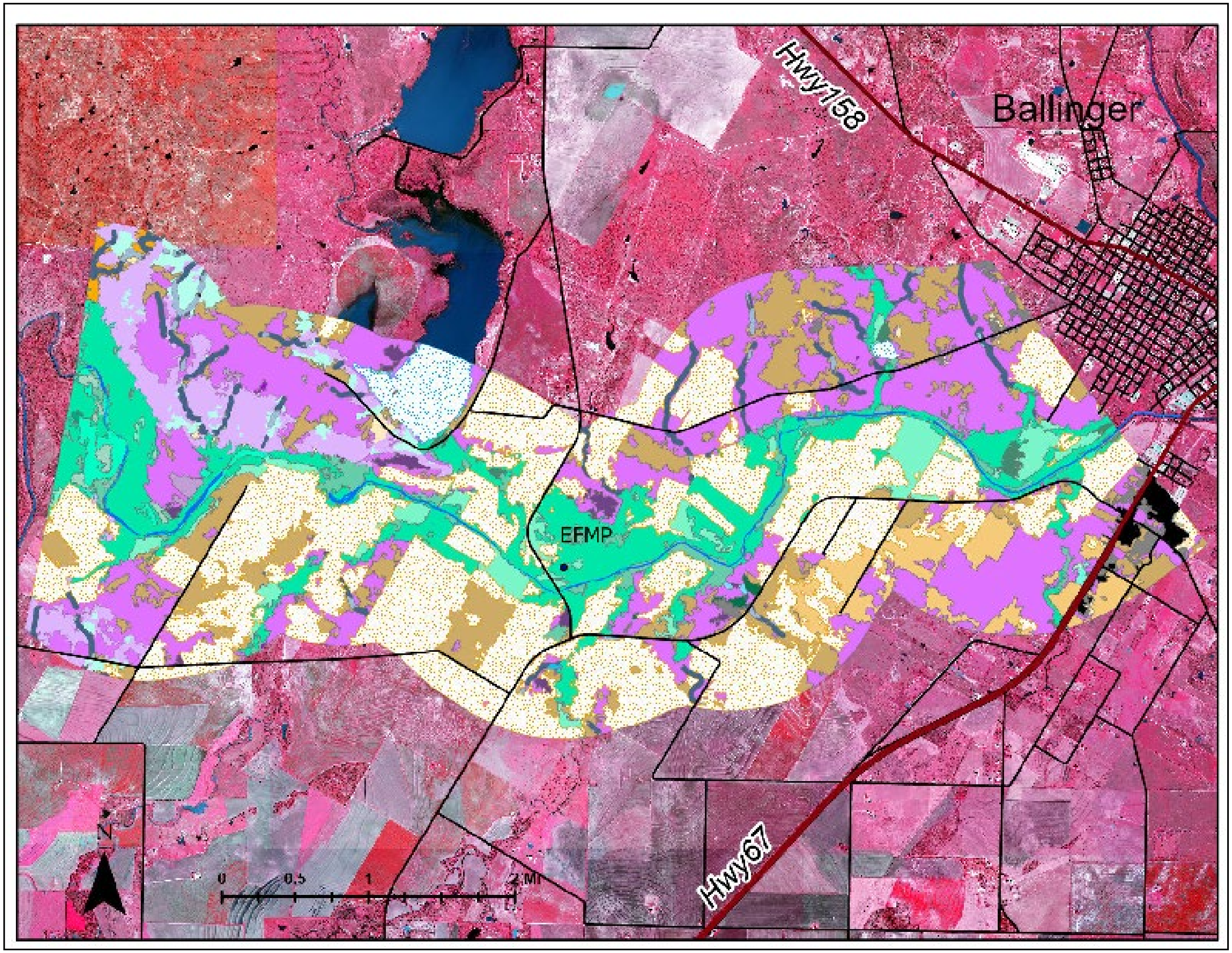
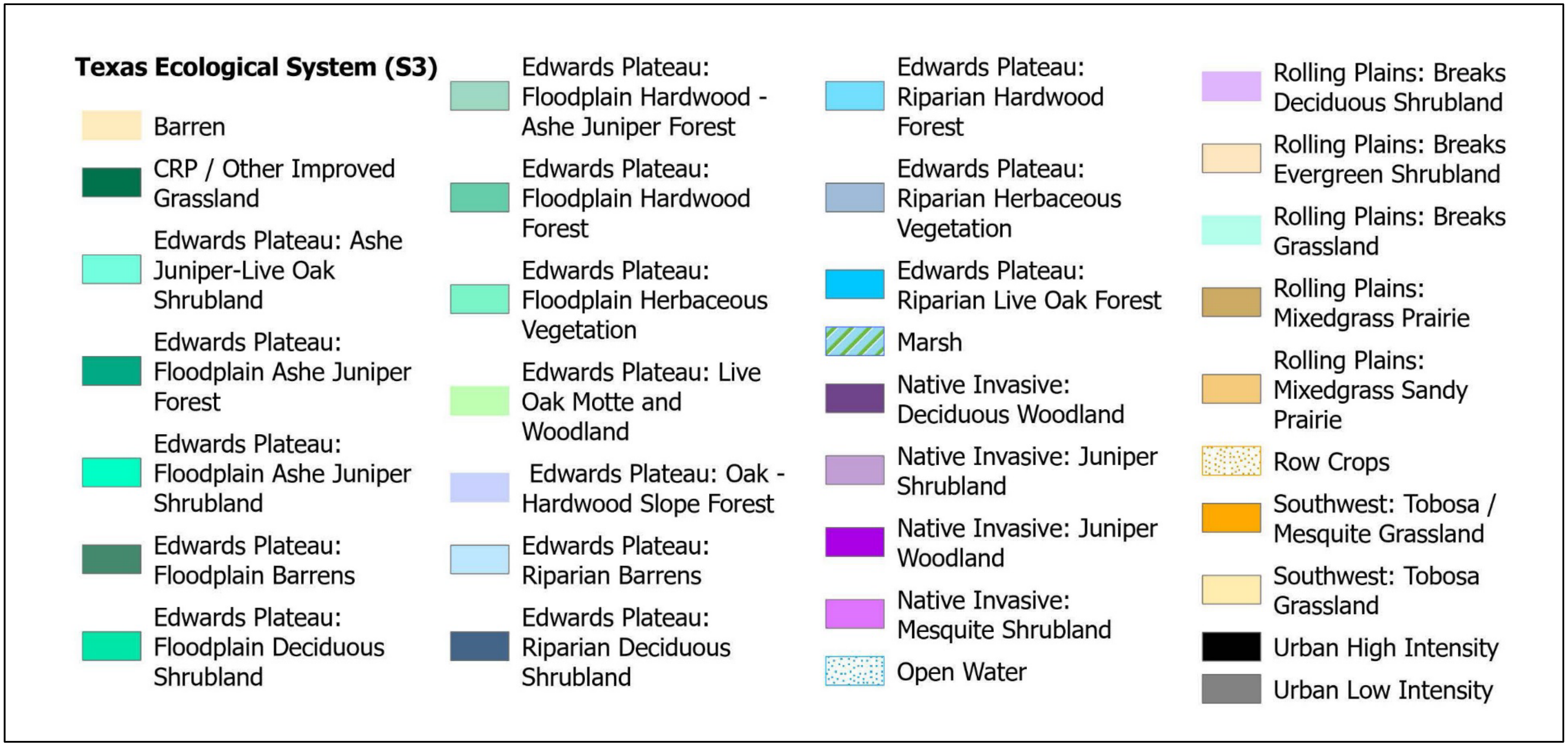


Figure 10. Site 3. Inundation Map Legend: TES Habitat Types



Red Overlay in Maps Denotes Areas of Event Inundation

Figure 11. Site 4: Colorado River above Silver, TX, 12/23/91
Habitat Inundation, MDD: 748.00 cfs

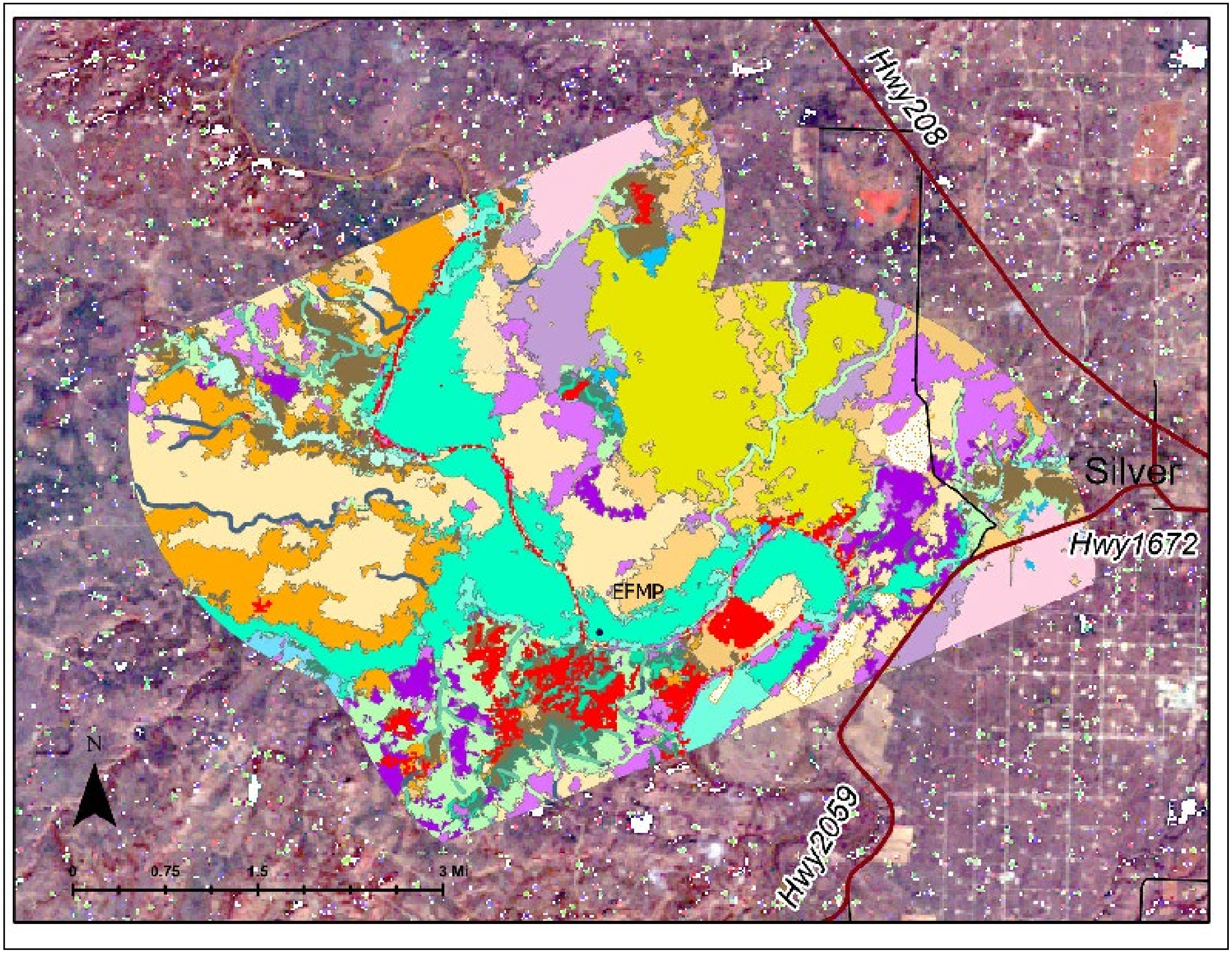


Figure 12. Site 4: Colorado River above Silver, TX, 02/08/96
Habitat Inundation, MDD: 3.20 cfs

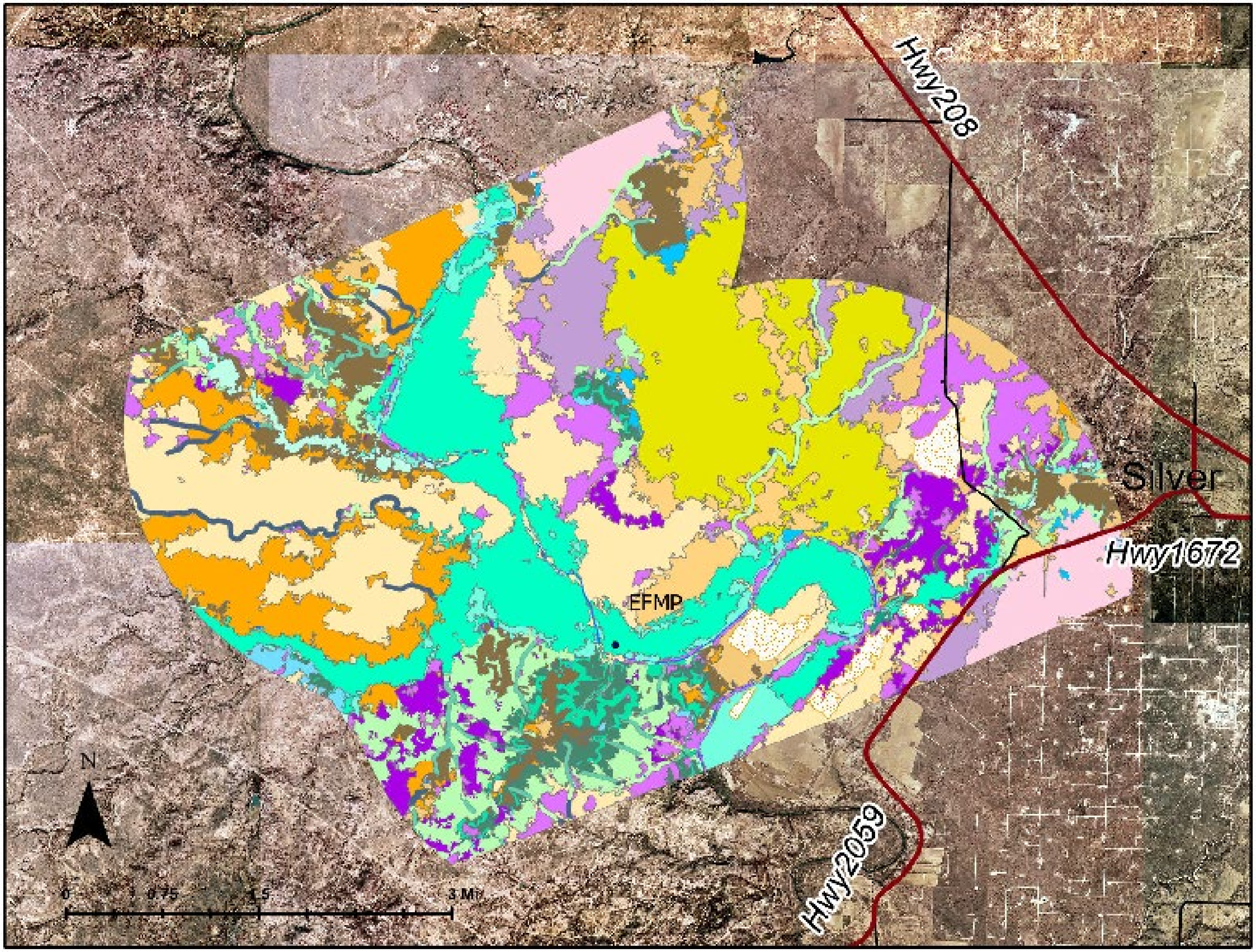


Figure 13. Site 4. Inundation Map Legend: TES Habitat Types

Texas Ecological System (S4)

- Barren
- Edwards Plateau: Floodplain Ashe Juniper Shrubland
- Edwards Plateau: Floodplain Barrens
- Edwards Plateau: Floodplain Deciduous Shrubland
- Edwards Plateau: Floodplain Hardwood Forest
- Edwards Plateau: Floodplain Herbaceous Vegetation
- Edwards Plateau: Juniper Semi-arid Shrubland
- Edwards Plateau: Juniper Semi-arid Slope Shrubland
- Edwards Plateau: Riparian Ashe Juniper Forest
- Edwards Plateau: Riparian Ashe Juniper Shrubland
- Edwards Plateau: Riparian Barrens
- Edwards Plateau: Riparian Deciduous Shrubland
- Edwards Plateau: Riparian Hardwood Forest
- Edwards Plateau: Riparian Herbaceous Vegetation
- Edwards Plateau: Semi-arid Grassland
- Edwards Plateau: Wooded Cliff/Bluff
- High Plains: Deep Sand Woodland
- High Plains: Sandhill Deciduous Shrub Duneland
- High Plains: Sandhill Shinnery Duneland
- High Plains: Sandy Deciduous Shrubland
- High Plains: Shortgrass Prairie
- Marsh
- Native Invasive: Deciduous Woodland
- Native Invasive: Juniper Shrubland
- Native Invasive: Juniper Woodland
- Native Invasive: Juniper Shrubland
- Native Invasive: Juniper Shrubland
- Rolling Plains: Breaks Canyon
- Rolling Plains: Breaks Deciduous Shrubland
- Rolling Plains: Breaks Evergreen Shrubland
- Rolling Plains: Breaks Grassland
- Rolling Plains: Mixedgrass Prairie
- Rolling Plains: Mixedgrass Sandy Prairie
- Row Crops
- Southwest: Tobosa / Mesquite Grassland
- Southwest: Tobosa Grassland
- Urban High Intensity
- Urban Low Intensity

Red Overlay in Maps Denotes Areas of Event Inundation

Figure 14. Site 5: Colorado River near San Saba, TX, 03/03/97
Habitat Inundation, MDD: 7,410.00 cfs

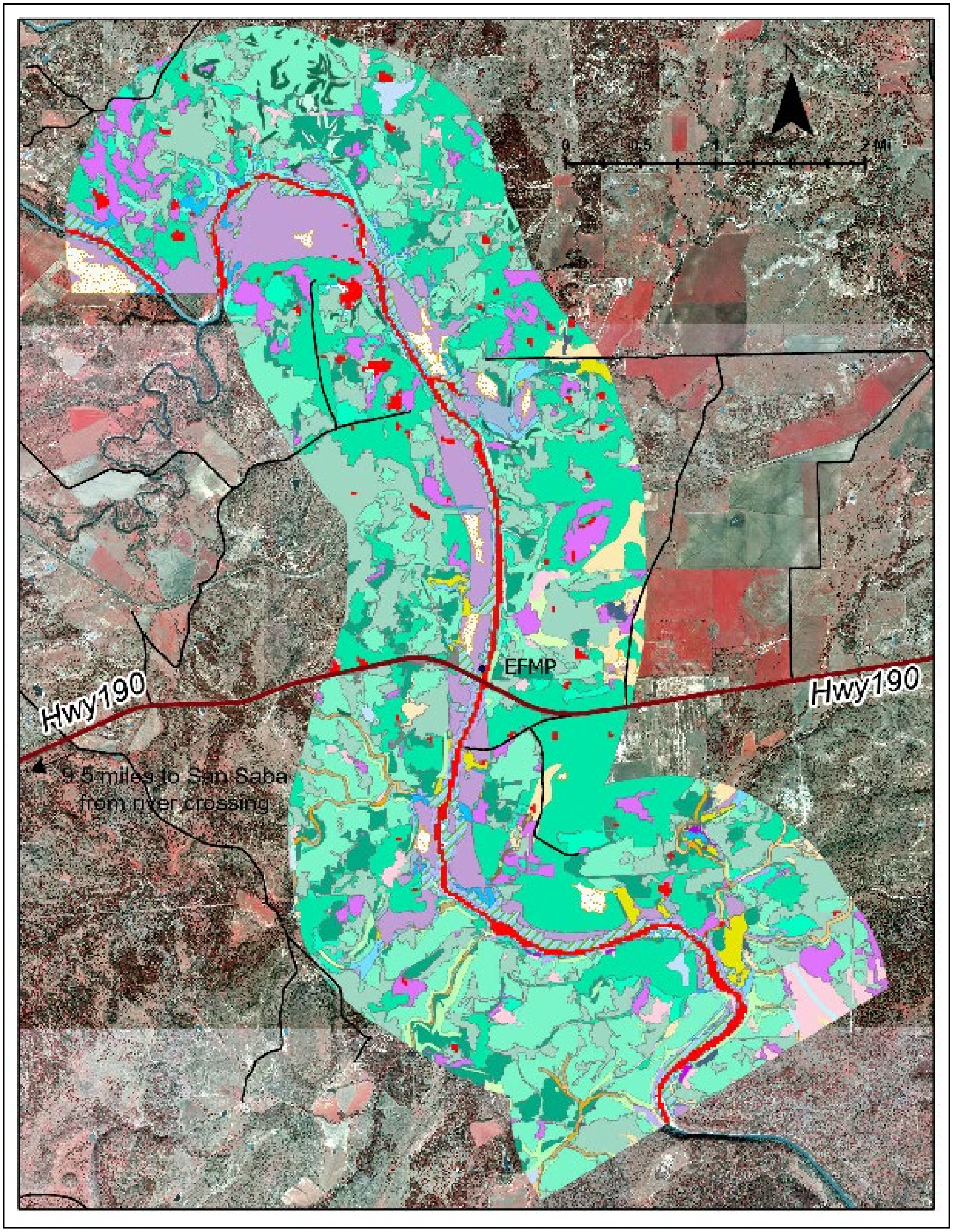


Figure 15. Site 5: Colorado River near San Saba, TX, 01/02/07
Habitat Inundation, MDD: 64.50 cfs

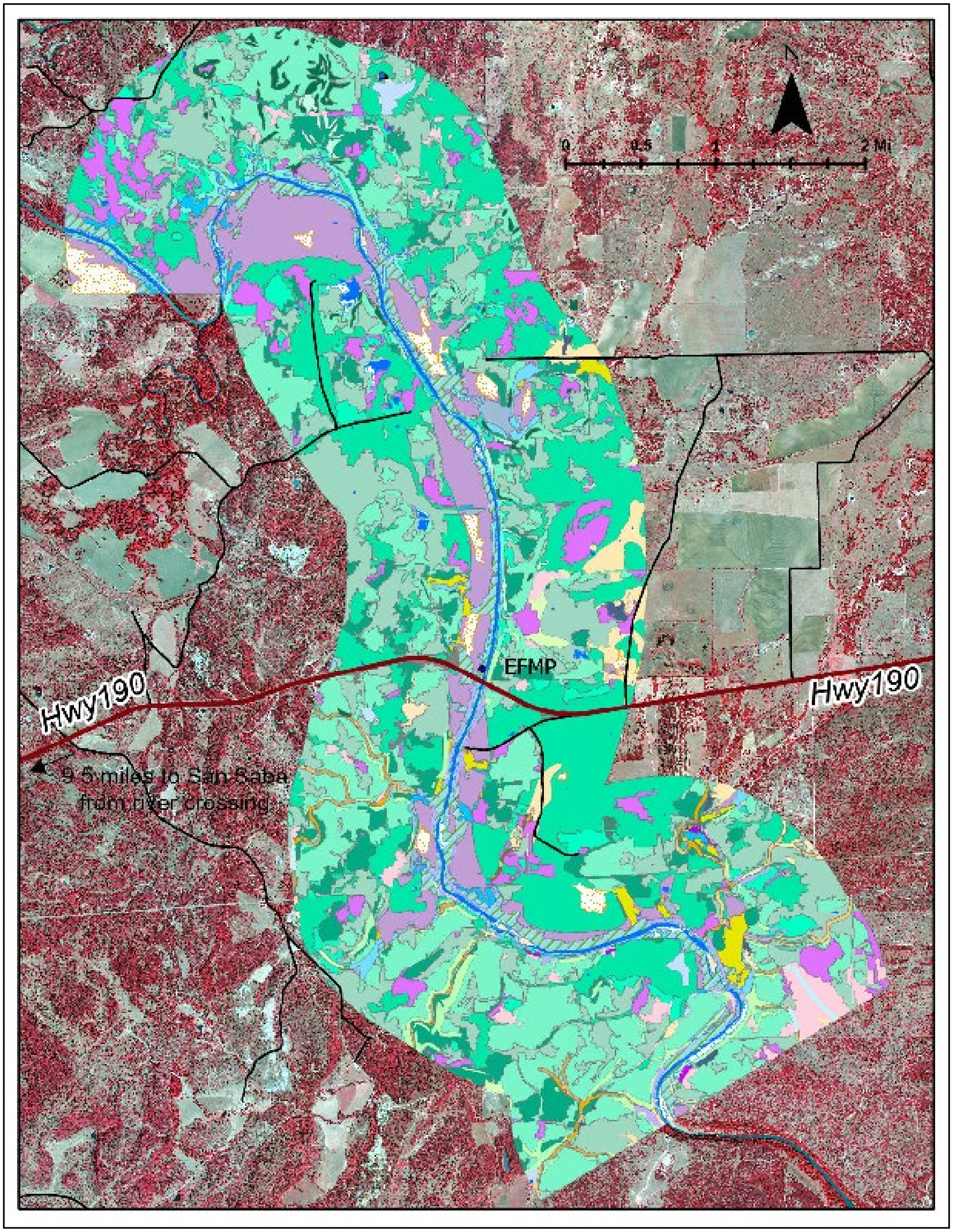
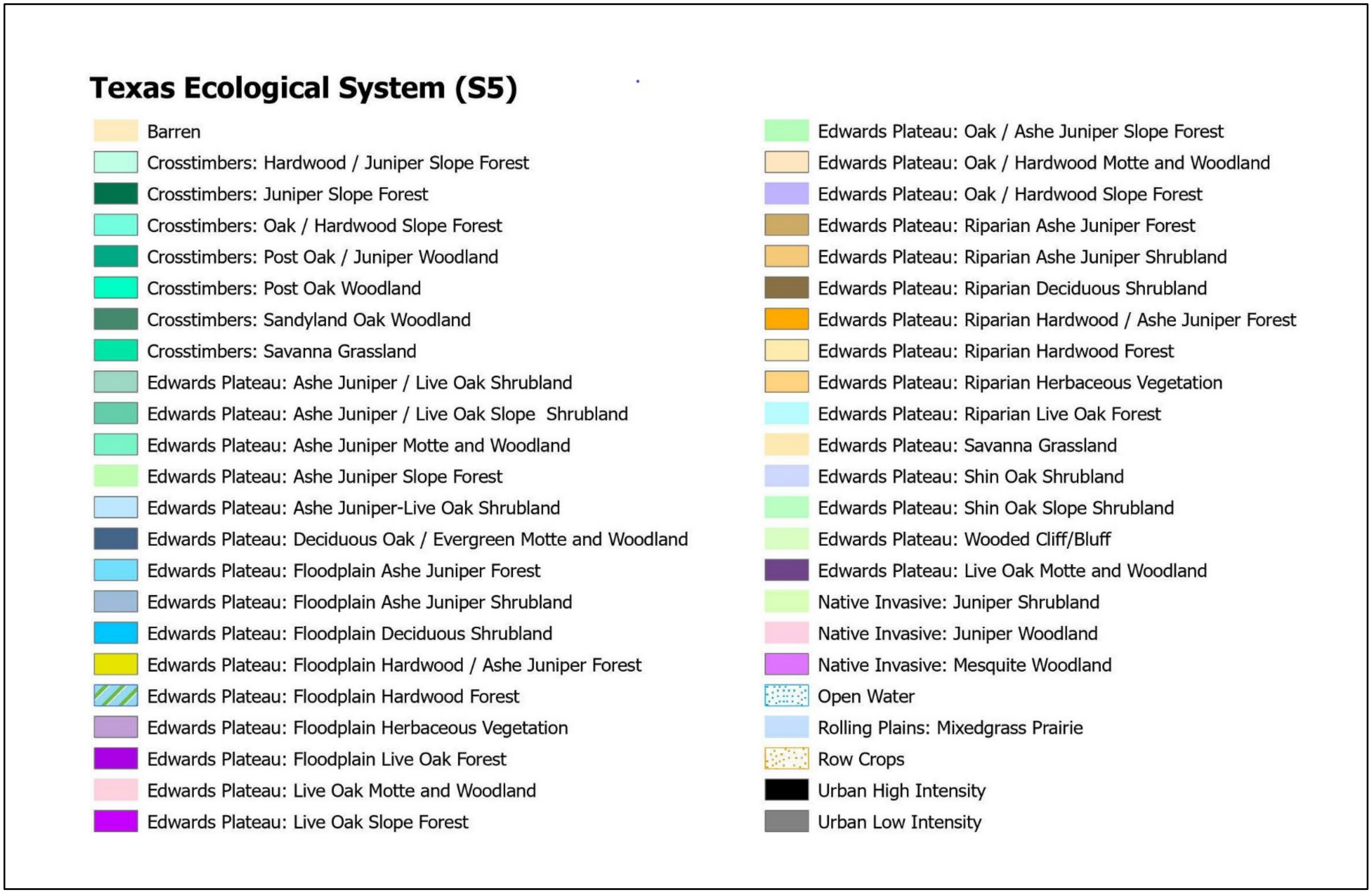


Figure 16. Site 5. Inundation Map Legend: TES Habitat Types



Red Overlay in Maps Denotes Areas of Event Inundation

Figure 17. Site 6: Concho River at Paint Rock, TX, 02/25/92
Habitat Inundation, MDD: 2,220.00 cfs

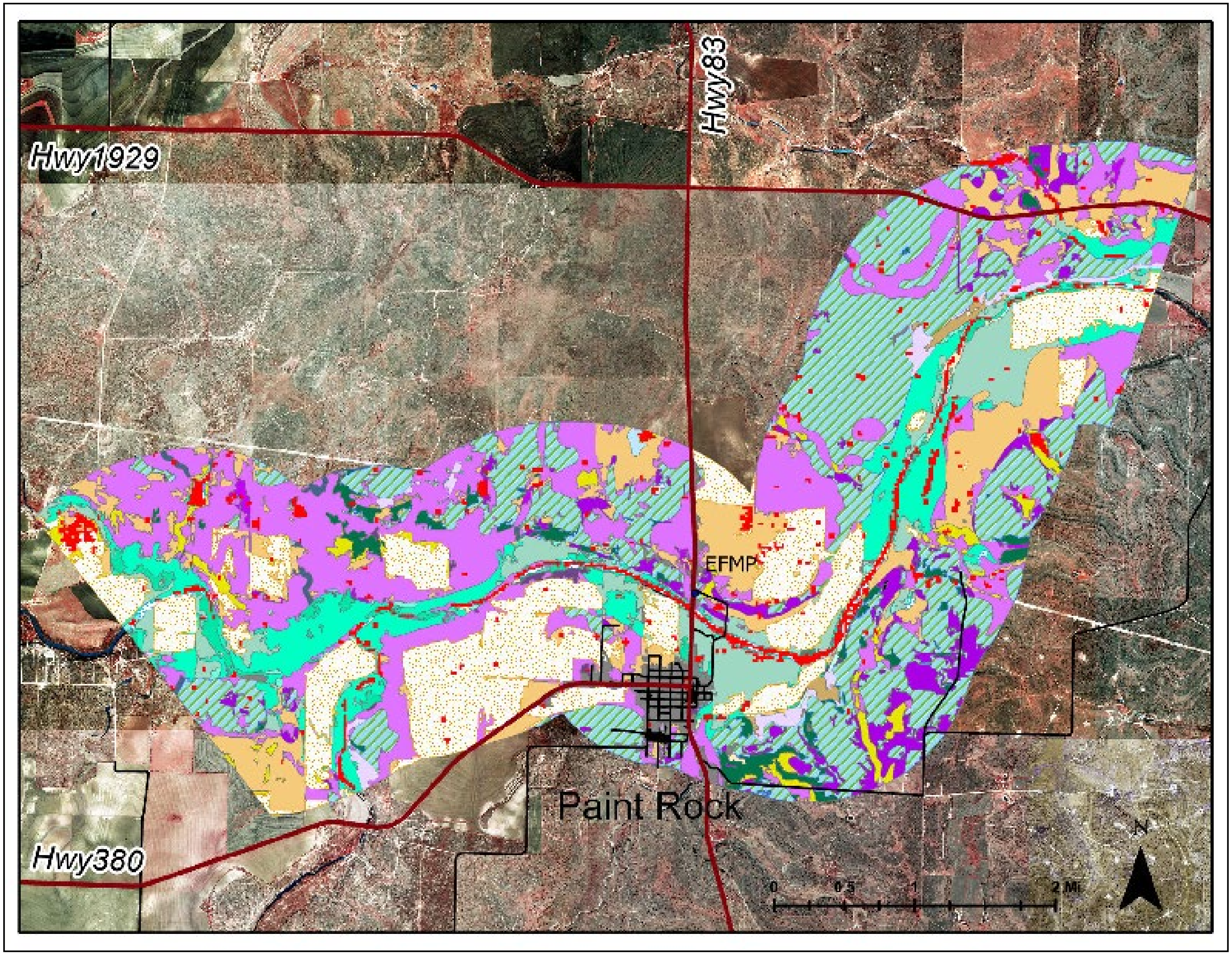


Figure 18. Site 6: Concho River at Paint Rock, TX, 03/14/18
Habitat Inundation, MDD: 6.22 cfs

