Aerial Assessment of Aquatic and Riparian Habitat in the Brazos River and Blanco River, Texas

Prepared for:

Final Report

Texas Water Development Board

TWDB Contract No. 1104831144

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April 20, 2012

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Introduction

Use of small, autonomous UAVs (unmanned aerial vehicles) in fisheries, watershed management, and restoration practices has gained increasing attention. This is due, in part, to the UAV's (Aggieair™) relatively low cost, versatility, and instantaneous acquisition of multispectral digital aerial imagery (Chao et al. 2009; Jensen et al. 2009). Recent and current applications of the UAV include management of invasive plant species and mapping riparian habitat (Zaman et al. 2011; Jensen et al. 2011). The purpose of this study was to evaluate the use the UAV to acquire high resolution multispectral aerial imagery from Texas rivers supporting natural resource management objectives. Specifically, we sought to capture images of riparian and instream habitat within selected reaches of the Brazos River and the Blanco River. Our goal was to obtain imagery $\leq$ 25 cm pixel resolution and produce geo-referenced mosaics of the UAV imagery. Imagery collected by the UAV will be used by Texas Parks and Wildlife to identify available fish habitat at selected Brazos River sites and to locate areas of isolated pools within the Blanco River to facilitate removal of non native smallmouth bass.

Methods

Locations of selected reaches for the Brazos and Blanco Rivers were identified by Texas Parks and Wildlife personnel based on instream flow and native bass restoration programs. Study sites included five reaches on the Brazos River ranging from 5.5 to 9.5 river kilometers and two reaches on the Blanco River encompassing 16 and 24 river kilometers (Fig. 1 and Fig. 2).

On the Brazos River, flight altitude for the UAV was set at 500 m above ground level (AGL) (14 cm pixel resolution) except for one site which was set at 600 m AGL (16 cm pixel resolution). All Blanco River reaches were flown at 600 m AGL. Flight line planning and ground based image swath areas captured by the onboard cameras were created in Google Earth Pro software and transferred to the flight planning software (Fig. 3). The coordinates (decimal degrees) for each node of the flight lines and geo-referenced base maps were exported as kml files and used to create flight plans in the Paparazzi Center software (Fig. 4). Paparazzi was also used to simulate the flight plans to verify they functioned properly prior to flight missions.