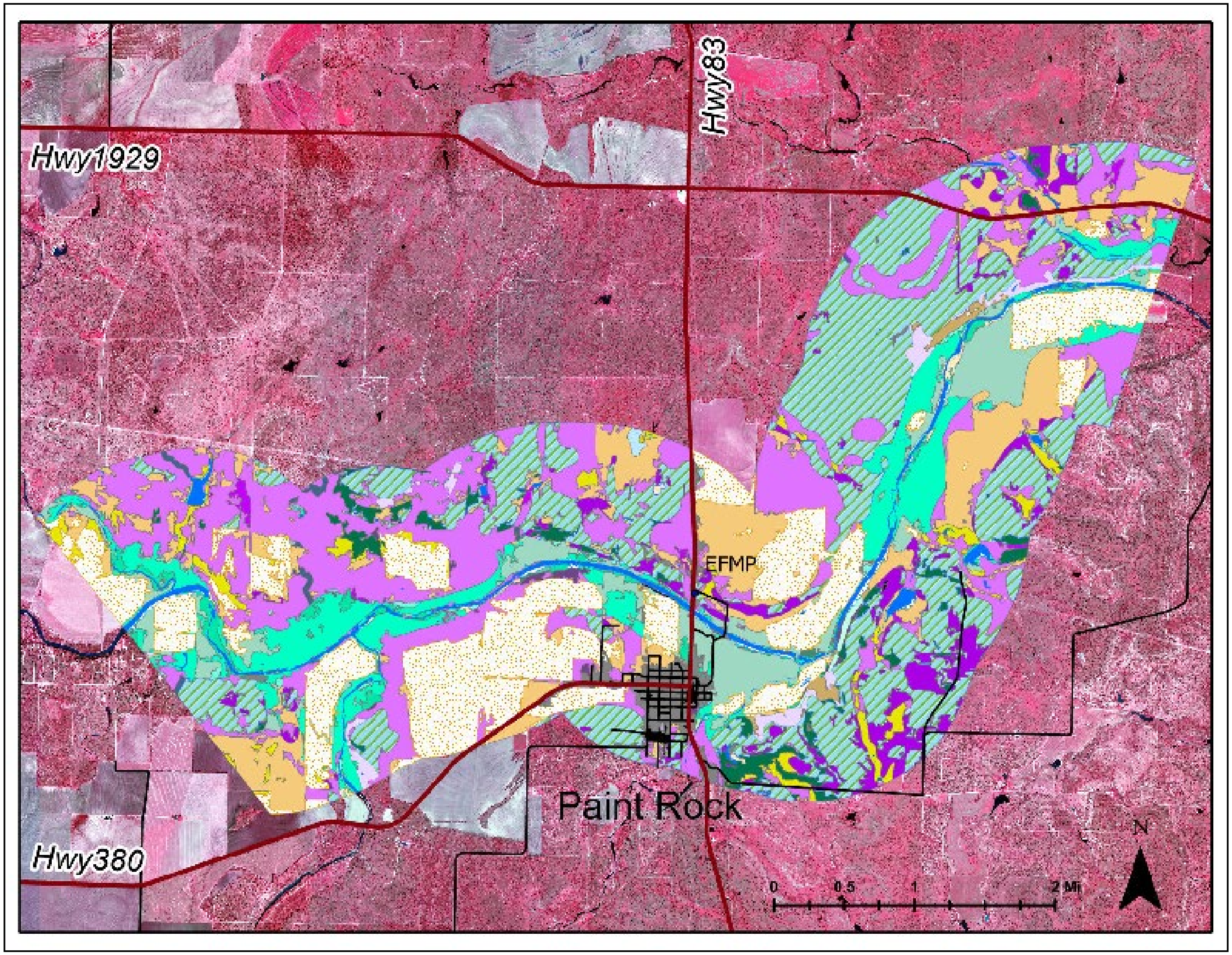


Figure 19. Site 6. Inundation Map Legend: TES Habitat Types

Red Overlay in Maps Denotes Areas of Event Inundation

Figure 20. Site 9: Pedernales R near Johnson City, 01/28/19
Habitat Inundation, MDD: 319.00 cfs

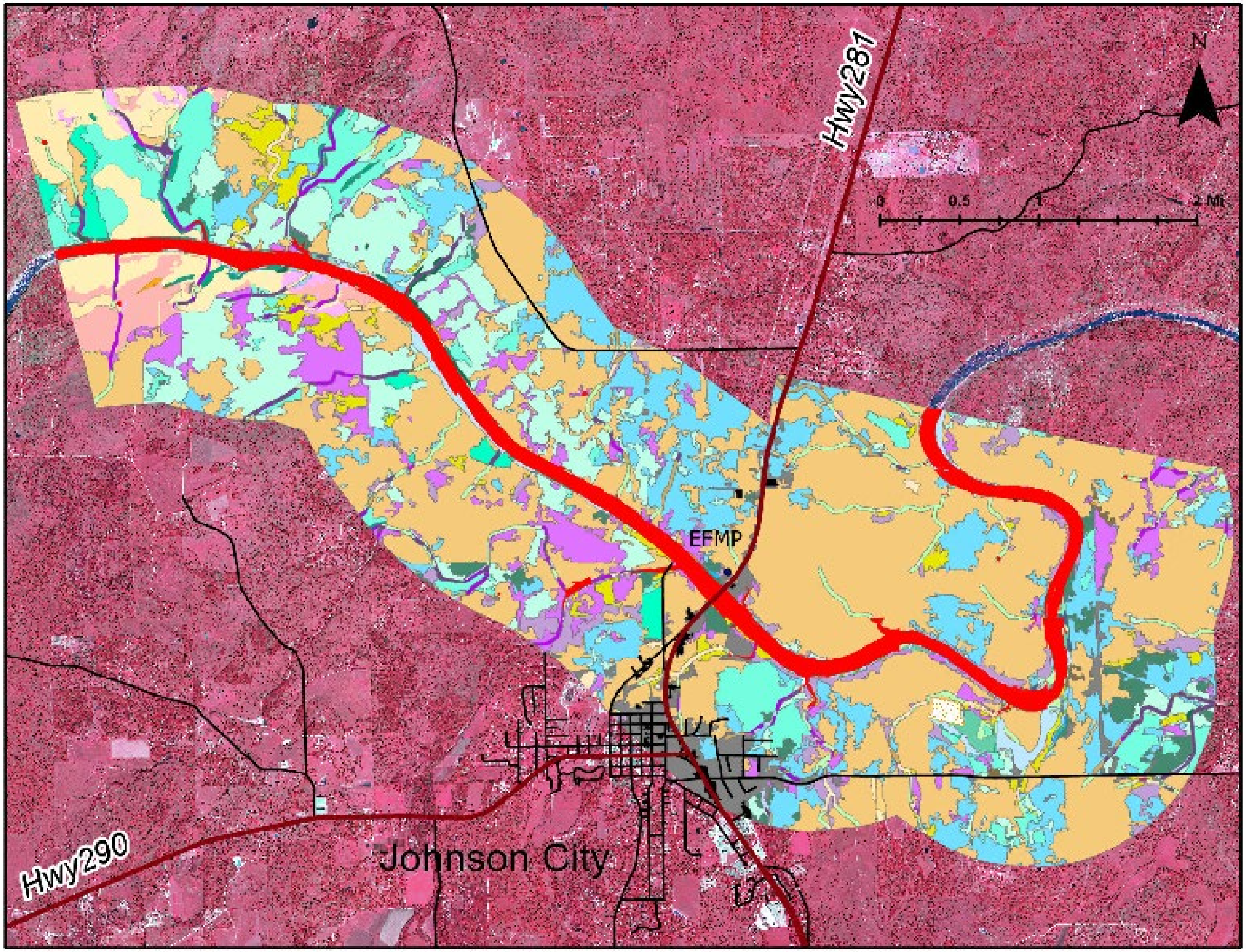


Figure 21. Site 9: Pedernales R near Johnson City, 01/28/19
Habitat Inundation, MDD: 13.10 cfs

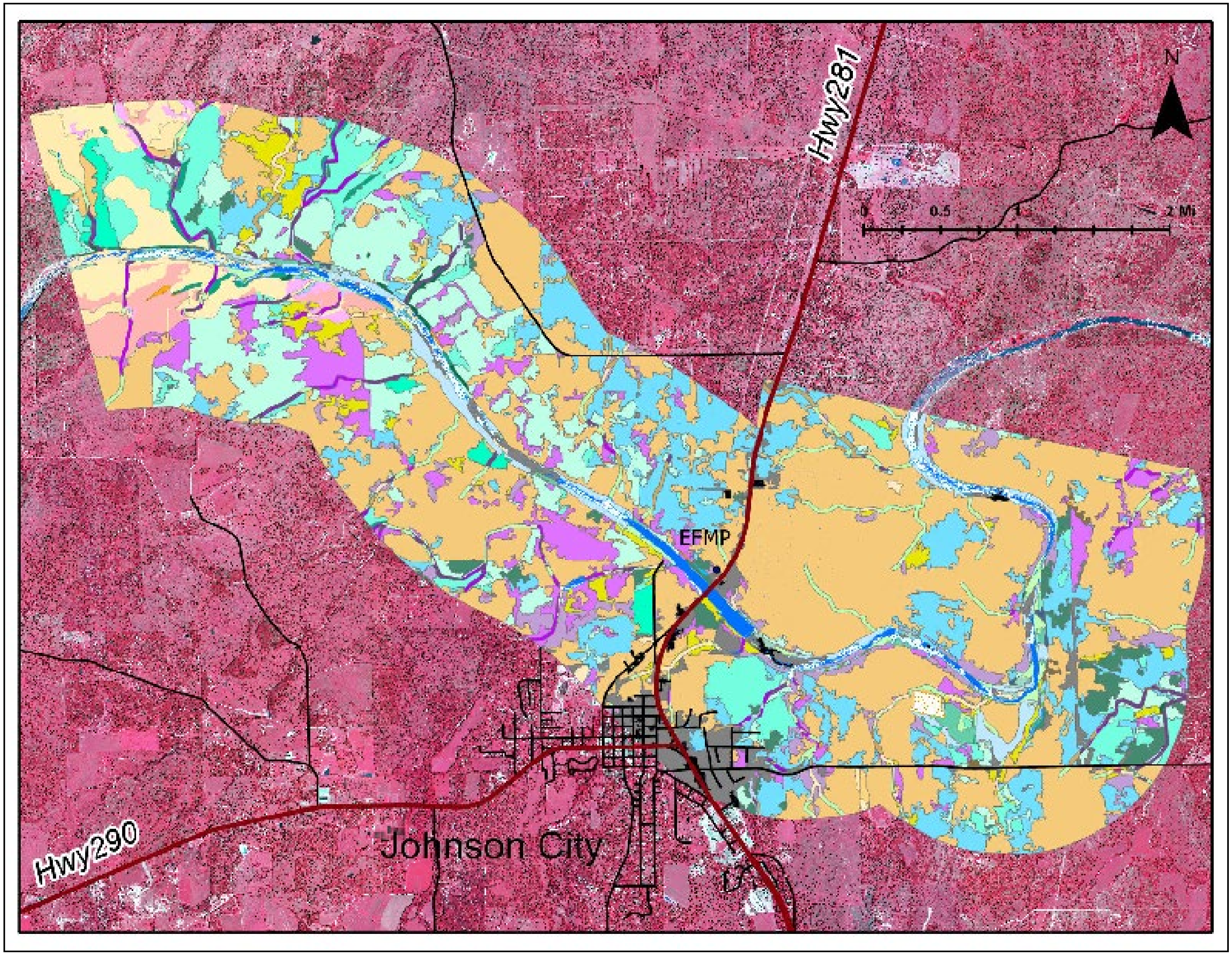


Figure 22. Site 9. Inundation Map Legend: TES Habitat Types

Texas Ecological System (S9)

- Barren
- Edwards Plateau: Ashe Juniper / Live Oak Shrubland
- Edwards Plateau: Ashe Juniper / Live Oak Slope Shrubland
- Edwards Plateau: Ashe Juniper Motte and Woodland
- Edwards Plateau: Ashe Juniper Slope Forest
- Edwards Plateau: Ashe Juniper-Live Oak Shrubland
- Edwards Plateau: Deciduous Oak / Evergreen Motte and Woodland
- Edwards Plateau: Floodplain Ashe Juniper Forest
- Edwards Plateau: Floodplain Ashe Juniper Shrubland
- Edwards Plateau: Floodplain Deciduous Shrubland
- Edwards Plateau: Floodplain Hardwood / Ashe Juniper Forest
- Edwards Plateau: Floodplain Hardwood Forest
- Edwards Plateau: Floodplain Herbaceous Vegetation
- Edwards Plateau: Floodplain Live Oak Forest
- Edwards Plateau: Live Oak Motte and Woodland
- Edwards Plateau: Live Oak Slope Forest
- Edwards Plateau: Oak / Ashe Juniper Slope Forest
- Edwards Plateau: Oak / Hardwood Motte and Woodland
- Edwards Plateau: Oak / Hardwood Slope Forest
- Edwards Plateau: Post Oak Motte and Woodland
- Edwards Plateau: Riparian Ashe Juniper Forest
- Edwards Plateau: Riparian Ashe Juniper Shrubland
- Edwards Plateau: Riparian Deciduous Shrubland
- Edwards Plateau: Riparian Hardwood / Ashe Juniper Forest
- Edwards Plateau: Riparian Hardwood Forest
- Edwards Plateau: Riparian Herbaceous Vegetation
- Edwards Plateau: Riparian Live Oak Forest
- Edwards Plateau: Savanna Grassland
- Edwards Plateau: Shin Oak Shrubland
- Edwards Plateau: Shin Oak Slope Shrubland
- Llano Uplift: Grassland
- Llano Uplift: Live Oak Woodland
- Llano Uplift: Mesquite / Whitebrush Shrubland
- Llano Uplift: Post Oak Woodland
- Native Invasive: Juniper Shrubland
- Native Invasive: Juniper Woodland
- Native Invasive: Mesquite Shrubland
- Open Water
- Row Crops
- Urban High Intensity
- Urban Low Intensity

Red Overlay in Maps Denotes Areas of Event Inundation

Figure 23. Site 11: Sandy Ck near Ganado, TX, 01/01/03
Habitat Inundation, MDD: 1,130.50 cfs

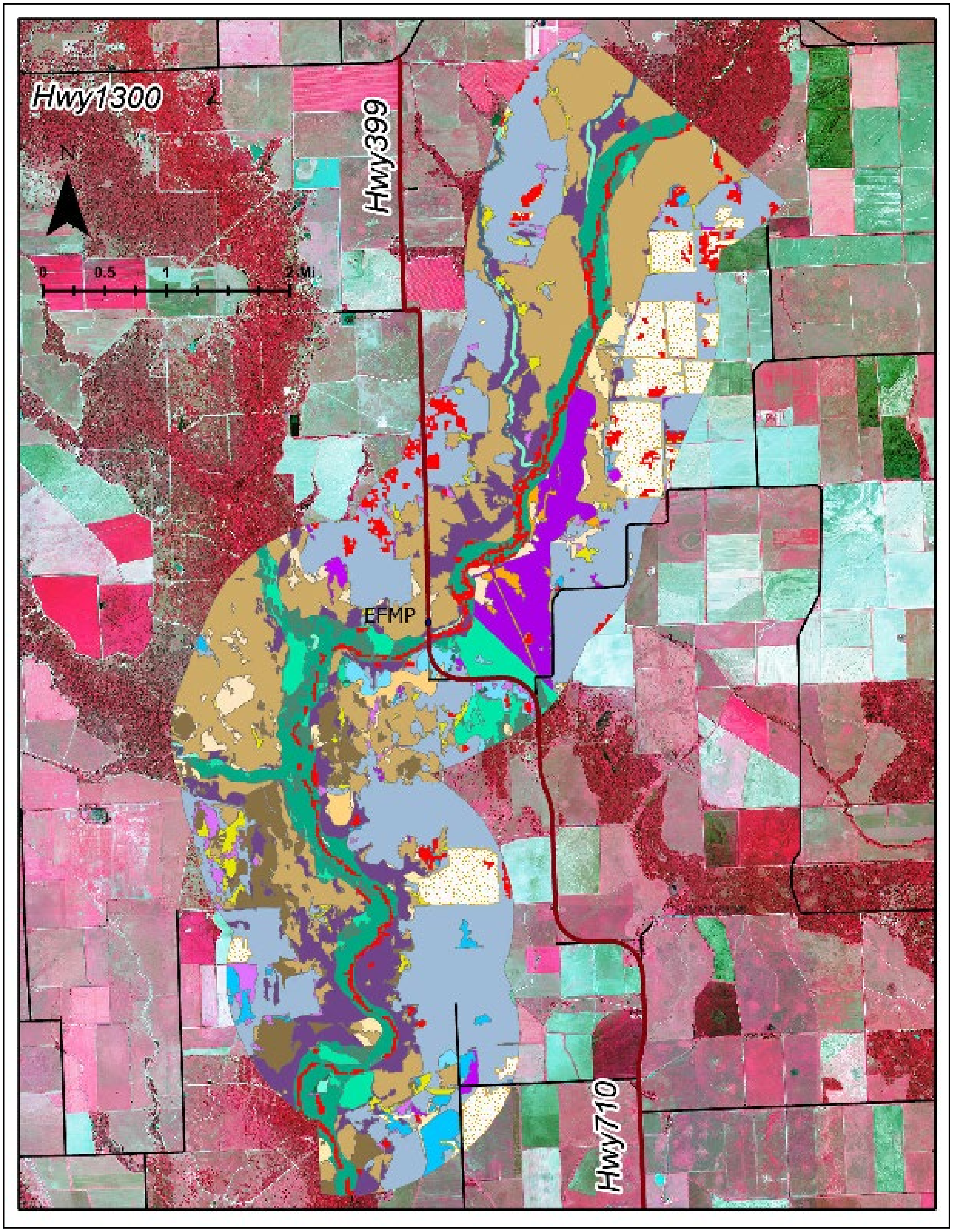


Figure 24. Site 11: Sandy Ck near Ganado, TX, 12/01/183
Habitat Inundation, MDD: 33.50 cfs

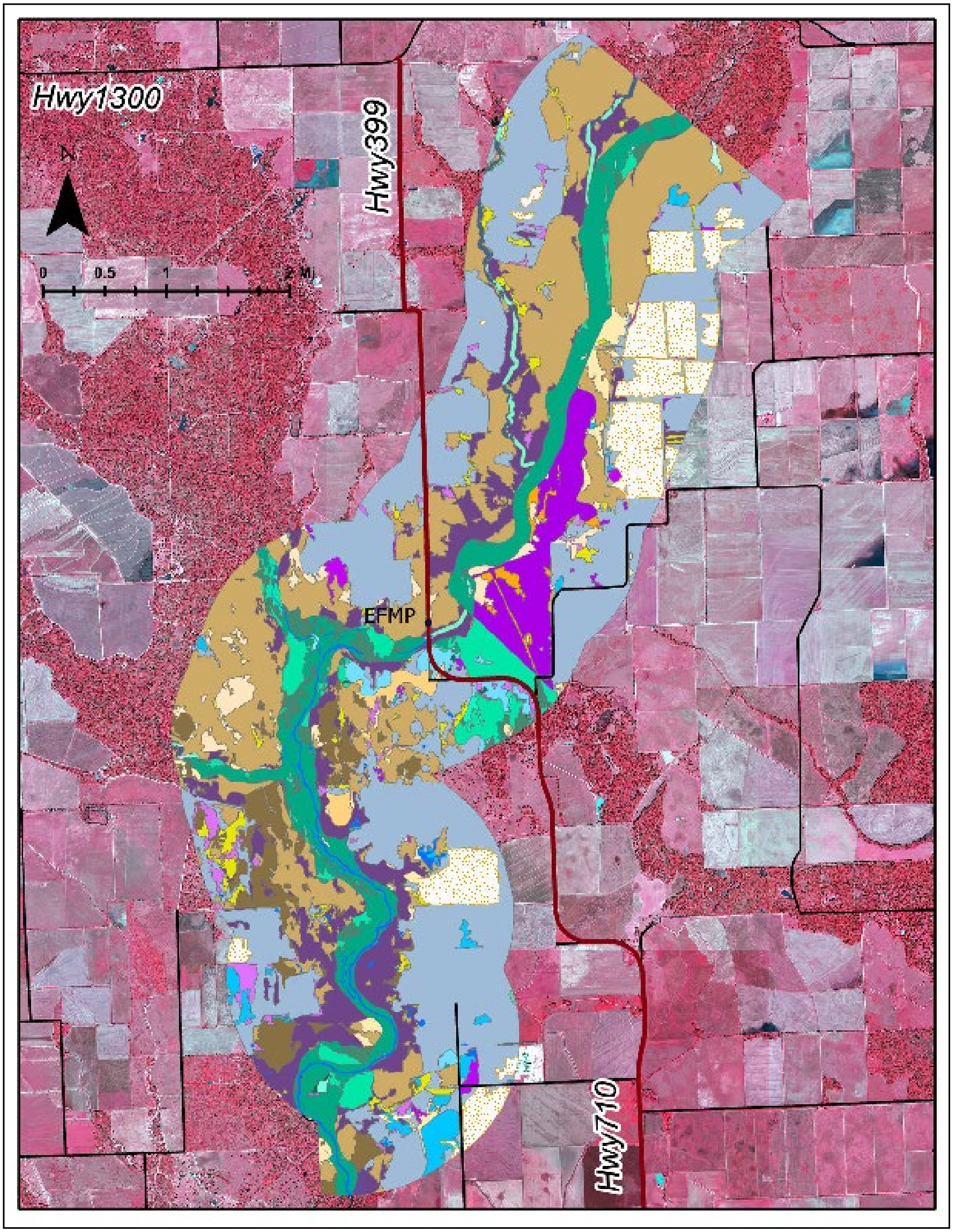
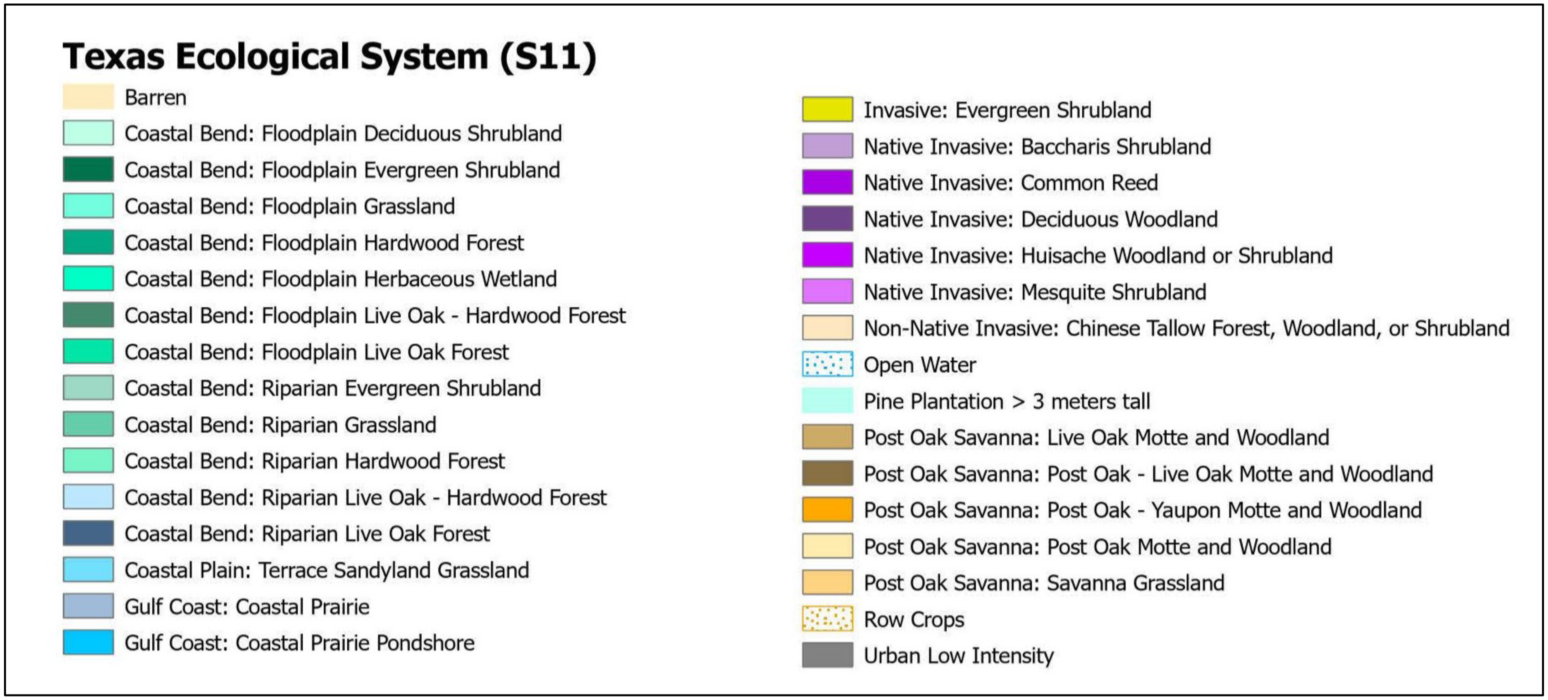


Figure 25. Site 11. Inundation Map Legend: TES Habitat Types



Red Overlay in Maps Denotes Areas of Event Inundation

Figure 26. Site 13: W. Mustang Creek near Ganado, TX, TX, 03/08/95
Habitat Inundation, MDD: 351.00 cfs

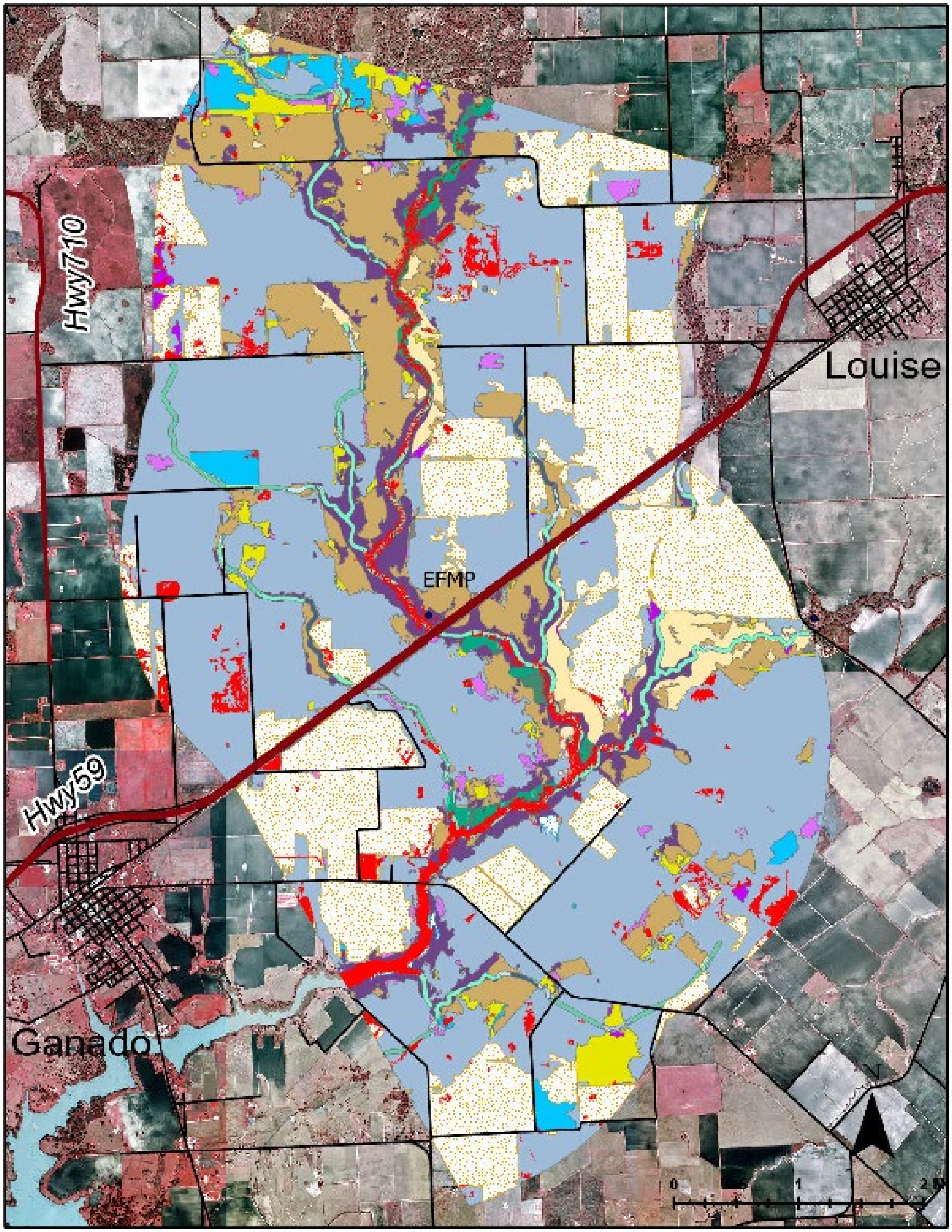


Figure 27. Site 13: W. Mustang Creek near Ganado, TX, TX, 01/26/90
Habitat Inundation, MDD: 2.40 cfs

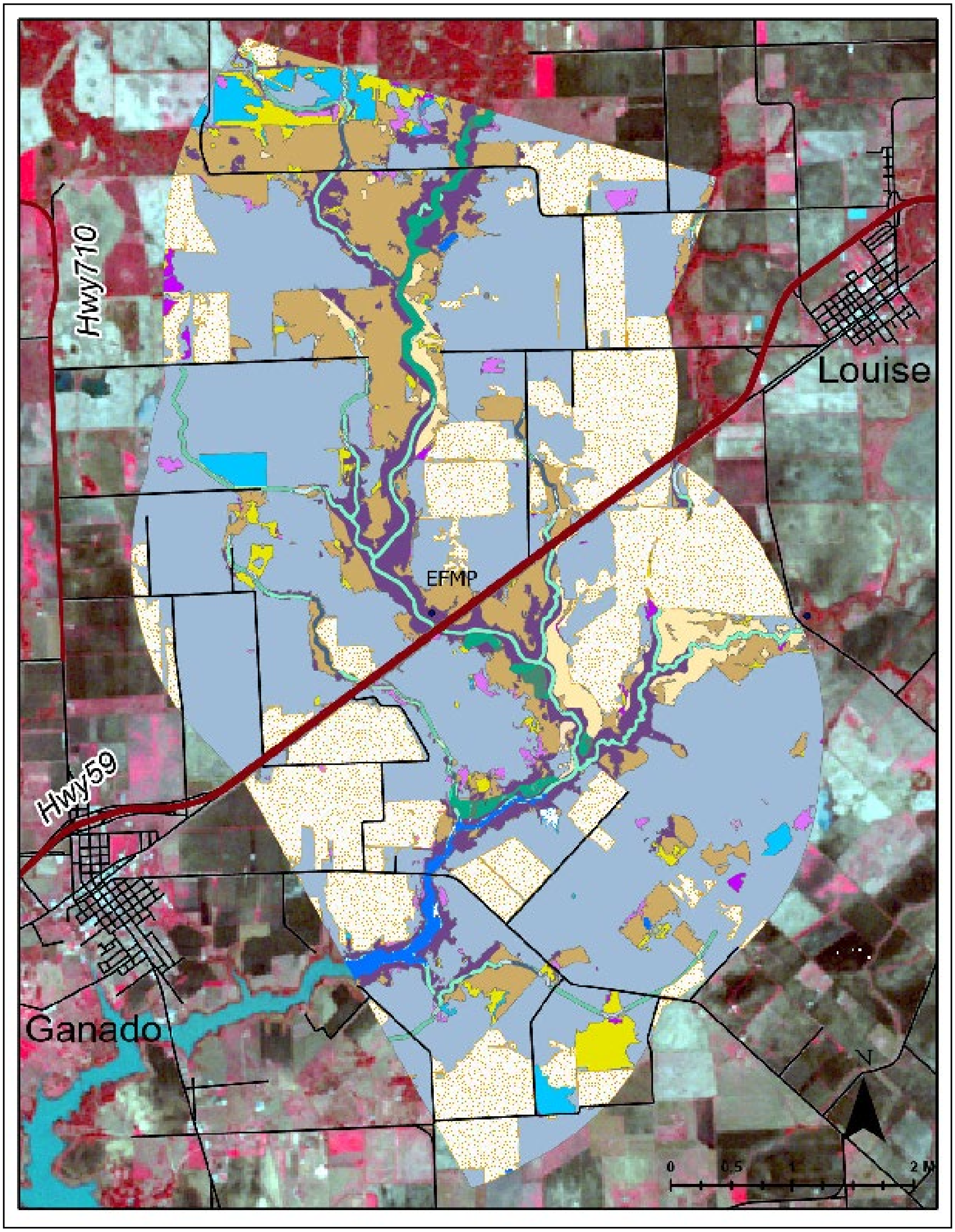
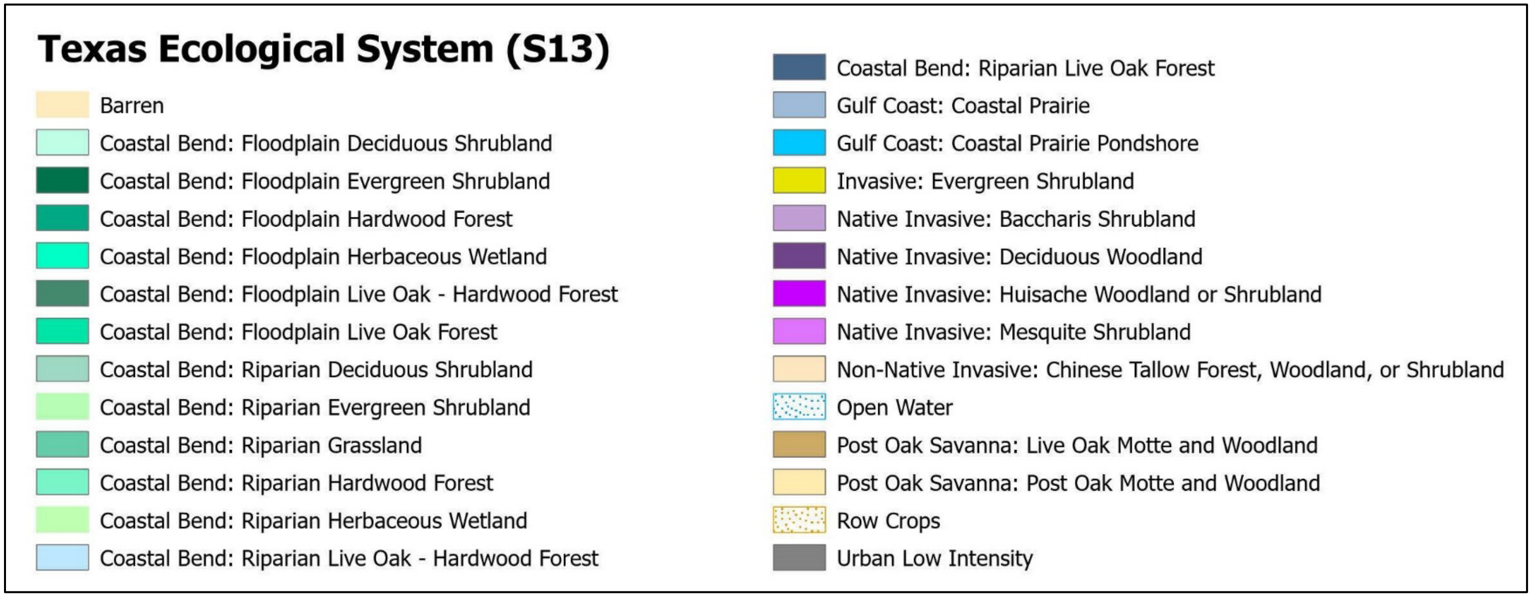


Figure 28. Site 13. Inundation Map Legend: TES Habitat Types



Red Overlay in Maps Denotes Areas of Event Inundation

Figure 29. Site 14: Tres Palacios Rv nr Midfield, TX, 12/07/09
Habitat Inundation, MDD: 700.00 cfs

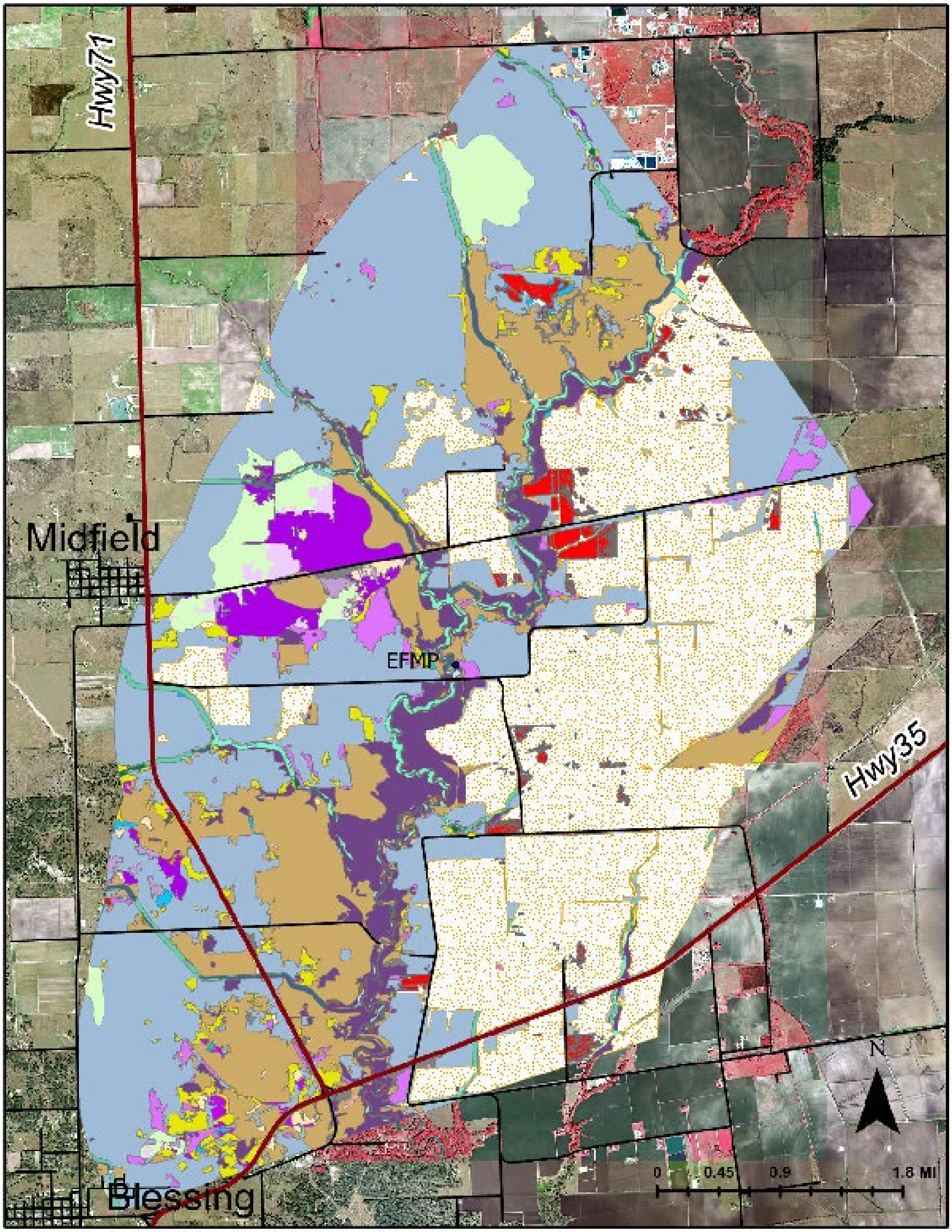


Figure 30. Site 14: Tres Palacios River near Midfield, TX, 03/10/89
Habitat Inundation, MDD: 6.70 cfs