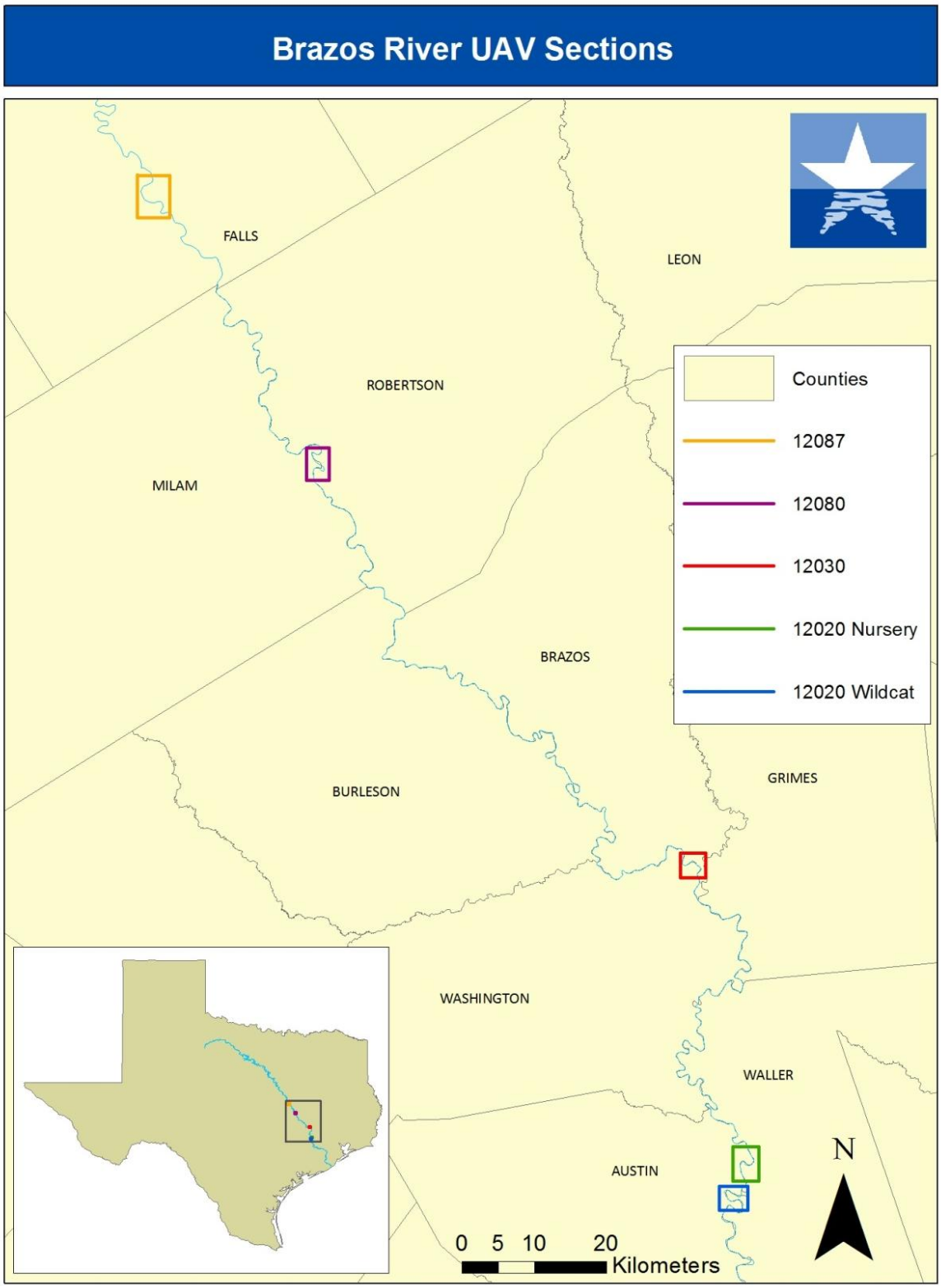

Figure 1. Selected reaches on the Brazos River, Texas.

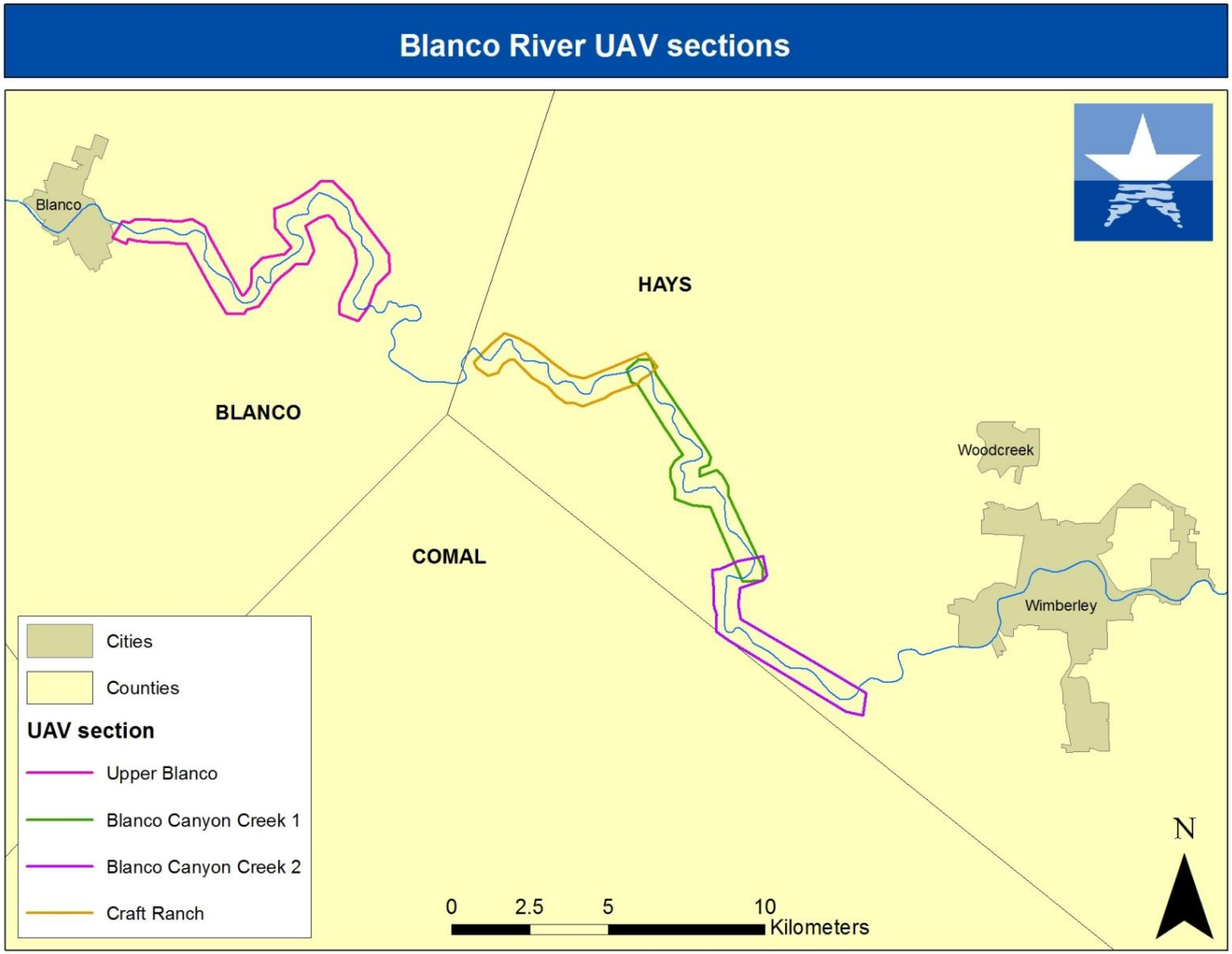

Figure 2. Selected reaches on the Blanco River, Texas

Figure 3. Example of Flight line measurement and creation in Google Earth Pro.