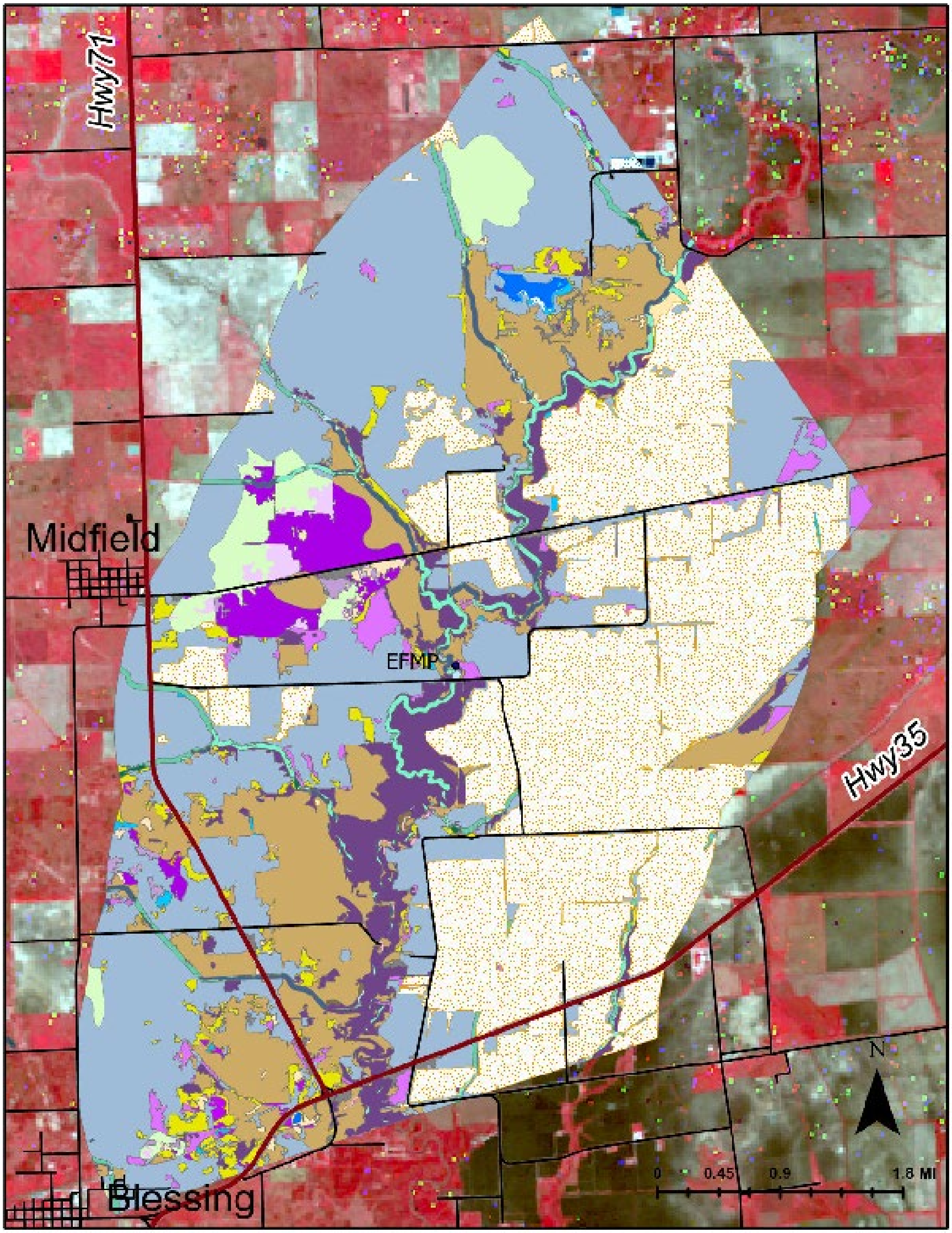


Figure 31. Site 14. Inundation Map Legend: TES Habitat Types

Red Overlay in Maps Denotes Areas of Event Inundation

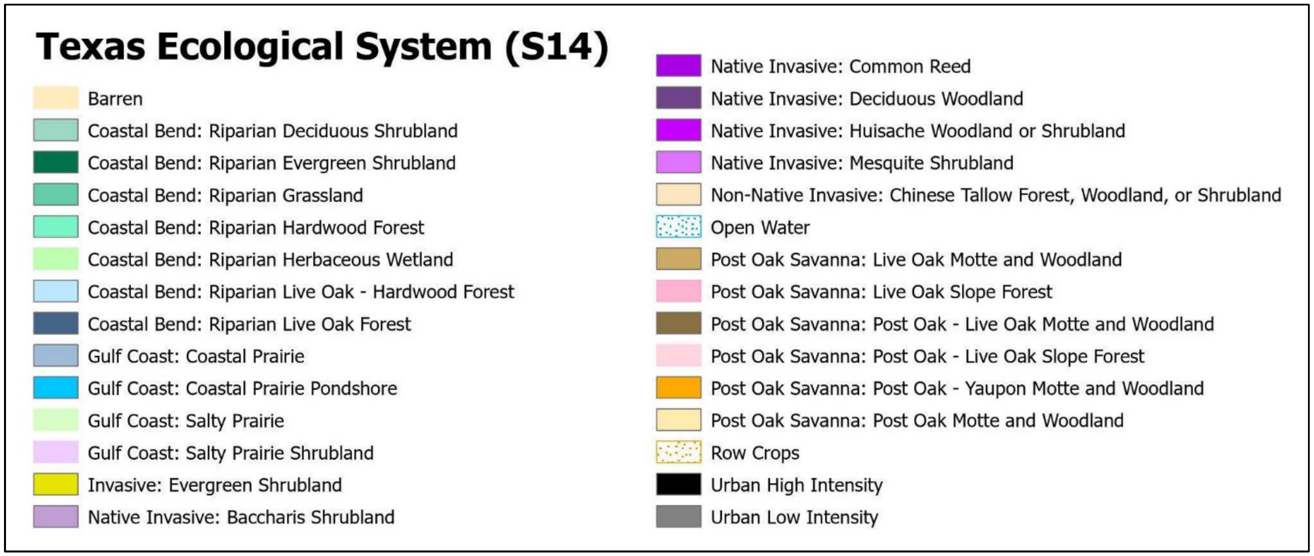


Figure 32. Site 1. Lavaca River near Edna, TX

Scatterplots: Total Event Inundation and Prime Backwater Habitat Availability

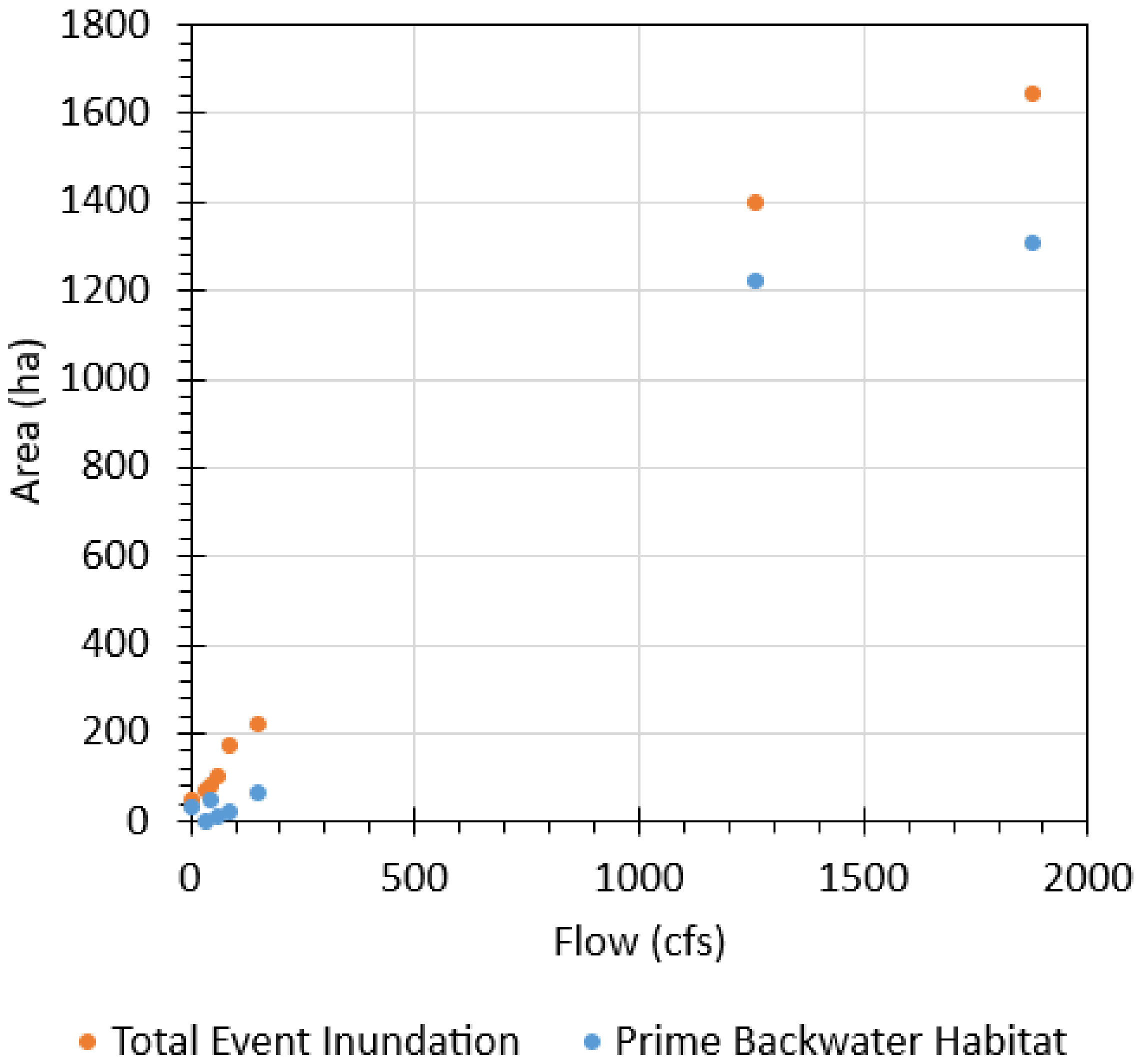


Figure 33. Site 2: Navidad River at Strane Park near Edna, TX

Scatterplots: Total Event Inundation and Prime Backwater Habitat Availability

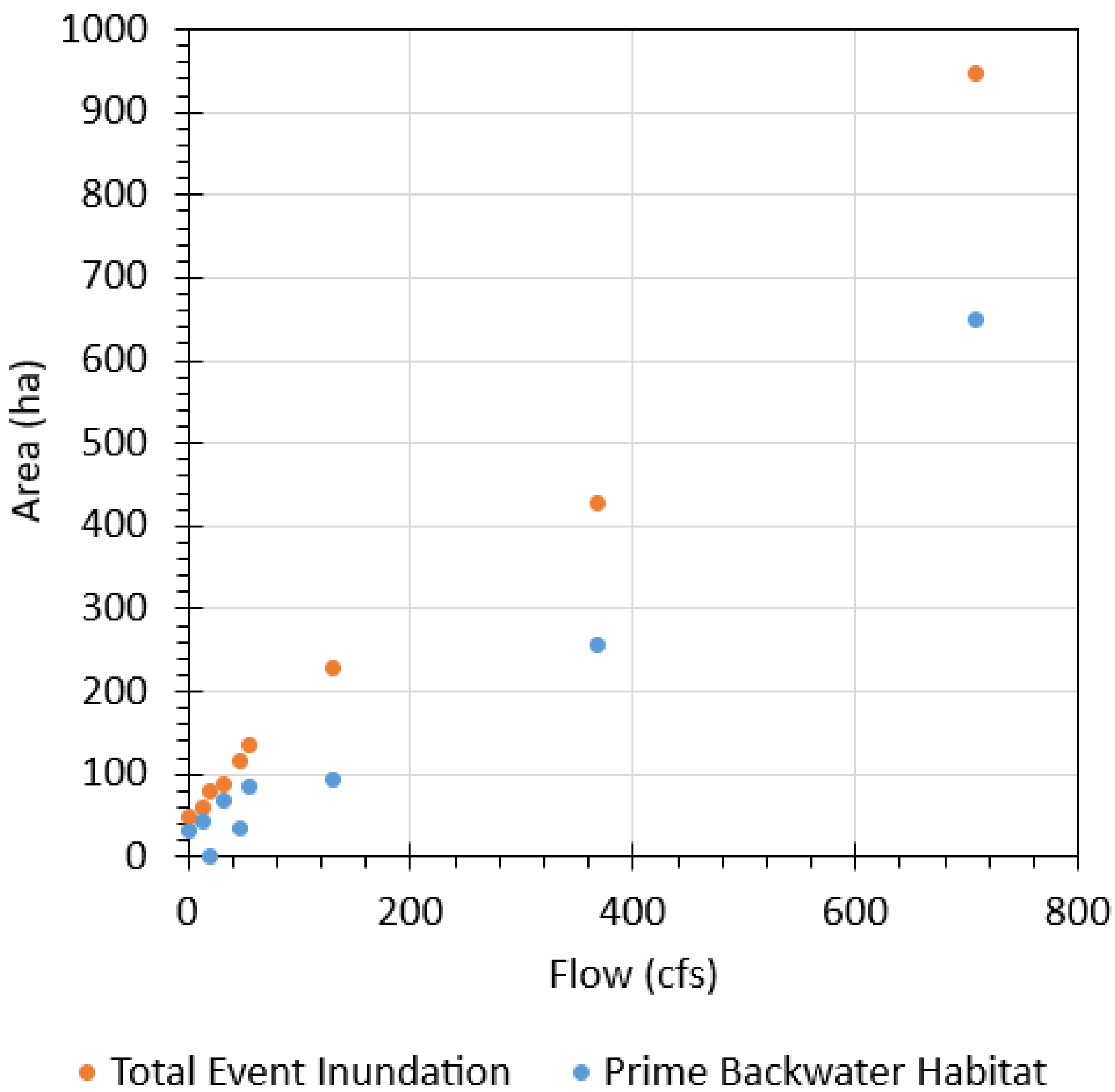


Figure 34. Site 3: Colorado River near Ballinger, TX

Scatterplots: Total Event Inundation and Prime Backwater Habitat Availability

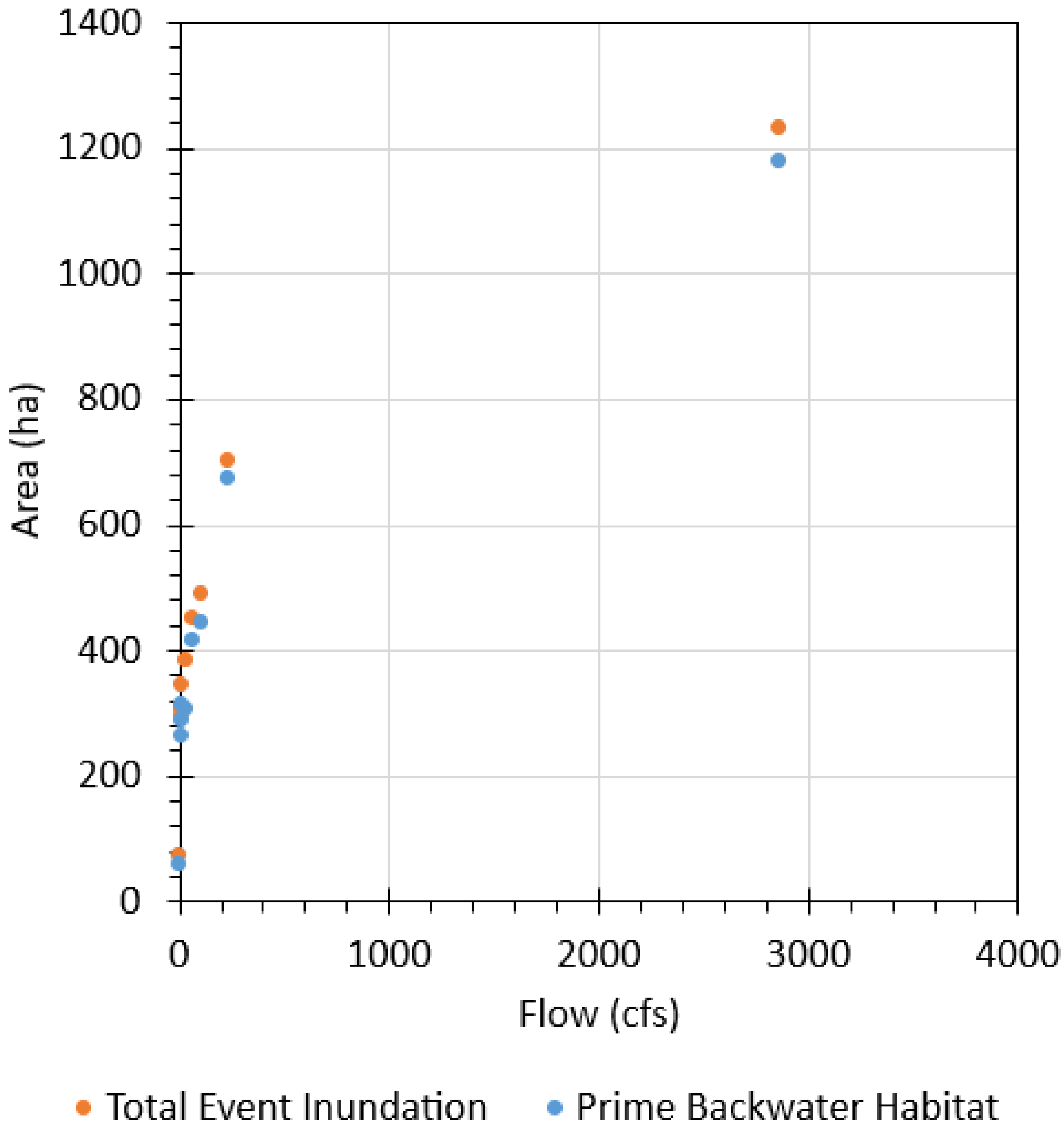


Figure 35. Site 4: Colorado River above Silver, TX

Scatterplots: Total Event Inundation and Prime Backwater Habitat Availability

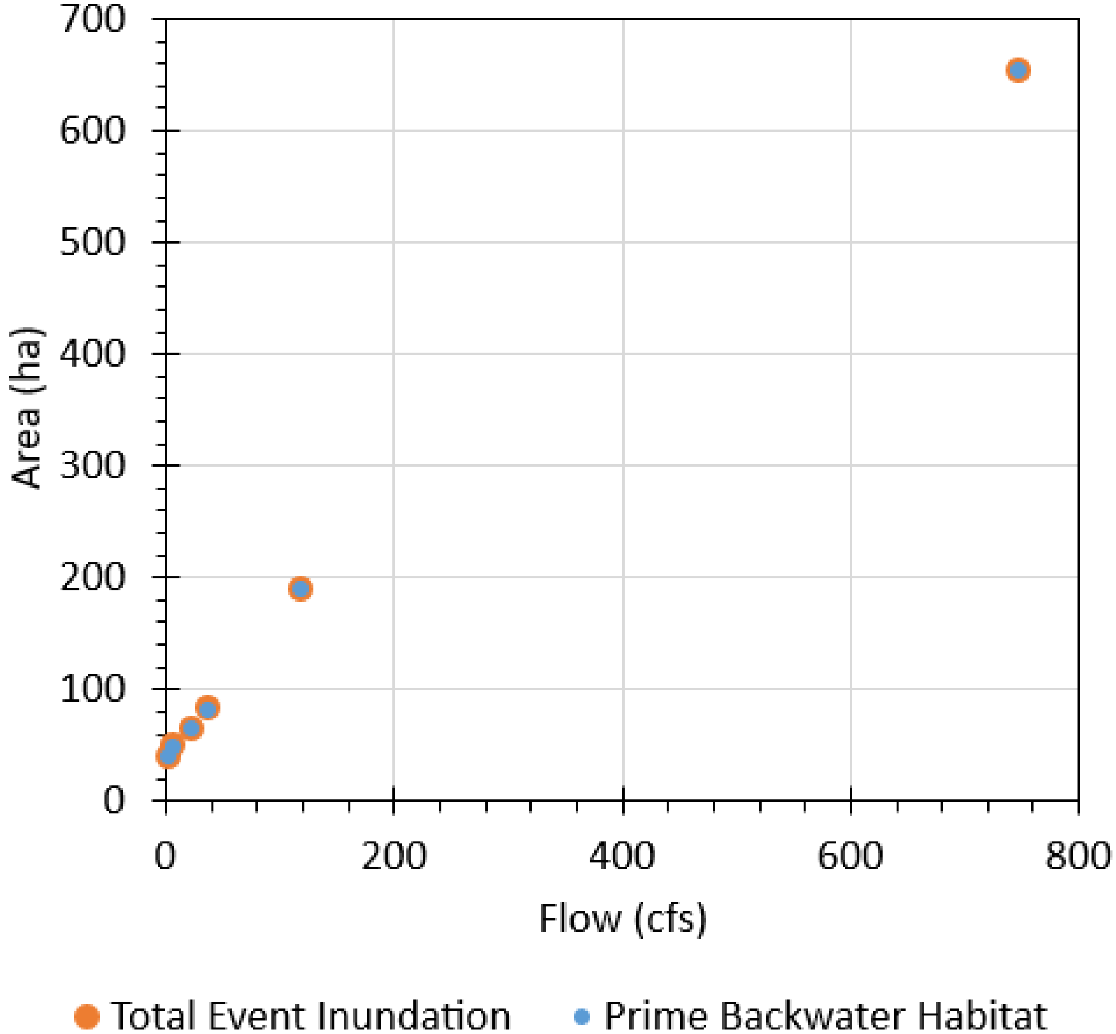


Figure 36. Site 5: Colorado River near San Saba, TX

Scatterplots: Total Event Inundation and Prime Backwater Habitat Availability

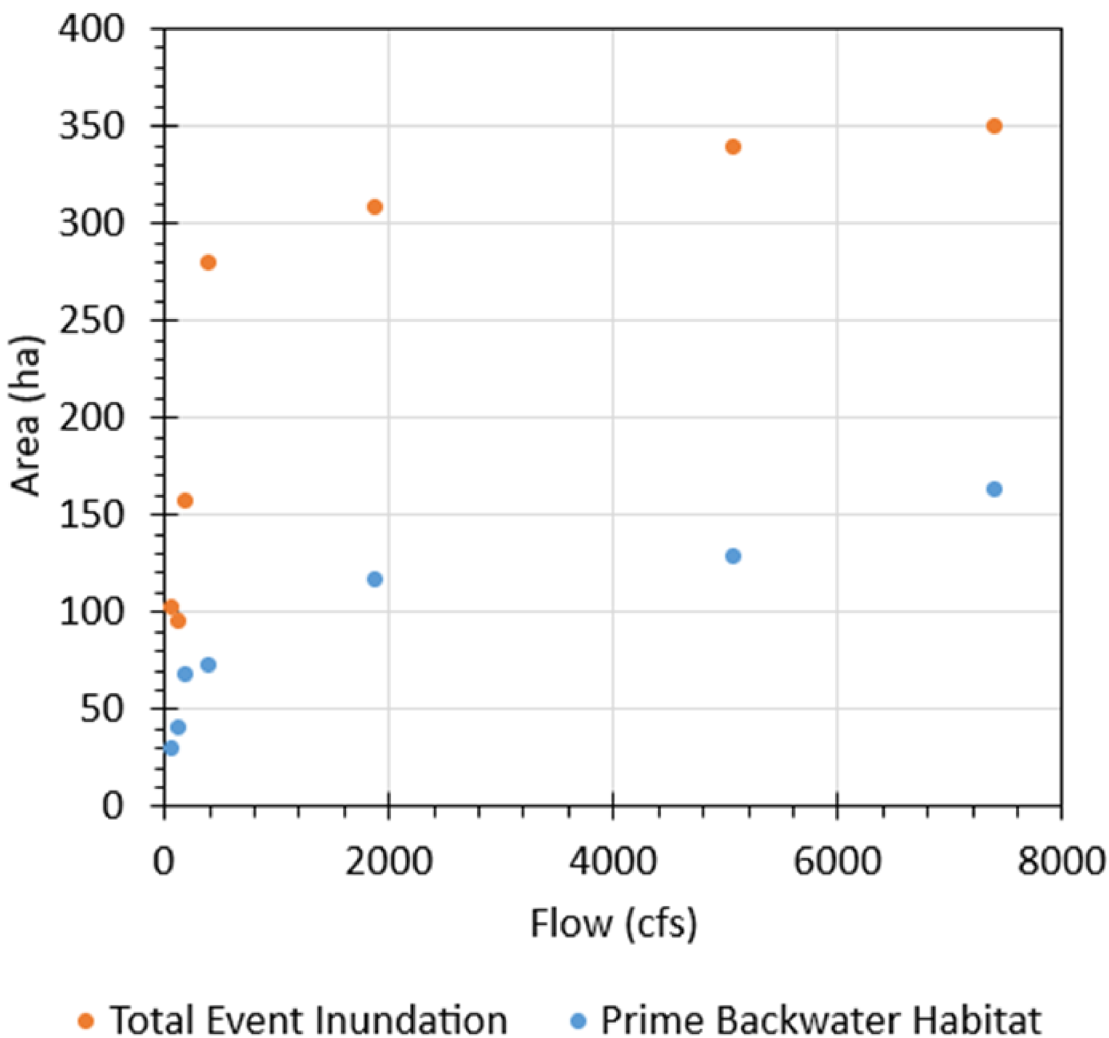


Figure 37. Site 6. Concho River at Paint Rock, TX

Scatterplots: Total Event Inundation and Prime Backwater Habitat Availability

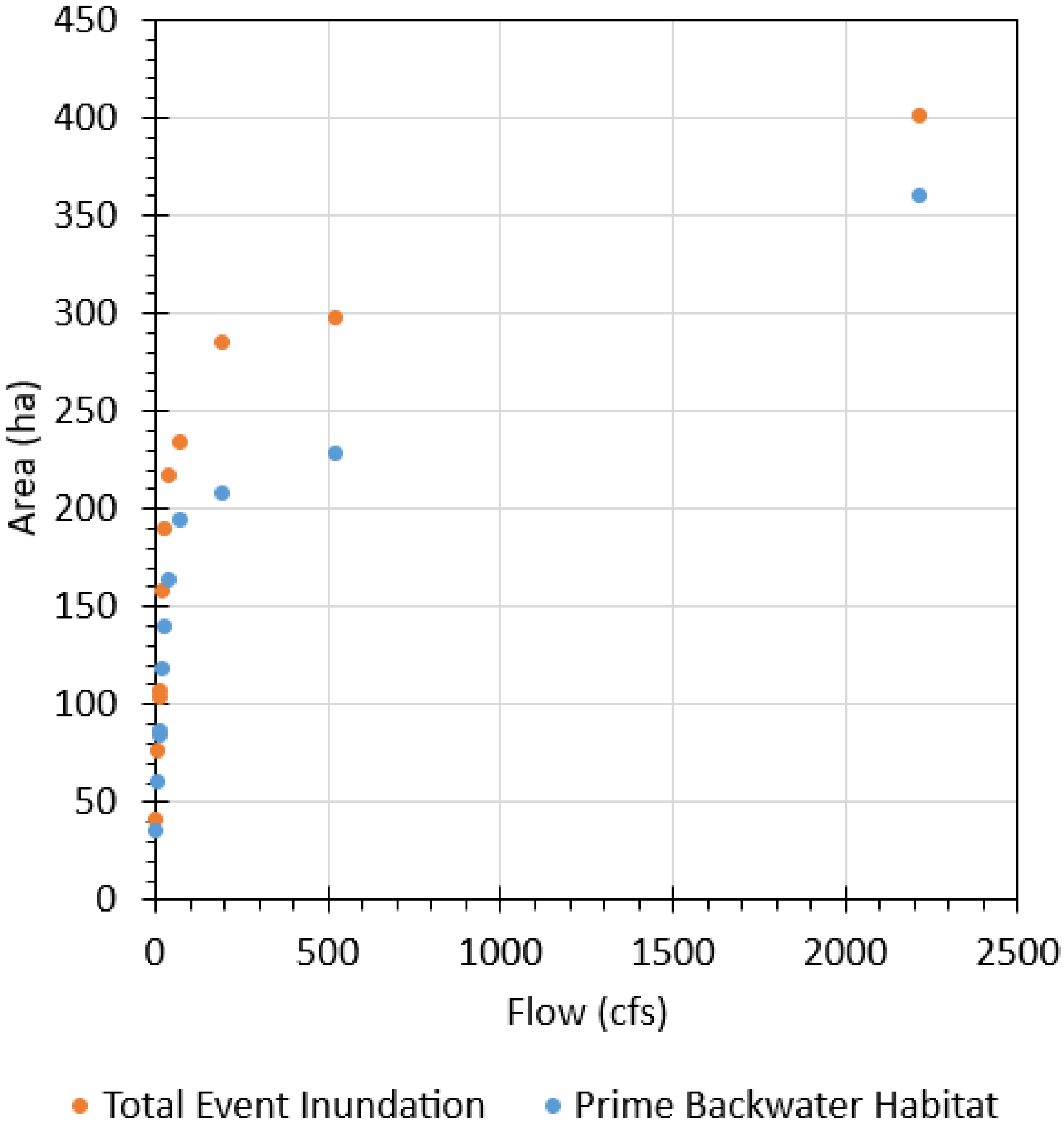


Figure 38. Site 9: Pedernales River near Johnson City, TX

Scatterplots: Total Event Inundation and Prime Backwater Habitat Availability

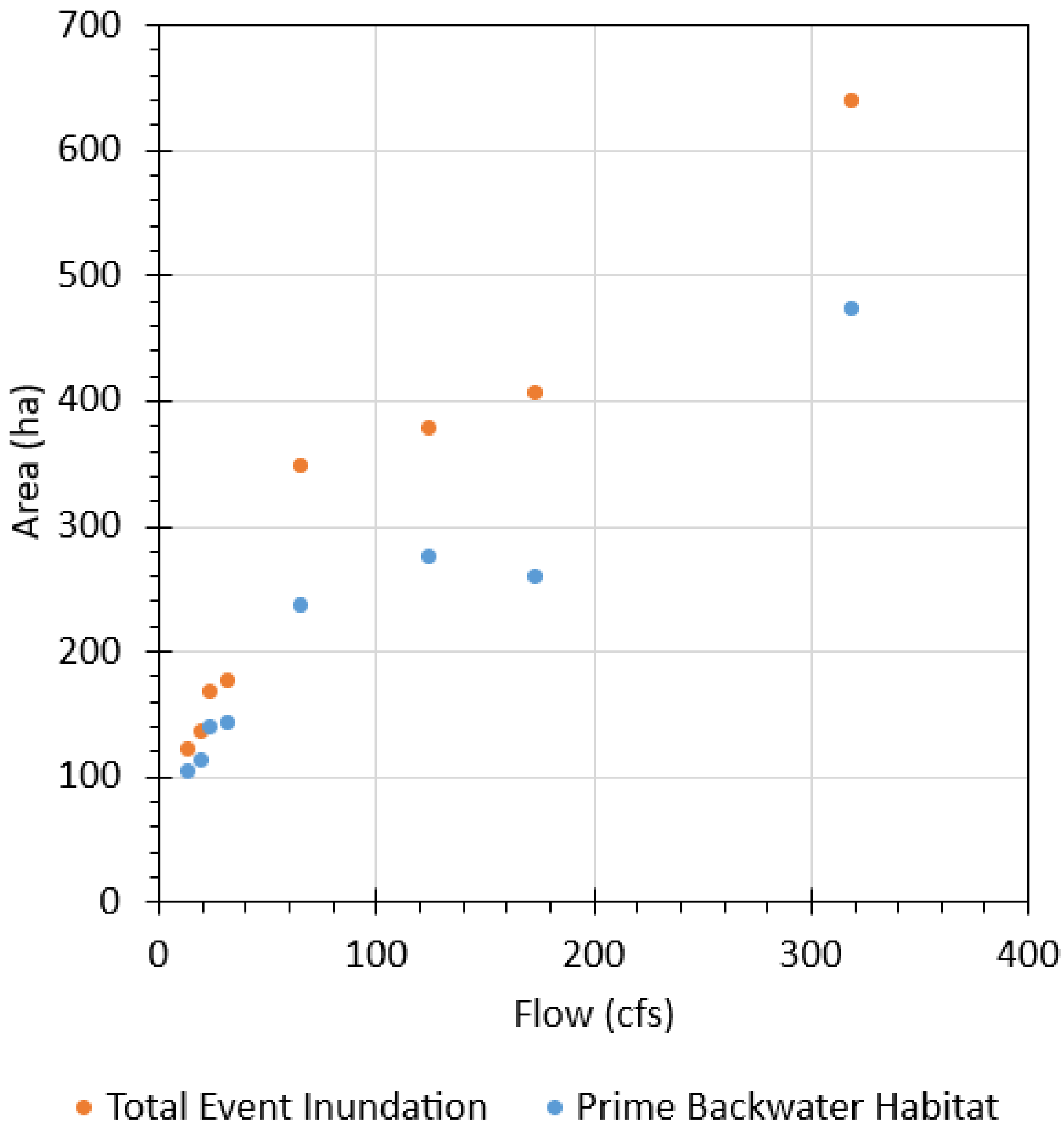


Figure 39. Site 11: Sandy Creek near Ganado, TX

Scatterplots: Total Event Inundation and Prime Backwater Habitat Availability

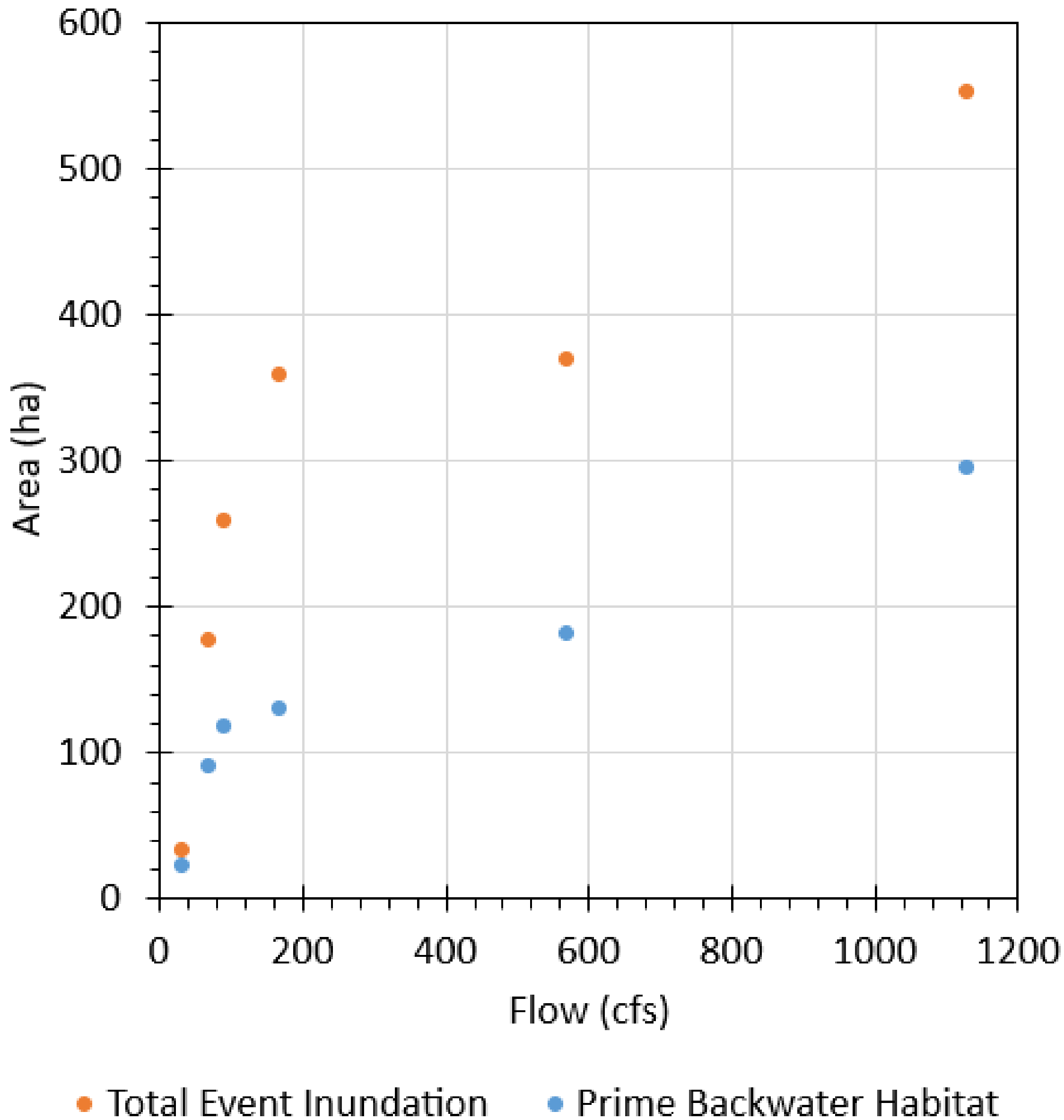


Figure 40. Site 13: West Mustang Creek near Ganado, TX

Scatterplots: Total Event Inundation and Prime Backwater Habitat Availability

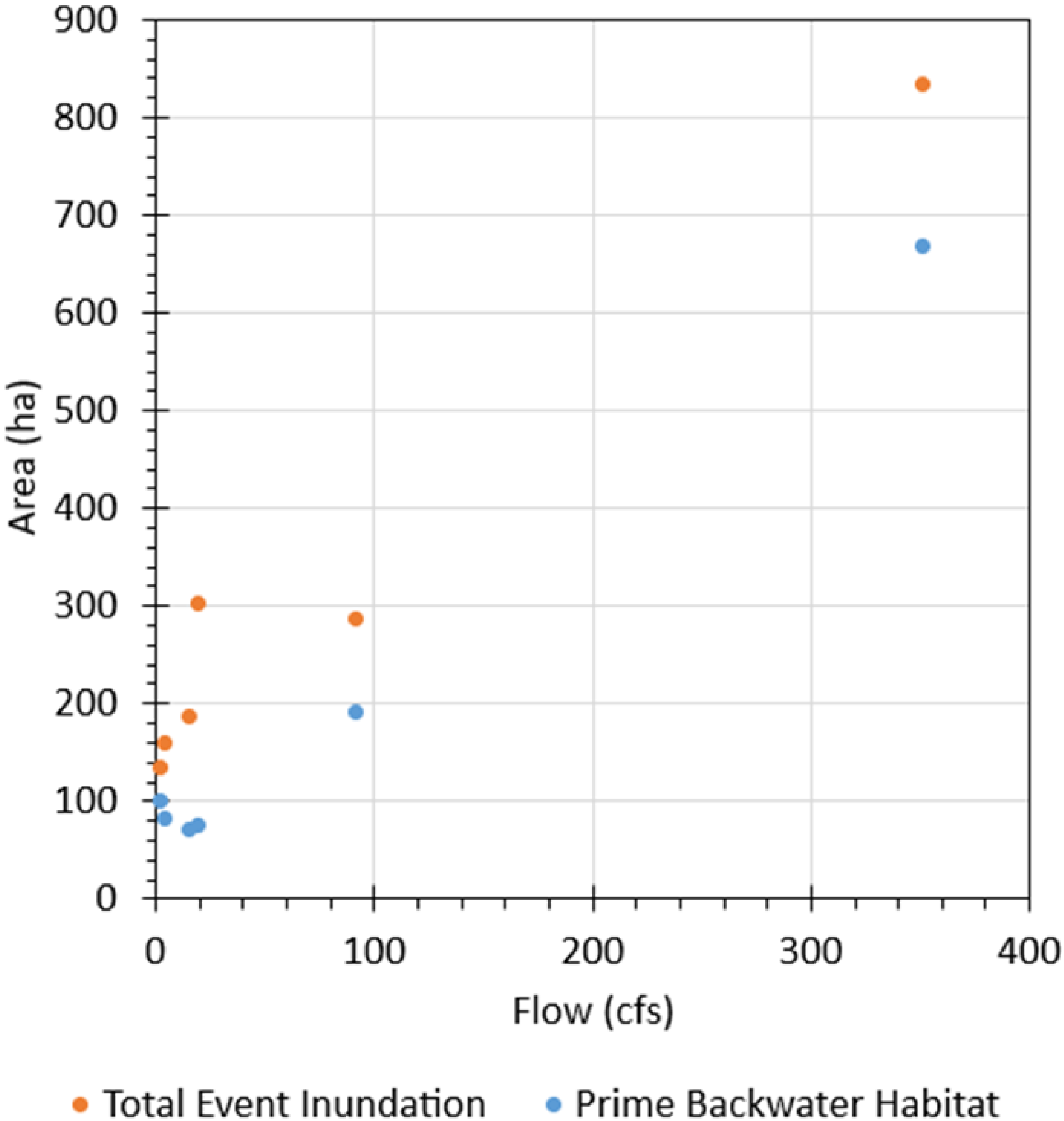


Figure 41. Site 14: Tres Palacios River near Midfield, Texas.

Scatterplots: Total Event Inundation and Prime Backwater Habitat Availability

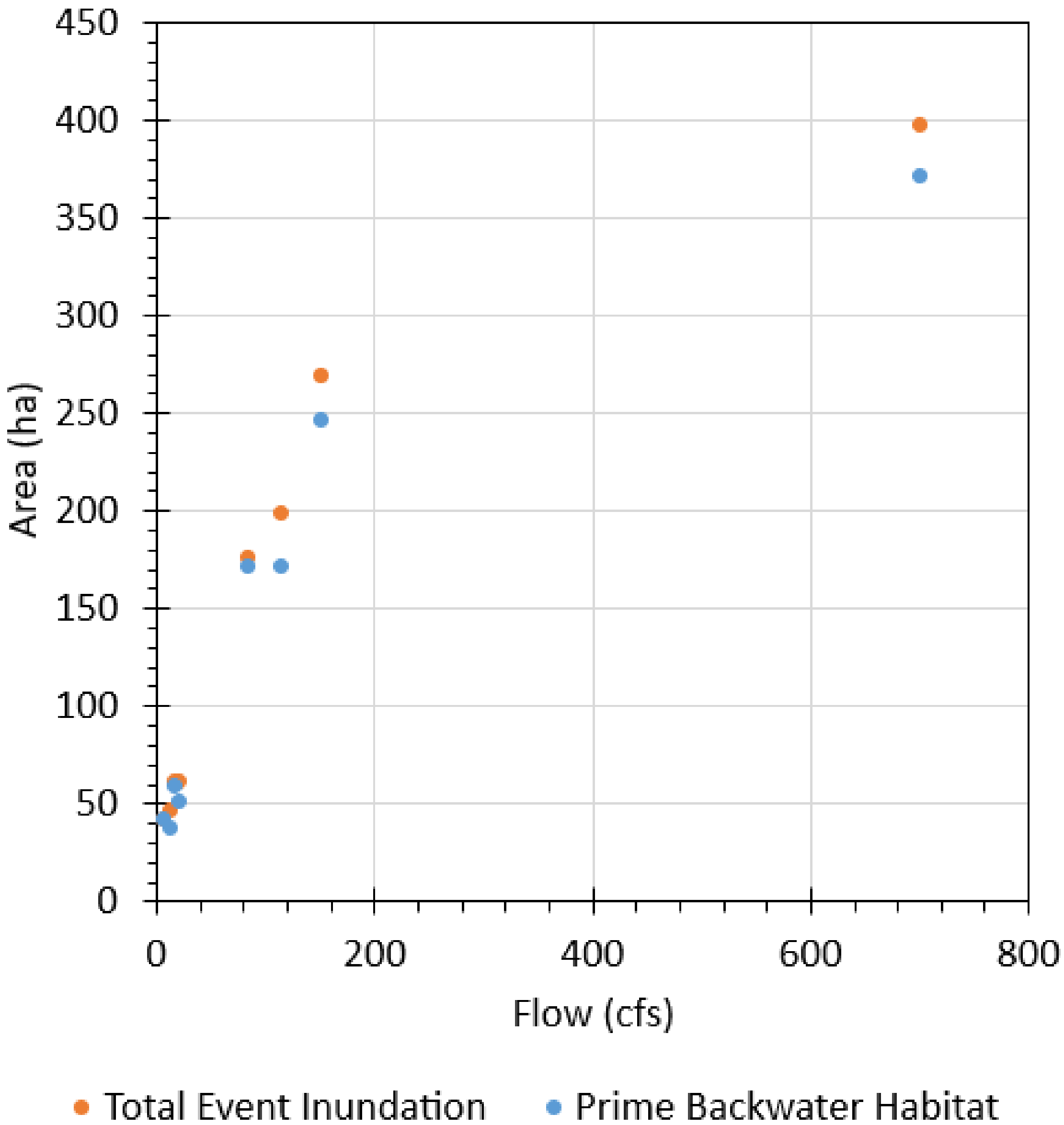


Table 1. Study Site Location Information

Hydraulic Connectivity Study Sites: USGS Stream Gages and Coordinates

Site #	Stream	USGS Stream Gage*	USGS ID	Latitude	Longitude	Datum
1	Main stem Lavaca R.	Lavaca Rv nr Edna, TX	8164000	28°57'35"	96°41'10"	NAD27
2	Main stem Navidad R.	Navidad Rv at Strane Pk nr Edna, TX	8164390	29°03'55"	96°40'26"	NAD27
3	Upper Colorado R.	Colorado Rv nr Ballinger, TX	8126380	31°42'55"	100°01'34"	NAD27
4	Upper Colorado R.	Colorado Rv abv Silver, TX	8123850	32°03'13"	100°45'42"	NAD27
5	Middle Colorado R.	Colorado Rv nr San Saba, TX	8147000	31°13'04"	98°33'51"	NAD27
6	Concho R.	Concho Rv at Paint Rock, TX	8136500	31°30'57"	99°55'09"	NAD27
9	Pedernales R.	Pedernales Rv nr Johnson City, TX	8153500	30°17'30"	98°23'57"	NAD27
11	Sandy Ck.	Sandy Ck nr Ganado, TX	8164450	29°09'36"	96°32'46"	NAD27
13	W. Mustang Ck.	W Mustang Ck nr Ganado, TX	8164503	29°04'18.69"	96°28'04.90"	NAD83
14	Tres Palacios R.	Tres Palacios Rv nr Midfield, TX	8162600	28°55'40"	96°10'15"	NAD27

* TCEQ Environmental Flows Measurement Point

Table 2. Hydraulic Connectivity Study Sites

USGS Gages, Seasonal Base Flows, and Small Pulse Triggers

Site#	USGS Stream Gage		Winter (cfs)		Spring (cfs)		Summer (cfs)		Fall (cfs)	
	Description	USGS ID	Avg Base	Small Pulse Trigger	Avg Base	Small Pulse Trigger	Avg Base	Small Pulse Trigger	Avg Base	Small Pulse Trigger
1	Lavaca Rv nr Edna, TX	8164000	55	2,000	55	4,500	48	88	33	1,600
2	Navidad Rv at Strane Pk nr Edna, TX	8164390	35	2,000	35	2,500	47	200	35	2,000
3	Colorado Rv nr Ballinger, TX	8126380	9	27	9	1,300	6	130	9	250
4	Colorado Rv abv Silver, TX	8123850	4	18	5	600	3	100	4	100
5	Colorado Rv nr San Saba, TX	8147000	150	520	190	5,800	120	510	150	890
6	Concho Rv at Paint Rock, TX	8136500	20	61	14	500	4	32	16	74
9	Pedernales Rv nr Johnson City, TX	8153500	45	270	60	1,700	29	N/A	29	160
11	Sandy Ck nr Ganado, TX	8164450	14	800	14	1,400	21	91	21	630
13	W Mustang Ck nr Ganado, TX	8164503	9	470	11	810	18	75	14	470
14	Tres Palacios Rv nr Midfield, TX	8162600	13	650	13	1,200	13	75	13	800

Table 3. Site 1. Lavaca Rv nr Edna, TX
Summary Data: TES Habitat Inundation & River Discharge

Site 1: Lavaca Rv nr Edna, TX TES Habitat Inundation & River Discharge Summary	**Event:**	**02/18/15**		**01/16/18**		**12/01/18**		**12/27/06**		**01/27/02**		**02/22/18**		**01/21/93**		**01/01/03**	
	MDD*:	**3.52**		**38.10**		**48.80**		**62.40**		**87.00**		**154.00**		**1,260.00**		**1,880.00**	
	Res. (m):**	**0.5**		**0.7**		**0.6**		**30.0**		**2.5**		**0.7**		**30.0**		**30.0**	
TES Habitat Types:	**Site Totals (ha) per Habitat:**	**%**	**ha**	**%**	**ha**	**%**	**ha**	**%**	**ha**	**%**	**ha**	**%**	**ha**	**%**	**ha**	**%**	**ha**
Prime Backwater Habitats: Herbaceous	**6,985.2**	**0.3%**	**23.6**	**0.0%**	**0.0**	**0.5%**	**32.7**	**0.1%**	**4.4**	**0.2%**	**16.0**	**0.6%**	**39.1**	**17.0%**	**1,189.8**	**18.1%**	**1,262.3**
Prime Backwater Habitats: Open Woody (Non-Forest)	**2,036.4**	**0.5%**	**9.60**	**0.0%**	**0.13**	**0.6%**	**12.38**	**0.3%**	**6.00**	**0.2%**	**4.61**	**1.1%**	**22.92**	**1.4%**	**28.24**	**2.0%**	**40.48**
Prime Backwater Habitats: Open Water	2.6	0.0%	0.00	0.0%	0.00	2.8%	0.07	0.0%	0.00	88.6%	2.27	3.2%	0.08	86.9%	2.22	52.2%	1.33
Other Habitats: Forest, Urban, & Barren	2,505.8	0.6%	14.55	2.8%	70.71	1.3%	32.42	3.6%	90.74	5.8%	146.05	6.3%	158.66	7.1%	178.14	13.6%	340.04
TOTAL PRIME BACKWATER HABITATS:	**9,024.2**	**0.4%**	**33.24**	**0.0%**	**0.13**	**0.5%**	**45.12**	**0.1%**	**10.45**	**0.3%**	**22.84**	**0.7%**	**62.11**	**13.5%**	**1,220.28**	**14.5%**	**1,304.12**
TOTAL EVENT INUNDATION:	**11,529.9**	**0.4%**	**47.79**	**0.6%**	**70.84**	**0.7%**	**77.54**	**0.9%**	**101.19**	**1.5%**	**168.89**	**1.9%**	**220.77**	**12.1%**	**1,398.42**	**14.3%**	**1,644.16**

* MDD: Mean Daily Discharge (cfs)
** Res (m): Imagery resolution in meters.

Table 4. Site 2: Navidad Rv at Strane Pk nr Edna, TX
Summary Data: TES Habitat Inundation & River Discharge

Site 2: Navidad Rv at Strane Pk nr Edna, TX TES Habitat Inundation & River Discharge Summary	**Event:**	**02/18/15**		**01/21/20**		**02/20/21**		**12/16/20**		**01/27/20**		**12/01/18**		**02/23/18**		**01/06/02**		**01/01/21**	
	MDD*:	**1.25**		**14.40**		**20.50**		**32.20**		**47.00**		**55.10**		**131.00**		**369.00**		**710.00**	
	Res. (m):**	**0.5**		**10.0**		**10.0**		**0.6**		**2.5**		**0.6**		**0.7**		**30.0**		**10.0**	
TES Habitat Types:	**Site Totals (ha) per Habitat:**	**%**	**ha**	**%**	**ha**	**%**	**ha**	**%**	**ha**	**%**	**ha**	**%**	**ha**	**%**	**ha**	**%**	**ha**	**%**	**ha**
Prime Backwater Habitats: Herbaceous	**12,541.6**	**0.1%**	**14.7**	**0.2%**	**26.2**	**0.0%**	**0.2**	**0.3%**	**33.7**	**0.1%**	**15.2**	**0.4%**	**46.0**	**0.4%**	**49.6**	**1.7%**	**208.2**	**4.3%**	**542.6**
Prime Backwater Habitats: Open Woody (Non-Forest)	**7,728.0**	**0.1%**	**10.1**	**0.1%**	**10.2**	**0.0%**	**0.4**	**0.4%**	**28.9**	**0.2%**	**15.6**	**0.4%**	**32.4**	**0.5%**	**38.3**	**0.5%**	**42.0**	**1.3%**	**99.2**
Prime Backwater Habitats: Open Water	10.4	42.6%	4.4	36.4%	3.8	0.0%	0.0	49.4%	5.1	33.9%	3.5	49.4%	5.1	52.0%	5.4	49.2%	5.1	51.4%	5.3
Other Habitats: Forest, Urban, & Barren	2,524.0	0.7%	17.7	0.7%	18.0	3.1%	77.8	0.8%	19.1	3.2%	80.0	2.0%	50.8	5.3%	133.7	6.8%	170.8	11.8%	298.2
TOTAL PRIME BACKWATER HABITATS:	**20,279.9**	**0.1%**	**29.2**	**0.2%**	**40.3**	**0.0%**	**0.7**	**0.3%**	**67.8**	**0.2%**	**34.3**	**0.4%**	**83.6**	**0.5%**	**93.3**	**1.3%**	**255.3**	**3.2%**	**647.2**
TOTAL EVENT INUNDATION:	**22,803.9**	**0.2%**	**46.9**	**0.3%**	**58.3**	**0.3%**	**78.5**	**0.4%**	**86.8**	**0.5%**	**114.2**	**0.6%**	**134.4**	**1.0%**	**227.0**	**1.9%**	**426.1**	**4.1%**	**945.4**

* MDD: Mean Daily Discharge (cfs)
** Res (m): Imagery resolution in meters.

Table 5. Site 3. Colorado Rv nr Ballinger, TX
Summary Data: TES Habitat Inundation & River Discharge

Site 3: Colorado Rv nr Ballinger, TX TES Habitat Inundation & River Discharge Summary	Event:	02/11/18		02/23/18		02/20/05		12/13/89		12/20/07		02/15/97		02/12/19		03/03/97		02/25/92	
	MDD*:	1.96		7.65		9.10		12.00		29.40		65.00		107.00		234.00		2,860.00	
	Res. (m)**:	0.7		0.7		30.0		2.5		30.0		2.5		30.0		2.5		60.0	
TES Habitat Types:	Site Totals (ha) per Habitat:	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha
Prime Backwater Habitats: Herbaceous	5,833.35	0.0%	0.3	0.4%	22.7	0.2%	11.3	0.6%	37.6	0.7%	43.1	0.7%	39.8	0.6%	34.7	2.9%	167.1	10.3%	598.5
Prime Backwater Habitats: Open Woody (Non-Forest)	5,109.29	1.1%	58.58	1.6%	79.96	1.8%	93.18	1.8%	89.94	2.6%	133.21	3.5%	178.83	4.3%	221.95	6.1%	309.48	7.5%	381.18
Prime Backwater Habitats: Open Water	198.89	0.0%	0.00	94.5%	187.88	80.2%	159.46	94.1%	187.21	65.6%	130.55	99.8%	198.53	94.7%	188.37	99.6%	198.03	99.9%	198.60
Other Habitats: Forest, Urban, & Barren	525.47	0.7%	17.7	0.7%	18.0	3.1%	77.8	0.8%	19.1	3.2%	80.0	2.0%	50.8	5.3%	133.7	6.8%	170.8	11.8%	298.2
TOTAL PRIME BACKWATER HABITATS:	11,141.53	0.1%	29.2	0.2%	40.3	0.0%	0.7	0.3%	67.8	0.2%	34.3	0.4%	83.6	0.5%	93.3	1.3%	255.3	3.2%	647.2
TOTAL EVENT INUNDATION:	11,667.01	0.2%	46.9	0.3%	58.3	0.3%	78.5	0.4%	86.8	0.5%	114.2	0.6%	134.4	1.0%	227.0	1.9%	426.1	4.1%	945.4

* MDD: Mean Daily Discharge (cfs)
** Res (m): Imagery resolution in meters.

Table 6. Site 4. Colorado Rv abv Silver, TX
Summary Data: TES Habitat Inundation & River Discharge

Site 4: Colorado Rv abv Silver, TX TES Habitat Inundation & River Discharge Summary	Event:	02/08/96		05/04/18		04/28/18		10/16/08		01/10/87		12/23/91	
	MDD (cfs)*:	3.2		7.4		22.3		37.0		118.0		748.0	
	Res. (m)**:	1.0		0.7		0.7		0.5		30.0		30.0	
TES Habitat Types:	Site Totals (ha) per Habitat:	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha
Prime Backwater Habitats: Herbaceous	8,474.3	0.1%	10.3	0.2%	18.7	0.3%	24.4	0.3%	27.6	0.5%	41.2	2.2%	188.6
Prime Backwater Habitats: Open Woody (Non-Forest)	9,255.9	0.3%	28.2	0.3%	28.5	0.4%	39.4	0.6%	53.2	1.6%	147.0	5.0%	464.1
Prime Backwater Habitats: Open Water	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0
Other Habitats: Forest, Urban, & Barren	78.3	0.0%	0.0	2.0%	1.6	0.1%	0.1	3.6%	2.8	0.6%	0.4	2.0%	1.6
TOTAL PRIME BACKWATER HABITATS:	17,730.13	0.2%	38.48	0.3%	47.15	0.4%	63.82	0.5%	80.80	1.1%	188.22	3.7%	652.73
TOTAL EVENT INUNDATION:	17,808.43	0.2%	38.52	0.3%	48.70	0.4%	63.89	0.5%	83.62	1.1%	188.66	3.7%	654.28

* MDD: Mean Daily Discharge (cfs)
** Res (m): Imagery resolution in meters.

Table 7. Site 5. Colorado River near San Saba, TX
Summary Data: TES Habitat Inundation & River Discharge

Site 5: Colorado River near San Saba, TX TES Habitat Inundation & River Discharge Summary	Event:	01/02/07		01/19/04		02/17/83		02/01/19		12/27/18		03/01/87		03/03/97	
	MDD (cfs)*:	64.50		124.00		188.00		404.00		1,880.00		5,080.00		7,410.00	
	Res. (m)**:	1.4		30.0		30.0		0.7		30.0		30.0		30.0	
TES Habitat Types:	Site Totals (ha) per Habitat	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha
Prime Backwater Habitats: Herbaceous	3,946.80	0.0%	0.36	0.0%	1.33	0.5%	18.46	0.1%	2.76	0.4%	17.12	1.0%	39.14	0.8%	30.69
Prime Backwater Habitats: Open Woody (Non-Forest)	6,620.41	0.1%	3.65	0.1%	7.78	0.3%	19.57	0.3%	19.71	0.7%	47.81	0.4%	27.13	0.9%	59.82
Prime Backwater Habitats: Open Water	118.45	21.7%	25.68	26.3%	31.14	24.8%	29.36	42.2%	49.99	43.9%	52.04	52.6%	62.27	60.6%	71.83
Other Habitats: Forest, Urban, & Barren	1,537.13	4.7%	72.37	3.6%	54.71	5.8%	89.62	13.5%	207.13	12.4%	191.06	13.6%	209.72	12.2%	187.50
TOTAL PRIME BACKWATER HABITATS:	10,685.66	0.3%	29.68	0.4%	40.25	0.6%	67.39	0.7%	72.47	1.1%	116.98	1.2%	128.54	1.5%	162.35
TOTAL EVENT INUNDATION:	12,222.78	0.8%	102.06	0.8%	94.96	1.3%	157.01	2.3%	279.60	2.5%	308.04	2.8%	338.26	2.9%	349.85

* MDD: Mean Daily Discharge (cfs)
** Res (m): Imagery resolution in meters.

Table 8. Site 6. Concho Rv at Paint Rock, TX
Summary Data: TES Habitat Inundation & River Discharge

Site 6: Concho Rv at Paint Rock, TX TES Habitat Inundation & River Discharge Summary	Event:	12/26/01		03/14/18		02/27/16		03/04/18		01/14/09		12/10/89		03/30/18		02/23/18		05/16/18		02/22/97		02/25/92	
	MDD (cfs)*:	4.03		6.22		15.60		18.20		21.70		28.00		42.00		71.70		195.00		526.00		2,220.00	
	Res. (m)**:	30.00		0.70		30.00		0.70		30.00		2.50		0.70		0.70		0.70		30.00		30.00	
TES Habitat Types:	Site Totals (ha) per Habitat:	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha
Prime Backwater Habitats: Herbaceous	4,739.13	0.0%	2.22	0.2%	7.87	0.2%	8.45	0.2%	8.96	0.4%	17.35	0.5%	25.47	0.5%	23.61	0.8%	36.92	0.7%	30.95	0.7%	31.36	2.6%	125.21
Prime Backwater Habitats: Open Woody (Non-Forest)	6,923.05	0.2%	14.90	0.8%	52.60	0.5%	35.58	0.7%	45.70	1.0%	67.83	1.3%	88.09	1.3%	87.14	1.6%	110.81	1.9%	128.55	2.0%	139.89	2.8%	195.04
Prime Backwater Habitats: Open Water	89.72	20.6%	18.46	0.0%	0.00	43.9%	39.36	34.6%	31.04	36.7%	32.91	29.4%	26.39	58.2%	52.18	51.8%	46.47	53.5%	47.97	63.5%	56.93	44.1%	39.59
Other Habitats: Forest, Urban, & Barren	497.69	1.0%	4.89	3.2%	15.78	3.9%	19.57	4.2%	20.76	7.9%	39.36	9.8%	48.94	10.8%	53.94	7.9%	39.37	15.5%	77.28	13.9%	69.16	8.3%	41.37
TOTAL PRIME BACKWATER HABITATS:	11,751.90	0.3%	35.58	0.5%	60.47	0.7%	83.40	0.7%	85.70	1.0%	118.09	1.2%	139.96	1.4%	162.94	1.7%	194.20	1.8%	207.47	1.9%	228.18	3.1%	359.83
TOTAL EVENT INUNDATION:	12,249.59	0.3%	40.48	0.6%	76.25	0.8%	102.97	0.9%	106.46	1.3%	157.46	1.5%	188.90	1.8%	216.87	1.9%	233.57	2.3%	284.75	2.4%	297.34	3.3%	401.20

* MDD: Mean Daily Discharge (cfs)
** Res (m): Imagery resolution in meters.

Table 9. Site 9. Pedernales R nr Johnson City
Summary Data: TES Habitat Inundation & River Discharge

Site 9: Pedernales R nr Johnson City TES Habitat Inundation & River Discharge Summary	Event:	12/07/20		01/14/18		01/11/20		01/28/20		02/05/16		01/04/16		2/11/19		01/28/19	
	MDD (cfs)*:	13.10		19.90		23.70		31.40		65.50		125.00		173.00		319.00	
	Res. (m)**:	0.6		0.3		0.3		0.3		30.0		30.0		0.7		0.7	
TES Habitat Types:	Site Totals (ha) per Habitat:	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha
Prime Backwater Habitats: Herbaceous	5,137.3	0.2%	10.3	0.2%	12.1	0.2%	12.2	0.3%	15.7	0.7%	33.8	1.1%	58.7	1.0%	49.5	3.1%	159.3
Prime Backwater Habitats: Open Woody (Non-Forest)	5,560.7	0.1%	5.4	0.1%	6.4	0.1%	6.7	0.2%	9.9	0.9%	52.5	1.2%	65.4	0.7%	41.0	2.1%	117.2
Prime Backwater Habitats: Open Water	287.6	30.6%	88.08	32.7%	93.93	42.0%	120.76	40.8%	117.34	52.4%	150.78	52.5%	151.01	58.5%	168.24	68.2%	196.29
Other Habitats: Forest, Urban, & Barren	865.6	2.1%	18.33	2.6%	22.6	3.3%	28.47	3.9%	33.57	12.7%	110.09	11.9%	102.97	17.0%	147.13	19.2%	166.61
TOTAL PRIME BACKWATER HABITATS:	10,985.7	0.9%	103.74	1.0%	112.4	1.3%	139.66	1.3%	142.99	2.2%	237.07	2.5%	275.10	2.4%	258.77	4.3%	472.81
TOTAL EVENT INUNDATION:	11,851.3	1.0%	122.07	1.1%	135.0	1.4%	168.13	1.5%	176.56	2.9%	347.16	3.2%	378.07	3.4%	405.89	5.4%	639.42

* MDD: Mean Daily Discharge (cfs)
** Res (m): Imagery resolution in meters.

Table 10. Site 11. Sandy Ck nr Ganado, TX
Summary Data: TES Habitat Inundation & River Discharge

Site 11: Sandy Ck nr Ganado, TX TES Habitat Inundation & River Discharge Summary	Event:	12/01/18		01/31/17		01/06/02		01/14/05		12/28/15		01/01/03	
	MDD (cfs)*:	33.50		68.00		90.50		167.00		571.00		1,130.00	
	Res. (m)**:	0.6		30.0		30.0		30.0		30.0		30.0	
TES Habitat Types:	Site Totals (ha) per	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha
Prime Backwater Habitats: Herbaceous	5,228.24	0.3%	16.52	1.3%	69.61	1.7%	90.51	2.0%	103.86	2.4%	127.88	4.7%	243.30
Prime Backwater Habitats: Open Woody (Non-Forest)	6,110.57	0.1%	5.84	0.3%	19.79	0.4%	25.80	0.4%	25.13	0.9%	53.37	0.8%	50.26
Prime Backwater Habitats: Open Water	1.11	0.0%	0.00	60.0%	0.67	80.0%	0.89	60.0%	0.67	40.0%	0.44	100.0%	1.11
Other Habitats: Forest, Urban, & Barren	2,004.02	0.6%	11.47	4.4%	87.40	7.0%	140.78	11.4%	228.40	9.4%	188.15	12.8%	257.31
TOTAL PRIME BACKWATER HABITATS:	11,339.93	0.2%	22.36	0.8%	90.07	1.0%	117.20	1.1%	129.66	1.6%	181.70	2.6%	294.67
TOTAL EVENT INUNDATION:	13,343.95	0.0%	33.84	1.3%	177.47	1.9%	257.98	2.7%	358.06	2.8%	369.84	4.1%	551.98

* MDD: Mean Daily Discharge (cfs)
** Res (m): Imagery resolution in meters.

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Table 11. Site 13. W. Mustang Ck nr Ganado, TX
Summary Data: TES Habitat Inundation & River Discharge

Site 13: W. Mustang Ck nr Ganado, TX TES Habitat Inundation & River Discharge Summary	Event:	01/26/90		02/07/02		01/17/18		01/08/18		01/16/97		03/08/95	
	MDD (cfs)*:	2.40		4.30		15.30		19.60		92.00		351.00	
	Res. (m)**:	2.5		0.7		0.7		0.7		30.0		2.5	
TES Habitat Types:	Site Totals (ha) per Habitat:	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha
Prime Backwater Habitats: Herbaceous	16,737.98	0.1%	11.98	0.0%	3.02	0.0%	6.11	0.1%	9.85	0.5%	89.40	2.7%	454.64
Prime Backwater Habitats: Open Woody (Non-Forest)	5,092.10	0.8%	42.72	0.8%	40.39	0.5%	27.21	0.6%	28.97	1.1%	53.82	3.3%	170.36
Prime Backwater Habitats: Open Water	106.11	42.5%	45.07	34.8%	36.89	33.7%	35.73	33.7%	35.72	45.3%	48.04	39.5%	41.88
Other Habitats: Forest, Urban, & Barren	986.67	3.5%	34.13	8.0%	79.07	11.8%	116.35	23.1%	227.78	9.7%	95.41	16.8%	166.14
TOTAL PRIME BACKWATER HABITATS:	21,936.19	0.5%	99.77	0.4%	80.30	0.3%	69.05	0.3%	74.54	0.9%	191.26	3.0%	666.87
TOTAL EVENT INUNDATION:	22,922.86	0.6%	133.91	0.7%	159.37	0.8%	185.40	1.3%	302.32	1.3%	286.67	3.6%	833.01

* MDD: Mean Daily Discharge (cfs)
** Res (m): Imagery resolution in meters.

Table 12. Site 14. Tres Palacios Rv nr Midfield, TX
Summary Data: TES Habitat Inundation & River Discharge

Site 14: Tres Palacios Rv nr Midfield, TX TES Habitat Inundation & River Discharge Summary	Event:	03/10/89		02/10/15		01/25/02		12/28/20		01/17/06		01/21/93		01/14/05		12/07/09	
	MDD (cfs)*:	6.70		12.40		16.00		20.70		84.50		114.00		152.00		700.00	
	Res. (m)**:	2.5		0.5		2.5		0.6		30.0		30.0		30.0		0.5	
TES Habitat Types:	Site Totals (ha) per Habitat:	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha
Prime Backwater Habitats: Herbaceous	14,307.4	0.1%	16.74	0.0%	7.07	0.1%	20.40	0.1%	16.88	0.9%	131.21	0.7%	94.30	0.5%	68.50	2.1%	295.45
Prime Backwater Habitats: Open Woody (Non-Forest)	4,784.2	0.1%	4.26	0.4%	20.76	0.4%	21.47	0.5%	21.82	0.5%	26.24	1.6%	76.73	3.3%	156.12	1.1%	54.38
Prime Backwater Habitats: Open Water	59.6	35.2%	20.96	16.7%	9.97	28.6%	17.06	21.2%	12.61	22.4%	13.34	0.0%	0.00	36.2%	21.57	35.5%	21.17
Other Habitats: Forest, Urban, & Barren	547.6	0.0%	0.00	1.6%	9.01	0.4%	2.13	1.9%	10.35	1.0%	5.34	5.1%	27.80	4.1%	22.46	4.9%	26.71
TOTAL PRIME BACKWATER HABITATS:	19,151.1	0.2%	42.0	0.2%	37.8	0.3%	58.9	0.3%	51.3	0.9%	170.8	0.9%	171.0	1.3%	246.2	1.9%	371.0
TOTAL EVENT INUNDATION:	19,698.7	0.2%	42.0	0.2%	46.8	0.3%	61.1	0.3%	61.7	0.9%	176.1	1.0%	198.8	1.4%	268.7	2.0%	397.7

* MDD: Mean Daily Discharge (cfs)
** Res (m): Imagery resolution in meters.

Table 13. Site 1: Lavaca River near Edna, TX.
River Discharge and Inundated Habitats, Details.

Site 1: Lavaca Rv nr Edna, TX TES Habitat Inundation & River Discharge Details	Event:	02/18/15		01/16/18		12/01/18		12/27/06		01/27/02		02/22/18		01/21/93		01/01/03	
	MDD*:	3.52		38.10		48.80		62.40		87.00		154.00		1,260.00		1,880.00	
	Res. (m)**:	0.5		0.7		0.6		30.0		2.5		0.7		30.0		30.0	
TES Habitat Types:	Site Totals (ha) per Habitat:	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha
Prime Backwater Habitats: Herbaceous																	
Coastal Bend: Floodplain Grassland	1,002.4	0.3%	2.80	0.0%	0.00	0.5%	4.89	0.0%	0.00	0.0%	0.00	0.7%	7.00	3.7%	37.36	5.1%	51.37
Coastal Bend: Floodplain Herbaceous Wetland	15.0	19.7%	2.95	0.0%	0.00	17.9%	2.68	29.7%	4.45	19.0%	2.84	22.7%	3.41	25.2%	3.78	26.7%	4.00
Coastal Bend: Riparian Grassland	43.3	0.0%	0.00	0.0%	0.00	0.3%	0.12	0.0%	0.00	0.0%	0.00	0.0%	0.00	2.6%	1.11	0.5%	0.22
Coastal Bend: Riparian Herbaceous Wetland	1.2	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00
Coastal Plain: Terrace Sandyland Grassland	36.5	4.6%	1.69	0.0%	0.00	5.1%	1.87	0.0%	0.00	0.0%	0.00	5.9%	2.14	1.2%	0.44	6.1%	2.22
Gulf Coast: Coastal Prairie	4,552.1	0.2%	11.04	0.0%	0.00	0.4%	18.35	0.0%	0.00	0.2%	10.91	0.5%	20.92	6.7%	305.57	4.9%	220.84
Gulf Coast: Coastal Prairie Pondshore	26.5	17.7%	4.69	0.0%	0.00	17.0%	4.49	0.0%	0.00	8.4%	2.21	18.6%	4.91	28.6%	7.56	34.5%	9.12
Marsh	0.7	45.1%	0.33	0.0%	0.00	8.5%	0.06	0.0%	0.00	0.0%	0.00	51.5%	0.37	61.5%	0.44	61.5%	0.44
Native Invasive: Common Reed	62.2	0.1%	0.06	0.0%	0.00	0.2%	0.10	0.0%	0.00	0.0%	0.00	0.4%	0.26	0.4%	0.22	0.4%	0.22
Post Oak Savanna: Savanna Grassland	37.4	0.2%	0.07	0.0%	0.00	0.0%	0.01	0.0%	0.00	0.0%	0.00	0.3%	0.10	0.6%	0.22	0.6%	0.22
Row Crops	1,207.9	0.0%	0.00	0.0%	0.00	0.0%	0.09	0.0%	0.00	0.0%	0.00	0.0%	0.00	69.0%	833.09	80.6%	973.64
Prime Backwater Habitats: Herbaceous-Site Totals	**6,985.2**	**0.3%**	**23.6**	**0.0%**	**0.0**	**0.5%**	**32.7**	**0.1%**	**4.4**	**0.2%**	**16.0**	**0.6%**	**39.1**	**17.0%**	**1,189.8**	**18.1%**	**1,262.3**
Prime Backwater Habitats: Open Woody																	
Coastal Bend: Floodplain Deciduous Shrubland	89.1	0.3%	0.27	0.0%	0.01	0.4%	0.37	0.0%	0.00	0.0%	0.00	8.1%	7.23	5.0%	4.45	8.5%	7.56
Coastal Bend: Floodplain Evergreen Shrubland	76.0	0.1%	0.05	0.2%	0.12	0.2%	0.13	0.3%	0.22	0.4%	0.29	0.6%	0.45	0.9%	0.67	2.6%	2.00
Coastal Bend: Riparian Deciduous Shrubland	7.3	0.0%	0.00	0.0%	0.00	0.1%	0.01	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00
Invasive: Evergreen Shrubland	56.3	0.4%	0.20	0.0%	0.00	1.4%	0.78	0.0%	0.00	0.0%	0.00	1.7%	0.93	4.0%	2.22	2.8%	1.56
Native Invasive: Baccharis Shrubland	9.5	0.8%	0.08	0.0%	0.00	0.3%	0.03	0.0%	0.00	42.0%	4.01	5.2%	0.49	51.3%	4.89	2.3%	0.22
Native Invasive: Deciduous Woodland	712.5	0.7%	4.85	0.0%	0.00	0.8%	6.00	0.6%	4.45	0.0%	0.06	1.1%	7.68	1.2%	8.23	1.8%	13.12
Native Invasive: Huisache Woodland or Shrubland	25.8	0.0%	0.00	0.0%	0.00	0.2%	0.05	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.9%	0.22	0.0%	0.00
Native Invasive: Mesquite Shrubland	364.7	0.4%	1.58	0.0%	0.00	0.6%	2.10	0.1%	0.44	0.1%	0.22	0.8%	2.79	0.7%	2.45	2.9%	10.67
Non-Native Invasive: Chinese Tallow Forest, Woodland, or Shrubland	33.2	0.0%	0.00	0.0%	0.00	0.2%	0.06	0.0%	0.00	0.0%	0.00	0.5%	0.15	2.7%	0.89	2.7%	0.89
Post Oak Savanna: Live Oak Motte and Woodland	520.3	0.4%	2.31	0.0%	0.00	0.5%	2.35	0.2%	0.89	0.0%	0.03	0.5%	2.60	0.7%	3.78	0.8%	4.00
Post Oak Savanna: Live Oak Shrubland	83.2	0.3%	0.28	0.0%	0.00	0.4%	0.33	0.0%	0.00	0.0%	0.00	0.4%	0.36	0.5%	0.44	0.5%	0.44
Post Oak Savanna: Post Oak - Live Oak Motte and Woodland	17.9	0.0%	0.00	0.0%	0.00	0.3%	0.05	0.0%	0.00	0.0%	0.00	0.6%	0.10	0.0%	0.00	0.0%	0.00
Post Oak Savanna: Post Oak - Yaupon Motte and Woodland	24.6	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00
Post Oak Savanna: Post Oak Motte and Woodland	16.0	0.0%	0.00	0.0%	0.00	0.7%	0.12	0.0%	0.00	0.0%	0.00	0.8%	0.13	0.0%	0.00	0.0%	0.00
Prime Backwater Habitats: Open Woody-Site Totals	**2,036.4**	**0.5%**	**9.60**	**0.0%**	**0.13**	**0.6%**	**12.38**	**0.3%**	**6.00**	**0.2%**	**4.61**	**1.1%**	**22.92**	**1.4%**	**28.24**	**2.0%**	**40.48**
Prime Backwater Habitats: Open Water																	
Prime Backwater Habitats: Open Water-Site Totals	**2.6**	**0.0%**	**0.00**	**0.0%**	**0.00**	**2.8%**	**0.07**	**0.0%**	**0.00**	**88.6%**	**2.27**	**3.2%**	**0.08**	**86.9%**	**2.22**	**52.2%**	**1.33**
Other Habitats: Forest, Urban, & Barren																	
Barren	1.7	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	65.5%	1.11	26.2%	0.44
Coastal Bend: Floodplain Hardwood Forest	2,099.7	0.7%	14.04	3.3%	70.27	1.5%	31.22	4.2%	88.51	6.7%	141.31	7.4%	155.75	7.8%	163.02	15.6%	327.36
Coastal Bend: Floodplain Live Oak - Hardwood Forest	151.6	0.1%	0.22	0.0%	0.00	0.4%	0.56	0.0%	0.00	0.0%	0.00	0.8%	1.27	4.4%	6.67	4.8%	7.34
Coastal Bend: Floodplain Live Oak Forest	115.9	0.1%	0.10	0.2%	0.22	0.2%	0.24	0.4%	0.44	0.6%	0.73	0.8%	0.93	0.2%	0.22	0.2%	0.22
Coastal Bend: Riparian Hardwood Forest	11.2	0.0%	0.00	0.5%	0.06	0.2%	0.03	6.0%	0.67	1.5%	0.17	1.2%	0.14	2.0%	0.22	0.0%	0.00
Coastal Bend: Riparian Live Oak - Hardwood Forest	1.9	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00
Coastal Bend: Riparian Live Oak Forest	2.2	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00
Urban High Intensity	2.8	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	79.3%	2.22	0.0%	0.00	71.5%	2.00	63.5%	1.78
Urban Low Intensity	118.8	0.2%	0.20	0.1%	0.16	0.3%	0.37	0.9%	1.11	1.4%	1.63	0.5%	0.58	4.1%	4.89	2.4%	2.89
Other Habitats: Forest, Urban, & Barren-Site Totals	**2,505.8**	**0.6%**	**14.55**	**2.8%**	**70.71**	**1.3%**	**32.42**	**3.6%**	**90.74**	**5.8%**	**146.05**	**6.3%**	**158.66**	**7.1%**	**178.14**	**13.6%**	**340.04**
TOTAL PRIME BACKWATER HABITATS:	**9,024.2**	**0.4%**	**33.24**	**0.0%**	**0.13**	**0.5%**	**45.12**	**0.1%**	**10.45**	**0.3%**	**22.84**	**0.7%**	**62.11**	**13.5%**	**1,220.28**	**14.5%**	**1,304.12**
TOTAL EVENT INUNDATION:	**11,529.9**	**0.4%**	**47.79**	**0.6%**	**70.84**	**0.7%**	**77.54**	**0.9%**	**101.19**	**1.5%**	**168.89**	**1.9%**	**220.77**	**12.1%**	**1,398.42**	**14.3%**	**1,644.16**
Event:		**02/18/15**		**01/16/18**		**12/01/18**		**12/27/06**		**01/27/02**		**02/22/18**		**01/21/93**		**01/01/03**	

* MDD: Mean Daily Discharge (cfs)

** Res (m): Imagery resolution in meters.

Table 14. Site 2: Navidad River at Strane Park near Edna, TX. River Discharge and Inundated Habitats, Details.

Site 2: Navidad Rv at Strane Pk nr Edna, TX TES Habitat Inundation & River Discharge Details	Event:	02/18/15		01/21/20		02/20/21		12/16/20		01/27/20		12/01/18		02/23/18		01/06/02		01/01/21	
	MDD*	1.25		14.40		20.50		32.20		47.00		55.10		131.00		369.00		710.00	
	Res. (m)**	0.5		10.0		10.0		0.6		2.5		0.6		0.7		30.0		10.0	
TES Habitat Types:	Site Totals (ha) per Habitat:	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha
Prime Backwater Habitats: Herbaceous																			
Coastal Bend: Floodplain Grassland	1,694.6	0.2%	3.1	0.1%	2.4	0.0%	0.2	0.1%	2.5	0.2%	3.5	0.4%	6.0	0.4%	7.4	0.3%	5.8	12.9%	218.8
Coastal Bend: Floodplain Herbaceous Wetland	13.6	14.3%	1.9	21.3%	2.9	0.0%	0.0	12.7%	1.7	27.7%	3.8	24.6%	3.3	24.8%	3.4	36.1%	4.9	36.1%	4.9
Coastal Bend: Riparian Grassland	18.6	0.0%	0.0	0.0%	0.0	0.0%	0.0	1.5%	0.3	0.0%	0.0	1.5%	0.3	1.6%	0.3	0.0%	0.0	1.2%	0.2
Coastal Bend: Riparian Herbaceous Wetland	101.9	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.1%	0.1	0.0%	0.0	0.3%	0.3	1.1%	1.1	0.7%	0.7	1.3%	1.3
Coastal Plain: Terrace Sandyland Grassland	106.8	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.1%	0.1	0.0%	0.0	0.1%	0.1	0.1%	0.1	1.5%	1.6	2.3%	2.4
Gulf Coast: Coastal Prairie	9,167.8	0.1%	8.1	0.1%	6.0	0.0%	0.0	0.2%	16.6	0.0%	3.6	0.2%	22.9	0.2%	22.7	1.6%	151.0	2.9%	266.7
Gulf Coast: Coastal Prairie Pondshore	95.8	1.6%	1.5	2.1%	2.0	0.0%	0.0	7.3%	7.0	4.4%	4.3	4.6%	4.4	4.8%	4.6	9.1%	8.7	13.0%	12.5
Marsh	8.6	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	9.5%	0.8	15.9%	1.4	0.0%	0.0	2.6%	0.2
Native Invasive: Common Reed	24.5	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0
Post Oak Savanna: Savanna Grassland	181.4	0.0%	0.0	0.0%	0.0	0.0%	0.0	2.0%	3.5	0.0%	0.0	3.9%	7.0	4.3%	7.7	0.0%	0.0	2.3%	4.2
Row Crops	1,128.1	0.0%	0.0	1.1%	12.9	0.0%	0.0	0.2%	1.8	0.0%	0.0	0.1%	0.9	0.1%	0.8	3.2%	35.6	2.8%	31.4
Prime Backwater Habitats: Herbaceous-Site Totals	**12,541.6**	**0.1%**	**14.7**	**0.2%**	**26.2**	**0.0%**	**0.2**	**0.3%**	**33.7**	**0.1%**	**15.2**	**0.4%**	**46.0**	**0.4%**	**49.6**	**1.7%**	**208.2**	**4.3%**	**542.6**
Prime Backwater Habitats: Open Woody																			
Coastal Bend: Floodplain Deciduous Shrubland	26.1	8.4%	2.2	13.6%	3.6	0.0%	0.0	9.3%	2.4	0.0%	0.0	10.8%	2.8	11.8%	3.1	11.9%	3.1	28.9%	7.6
Coastal Bend: Floodplain Evergreen Shrubland	66.6	0.3%	0.2	0.0%	0.0	0.3%	0.2	0.4%	0.3	0.6%	0.4	0.4%	0.3	0.2%	0.2	0.7%	0.4	4.7%	3.1
Coastal Bend: Riparian Deciduous Shrubland	19.2	0.0%	0.0	0.0%	0.0	0.0%	0.0	3.1%	0.6	0.0%	0.0	2.8%	0.5	0.0%	0.0	0.0%	0.0	1.2%	0.2
Invasive: Evergreen Shrubland	514.9	0.1%	0.6	0.3%	1.6	0.0%	0.2	1.6%	8.1	0.6%	3.0	1.0%	5.2	1.1%	5.8	0.7%	3.6	2.6%	13.6
Native Invasive: Baccharis Shrubland	20.1	0.0%	0.0	0.0%	0.0	0.0%	0.0	1.0%	0.2	0.0%	0.0	0.7%	0.1	0.8%	0.2	0.0%	0.0	0.0%	0.0
Native Invasive: Deciduous Woodland	1,654.0	0.2%	2.6	0.1%	0.9	0.0%	0.0	0.5%	8.0	0.1%	2.2	0.2%	4.0	0.3%	5.3	0.8%	13.8	2.0%	33.8
Native Invasive: Huisache Woodland or Shrubland	22.8	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0
Native Invasive: Mesquite Shrubland	683.1	0.2%	1.6	0.3%	1.8	0.0%	0.0	0.3%	1.9	0.1%	0.4	0.8%	5.3	1.0%	6.7	0.1%	0.7	1.6%	10.9
Non-Native Invasive: Chinese Tallow Forest, Woodland, or Shrubland	83.9	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.5%	0.4	0.0%	0.0	0.8%	0.7	0.8%	0.7	0.5%	0.4	3.7%	3.1
Post Oak Savanna: Live Oak Motte and Woodland	3,046.9	0.0%	1.4	0.0%	1.3	0.0%	0.0	0.1%	4.3	0.2%	5.8	0.3%	9.2	0.4%	11.8	0.5%	13.8	0.6%	19.3
Post Oak Savanna: Post Oak - Live Oak Motte and Woodland	1,485.6	0.1%	1.1	0.1%	0.9	0.0%	0.0	0.1%	2.2	0.1%	2.0	0.2%	3.7	0.2%	3.6	0.3%	4.0	0.4%	5.6
Post Oak Savanna: Post Oak - Yaupon Motte and Woodland	18.6	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0
Post Oak Savanna: Post Oak Motte and Woodland	86.2	0.3%	0.3	0.3%	0.2	0.0%	0.0	0.6%	0.5	1.9%	1.7	0.7%	0.6	1.2%	1.0	2.6%	2.2	2.3%	2.0
Prime Backwater Habitats: Open Woody-Site Totals	**7,728.0**	**0.1%**	**10.1**	**0.1%**	**10.2**	**0.0%**	**0.4**	**0.4%**	**28.9**	**0.2%**	**15.6**	**0.4%**	**32.4**	**0.5%**	**38.3**	**0.5%**	**42.0**	**1.3%**	**99.2**
Prime Backwater Habitats: Open Water																			
Prime Backwater Habitats: Open Water-Site Totals	**10.4**	**42.6%**	**4.4**	**36.4%**	**3.8**	**0.0%**	**0.0**	**49.4%**	**5.1**	**33.9%**	**3.5**	**49.4%**	**5.1**	**52.0%**	**5.4**	**49.2%**	**5.1**	**51.4%**	**5.3**
Other Habitats: Forest, Urban, & Barren																			
Barren	4.4	0.0%	0.0	15.2%	0.7	0.0%	0.0	17.4%	0.8	0.0%	0.0	38.4%	1.7	39.8%	1.7	20.3%	0.9	76.0%	3.3
Coastal Bend: Floodplain Hardwood Forest	1,825.8	0.9%	16.5	0.9%	15.8	4.2%	77.2	0.9%	16.1	4.4%	79.5	2.5%	46.0	7.1%	128.9	9.0%	165.0	14.6%	266.4
Coastal Bend: Floodplain Live Oak - Hardwood Forest	126.6	0.4%	0.6	0.5%	0.7	0.5%	0.7	0.5%	0.7	0.1%	0.1	0.8%	1.0	1.0%	1.3	0.5%	0.7	2.8%	3.6
Coastal Bend: Floodplain Live Oak Forest	309.1	0.1%	0.5	0.3%	0.9	0.0%	0.0	0.2%	0.6	0.1%	0.2	0.3%	0.9	0.3%	1.1	0.1%	0.4	1.8%	5.6
Coastal Bend: Riparian Hardwood Forest	122.8	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.5%	0.6	0.0%	0.0	0.5%	0.7	0.3%	0.3	0.4%	0.4	3.6%	4.4
Coastal Bend: Riparian Live Oak - Hardwood Forest	17.3	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.4%	0.1	0.0%	0.0	0.0%	0.0
Coastal Bend: Riparian Live Oak Forest	24.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.3%	0.1	0.0%	0.0	0.6%	0.1	0.0%	0.0	0.0%	0.0	2.8%	0.7
Urban High Intensity	2.4	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	55.3%	1.3	73.7%	1.8
Urban Low Intensity	91.6	0.2%	0.2	0.0%	0.0	0.0%	0.0	0.3%	0.2	0.1%	0.1	0.4%	0.3	0.3%	0.3	2.2%	2.0	13.6%	12.5
Other Habitats: Forest, Urban, & Barren-Site Totals	**2,524.0**	**0.7%**	**17.7**	**0.7%**	**18.0**	**3.1%**	**77.8**	**0.8%**	**19.1**	**3.2%**	**80.0**	**2.0%**	**50.8**	**5.3%**	**133.7**	**6.8%**	**170.8**	**11.8%**	**298.2**
TOTAL PRIME BACKWATER HABITATS:	**20,279.9**	**0.1%**	**29.2**	**0.2%**	**40.3**	**0.0%**	**0.7**	**0.3%**	**67.8**	**0.2%**	**34.3**	**0.4%**	**83.6**	**0.5%**	**93.3**	**1.3%**	**255.3**	**3.2%**	**647.2**
TOTAL EVENT INUNDATION:	**22,803.9**	**0.2%**	**46.9**	**0.3%**	**58.3**	**0.3%**	**78.5**	**0.4%**	**86.8**	**0.5%**	**114.2**	**0.6%**	**134.4**	**1.0%**	**227.0**	**1.9%**	**426.1**	**4.1%**	**945.4**
Event:		**02/18/15**		**01/21/20**		**02/20/21**		**12/16/20**		**01/27/20**		**12/01/18**		**02/23/18**		**01/16/20**		**01/01/21**	

* MDD: Mean Daily Discharge (cfs)

** Res (m): Imagery resolution in meters.

Table 15. Site 3: Colorado River near Ballinger, TX. River Discharge and Inundated Habitats, Details.

Site 3: Colorado Rv nr Ballinger, TX TES Habitat Inundation & River Discharge Details	Event:	02/11/18		02/23/18		02/20/05		12/13/89		12/20/07		02/15/97		02/12/19		03/03/97		02/25/92	
	MDD*:	1.96		7.65		9.10		12.00		29.40		65.00		107.00		234.00		2,860.00	
	Res. (m)**:	0.7		0.7		30.0		2.5		30.0		2.5		30.0		2.5		60.0	
TES Habitat Types:	Site Totals (ha) per	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha
Prime Backwater Habitats: Herbaceous																			
CRP / Other Improved Grassland	12.59	0.0%	0.00	0.0%	0.00	0.0%	0.00	2.0%	0.25	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	7.1%	0.89
Edwards Plateau: Floodplain Herbaceous Vegetation	386.78	0.1%	0.24	0.0%	0.12	0.5%	1.78	0.4%	1.68	1.8%	6.89	1.8%	7.14	1.1%	4.23	3.4%	12.98	16.3%	63.16
Edwards Plateau: Riparian Herbaceous Vegetation	58.11	0.0%	0.00	0.8%	0.44	1.5%	0.89	0.2%	0.14	3.1%	1.78	4.4%	2.56	1.5%	0.89	4.2%	2.41	3.8%	2.22
Marsh	4.77	0.0%	0.00	41.2%	1.96	41.9%	2.00	36.6%	1.75	51.3%	2.45	56.1%	2.68	55.9%	2.67	41.2%	1.96	51.3%	2.45
Rolling Plains: Breaks Grassland	148.28	0.0%	0.00	0.5%	0.74	0.9%	1.33	1.2%	1.73	1.6%	2.45	1.5%	2.18	1.0%	1.56	4.0%	5.94	1.5%	2.22
Rolling Plains: Mixedgrass Prairie	1,232.58	0.0%	0.00	0.9%	11.64	0.2%	2.00	0.9%	11.17	0.9%	11.56	1.3%	15.84	1.4%	16.68	5.6%	68.79	5.9%	73.17
Rolling Plains: Mixedgrass Sandy Prairie	354.38	0.0%	0.00	0.0%	0.01	0.1%	0.22	0.0%	0.08	0.0%	0.00	0.0%	0.01	0.0%	0.00	0.5%	1.62	0.4%	1.56
Row Crops	3,608.22	0.0%	0.09	0.2%	7.57	0.1%	3.11	0.6%	20.84	0.5%	18.01	0.1%	5.34	0.2%	8.67	2.0%	71.44	12.5%	452.80
Southwest: Tobosa / Mesquite Grassland	25.52	0.0%	0.00	0.6%	0.16	0.0%	0.00	0.0%	0.00	0.0%	0.00	16.0%	4.09	0.0%	0.00	7.7%	1.96	0.0%	0.00
Southwest: Tobosa Grassland	2.10	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00
Prime Backwater Habitats: Herbaceous-Site Totals	**5,833.35**	**0.0%**	**0.33**	**0.4%**	**22.65**	**0.2%**	**11.34**	**0.6%**	**37.64**	**0.7%**	**43.14**	**0.7%**	**39.84**	**0.6%**	**34.69**	**2.9%**	**167.10**	**10.3%**	**598.46**
Prime Backwater Habitats: Open Woody																			
Edwards Plateau: Ashe Juniper-Live Oak Shrubland	6.02	0.0%	0.00	0.0%	0.00	192.0%	11.56	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00
Edwards Plateau: Floodplain Ashe Juniper Shrubland	120.62	10.4%	12.55	2.2%	2.69	0.0%	0.00	0.0%	0.00	20.3%	24.46	16.6%	19.99	27.5%	33.14	19.4%	23.43	24.0%	28.91
Edwards Plateau: Floodplain Deciduous Shrubland	1,546.71	3.0%	46.01	1.0%	15.89	1.2%	19.13	2.1%	32.07	4.2%	65.61	4.3%	66.34	7.3%	112.98	4.3%	65.99	11.0%	170.35
Edwards Plateau: Live Oak Motte and Woodland	0.80	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00
Edwards Plateau: Riparian Deciduous Shrubland	245.87	0.0%	0.00	1.3%	3.16	2.1%	5.12	0.6%	1.58	1.8%	4.45	2.4%	5.92	1.1%	2.67	5.1%	12.64	8.4%	20.68
Native Invasive: Deciduous Woodland	61.33	0.0%	0.00	7.8%	4.78	8.0%	4.89	7.7%	4.72	0.4%	0.22	11.7%	7.16	11.6%	7.12	10.4%	6.40	19.9%	12.23
Native Invasive: Juniper Shrubland	28.36	0.0%	0.00	168.1%	47.67	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00
Native Invasive: Juniper Woodland	2.77	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	8.0%	0.22
Native Invasive: Mesquite Shrubland	2,565.02	0.0%	0.00	0.0%	0.00	1.8%	44.92	1.8%	45.37	0.9%	23.35	2.5%	64.92	2.2%	57.38	6.6%	169.30	5.1%	129.66
Rolling Plains: Breaks Deciduous Shrubland	527.86	0.0%	0.02	1.1%	5.77	1.4%	7.56	1.2%	6.20	2.9%	15.12	2.7%	14.46	1.6%	8.67	5.9%	31.27	3.6%	19.13
Rolling Plains: Breaks Evergreen Shrubland	3.92	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.9%	0.03	0.0%	0.00	11.5%	0.45	0.0%	0.00
Prime Backwater Habitats: Open Woody-Site Totals	**5,109.29**	**1.1%**	**58.58**	**1.6%**	**79.96**	**1.8%**	**93.18**	**1.8%**	**89.94**	**2.6%**	**133.21**	**3.5%**	**178.83**	**4.3%**	**221.95**	**6.1%**	**309.48**	**7.5%**	**381.18**
Prime Backwater Habitats: Open Water																			
Prime Backwater Habitats: Open Water-Site Totals	**198.89**	**0.0%**	**0.00**	**94.5%**	**187.88**	**80.2%**	**159.46**	**94.1%**	**187.21**	**65.6%**	**130.55**	**99.8%**	**198.53**	**94.7%**	**188.37**	**99.6%**	**198.03**	**99.9%**	**198.60**
Other Habitats: Forest, Urban, & Barren																			
Barren	24.09	0.0%	0.00	0.1%	0.02	7.4%	1.78	1.6%	0.38	14.8%	3.56	9.5%	2.29	12.9%	3.11	45.9%	11.05	24.0%	5.78
Edwards Plateau: Floodplain Ashe Juniper Forest	2.94	0.0%	0.00	0.0%	0.00	0.0%	0.00	35.6%	1.05	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00
Edwards Plateau: Floodplain Barrens	29.82	0.1%	0.04	0.0%	0.00	2.2%	0.67	0.0%	0.00	2.2%	0.67	4.0%	1.20	0.0%	0.00	1.4%	0.42	4.5%	1.33
Edwards Plateau: Floodplain Hardwood - Ashe Juniper Forest	32.47	0.0%	0.01	0.1%	0.02	0.7%	0.22	0.0%	0.00	0.0%	0.00	2.5%	0.80	0.7%	0.22	3.4%	1.09	0.7%	0.22
Edwards Plateau: Floodplain Hardwood Forest	230.59	6.6%	15.23	2.3%	5.31	0.3%	0.67	12.7%	29.27	9.2%	21.13	6.5%	15.04	17.6%	40.70	5.3%	12.18	15.9%	36.70
Edwards Plateau: Oak - Hardwood Slope Forest	0.94	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	13.2%	0.12	94.9%	0.89	0.0%	0.00	0.0%	0.00
Edwards Plateau: Riparian Barrens	0.30	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	22.9%	0.07	0.0%	0.00
Edwards Plateau: Riparian Hardwood Forest	4.70	0.0%	0.00	4.4%	0.21	0.0%	0.00	6.3%	0.29	0.0%	0.00	5.0%	0.24	0.0%	0.00	5.9%	0.27	0.0%	0.00
Edwards Plateau: Riparian Live Oak Forest	1.88	0.0%	0.00	0.0%	0.00	0.0%	0.00	7.4%	0.14	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00
Urban High Intensity	93.94	0.0%	0.00	0.3%	0.24	35.5%	33.36	0.0%	0.00	47.1%	44.26	14.3%	13.43	0.0%	0.00	0.3%	0.25	5.9%	5.56
Urban Low Intensity	103.81	0.0%	0.00	0.5%	0.53	4.3%	4.45	0.7%	0.72	8.1%	8.45	1.7%	1.81	1.5%	1.56	1.2%	1.24	5.8%	6.00
Other Habitats: Forest, Urban, & Barren-Site Totals	**525.47**	**2.9%**	**15.28**	**1.2%**	**6.32**	**7.8%**	**41.14**	**6.1%**	**31.85**	**14.9%**	**78.06**	**6.6%**	**34.92**	**8.8%**	**46.48**	**5.1%**	**26.58**	**10.6%**	**55.60**
TOTAL PRIME BACKWATER HABITATS:	**11,141.53**	**0.5%**	**58.91**	**2.6%**	**290.49**	**2.4%**	**263.98**	**2.8%**	**314.79**	**2.8%**	**306.90**	**3.7%**	**417.20**	**4.0%**	**445.01**	**6.1%**	**674.60**	**10.6%**	**1,178.25**
TOTAL EVENT INUNDATION:	**11,667.01**	**0.6%**	**74.19**	**2.5%**	**296.81**	**2.6%**	**305.13**	**3.0%**	**346.64**	**3.3%**	**384.96**	**3.9%**	**452.12**	**4.2%**	**491.49**	**6.0%**	**701.18**	**10.6%**	**1,233.84**
Event:		**02/11/18**		**02/23/18**		**02/20/05**		**12/13/89**		**12/20/07**		**02/15/97**		**02/12/19**		**03/03/97**		**02/25/92**	

* MDD: Mean Daily Discharge (cfs)

** Res (m): Imagery resolution in meters.

Table 16. Site 4: Colorado River above Silver, TX. River Discharge and Inundated Habitats, Details.

Site 4: Colorado Rv abv Silver, TX TES Habitat Inundation & River Discharge Details	Event:	02/08/96		05/04/18		04/28/18		10/16/08		01/10/87		12/23/91	
	MDD (cfs)*:	3.2		7.4		22.3		37.0		118.0		748.0	
	Res. (m)**:	1.0		0.7		0.7		0.5		30.0		30.0	
TES Habitat Types:	Site Totals (ha) per Habitat:	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha
Prime Backwater Habitats: Herbaceous													
Edwards Plateau: Floodplain Herbaceous Vegetation	2,090.71	0.1%	3.04	0.3%	6.45	0.5%	10.37	0.5%	9.59	0.7%	14.7	0.9%	18.46
Edwards Plateau: Riparian Herbaceous Vegetation	185.40	0.1%	0.11	0.0%	0.00	1.8%	3.27	0.3%	0.54	1.6%	2.9	0.7%	1.33
Edwards Plateau: Semi-arid Grassland	84.26	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.8%	0.7	14.0%	11.79
High Plains: Shortgrass Prairie	681.67	0.0%	0.00	0.0%	0.00	0.1%	0.95	0.4%	2.63	0.0%	0.0	3.2%	21.79
Marsh	0.30	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	100.0%	0.3	0.0%	0.00
Rolling Plains: Breaks Grassland	1,412.91	0.0%	0.29	0.1%	1.33	0.1%	0.87	0.1%	1.27	0.2%	2.7	2.0%	27.80
Rolling Plains: Mixedgrass Prairie	2,873.58	0.2%	6.86	0.4%	10.90	0.3%	8.32	0.4%	12.25	0.7%	19.6	0.7%	19.13
Rolling Plains: Mixedgrass Sandy Prairie	674.19	0.0%	0.02	0.0%	0.00	0.0%	0.00	0.0%	0.11	0.0%	0.0	1.0%	6.67
Row Crops	266.06	0.0%	0.00	0.0%	0.00	0.2%	0.52	0.3%	0.89	0.0%	0.0	30.1%	80.06
Southwest: Tobosa / Mesquite Grassland	7.02	0.0%	0.00	0.0%	0.00	0.3%	0.02	0.3%	0.02	3.2%	0.2	9.5%	0.67
Southwest: Tobosa Grassland	198.18	0.0%	0.00	0.0%	0.00	0.0%	0.09	0.2%	0.30	0.1%	0.2	0.4%	0.89
Prime Backwater Habitats: Herbaceous-Site Totals	**8,474.3**	**0.1%**	**10.3**	**0.2%**	**18.7**	**0.3%**	**24.4**	**0.3%**	**27.6**	**0.5%**	**41.2**	**2.2%**	**188.6**
Prime Backwater Habitats: Open Woody													
Edwards Plateau: Floodplain Ashe Juniper Shrubland	146.19	0.4%	0.57	0.8%	1.11	0.5%	0.74	1.2%	1.82	1.4%	2.0	1.5%	2.22
Edwards Plateau: Floodplain Deciduous Shrubland	555.80	1.6%	9.00	2.7%	15.12	2.5%	13.85	3.7%	20.51	8.6%	47.8	5.6%	31.36
Edwards Plateau: Juniper Semi-arid Shrubland	329.72	0.0%	0.12	0.0%	0.00	0.0%	0.12	0.0%	0.16	0.6%	2.0	26.2%	86.29
Edwards Plateau: Juniper Semi-arid Slope Shrubland	212.00	0.1%	0.15	0.1%	0.22	0.1%	0.14	0.2%	0.36	8.3%	17.6	39.5%	83.84
Edwards Plateau: Riparian Ashe Juniper Shrubland	223.05	0.1%	0.24	0.0%	0.00	0.1%	0.20	0.1%	0.24	0.2%	0.4	6.1%	13.57
Edwards Plateau: Riparian Deciduous Shrubland	290.46	0.3%	0.81	0.3%	0.89	0.7%	2.15	0.9%	2.65	0.8%	2.4	0.8%	2.22
High Plains: Deep Sand Woodland	92.16	0.0%	0.00	0.0%	0.00	0.1%	0.10	0.2%	0.14	1.0%	0.9	5.1%	4.67
High Plains: Sandhill Deciduous Shrub Duneland	2,137.83	0.0%	0.26	0.0%	0.22	0.1%	1.16	0.1%	1.58	0.1%	2.4	0.7%	15.79
High Plains: Sandhill Shinnery Duneland	764.81	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.0	0.0%	0.00
High Plains: Sandy Deciduous Shrubland	763.93	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.04	0.1%	0.4	0.0%	0.00
Native Invasive: Deciduous Woodland	2.41	1.2%	0.03	0.0%	0.00	0.7%	0.02	1.3%	0.03	9.2%	0.2	0.0%	0.00
Native Invasive: Juniper Shrubland	993.81	0.1%	0.73	0.0%	0.22	0.1%	0.68	0.1%	1.36	0.6%	5.6	7.2%	71.17
Native Invasive: Juniper Woodland	27.06	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.0	4.1%	1.11
Native Invasive: Mesquite Shrubland	1,173.08	1.1%	13.22	0.8%	9.79	1.3%	14.86	1.5%	18.10	3.7%	43.1	2.6%	30.69
Rolling Plains: Breaks Canyon	0.85	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.0	0.0%	0.00
Rolling Plains: Breaks Deciduous Shrubland	719.56	0.3%	2.51	0.1%	0.67	0.6%	4.52	0.7%	4.72	1.6%	11.3	2.6%	18.46
Rolling Plains: Breaks Evergreen Shrubland	823.11	0.1%	0.54	0.0%	0.22	0.1%	0.85	0.2%	1.45	1.3%	10.7	12.5%	102.75
Prime Backwater Habitats: Open Woody-Site Totals	**9,255.9**	**0.3%**	**28.2**	**0.3%**	**28.5**	**0.4%**	**39.4**	**0.6%**	**53.2**	**1.6%**	**147.0**	**5.0%**	**464.1**
Other Habitats: Forest, Urban, & Barren													
Barren	36.76	0.0%	0.00	0.0%	0.00	0.0%	0.00	7.6%	2.78	0.0%	0.0	1.8%	0.67
Edwards Plateau: Floodplain Barrens	1.19	0.0%	0.00	0.0%	0.00	0.0%	0.00	1.4%	0.02	0.0%	0.0	0.0%	0.00
Edwards Plateau: Floodplain Hardwood Forest	8.98	0.1%	0.01	17.3%	1.56	0.0%	0.00	0.0%	0.00	2.5%	0.2	0.0%	0.00
Edwards Plateau: Riparian Ashe Juniper Forest	1.69	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.0	0.0%	0.00
Edwards Plateau: Riparian Barrens	0.26	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.0	0.0%	0.00
Edwards Plateau: Riparian Hardwood Forest	0.57	0.0%	0.00	0.0%	0.00	0.4%	0.00	0.0%	0.00	0.0%	0.0	0.0%	0.00
Edwards Plateau: Wooded Cliff/Bluff	1.01	2.4%	0.02	0.0%	0.00	7.1%	0.07	2.2%	0.02	22.1%	0.2	22.1%	0.22
Urban High Intensity	25.84	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.0	0.0%	0.00
Urban Low Intensity	2.02	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.0	33.0%	0.67
Other Habitats: Forest, Urban, & Barren-Site Totals	**78.3**	**0.0%**	**0.0**	**2.0%**	**1.6**	**0.1%**	**0.1**	**3.6%**	**2.8**	**0.6%**	**0.4**	**2.0%**	**1.6**
TOTAL PRIME BACKWATER HABITATS:	**17,730.13**	**0.2%**	**38.48**	**0.3%**	**47.15**	**0.4%**	**63.82**	**0.5%**	**80.80**	**1.1%**	**188.22**	**3.7%**	**652.73**
TOTAL EVENT INUNDATION:	**17,808.43**	**0.2%**	**38.52**	**0.3%**	**48.70**	**0.4%**	**63.89**	**0.5%**	**83.62**	**1.1%**	**188.66**	**3.7%**	**654.28**
Event:		**02/08/96**		**05/04/18**		**04/28/18**		**10/16/08**		**01/10/87**		**12/23/91**	

* MDD: Mean Daily Discharge (cfs)

** Res (m): Imagery resolution in meters.

Table 17. Site 5: Colorado River above Silver, TX. River Discharge and Inundated Habitats, Details.

Site 5: Colorado Rv nr San Saba, TX TES Habitat Inundation & River Discharge Details	Event:	01/02/07		01/19/04		02/17/83		02/01/19		12/27/18		03/01/87		03/03/97	
	MDD (cfs)*:	64.50		124.00		188.00		404.00		1,880.00		5,080.00		7,410.00	
	Res. (m)**:	1.4		30.0		30.0		0.7		30.0		30.0		30.0	
TES Habitat Types:	Site Totals (ha) per	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha
Prime Backwater Habitats: Herbaceous															
Crosstimbers: Savanna Grassland	2,695.40	0.0%	0.00	0.0%	0.00	0.5%	13.12	0.0%	0.07	0.3%	8.67	0.8%	20.46	0.7%	18.68
Edwards Plateau: Floodplain Herbaceous Vegetation	875.12	0.0%	0.36	0.2%	1.33	0.4%	3.56	0.3%	2.51	0.9%	8.01	1.1%	10.01	1.2%	10.45
Edwards Plateau: Riparian Herbaceous Vegetation	11.10	0.0%	0.00	0.0%	0.00	0.0%	0.00	1.6%	0.18	0.0%	0.00	0.0%	0.00	10.0%	1.11
Edwards Plateau: Savanna Grassland	168.15	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.4%	0.67	0.1%	0.22
Rolling Plains: Mixedgrass Prairie	36.60	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	1.2%	0.44	0.0%	0.00	0.6%	0.22
Row Crops	160.42	0.0%	0.00	0.0%	0.00	1.1%	1.78	0.0%	0.00	0.0%	0.00	5.0%	8.01	0.0%	0.00
Prime Backwater Habitats: Herbaceous-Site Totals	**3,946.80**	**0.0%**	**0.36**	**0.0%**	**1.33**	**0.5%**	**18.46**	**0.1%**	**2.76**	**0.4%**	**17.12**	**1.0%**	**39.14**	**0.8%**	**30.69**
Prime Backwater Habitats: Open Woody															
Crosstimbers: Post Oak / Juniper Woodland	652.41	0.0%	0.00	0.0%	0.22	0.1%	0.44	0.2%	1.40	0.2%	1.33	0.4%	2.67	0.4%	2.67
Crosstimbers: Post Oak Woodland	424.59	0.8%	3.37	1.0%	4.23	1.3%	5.34	2.3%	9.62	3.2%	13.57	2.7%	11.56	5.0%	21.13
Crosstimbers: Sandyland Oak Woodland	5.05	0.0%	0.00	17.6%	0.89	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	4.4%	0.22
Edwards Plateau: Ashe Juniper-Live Oak Shrubland	5.28	0.0%	0.00	21.1%	1.11	0.0%	0.00	0.0%	0.00	33.7%	1.78	0.0%	0.00	0.0%	0.00
Edwards Plateau: Ashe Juniper / Live Oak Shrubland	2,146.78	0.0%	0.00	0.0%	0.67	0.3%	7.12	0.0%	0.71	0.5%	10.67	0.2%	3.78	0.7%	16.01
Edwards Plateau: Ashe Juniper / Live Oak Slope Shrubland	20.24	0.0%	0.00	0.0%	0.00	0.0%	0.00	1.1%	0.21	0.0%	0.00	0.0%	0.00	0.0%	0.00
Edwards Plateau: Ashe Juniper Motte and Woodland	2,270.94	0.0%	0.00	0.0%	0.00	0.1%	2.67	0.0%	0.63	0.3%	6.45	0.0%	0.67	0.1%	2.22
Edwards Plateau: Deciduous Oak / Evergreen Motte and Woodland	23.08	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	4.8%	1.11	0.0%	0.00
Edwards Plateau: Floodplain Ashe Juniper Shrubland	58.83	0.0%	0.00	0.0%	0.00	0.8%	0.44	3.9%	2.27	6.0%	3.56	5.3%	3.11	5.3%	3.11
Edwards Plateau: Floodplain Deciduous Shrubland	67.69	0.3%	0.20	0.3%	0.22	0.3%	0.22	2.2%	1.47	2.6%	1.78	2.6%	1.78	5.3%	3.56
Edwards Plateau: Live Oak Motte and Woodland	195.85	0.0%	0.00	0.0%	0.00	0.1%	0.22	0.0%	0.01	0.0%	0.00	0.0%	0.00	0.0%	0.00
Edwards Plateau: Oak / Hardwood Motte and Woodland	20.15	0.0%	0.00	0.0%	0.00	0.0%	0.00	2.5%	0.50	4.4%	0.89	2.2%	0.44	0.0%	0.00
Edwards Plateau: Riparian Ashe Juniper Shrubland	33.83	0.0%	0.00	0.0%	0.00	0.0%	0.00	4.4%	1.50	0.0%	0.00	0.0%	0.00	0.0%	0.00
Edwards Plateau: Riparian Deciduous Shrubland	5.74	0.0%	0.00	0.0%	0.00	0.0%	0.00	3.7%	0.21	0.0%	0.00	0.0%	0.00	0.0%	0.00
Edwards Plateau: Shin Oak Shrubland	2.36	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00
Edwards Plateau: Shin Oak Slope Shrubland	0.81	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00
Native Invasive: Deciduous Woodland	0.33	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00
Native Invasive: Juniper Shrubland	27.89	0.3%	0.07	0.0%	0.00	1.6%	0.44	0.0%	0.00	0.0%	0.00	0.0%	0.00	1.6%	0.44
Native Invasive: Juniper Woodland	22.79	0.0%	0.00	0.0%	0.00	1.0%	0.22	3.8%	0.86	10.7%	2.45	4.9%	1.11	3.9%	0.89
Native Invasive: Mesquite Shrubland	635.76	0.0%	0.00	0.1%	0.44	0.4%	2.45	0.1%	0.32	0.8%	5.34	0.1%	0.89	1.5%	9.56
Prime Backwater Habitats: Open Woody-Site Totals	**6,620.41**	**0.1%**	**3.65**	**0.1%**	**7.78**	**0.3%**	**19.57**	**0.3%**	**19.71**	**0.7%**	**47.81**	**0.4%**	**27.13**	**0.9%**	**59.82**
Prime Backwater Habitats: Open Water															
Prime Backwater Habitats: Open Water-Site Totals	**118.45**	**21.7%**	**25.68**	**26.3%**	**31.14**	**24.8%**	**29.36**	**42.2%**	**49.99**	**43.9%**	**52.04**	**52.6%**	**62.27**	**60.6%**	**71.83**
Other Habitats: Forest, Urban, & Barren															
Barren	31.84	0.1%	0.04	0.0%	0.00	18.9%	6.00	32.2%	10.26	12.6%	4.00	41.2%	13.12	43.3%	13.79
Crosstimbers: Hardwood / Juniper Slope Forest	35.96	0.0%	0.00	0.0%	0.00	1.9%	0.67	0.2%	0.07	0.0%	0.00	2.5%	0.89	1.2%	0.44
Crosstimbers: Juniper Slope Forest	85.66	0.0%	0.00	0.3%	0.22	1.0%	0.89	0.1%	0.06	0.5%	0.44	0.5%	0.44	1.3%	1.11
Crosstimbers: Oak / Hardwood Slope Forest	140.91	0.2%	0.31	2.7%	3.78	5.8%	8.23	4.3%	6.02	17.5%	24.69	7.9%	11.12	13.3%	18.68
Edwards Plateau: Ashe Juniper Slope Forest	122.85	0.0%	0.00	0.0%	0.00	1.3%	1.56	0.9%	1.07	1.3%	1.56	1.6%	2.00	0.0%	0.00
Edwards Plateau: Floodplain Ashe Juniper Forest	66.59	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.3%	0.22	0.0%	0.00	0.0%	0.00
Edwards Plateau: Floodplain Hardwood / Ashe Juniper Forest	110.34	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.05	0.0%	0.00	0.0%	0.00	0.6%	0.67
Edwards Plateau: Floodplain Hardwood Forest	661.54	10.9%	72.01	7.7%	50.71	10.0%	66.05	28.1%	185.82	22.6%	149.45	24.9%	164.57	22.3%	147.45
Edwards Plateau: Floodplain Live Oak Forest	3.96	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00
Edwards Plateau: Live Oak Slope Forest	5.24	0.0%	0.00	0.0%	0.00	4.2%	0.22	0.0%	0.00	0.0%	0.00	8.5%	0.44	0.0%	0.00
Edwards Plateau: Oak / Ashe Juniper Slope Forest	59.66	0.0%	0.00	0.0%	0.00	7.1%	4.23	0.0%	0.03	4.8%	2.89	17.1%	10.23	3.4%	2.00
Edwards Plateau: Oak / Hardwood Slope Forest	62.20	0.0%	0.00	0.0%	0.00	2.1%	1.33	1.1%	0.67	8.2%	5.12	8.6%	5.34	1.8%	1.11
Edwards Plateau: Riparian Ashe Juniper Forest	57.49	0.0%	0.00	0.0%	0.00	0.0%	0.00	2.0%	1.13	0.0%	0.00	0.0%	0.00	0.0%	0.00
Edwards Plateau: Riparian Hardwood / Ashe Juniper Forest	26.70	0.0%	0.00	0.0%	0.00	0.0%	0.00	2.9%	0.77	0.0%	0.00	0.0%	0.00	0.8%	0.22
Edwards Plateau: Riparian Hardwood Forest	14.45	0.0%	0.00	0.0%	0.00	1.5%	0.22	7.3%	1.06	1.5%	0.22	0.0%	0.00	1.5%	0.22
Edwards Plateau: Riparian Live Oak Forest	13.40	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00
Edwards Plateau: Wooded Cliff/Bluff	1.08	0.0%	0.00	0.0%	0.00	20.6%	0.22	0.0%	0.00	20.6%	0.22	41.3%	0.44	0.0%	0.00
Urban High Intensity	1.58	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	100.0%	1.58	0.0%	0.00	100.0%	1.58
Urban Low Intensity	35.71	0.1%	0.02	0.0%	0.00	0.0%	0.00	0.3%	0.12	1.9%	0.67	3.1%	1.11	0.6%	0.22
Other Habitats: Forest, Urban, & Barren-Site Totals	**1,537.13**	**4.7%**	**72.37**	**3.6%**	**54.71**	**5.8%**	**89.62**	**13.5%**	**207.13**	**12.4%**	**191.06**	**13.6%**	**209.72**	**12.2%**	**187.50**
TOTAL PRIME BACKWATER HABITATS:	**10,685.66**	**0.3%**	**29.68**	**0.4%**	**40.25**	**0.6%**	**67.39**	**0.7%**	**72.47**	**1.1%**	**116.98**	**1.2%**	**128.54**	**1.5%**	**162.35**
TOTAL EVENT INUNDATION:	**12,222.78**	**0.8%**	**102.06**	**0.8%**	**94.96**	**1.3%**	**157.01**	**2.3%**	**279.60**	**2.5%**	**308.04**	**2.8%**	**338.26**	**2.9%**	**349.85**
Event:		01/02/07		01/19/04		02/17/83		02/01/19		12/27/18		03/01/87		03/03/97	

* MDD: Mean Daily Discharge (cfs)

** Res (m): Imagery resolution in meters.

Table 18. Site 6: Concho River at Paint Rock TX. River Discharge and Inundated Habitats, Details.

Site 6: Concho Rv at Paint Rock, TX TES Habitat Inundation & River Discharge	Event:	12/26/01		03/14/18		02/27/16		03/04/18		01/14/09		12/10/89		03/30/18		02/23/18		05/16/18		02/22/97		02/25/92	
	MDD (cfs)*:	4.03		6.22		15.60		18.20		21.70		28.00		42.00		71.70		195.00		526.00		2,220.00	
	Res. (m)**:	30.0		0.7		30.0		0.7		30.0		2.5		0.7		0.7		0.7		30.0		30.0	
TES Habitat Types:	Site Totals (ha) per Habitat:	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha
Prime Backwater Habitats: Herbaceous																							
Edwards Plateau: Floodplain Herbaceous Vegetation	694.28	0.3%	2.22	1.1%	7.73	1.2%	8.45	1.3%	8.69	2.2%	15.35	2.6%	17.97	3.0%	20.90	4.2%	29.19	4.2%	29.39	3.6%	24.69	4.8%	33.58
Edwards Plateau: Playa	10.56	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	2.1%	0.22
Edwards Plateau: Riparian Herbaceous Vegetation	4.99	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	5.0%	0.25	0.0%	0.00	0.0%	0.00	35.7%	1.78
Edwards Plateau: Riparian Herbaceous Wetland	0.44	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	77.4%	0.34	0.0%	0.00	79.8%	0.35	0.0%	0.00	100.0%	0.44	100.0%	0.44
Edwards Plateau: Savanna Grassland	249.04	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.12	0.0%	0.00	0.4%	1.11	0.0%	0.00	0.0%	0.00	5.4%	13.57
Grass Farm	1.51	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00
High Plains: Shortgrass Prairie	510.73	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.1%	0.53	0.0%	0.00	0.1%	0.52	0.0%	0.00	0.1%	0.67	0.9%	4.67
Rolling Plains: Mixedgrass Prairie	1,357.43	0.0%	0.00	0.0%	0.06	0.0%	0.00	0.0%	0.05	0.0%	0.44	0.2%	3.20	0.0%	0.16	0.3%	4.00	0.0%	0.33	0.2%	2.45	2.8%	37.81
Row Crops	1,910.16	0.0%	0.00	0.0%	0.08	0.0%	0.00	0.0%	0.22	0.1%	1.56	0.2%	3.32	0.1%	2.55	0.1%	1.49	0.1%	1.23	0.2%	3.11	1.7%	33.14
Prime Backwater Habitats: Herbaceous-Site Totals	**4,739.13**	**0.0%**	**2.22**	**0.2%**	**7.87**	**0.2%**	**8.45**	**0.2%**	**8.96**	**0.4%**	**17.35**	**0.5%**	**25.47**	**0.5%**	**23.61**	**0.8%**	**36.92**	**0.7%**	**30.95**	**0.7%**	**31.36**	**2.6%**	**125.21**
Prime Backwater Habitats: Open Woody																							
Edwards Plateau: Ashe Juniper-Live Oak Shrubland	249.37	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.6%	1.51	0.0%	0.00	0.4%	1.12	0.0%	0.00	0.4%	0.89	1.5%	3.78
Edwards Plateau: Floodplain Ashe Juniper Shrubland	47.21	5.7%	2.67	6.9%	3.27	8.0%	3.78	8.2%	3.89	23.1%	10.90	13.2%	6.22	19.8%	9.34	21.9%	10.32	28.2%	13.30	25.9%	12.23	11.3%	5.34
Edwards Plateau: Floodplain Deciduous Shrubland	1,012.82	0.9%	9.12	1.7%	16.95	2.1%	21.35	3.0%	29.96	3.7%	37.58	3.9%	39.77	5.5%	55.33	6.6%	67.08	8.6%	87.40	8.3%	84.07	7.7%	77.62
Edwards Plateau: Live Oak Motte and Woodland	0.28	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00
Edwards Plateau: Oak - Hardwood Motte and Woodland	1.67	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	6.1%	0.10	3.2%	0.05	0.0%	0.00	0.0%	0.00
Edwards Plateau: Riparian Deciduous Shrubland	34.35	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.4%	0.15	0.0%	0.00	3.1%	1.08	0.0%	0.00	0.0%	0.00	5.8%	2.00
Edwards Plateau: Shin Oak Shrubland	2,731.62	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.2%	6.02	0.0%	0.00	0.0%	0.90	0.0%	0.03	0.1%	3.78	1.3%	35.36
Native Invasive: Deciduous Woodland	29.95	0.7%	0.22	0.0%	0.00	1.5%	0.44	1.0%	0.29	3.7%	1.11	5.7%	1.71	4.6%	1.38	1.8%	0.55	7.6%	2.28	8.2%	2.45	8.2%	2.45
Native Invasive: Juniper Shrubland	53.50	0.0%	0.00	0.8%	0.43	0.4%	0.22	0.1%	0.07	0.0%	0.00	1.1%	0.57	0.6%	0.35	3.9%	2.11	0.6%	0.35	3.3%	1.78	11.2%	6.00
Native Invasive: Mesquite Shrubland	2,587.98	0.1%	2.89	0.0%	0.11	0.4%	9.56	0.4%	11.07	0.6%	16.23	0.7%	19.25	0.7%	18.85	1.0%	26.40	0.8%	21.49	1.1%	29.58	2.3%	58.71
Rolling Plains: Breaks Deciduous Shrubland	125.60	0.0%	0.00	7.7%	9.64	0.0%	0.00	0.3%	0.42	1.2%	1.56	6.8%	8.56	1.5%	1.89	0.9%	1.16	2.6%	3.27	2.8%	3.56	2.3%	2.89
Rolling Plains: Breaks Evergreen Shrubland	48.70	0.0%	0.00	45.6%	22.21	0.5%	0.22	0.0%	0.00	0.9%	0.44	8.8%	4.31	0.0%	0.02	0.0%	0.00	0.8%	0.38	3.2%	1.56	1.8%	0.89
Prime Backwater Habitats: Open Woody-Site Totals	**6,923.05**	**0.2%**	**14.90**	**0.8%**	**52.60**	**0.5%**	**35.58**	**0.7%**	**45.70**	**1.0%**	**67.83**	**1.3%**	**88.09**	**1.3%**	**87.14**	**1.6%**	**110.81**	**1.9%**	**128.55**	**2.0%**	**139.89**	**2.8%**	**195.04**
Prime Backwater Habitats: Open Water																							
Prime Backwater Habitats: Open Water-Site Totals	**89.72**	**20.6%**	**18.46**	**0.0%**	**0.00**	**43.9%**	**39.36**	**34.6%**	**31.04**	**36.7%**	**32.91**	**29.4%**	**26.39**	**58.2%**	**52.18**	**51.8%**	**46.47**	**53.5%**	**47.97**	**63.5%**	**56.93**	**44.1%**	**39.59**
Other Habitats: Forest, Urban, & Barren																							
Crosstimbers: Oak - Hardwood Slope Forest	22.18	0.0%	0.00	1.8%	0.39	0.0%	0.00	2.7%	0.61	36.1%	8.01	53.0%	11.76	23.1%	5.13	6.9%	1.54	15.1%	3.34	42.1%	9.34	27.1%	6.00
Barren	41.49	1.1%	0.44	9.3%	3.86	11.8%	4.89	13.8%	5.71	26.8%	11.12	11.5%	4.77	31.7%	13.17	23.5%	9.76	40.7%	16.87	38.6%	16.01	23.6%	9.79
Edwards Plateau: Floodplain Barrens	0.46	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00
Edwards Plateau: Floodplain Hardwood - Ashe Juniper Forest	5.72	0.0%	0.00	9.6%	0.55	0.0%	0.00	0.0%	0.00	0.0%	0.00	1.1%	0.06	3.3%	0.19	1.2%	0.07	54.7%	3.13	3.9%	0.22	11.7%	0.67
Edwards Plateau: Floodplain Hardwood Forest	142.96	3.0%	4.23	6.9%	9.87	9.6%	13.79	9.7%	13.86	12.1%	17.35	18.5%	26.52	21.7%	30.99	17.7%	25.29	33.7%	48.11	25.2%	36.03	10.3%	14.68
Edwards Plateau: Floodplain Live Oak Forest	5.01	0.0%	0.00	0.0%	0.00	0.0%	0.00	2.4%	0.12	0.0%	0.00	0.1%	0.00	0.6%	0.03	6.1%	0.31	13.4%	0.67	4.4%	0.22	8.9%	0.44
Edwards Plateau: Riparian Hardwood Forest	0.94	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00
Urban High Intensity	22.00	0.0%	0.00	0.4%	0.09	1.0%	0.22	0.0%	0.00	0.0%	0.00	9.1%	2.00	5.5%	1.21	0.5%	0.11	2.7%	0.59	5.1%	1.11	4.0%	0.89
Urban Low Intensity	256.92	0.1%	0.22	0.4%	1.02	0.3%	0.67	0.2%	0.46	1.1%	2.89	1.5%	3.82	1.2%	3.21	0.9%	2.31	1.8%	4.57	2.4%	6.23	3.5%	8.90
Other Habitats: Forest, Urban, & Barren-Site Totals	**497.69**	**1.0%**	**4.89**	**3.2%**	**15.78**	**3.9%**	**19.57**	**4.2%**	**20.76**	**7.9%**	**39.36**	**9.8%**	**48.94**	**10.8%**	**53.94**	**7.9%**	**39.37**	**15.5%**	**77.28**	**13.9%**	**69.16**	**8.3%**	**41.37**
TOTAL PRIME BACKWATER HABITATS:	**11,751.90**	**0.3%**	**35.58**	**0.5%**	**60.47**	**0.7%**	**83.40**	**0.7%**	**85.70**	**1.0%**	**118.09**	**1.2%**	**139.96**	**1.4%**	**162.94**	**1.7%**	**194.20**	**1.8%**	**207.47**	**1.9%**	**228.18**	**3.1%**	**359.83**
TOTAL EVENT INUNDATION:	**12,249.59**	**0.3%**	**40.48**	**0.6%**	**76.25**	**0.8%**	**102.97**	**0.9%**	**106.46**	**1.3%**	**157.46**	**1.5%**	**188.90**	**1.8%**	**216.87**	**1.9%**	**233.57**	**2.3%**	**284.75**	**2.4%**	**297.34**	**3.3%**	**401.20**
Event:		**12/26/01**		**03/14/18**		**02/27/16**		**03/04/18**		**01/14/09**		**12/10/89**		**03/30/18**		**02/23/18**		**05/16/18**		**02/22/97**		**02/25/92**	

* MDD: Mean Daily Discharge (cfs)

** Res (m): Imagery resolution in meters.

Table 19. Site 9: Pedernales River near Johnson City TX. River Discharge and Inundated Habitats, Details.

Site 9: Pedernales R near Johnson City, TX. TES Habitat Inundation & River Discharge Details	Event:	12/26/01		03/14/18		02/27/16		03/04/18		01/14/09		12/10/89		03/30/18		02/23/18		05/16/18		02/22/97		02/25/92	
	MDD (cfs)*:	4.03		6.22		15.60		18.20		21.70		28.00		42.00		71.70		195.00		526.00		2,220.00	
	Res. (m)**:	30.0		0.7		30.0		0.7		30.0		2.5		0.7		0.7		0.7		30.0		30.0	
TES Habitat Types:	Site Totals (ha) per Habitat:	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha
Prime Backwater Habitats: Herbaceous																							
Edwards Plateau: Floodplain Herbaceous Vegetation	694.28	0.3%	2.22	1.1%	7.73	1.2%	8.45	1.3%	8.69	2.2%	15.35	2.6%	17.97	3.0%	20.90	4.2%	29.19	4.2%	29.39	3.6%	24.69	4.8%	33.58
Edwards Plateau: Playa	10.56	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	2.1%	0.22
Edwards Plateau: Riparian Herbaceous Vegetation	4.99	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	5.0%	0.25	0.0%	0.00	0.0%	0.00	35.7%	1.78
Edwards Plateau: Riparian Herbaceous Wetland	0.44	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	77.4%	0.34	0.0%	0.00	79.8%	0.35	0.0%	0.00	100.0%	0.44	100.0%	0.44
Edwards Plateau: Savanna Grassland	249.04	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.1%	0.12	0.0%	0.00	0.4%	1.11	0.0%	0.00	0.0%	0.00	5.4%	13.57
Grass Farm	1.51	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00
High Plains: Shortgrass Prairie	510.73	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.1%	0.53	0.0%	0.00	0.1%	0.52	0.0%	0.00	0.1%	0.67	0.9%	4.67
Rolling Plains: Mixedgrass Prairie	1,357.43	0.0%	0.00	0.0%	0.06	0.0%	0.00	0.0%	0.05	0.0%	0.44	0.2%	3.20	0.0%	0.16	0.3%	4.00	0.0%	0.33	0.2%	2.45	2.8%	37.81
Row Crops	1,910.16	0.0%	0.00	0.0%	0.09	0.0%	0.00	0.0%	0.22	0.1%	1.56	0.2%	3.32	0.1%	2.55	0.1%	1.49	0.1%	1.23	0.2%	3.11	1.7%	33.14
Prime Backwater Habitats: Herbaceous-Site Totals	**4,739.13**	**0.1%**	**2.22**	**0.2%**	**7.87**	**0.2%**	**8.45**	**0.2%**	**8.96**	**0.4%**	**17.35**	**0.5%**	**25.47**	**0.5%**	**23.61**	**0.8%**	**36.92**	**0.7%**	**30.95**	**0.7%**	**31.36**	**2.6%**	**125.21**
Prime Backwater Habitats: Open Woody																							
Edwards Plateau: Ashe Juniper-Live Oak Shrubland	249.37	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.6%	1.51	0.0%	0.00	0.4%	1.12	0.0%	0.00	0.4%	0.89	1.5%	3.78
Edwards Plateau: Floodplain Ashe Juniper Shrubland	47.21	5.7%	2.67	6.9%	3.27	8.0%	3.78	8.2%	3.89	23.1%	10.90	13.2%	6.22	19.8%	9.34	21.9%	10.32	28.2%	13.30	25.9%	12.23	11.3%	5.34
Edwards Plateau: Floodplain Deciduous Shrubland	1,012.82	0.9%	9.12	1.7%	16.95	2.1%	21.35	3.0%	29.96	3.7%	37.58	3.9%	39.77	5.5%	55.33	6.6%	67.08	8.6%	87.40	8.3%	84.07	7.7%	77.62
Edwards Plateau: Live Oak Motte and Woodland	0.28	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00
Edwards Plateau: Oak - Hardwood Motte and Woodland	1.67	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	6.1%	0.10	3.2%	0.05	0.0%	0.00	0.0%	0.00
Edwards Plateau: Riparian Deciduous Shrubland	34.35	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.4%	0.15	0.0%	0.00	3.1%	1.08	0.0%	0.00	0.0%	0.00	5.8%	2.00
Edwards Plateau: Shin Oak Shrubland	2,731.62	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.2%	6.02	0.0%	0.00	0.0%	0.90	0.0%	0.03	0.1%	3.78	1.3%	35.36
Native Invasive: Deciduous Woodland	29.95	0.7%	0.22	0.0%	0.00	1.5%	0.44	1.0%	0.29	3.7%	1.11	5.7%	1.71	4.6%	1.38	1.8%	0.55	7.6%	2.28	8.2%	2.45	8.2%	2.45
Native Invasive: Juniper Shrubland	53.50	0.0%	0.00	0.8%	0.43	0.4%	0.22	0.1%	0.07	0.0%	0.00	1.1%	0.57	0.6%	0.35	3.9%	2.11	0.7%	0.35	3.3%	1.78	11.2%	6.00
Native Invasive: Mesquite Shrubland	2,587.98	0.1%	2.89	0.0%	0.11	0.4%	9.56	0.4%	11.07	0.6%	16.23	0.7%	19.25	0.7%	18.85	1.0%	26.40	0.8%	21.49	1.1%	29.58	2.3%	58.71
Rolling Plains: Breaks Deciduous Shrubland	125.60	0.0%	0.00	7.7%	9.64	0.0%	0.00	0.3%	0.42	1.2%	1.56	6.8%	8.56	1.5%	1.89	0.9%	1.16	2.6%	3.27	2.8%	3.56	2.3%	2.89
Rolling Plains: Breaks Evergreen Shrubland	48.70	0.0%	0.00	45.6%	22.21	0.5%	0.22	0.0%	0.00	0.9%	0.44	8.8%	4.31	0.0%	0.02	0.0%	0.00	0.8%	0.38	3.2%	1.56	1.8%	0.89
Prime Backwater Habitats: Open Woody-Site Totals	**6,923.05**	**0.2%**	**14.90**	**0.8%**	**52.60**	**0.5%**	**35.58**	**0.7%**	**45.70**	**1.0%**	**67.83**	**1.3%**	**88.09**	**1.3%**	**87.15**	**1.6%**	**110.81**	**1.9%**	**128.55**	**2.0%**	**139.89**	**2.8%**	**195.04**
Prime Backwater Habitats: Open Water																							
Prime Backwater Habitats: Open Water-Site Totals	**89.72**	**20.6%**	**18.46**	**0.0%**	**0.00**	**43.9%**	**39.36**	**34.6%**	**31.05**	**36.7%**	**32.91**	**29.4%**	**26.39**	**58.2%**	**52.18**	**51.8%**	**46.47**	**53.5%**	**47.97**	**63.5%**	**56.93**	**44.1%**	**39.59**
Other Habitats: Forest, Urban, & Barren-Site																							
Crosstimbers: Oak - Hardwood Slope Forest	22.18	0.0%	0.00	1.8%	0.39	0.0%	0.00	2.7%	0.61	36.1%	8.01	53.0%	11.76	23.1%	5.13	6.9%	1.54	15.1%	3.34	42.1%	9.34	27.1%	6.00
Barren	41.49	1.1%	0.44	9.3%	3.86	11.8%	4.89	13.8%	5.71	26.8%	11.12	11.5%	4.77	31.7%	13.17	23.5%	9.76	40.7%	16.87	38.6%	16.01	23.6%	9.79
Edwards Plateau: Floodplain Barrens	0.46	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00
Edwards Plateau: Floodplain Hardwood - Ashe Juniper Forest	5.72	0.0%	0.00	9.6%	0.55	0.0%	0.00	0.0%	0.00	0.0%	0.00	1.1%	0.06	3.3%	0.19	1.2%	0.07	54.7%	3.13	3.9%	0.22	11.7%	0.67
Edwards Plateau: Floodplain Hardwood Forest	142.96	3.0%	4.23	6.9%	9.87	9.6%	13.79	9.7%	13.86	12.1%	17.35	18.5%	26.52	21.7%	30.99	17.7%	25.29	33.7%	48.11	25.2%	36.03	10.3%	14.68
Edwards Plateau: Floodplain Live Oak Forest	5.01	0.0%	0.00	0.0%	0.00	0.0%	0.00	2.4%	0.12	0.0%	0.00	0.1%	0.00	0.6%	0.03	6.1%	0.31	13.4%	0.67	4.4%	0.22	8.9%	0.44
Edwards Plateau: Riparian Hardwood Forest	0.94	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00
Urban High Intensity	22.00	0.0%	0.00	0.4%	0.09	1.0%	0.22	0.0%	0.00	0.0%	0.00	9.1%	2.00	5.5%	1.21	0.5%	0.11	2.7%	0.59	5.1%	1.11	4.0%	0.89
Urban Low Intensity	256.92	0.1%	0.22	0.4%	1.02	0.3%	0.67	0.2%	0.46	1.1%	2.89	1.5%	3.82	1.2%	3.21	0.9%	2.31	1.8%	4.57	2.4%	6.23	3.5%	8.90
Other Habitats: Forest, Urban, & Barren-Site Totals	**497.69**	**1.0%**	**4.89**	**3.2%**	**15.78**	**3.9%**	**19.57**	**4.2%**	**20.76**	**7.9%**	**39.36**	**9.8%**	**48.94**	**10.8%**	**53.94**	**7.9%**	**39.37**	**15.5%**	**77.28**	**13.9%**	**69.17**	**8.3%**	**41.37**
TOTAL PRIME BACKWATER HABITATS:	**11,751.90**	**0.3%**	**35.58**	**0.5%**	**60.47**	**0.7%**	**83.40**	**0.7%**	**85.71**	**1.0%**	**118.09**	**1.2%**	**139.96**	**1.4%**	**162.94**	**1.7%**	**194.20**	**1.8%**	**207.47**	**1.9%**	**228.18**	**3.1%**	**359.83**
TOTAL EVENT INUNDATION:	**12,249.59**	**0.3%**	**40.48**	**0.6%**	**76.25**	**0.8%**	**102.97**	**0.9%**	**106.46**	**1.3%**	**157.46**	**1.5%**	**188.90**	**1.8%**	**216.87**	**1.9%**	**233.57**	**2.3%**	**284.75**	**2.4%**	**297.34**	**3.3%**	**401.20**
Event:		**12/26/01**		**03/14/18**		**02/27/16**		**03/04/18**		**01/14/09**		**12/10/89**		**03/30/18**		**02/23/18**		**05/16/18**		**02/22/97**		**02/25/92**	

* MDD: Mean Daily Discharge (cfs)

** Res (m): Imagery resolution in meters.

Table 20. Site 11: Sandy Creek near Ganado, TX. River Discharge and Inundated Habitats, Details.

Site 11: Sandy Ck nr Ganado, TX TES Habitat Inundation & River Discharge Details	Event:	12/01/18		01/31/17		01/06/02		01/14/05		12/28/15		01/01/03	
	MDD (cfs)*:	33.50		68.00		90.50		\\		571.00		1,130.00	
	Res. (m)**:	0.6		30.0		30.0		30.0		30.0		30.0	
TES Habitat Types:	Site Totals (ha) per	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha
Prime Backwater Habitats: Herbaceous													
Coastal Bend: Floodplain Grassland	**8.52**	0.2%	0.01	26.1%	2.22	31.3%	2.67	33.9%	2.89	62.6%	5.34	41.8%	3.56
Coastal Bend: Floodplain Herbaceous Wetland	**15.92**	0.0%	0.00	2.8%	0.44	11.2%	1.78	9.8%	1.56	11.2%	1.78	15.4%	2.45
Coastal Bend: Riparian Grassland	**4.83**	0.1%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00
Coastal Plain: Terrace Sandyland Grassland	**117.76**	0.4%	0.48	2.1%	2.45	1.7%	2.00	1.1%	1.33	1.9%	2.22	2.8%	3.34
Gulf Coast: Coastal Prairie	**3,915.46**	0.3%	10.44	0.8%	31.58	1.0%	38.03	1.5%	58.27	1.6%	60.71	3.8%	147.67
Gulf Coast: Coastal Prairie Pondshore	**199.86**	2.0%	4.07	8.7%	17.35	15.1%	30.25	10.2%	20.46	13.4%	26.69	11.5%	22.91
Post Oak Savanna: Savanna Grassland	**85.54**	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00
Row Crops	**880.36**	0.2%	1.52	1.8%	15.57	1.8%	15.79	2.2%	19.35	3.5%	31.14	7.2%	63.38
Prime Backwater Habitats: Herbaceous-Site Totals	**5,228.24**	**0.3%**	**16.52**	**1.3%**	**69.61**	**1.7%**	**90.51**	**2.0%**	**103.86**	**2.4%**	**127.88**	**4.7%**	**243.30**
Prime Backwater Habitats: Open Woody													
Coastal Bend: Floodplain Deciduous Shrubland	**3.63**	0.1%	0.00	36.7%	1.33	30.6%	1.11	49.0%	1.78	36.7%	1.33	49.0%	1.78
Coastal Bend: Floodplain Evergreen Shrubland	**10.81**	0.1%	0.01	2.1%	0.22	2.1%	0.22	2.1%	0.22	10.3%	1.11	2.1%	0.22
Coastal Bend: Riparian Evergreen Shrubland	**0.70**	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00
Invasive: Evergreen Shrubland	**200.08**	0.2%	0.37	1.1%	2.22	0.6%	1.11	0.2%	0.44	0.7%	1.33	2.4%	4.89
Native Invasive: Baccharis Shrubland	**7.71**	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00
Native Invasive: Common Reed	**449.31**	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.22	0.3%	1.33	0.0%	0.22
Native Invasive: Deciduous Woodland	**1,229.00**	0.2%	2.21	0.4%	4.67	0.9%	11.34	1.1%	13.57	0.7%	8.90	2.2%	27.35
Native Invasive: Huisache Woodland or Shrubland	**73.35**	1.4%	1.06	1.5%	1.11	2.1%	1.56	0.3%	0.22	0.9%	0.67	3.0%	2.22
Native Invasive: Mesquite Shrubland	**156.47**	0.4%	0.61	0.9%	1.33	0.4%	0.67	0.4%	0.67	4.3%	6.67	1.3%	2.00
Non-Native Invasive: Chinese Tallow Forest, Woodland, or Shrubland	**194.00**	0.0%	0.09	0.5%	0.89	0.7%	1.33	0.6%	1.11	0.3%	0.67	1.3%	2.45
Post Oak Savanna: Live Oak Motte and Woodland	**3,080.72**	0.0%	1.30	0.1%	3.56	0.2%	4.67	0.1%	1.78	0.7%	21.79	0.2%	6.67
Post Oak Savanna: Post Oak - Live Oak Motte and Woodland	**470.46**	0.0%	0.16	0.0%	0.00	0.0%	0.00	0.4%	1.78	1.2%	5.56	0.1%	0.44
Post Oak Savanna: Post Oak - Yaupon Motte and Woodland	**57.13**	0.0%	0.00	0.0%	0.00	0.0%	0.00	2.7%	1.56	0.0%	0.00	2.7%	1.56
Post Oak Savanna: Post Oak Motte and Woodland	**177.21**	0.0%	0.03	2.5%	4.45	2.1%	3.78	1.0%	1.78	2.3%	4.00	0.3%	0.44
Prime Backwater Habitats: Open Woody-Site Totals	**6,110.57**	**0.1%**	**5.84**	**0.3%**	**19.79**	**0.4%**	**25.80**	**0.4%**	**25.13**	**0.9%**	**53.37**	**0.8%**	**50.26**
Prime Backwater Habitats: Open Water													
Prime Backwater Habitats: Open Water-Site Totals	**1.11**	**0.0%**	**0.00**	**60.0%**	**0.67**	**80.0%**	**0.89**	**60.0%**	**0.67**	**40.0%**	**0.44**	**100.0%**	**1.11**
Other Habitats: Forest, Urban, & Barren													
Barren	**2.26**	40.9%	0.93	39.4%	0.89	39.4%	0.89	39.4%	0.89	0.0%	0.00	0.0%	0.00
Coastal Bend: Floodplain Hardwood Forest	**1,255.69**	0.8%	9.93	6.3%	78.51	10.0%	125.88	16.8%	210.39	13.8%	173.69	18.8%	236.18
Coastal Bend: Floodplain Live Oak - Hardwood Forest	**170.02**	0.0%	0.06	1.4%	2.45	1.6%	2.67	1.8%	3.11	2.1%	3.56	1.7%	2.89
Coastal Bend: Floodplain Live Oak Forest	**438.76**	0.1%	0.54	0.7%	2.89	1.1%	4.89	1.6%	6.89	1.3%	5.78	1.6%	6.89
Coastal Bend: Riparian Hardwood Forest	**78.00**	0.0%	0.00	3.4%	2.67	3.7%	2.89	7.1%	5.56	6.6%	5.12	8.8%	6.89
Coastal Bend: Riparian Live Oak - Hardwood Forest	**3.91**	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00
Coastal Bend: Riparian Live Oak Forest	**46.52**	0.0%	0.00	0.0%	0.00	0.5%	0.22	1.4%	0.67	0.0%	0.00	2.4%	1.11
Pine Plantation > 3 meters tall	**5.52**	0.3%	0.02	0.0%	0.00	60.4%	3.34	16.1%	0.89	0.0%	0.00	60.4%	3.34
Urban Low Intensity	**3.34**	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00
Other Habitats: Forest, Urban, & Barren-Site Totals	**2,004.02**	**0.6%**	**11.47**	**4.4%**	**87.40**	**7.0%**	**140.78**	**11.4%**	**228.40**	**9.4%**	**188.15**	**12.8%**	**257.31**
TOTAL PRIME BACKWATER HABITATS:	**11,339.93**	**0.2%**	**22.36**	**0.8%**	**90.07**	**1.0%**	**117.20**	**1.1%**	**129.66**	**1.6%**	**181.70**	**2.6%**	**294.67**
TOTAL EVENT INUNDATION:	**13,343.95**	**0.0%**	**33.84**	**1.3%**	**177.47**	**1.9%**	**257.98**	**2.7%**	**358.06**	**2.8%**	**369.84**	**4.1%**	**551.98**
Event:		12/01/18		01/31/17		01/06/02		01/14/05		12/07/09		12/28/15	

* MDD: Mean Daily Discharge (cfs)

** Res (m): Imagery resolution in meters.

Table 21. Site 13: Mustang Creek near Louise, TX. River Discharge and Inundated Habitats, Details.

Site 13: W. Mustang Ck nr Ganado, TX TES Habitat Inundation & River Discharge Details	Event:	01/26/90		02/07/02		01/17/18		01/08/18		01/16/97		03/08/95	
	MDD (cfs)*:	2.40		4.30		15.30		19.60		92.00		351.00	
	Res. (m)**:	2.5		0.7		0.7		0.7		30.0		2.5	
TES Habitat Types:	Site Totals (ha) per Habitat:	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha
Prime Backwater Habitats: Herbaceous													
Coastal Bend: Floodplain Herbaceous Wetland	**5.53**	42.1%	2.33	20.1%	1.11	13.5%	0.74	13.4%	0.74	24.1%	1.33	54.6%	3.02
Coastal Bend: Riparian Grassland	**136.98**	0.0%	0.00	0.0%	0.00	0.7%	0.93	0.8%	1.13	1.3%	1.78	1.1%	1.49
Coastal Bend: Riparian Herbaceous Wetland	**11.04**	18.1%	2.00	17.2%	1.90	15.1%	1.67	15.1%	1.67	32.2%	3.56	28.1%	3.10
Gulf Coast: Coastal Prairie	**11,083.34**	0.0%	0.50	0.0%	0.01	0.0%	0.06	0.0%	0.06	0.4%	41.59	2.9%	325.73
Gulf Coast: Coastal Prairie Pondshore	**374.95**	1.7%	6.25	0.0%	0.00	0.0%	0.00	0.0%	0.00	3.1%	11.56	4.1%	15.26
Row Crops	**5,126.14**	0.0%	0.91	0.0%	0.00	0.1%	2.72	0.1%	6.25	0.6%	29.58	2.1%	106.03
Prime Backwater Habitats: Herbaceous-Site Totals	**16,737.98**	**0.1%**	**11.98**	**0.0%**	**3.02**	**0.0%**	**6.11**	**0.1%**	**9.85**	**0.5%**	**89.40**	**2.7%**	**454.64**
Prime Backwater Habitats: Open Woody													
Coastal Bend: Floodplain Deciduous Shrubland	**0.27**	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00
Coastal Bend: Floodplain Evergreen Shrubland	**0.63**	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00
Coastal Bend: Riparian Deciduous Shrubland	**12.33**	0.0%	0.00	0.0%	0.00	4.2%	0.52	4.2%	0.52	0.0%	0.00	0.2%	0.02
Coastal Bend: Riparian Evergreen Shrubland	**11.07**	0.0%	0.00	0.0%	0.00	0.3%	0.03	5.3%	0.59	0.0%	0.00	0.2%	0.03
Invasive: Evergreen Shrubland	**479.77**	0.1%	0.32	0.0%	0.00	0.0%	0.02	0.1%	0.34	0.5%	2.22	1.2%	5.78
Native Invasive: Baccharis Shrubland	**4.04**	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00
Native Invasive: Deciduous Woodland	**1,332.24**	2.9%	39.15	3.0%	39.44	1.8%	24.49	1.9%	25.12	3.2%	42.25	9.4%	125.69
Native Invasive: Huisache Woodland or Shrubland	**78.24**	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	8.8%	6.88
Native Invasive: Mesquite Shrubland	**204.95**	0.0%	0.10	0.1%	0.25	0.1%	0.23	0.1%	0.23	1.0%	2.00	1.9%	3.93
Non-Native Invasive: Chinese Tallow Forest, Woodland, or Shrubland	**20.62**	0.0%	0.00	2.1%	0.43	0.1%	0.02	0.1%	0.02	3.2%	0.67	23.5%	4.85
Post Oak Savanna: Live Oak Motte and Woodland	**2,462.59**	0.1%	3.15	0.0%	0.26	0.0%	1.08	0.0%	1.15	0.2%	5.12	0.7%	16.05
Post Oak Savanna: Post Oak Motte and Woodland	**485.34**	0.0%	0.00	0.0%	0.01	0.2%	0.81	0.2%	0.99	0.3%	1.56	1.5%	7.13
Prime Backwater Habitats: Open Woody-Site Totals	**5,092.10**	**0.8%**	**42.72**	**0.8%**	**40.39**	**0.5%**	**27.21**	**0.6%**	**28.97**	**1.1%**	**53.82**	**3.3%**	**170.36**
Prime Backwater Habitats: Open Water													
Prime Backwater Habitats: Open Water-Site Totals	**106.11**	**42.5%**	**45.07**	**34.8%**	**36.89**	**33.7%**	**35.73**	**33.7%**	**35.72**	**45.3%**	**48.04**	**39.5%**	**41.88**
Other Habitats: Forest, Urban, & Barren													
Barren	**7.17**	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00
Coastal Bend: Floodplain Hardwood Forest	**217.20**	0.0%	0.00	2.8%	6.00	10.4%	22.58	12.4%	26.99	3.6%	7.78	29.1%	63.23
Coastal Bend: Floodplain Live Oak - Hardwood Forest	**30.44**	0.0%	0.00	0.0%	0.00	1.1%	0.34	1.4%	0.41	0.0%	0.00	6.4%	1.95
Coastal Bend: Floodplain Live Oak Forest	**7.96**	0.0%	0.00	0.0%	0.00	1.3%	0.11	2.2%	0.17	0.0%	0.00	8.6%	0.68
Coastal Bend: Riparian Hardwood Forest	**445.05**	6.7%	29.99	15.2%	67.72	19.5%	86.79	17.8%	79.22	18.5%	82.51	20.9%	92.86
Coastal Bend: Riparian Live Oak - Hardwood Forest	**45.44**	7.3%	3.34	9.8%	4.45	8.1%	3.66	10.6%	4.81	6.9%	3.11	8.2%	3.71
Coastal Bend: Riparian Live Oak Forest	**66.46**	1.2%	0.81	1.4%	0.90	4.0%	2.67	4.1%	2.74	1.3%	0.89	3.8%	2.53
Urban Low Intensity	**166.95**	0.0%	0.00	0.0%	0.00	0.1%	0.20	0.1%	0.09	0.7%	1.11	0.7%	1.18
Other Habitats: Forest, Urban, & Barren-Site Totals	**986.67**	**3.5%**	**34.13**	**8.0%**	**79.07**	**11.8%**	**116.35**	**23.1%**	**227.78**	**9.7%**	**95.41**	**16.8%**	**166.14**
TOTAL PRIME BACKWATER HABITATS:	**21,936.19**	**0.5%**	**99.77**	**0.4%**	**80.30**	**0.3%**	**69.05**	**0.3%**	**74.54**	**0.9%**	**191.26**	**3.0%**	**666.87**
TOTAL EVENT INUNDATION:	**22,922.86**	**0.6%**	**133.91**	**0.7%**	**159.37**	**0.8%**	**185.40**	**1.3%**	**302.32**	**1.3%**	**286.67**	**3.6%**	**833.01**
Event:		**01/26/90**		**02/07/02**		**01/17/18**		**01/08/18**		**01/16/97**		**03/08/95**	

* MDD: Mean Daily Discharge (cfs)

** Res (m): Imagery resolution in meters.

Table 22. Site 14: Tres Palacios River near Midfield, TX. River Discharge and Inundated Habitats, Details.

Site 14: Tres Palacios Rv nr Midfield, TX TES Habitat Inundation & River Discharge Details	Event:	03/10/89		02/10/15		01/25/02		12/28/20		01/17/06		01/21/93		01/14/05		12/07/09	
	MDD (cfs)*:	6.70		12.40		16.00		20.70		84.50		114.00		152.00		700.00	
	Res. (m)**:	2.5		0.5		2.5		0.6		30.0		30.0		30.0		0.5	
TES Habitat Types:	Site Totals (ha) per Habitat:	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha
Prime Backwater Habitats: Herbaceous																	
Coastal Bend: Riparian Grassland	191.0	0.00	0.00	0.36	0.70	0.00	0.00	0.52	1.01	0.23	0.44	1.15	2.22	0.00	0.00	1.83	3.56
Coastal Bend: Riparian Herbaceous Wetland	2.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.75	0.12
Gulf Coast: Coastal Prairie	6,849.3	0.05	3.09	0.06	3.81	0.09	6.48	0.16	11.07	1.37	94.96	1.00	68.94	0.50	34.47	0.37	25.42
Gulf Coast: Coastal Prairie Pondshore	68.3	19.99	13.65	3.82	2.17	19.34	13.09	2.16	1.21	11.85	7.34	0.81	0.44	19.90	13.57	22.62	15.96
Gulf Coast: Salty Prairie	562.8	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.30	4.31	25.35	0.55	3.11	0.94	5.34	0.31	1.74
Native Invasive: Common Reed	395.2	0.00	0.00	0.10	0.38	0.00	0.00	0.15	0.57	0.45	1.78	0.11	0.44	1.82	7.34	0.53	2.11
Row Crops	6,238.1	0.00	0.00	0.00	0.00	0.01	0.82	0.04	2.71	0.02	1.33	0.31	19.13	0.12	7.78	3.80	246.54
Prime Backwater Habitats: Herbaceous-Site Totals	**14,307.4**	**0.1%**	**16.74**	**0.0%**	**7.07**	**0.1%**	**20.40**	**0.1%**	**16.88**	**0.9%**	**#####**	**0.7%**	**####**	**0.5%**	**68.50**	**2.1%**	**#####**
Prime Backwater Habitats: Open Woody																	
Coastal Bend: Riparian Deciduous Shrubland	10.8	0.00	0.00	1.15	0.13	0.00	0.00	1.10	0.12	0.00	0.00	7.60	0.89	2.02	0.22	7.04	0.82
Coastal Bend: Riparian Evergreen Shrubland	16.0	0.00	0.00	0.03	0.00	0.00	0.00	0.43	0.07	0.00	0.00	1.37	0.22	0.00	0.00	0.90	0.15
Gulf Coast: Salty Prairie Shrubland	83.9	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.01	2.33	2.00	1.31	1.11	0.00	0.00	0.09	0.08
Invasive: Evergreen Shrubland	450.2	0.07	0.33	0.37	1.67	0.10	0.46	0.44	1.99	0.30	1.33	0.78	3.56	1.37	6.23	0.49	2.21
Native Invasive: Baccharis Shrubland	49.7	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.02	0.89	0.44	0.00	0.00	1.76	0.89	0.00	0.00
Native Invasive: Deciduous Woodland	1,101.8	0.13	1.47	1.31	14.55	1.36	15.13	1.17	13.05	1.22	13.57	4.50	51.82	5.37	62.49	3.36	38.20
Native Invasive: Huisache Woodland or Shrubland	34.8	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.63	0.22	1.26	0.44	0.00	0.00	0.50	0.18
Native Invasive: Mesquite Shrubland	333.5	0.00	0.00	0.07	0.24	0.11	0.35	0.11	0.38	1.51	5.12	1.06	3.56	0.40	1.33	0.62	2.09
Non-Native Invasive: Chinese Tallow Forest, Woodland, or Shrubland	38.4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.71	0.67	0.32	0.12
Post Oak Savanna: Live Oak Motte and Woodland	2,589.4	0.10	2.47	0.14	3.50	0.20	5.12	0.21	5.40	0.09	2.22	0.49	12.68	3.01	80.28	0.36	9.46
Post Oak Savanna: Post Oak - Live Oak Motte and Woodland	9.0	0.00	0.00	4.87	0.46	4.36	0.41	4.97	0.47	0.00	0.00	8.98	0.89	8.98	0.89	7.85	0.77
Post Oak Savanna: Post Oak - Yaupon Motte and Woodland	2.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Post Oak Savanna: Post Oak Motte and Woodland	64.5	0.00	0.00	0.31	0.20	0.00	0.00	0.48	0.31	2.03	1.33	2.36	1.56	4.61	3.11	0.47	0.31
Prime Backwater Habitats: Open Woody-Site Totals	**4,784.2**	**0.1%**	**4.26**	**0.4%**	**####**	**0.4%**	**21.47**	**0.5%**	**21.82**	**0.5%**	**26.24**	**1.6%**	**####**	**3.3%**	**#####**	**1.1%**	**54.38**
Prime Backwater Habitats: Open Water																	
Prime Backwater Habitats: Open Water-Site Totals	**59.6**	**35.2%**	**20.96**	**16.7%**	**9.97**	**28.6%**	**17.06**	**21.2%**	**12.61**	**22.4%**	**13.34**	**0.0%**	**0.00**	**36.2%**	**21.57**	**35.5%**	**21.17**
Other Habitats: Forest, Urban, & Barren																	
Barren	11.6	0.00	0.00	0.32	0.04	0.00	0.00	6.60	0.82	10.33	1.33	19.98	2.89	3.70	0.44	0.25	0.03
Coastal Bend: Riparian Hardwood Forest	235.6	0.00	0.00	2.42	5.83	0.37	0.87	2.27	5.48	0.28	0.67	7.59	19.35	5.70	14.23	6.91	17.49
Coastal Bend: Riparian Live Oak - Hardwood Forest	19.9	0.00	0.00	1.05	0.21	1.85	0.38	1.35	0.27	0.00	0.00	7.24	1.56	2.18	0.44	7.90	1.71
Coastal Bend: Riparian Live Oak Forest	135.8	0.00	0.00	0.98	1.34	0.50	0.69	1.30	1.79	0.00	0.00	1.77	2.45	2.08	2.89	4.56	6.48
Post Oak Savanna: Live Oak Slope Forest	5.5	0.00	0.00	4.76	0.27	2.13	0.12	3.54	0.20	0.00	0.00	10.88	0.67	19.62	1.33	9.60	0.58
Post Oak Savanna: Post Oak - Live Oak Slope Forest	1.0	0.00	0.00	1.18	0.01	0.00	0.00	1.44	0.01	0.00	0.00	0.00	0.00	0.00	0.00	3.11	0.03
Urban High Intensity	3.8	0.00	0.00	0.00	0.00	0.00	0.00	5.20	0.21	28.87	1.56	0.00	0.00	25.81	1.33	0.00	0.00
Urban Low Intensity	134.3	0.00	0.00	0.96	1.30	0.06	0.08	1.15	1.56	1.31	1.78	0.66	0.89	1.31	1.78	0.28	0.38
Other Habitats: Forest, Urban, & Barren-Site Totals	**547.6**	**0.0%**	**0.00**	**1.6%**	**9.01**	**0.4%**	**2.13**	**1.9%**	**10.35**	**1.0%**	**5.34**	**5.1%**	**####**	**4.1%**	**22.46**	**4.9%**	**26.71**
TOTAL PRIME BACKWATER HABITATS:	**19,151.1**	**0.2%**	**42.0**	**0.2%**	**37.8**	**0.3%**	**58.9**	**0.3%**	**51.3**	**0.9%**	**170.8**	**0.9%**	**####**	**1.3%**	**246.2**	**1.9%**	**371.0**
TOTAL EVENT INUNDATION:	**19,698.7**	**0.2%**	**42.0**	**0.2%**	**46.8**	**0.3%**	**61.1**	**0.3%**	**61.7**	**0.9%**	**176.1**	**1.0%**	**####**	**1.4%**	**268.7**	**2.0%**	**397.7**
Event:		**03/10/89**		**02/10/15**		**01/25/02**		**12/28/20**		**01/17/06**		**01/21/93**		**01/14/05**		**12/07/09**	

* MDD: Mean Daily Discharge (cfs)

** Res (m): Imagery resolution in meters.

Table 23. Discharge Rates Initiating Backwater Inundation

Study Sites		**MDD***
1	Site 1. Lavaca River near Edna, TX	250
2	Site 2. Navidad River at Strane Park near Edna, TX	250
3	Site 3. Colorado River near Ballinger, TX	200
4	Site 4. Colorado River above Silver, TX	125
5	Site 5. Colorado River near San Saba, TX	850
6	Site 6. Concho River at Paint Rock, TX	30
9	Site 9. Pedernales River near Johnson City, TX	30
11	Site 11. Sandy Creek near Ganado, TX	165
13	Site 13. E. Mustang Ck near Louise, TX	95
14	Site 14. Tres Palacios River near Midfield, TX	125

* MDD = Mean daily discharge (cfs)

Appendix C: TWDB comments and TCS response

Some of the TWDB comments and TCS responses may no longer apply, following the 08/09/23 decision by TWDB and TPWD not to include the TCS regression analyses in the report.

Texas Water Development Board

P.O. Box 13231, 1700 N. Congress Ave.
Austin, TX 78711-3231, www.twdb.texas.gov
Phone (512) 463-7847, Fax (512) 475-2053

Tammy Dunham, CTPM, CTCM
Texas Parks and Wildlife Department
4200 Smith School Road
Austin, TX 78744

RE: Contract No. 2000012438 TWDB comments on Draft Report entitled "Hydraulic Connectivity to Riparian Habitats in the Colorado and Lavaca Basins."

Dear Ms. Dunham:

Texas Water Development Board (TWDB) staff completed a review of the draft report prepared under the above-referenced contract. Attachment 1 provides the comments resulting from this review. As stated in the TWDB contract, Texas Parks and Wildlife Department (TPWD) will consider revising the final report in response to comments. Please also submit electronic copies of raw and processed data, metadata, maps, associated GIS files, any computer programs, models, or operations manuals developed under the terms of this contract.

TWDB staff looks forward to receiving an electronic copy of the entire Final Report in Portable Document Format (PDF) format, accompanied by a Transmittal Letter which identifies how the Executive Administrator's comments were addressed.

Note: The final deliverables must comply with the accessibility standards defined in the Texas Administrative Code (1TAC 213 & 1TAC 206.50). Contracted deliverables must meet the standards referenced in US Section 508 Appendix C Chapter 7 §702.10 (WCAG 2.0 Level AA, excluding Guideline 1.2 Time Based Media). WCAG guidelines are based on the standards set by the World Wide Web Consortium (W3C) and ensure all resources offer equal access opportunities to the public.

If you have any questions or need any further information, please contact your Contract Manager Dr. Mark Wentzel, of the Water Science & Conservation office at (512)-936-0823, Mark.Wentzel@twdb.texas.gov or Cameron Turner of the Procurement & Contract Services Division at (512) 936-6090, cameron.turner@twdb.texas.gov.

Sincerely,

7/12/2023

John T. Dupnik, P.G.
Deputy Executive Administrator

Date

Attachment
c w/o att.: Marl Wentzel, Ph.D./ Water Science & Conservation

TWDB Contract No. 2000012438
Received July 05, 2023

Hydraulic Connectivity to Riparian Habitats in the Colorado and Lavaca Basins

Draft-final report to the Texas Water Development Board

TWDB Contract No. 2000012438

General comments

Overall, the report is well-written and informative. This effort utilized analysis of available remotely sensed imagery to examine the relationship between flow and inundation of riparian areas at 10 study sites along the Colorado and Lavaca Rivers. Land classifications from the Texas Parks and Wildlife Departments' Texas Ecological System were utilized to determine the types of habitats available and inundated at each site. In addition to total inundation area, suitable Alligator Gar spawning area was calculated in each image. Results were used to construct a model for each site that estimated total area inundated and suitable Alligator Gar spawning area provided by specific flow rates. Flow rates in the existing environmental flow standards at each site were evaluated relative to their ability to inundate riparian areas and provide suitable Alligator Gar spawning habitat. As documented by the authors, this effort was hampered by a lack of suitable imagery to cover a larger range of flow events at some of the study sites.

Specific comments to be addressed

1. Report Cover. Please refer to Texas Water Development Board "Contract No. 2000012438" rather than "Grant No. 2000012438-01".
2. Report Cover. Please provide the following wording at the bottom of the report cover:

   "*Pursuant to House Bill 1 as approved by the 86th Texas Legislature, this study report was funded for the purpose of studying environmental flow needs for Texas rivers and estuaries as part of the adaptive management phase of the Senate Bill 3 process for environmental flows established by the 80th Texas Legislature. The views and conclusions expressed herein are those of the author(s) and do not necessarily reflect the views of the Texas Water Development Board.*"
3. Please provide the following paragraph as the first paragraph in the Introduction section on page 4:

   "In 2007, the passage of Senate Bill 3 (SB3) of the 80th Texas Legislature amended the Texas water code (Section 11.0235) and established a stakeholder-driven process for identifying and quantifying flow regimes needed to maintain sound ecological environments in Texas rivers and estuaries. Environmental flow

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recommendations for the Colorado and Lavaca rivers were made in 2011 and used to develop environmental flow standards by the Texas Commission on Environmental Quality (TCEQ) in 2012. The SB3 process includes an adaptive management component wherein a Basin and Bay Area Stakeholder Committee can recommend changes as new data and information become available within their areas. This study is one of several studies conducted since 2011 whose results could help guide refinement of flow standards for the Colorado and Lavaca rivers."

4. The distribution of Alligator Gar in Texas is not expected to extend upstream of Austin in the Colorado River Basin (see https://tpwd.texas.gov/fishboat/fish/management/alligator-gar/texas-range.phtml). In lieu of this expected distribution, please provide an explanation of why Alligator Gar spawning habitat was calculated for Sites 3, 4, 5, 6, and 9. Perhaps Alligator Gar habitat is considered an adequate surrogate for the habitat requirements of other species that utilize out-of-bank habitats at these sites? Perhaps Alligator Gar habitat was calculated for ease of comparison of results across all 10 sites? Please comment on whether total inundation should be given more importance when evaluating sites where Alligator Gar are not expected to be present.

5. In legends for figures related to imagery from the 10 sites (Figures 4, 7,10, 13, 16, 19, 22, 25, 28, and 31), please provide an entry describing what is denoted by the red color on the figures of imagery.

6. Please provide the equation for Habitat Area as a function of Mean Daily Discharge in Tables 23 through 32 in the column labeled "Model Equation." The current equations provide Mean Daily Discharge as a function of Habitat Area. Also, please double check the values provided for R^2. In Table 24 for Site 2, the R^2 for the equation for Mean Daily Discharge as a function of Total Habitat Inundation is given as 0.99. In fact, the R^2 is 0.82 (see figure below constructed in Excel with Site 2 data from Table 4).

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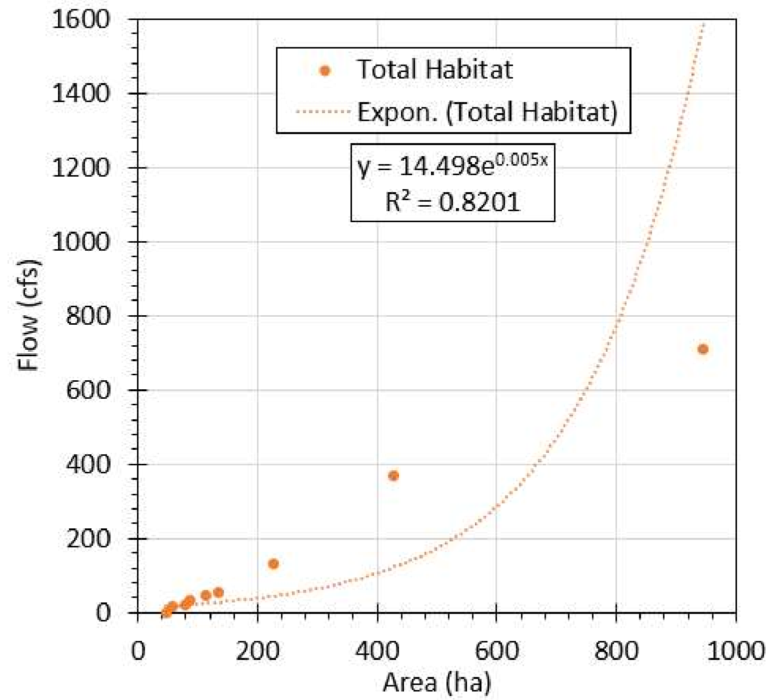
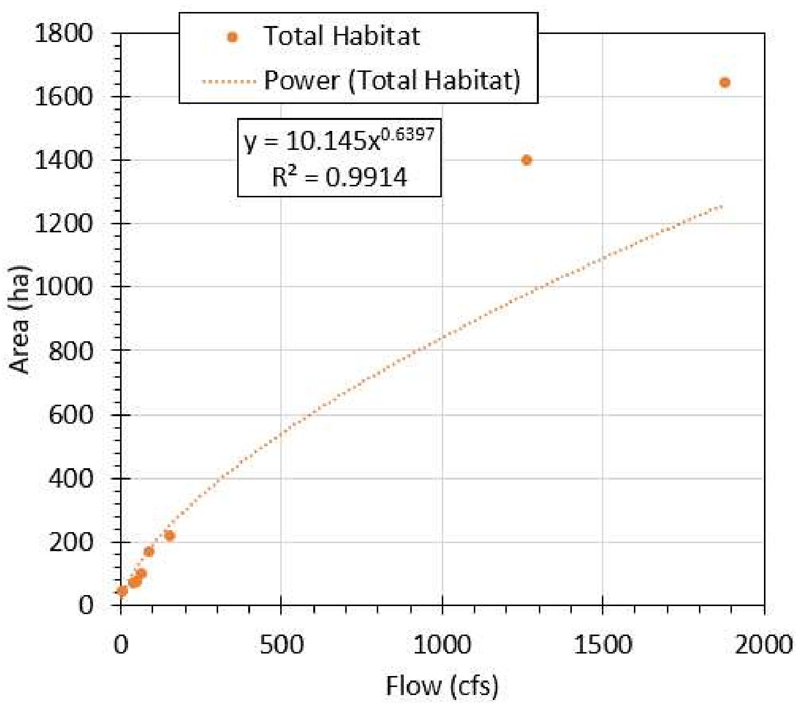


7. Please provide plots of the data and the proposed models (possibly as an appendix) to clearly show how the data compares to the proposed models. This provides a more accurate assessment of model suitability than the R^2 values provided in Tables 23 through 32. For Site 1, the data from Table 3 would plot up as shown below. Also shown in the plot, a power model fits the data with an R^2 of 0.99 but does not represent the underlying data well.



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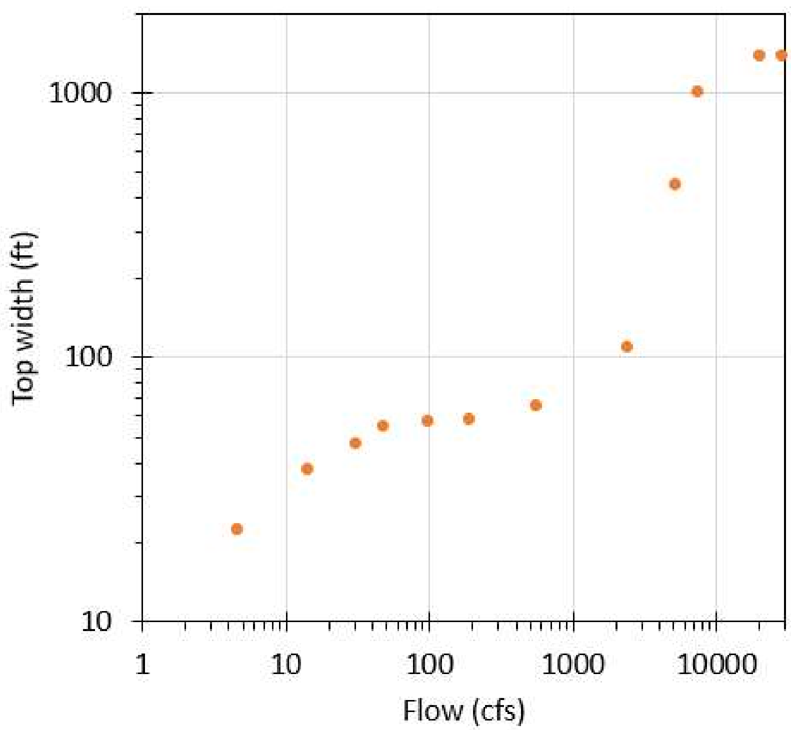
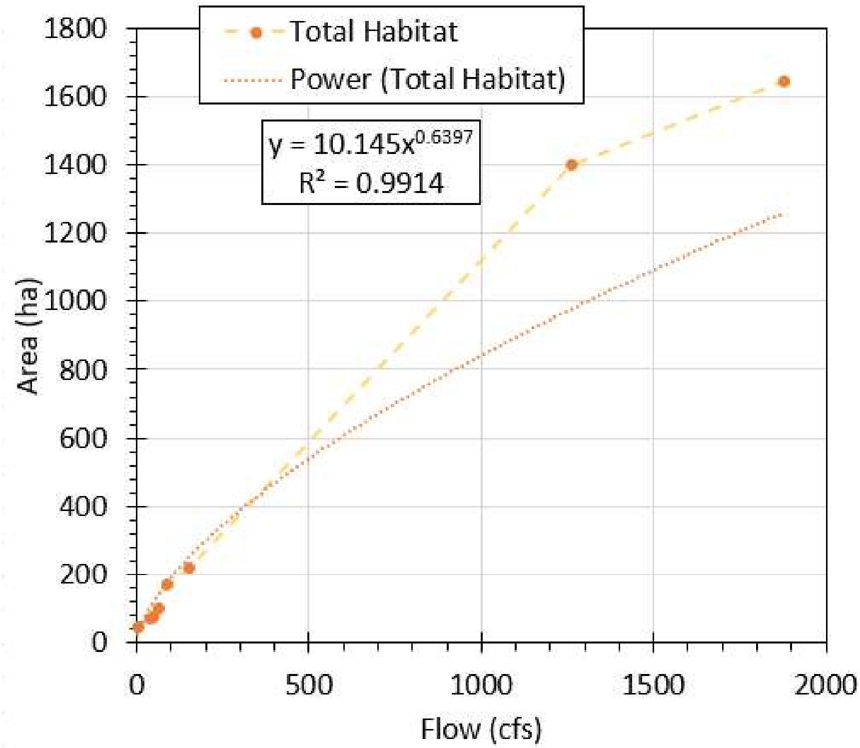
8. Please consider using linear interpolation between data points to estimate habitat area as a function of flow. Despite high R^2 values, the proposed models in the draft report do not fit the underlying data, as clearly shown by plotting the data and models. There is no reason to expect the relationship between inundated area and flow at any of the sites to fit an exponential, linear, logarithmic, polynomial, power, or other function readily available in a statistical software package for the entire range of flows. As flow increases, inundated area will respond to the flow and the physical shape of the channel. At lower flows, inundated area will increase rapidly as the flow covers the bottom of the channel. At slightly higher flows, inundated area will increase much slower as flow is constrained by the banks of the channel. As flow increases enough to reach low spots in the top-of-bank topography, inundated area will again increase rapidly as flow spills out into near-channel areas of the floodplain. As flow continues to increase, the rate of increase of inundated area may change additional times as the flow interacts with topographic features in the floodplain such as depressions, terraces, and meander scrolls. This interaction of flow and topography also shows up in the relationship between top width and flow (top width is proportional to inundated area since top width times reach length approximates inundated area) as shown in the plot below (generated from measurement data from USGS gage 0816400 located within Site 1).



Expecting inundated area to be a simple, continuously smooth function of flow is not realistic. An alternative approach to estimating inundated habitat area would be to use linear interpolation between data points. That approach (and a comparison to a power model) is shown in the figure below for the data associated with Site 1.

TWDB Contract No. 2000012438
Received July 05, 2023



9. Please provide appropriate caveats to the estimates of inundated habitat associated with flow rates from the e-flow standards (Tables 23 through 32). Extrapolating beyond the range of available data reduces confidence in estimates. For Sites 2, 3, and 4, the data (Tables 5 through 7) spans the range of flows in the e-flow standards (Tables 25 through 27), improving the confidence in those estimates. For the remaining sites, the available data does not span the range of the e-flow standards, reducing the confidence in some of the estimates for those sites.

10. In Section 5.1, beginning on page 23, please provide a brief explanation of why study sites did not correspond to sites specified in the Scope of Work. It is assumed this was due to availability (or lack of availability) of suitable imagery.

11. In Section 5.1, beginning on page 23, please provide a brief explanation of why the hydrologic analysis described in the Scope of Work ("Analyses will include assessment of how flow requirements compare to flow statistics [e.g. 85th percentile, 1 in 2-year high flow, etc.] for each site. Results will be analyzed to evaluate if a flow statistic approach could, in the future, serve as a surrogate for the site-specific analysis used for this project.") was not completed.

12. Please clarify the last bullet in Section 5.1 on page 24. It is not clear how the large effort required to develop and implement new classification methods provided any information about the effectiveness of using a flow statistics approach as a surrogate. If anything, the large effort associated with this approach would seem to justify the use of flow statistic surrogates, if in fact, they are found to be useful approximations.

13. Please provide Table 33 which is missing from the draft final report.

Suggestions for the report:

14. For readability for the largest audience, when areas and depths are provided in scientific units (hectares and meters) throughout the document, please consider providing these in imperial units as well (acres and feet). For example, on page 8, last paragraph, third sentence: shallow areas described as "(<1-m water depth)" could be described as "(<1-m [3.3 ft] water depth)." Alternatively, the document could remind readers that a meter is equivalent to 3.3 feet and a hectare is equivalent to 2.5 acres.
15. Throughout the document, the 10 sites are numbered 1 through 14 (7, 8, 10, and 12 missing). To avoid confusion, please consider renumbering sites as 1 through 10 (all whole numbers included).
16. For readability, please consider adopting a common format for figures and tables that are oriented in landscape format. The majority of figures in landscape format have the top of the figure oriented to the right edge of the page (toward the loose side of the document). The tables in landscape format have the top of the table oriented to the left edge of the page (toward the bound side of the document).

Hydraulic Connectivity to Riparian Habitats
in the Colorado and Lavaca Basins

Draft-final report to the Texas Water Development Board (TWDB)

TWDB Contract No. 2000012458

Texas Conservation Science (TCS) response to TWDB comments on Final Draft Report

Specific comments to be addressed (TWDB):
TCS Note: Some of the TWDB comments may no longer apply, following the 08/09/23 decision by TWDB and TPWD not include any regression analyses in the report.

TCS appreciates the insightful TWDB comments.

1. Report Cover. TCS agrees with TWDB edits.

2. Report Cover. TCS agrees with TWDB edits

3. Introduction. TCS agrees with TWDB edits.

4. The report identifies “Alligator Gar habitat” as a surrogate for prime backwater habitat for both fish and wildlife. As requested, TCS will emphasize more strongly that “Alligator Gar habitat” is a surrogate, by relabeling it as “Prime Backwater Habitat” in all tables and text, with additional discussion in the report. Since this is a significant task. please let us know if another label may be preferred.

5. In the respective legends, as suggested, TCS will explain that the red mask in imagery for the 10 listed sites denotes event inundation.

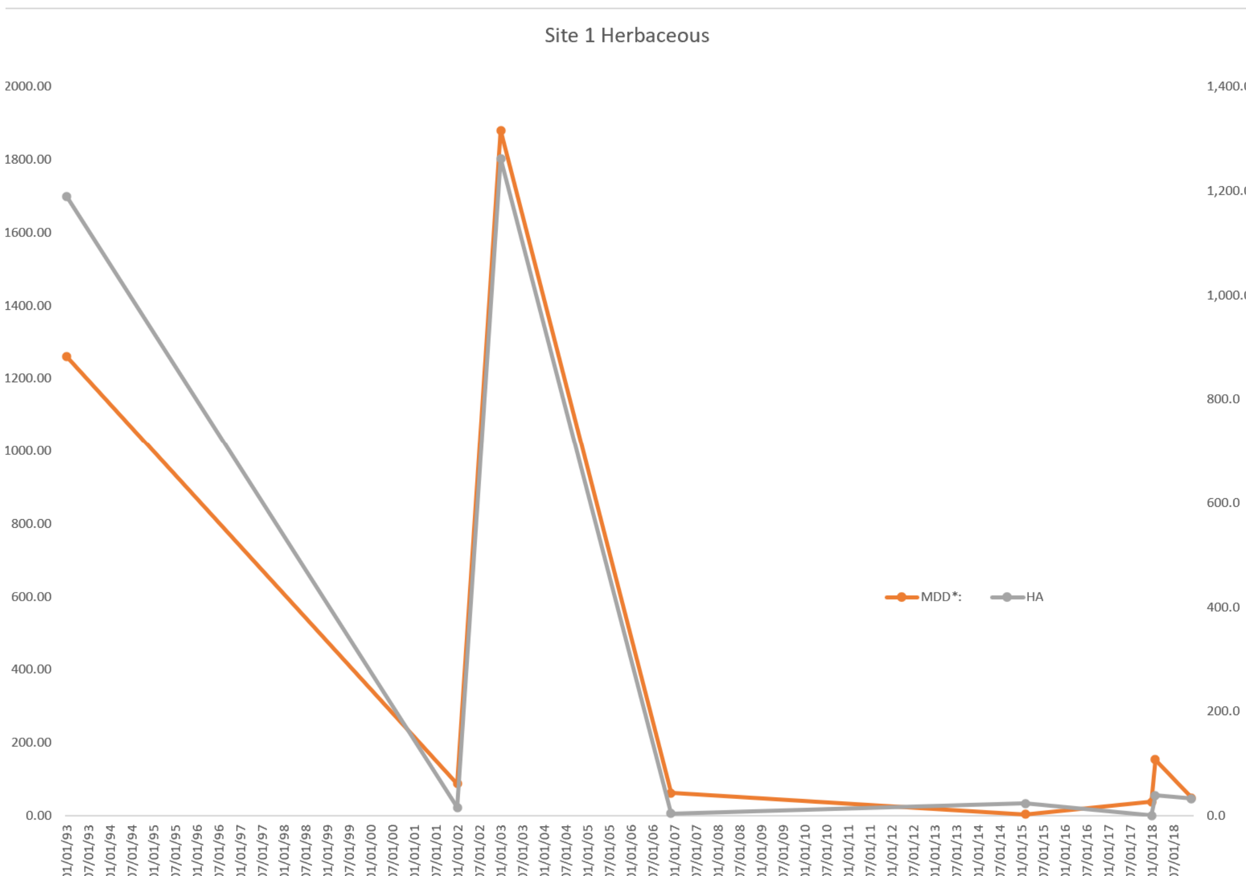
6. As necessary, TCS will provide the equation for Habitat Area as a function of Mean Daily Discharge in Tables 23 through 32 in the column labeled “Model Equation.” Accordingly, R^2 values will be revised as needed.

7. Yes, if necessary, TCS will provide plots of the data and proposed models for each site, in order to detail the degree to which data corresponds to the respective models.

8. Although the power function does not fit the data well, its advantage is that it allows statistical analysis. Linear extrapolation would require multiple cfs- and site-specific equations from one data point to another, which would lack statistical verification or justification. In TWDB’s figure example for site 1, there are no imagery data between the last data point between 100 - 200 cfs and the next data point at ~1200 cfs. The alternative approach of linear trends between one data point to another does not account for the time periods each data point represents.

   The TWDB relationship explanation of flow and topography is correct, if the data were indeed in a chronological order. However, the imagery available for classification has data points jumping back and forth in time over 25 years. In TWDB's site 1 figure, the data point is 154 cfs in 2018, then jumps to 1,260 cfs in 1993. There is no reason to expect a linear relationship between data points, when they are not in chronological order. Therefore, TCS's site-specific power equations are estimations, based on the given data set.

When taking into account the time of events, the following rough plot uses Site 1 Herbaceous Habitat as an example where MDD and HA are both on the Y axis and Event Date on the X axis. No site-specific equation is possible since no regression fits these data. That said, a linear interpolation from one event to another may give a better estimate, but without statistical support. However, to create a large number of CFS/HA relationship equations from one data point to another will take a very large effort. Other sites are not as simple as site 1, where a progression of flow events may be apparent based on limited data sets. A linear relationship is an unsupported assumption, since for this example 1993 to 2002 the next data point is a 9 year time gap, when anything could have happened for flow. Again, due to huge time gaps from one data point to leads to significant over- and under-estimation issues with the underlying assumption that its all linear.



9. As suggested, the following caveats will be added as follows:

For Sites 2, 3, and 4, the data (Tables 5 through 7) spans the range of flows in the e-flow standards (Tables 25 through 27), improving the confidence in those estimates. For the remaining sites, the available data does not span the range of the e-flow standards, reducing the confidence in some of the estimates for those sites.

10. All study sites correspond to sites specified in the Scope of Work (SOW), which can be seen since site labels in the report are the same as in the SOW.

11 The large effort to develop imagery classification methods for the various image formats that were available took an inordinate amount of time. Therefore, continuing to focus on flow relationships, such as the initiation of backwater inundation, was determined to be an appropriate use of limited time. Due to not having a staff hydrologist at TCS, deriving flow statistics would have taken more than the available time. If TWDB and/or TPWD can produce appropriate flow statistics, please let TCS know how we may assist.

12. The effort referred to in the bullet on page 24 was the above development of new imagery classification methods, unrelated to flow statistics. The bullet will be rewritten to be clearer.

13. Corrected.

14. The document will remind readers that a meter is equivalent to 3.3 feet and a hectare is equivalent to 2.5 acres.

15. Due to the large effort to re-number the sites, including revising the many tables, figures, and text entries, TCS prefers not to re-number the sites, due to budget limitations.

16. As suggested, a common format is now used for figures and tables.