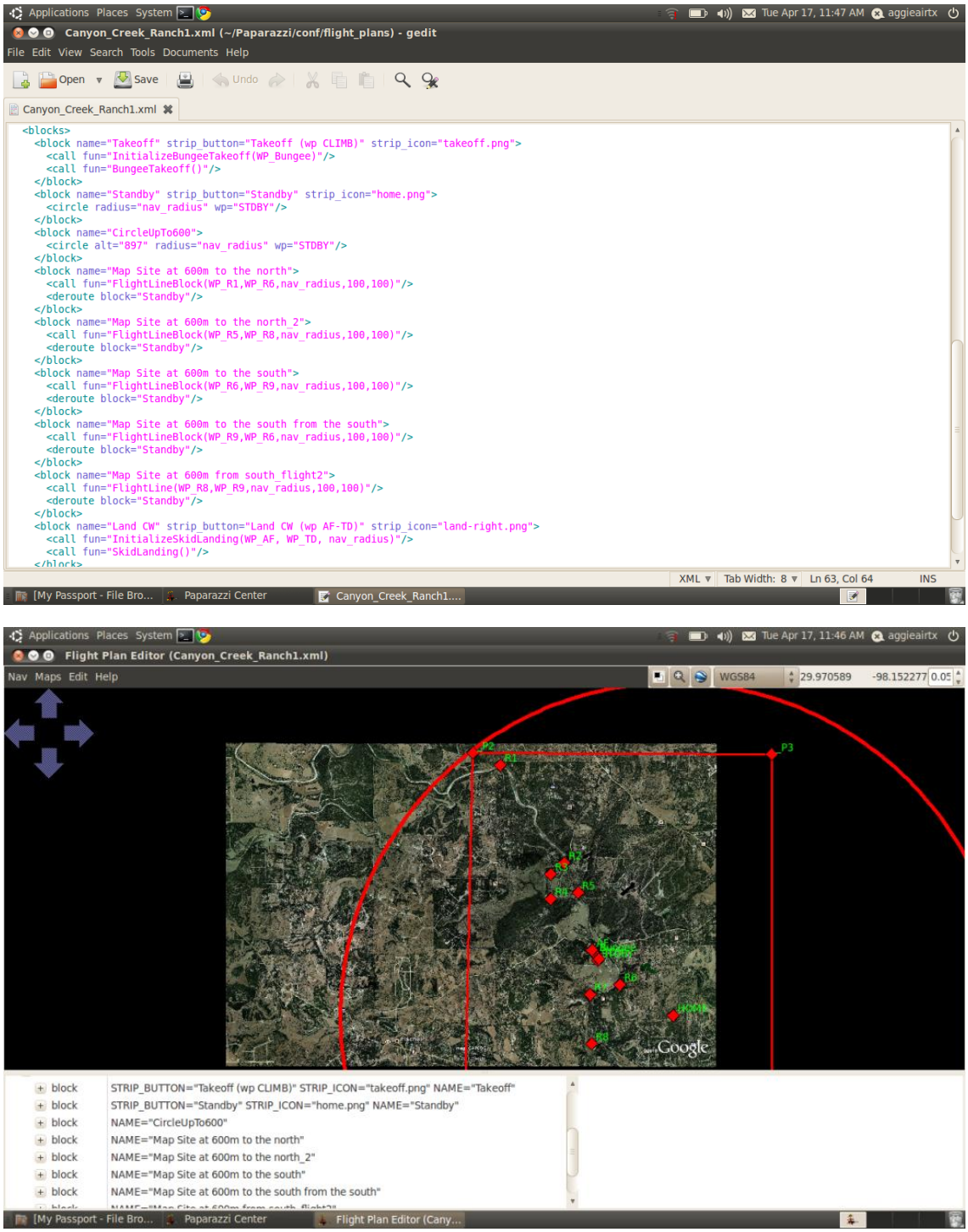

Figure 4. Example of Flight plan creation in Paparazzi Center Software.

We utilized a battery powered UAV equipped with an autopilot, GPS, inertial measurement unit (IMU) and an onboard computer (Gumstix). This system, developed by Utah State University's Water Research Lab (UWRL), is designed to perform pre-programmed flight plans. During flight, the UAV is controlled and monitored by the ground control station computer via antenna and modem and landing is controlled by a pilot directing the UAV with a radio transmitter. Two onboard digital cameras, a red-green-blue (RGB) and a near infrared (NIR) spectrum, were used to collect images with GPS position and orientation recorded for each image on the UAV's onboard computer (Fig. 5 and Fig. 6)

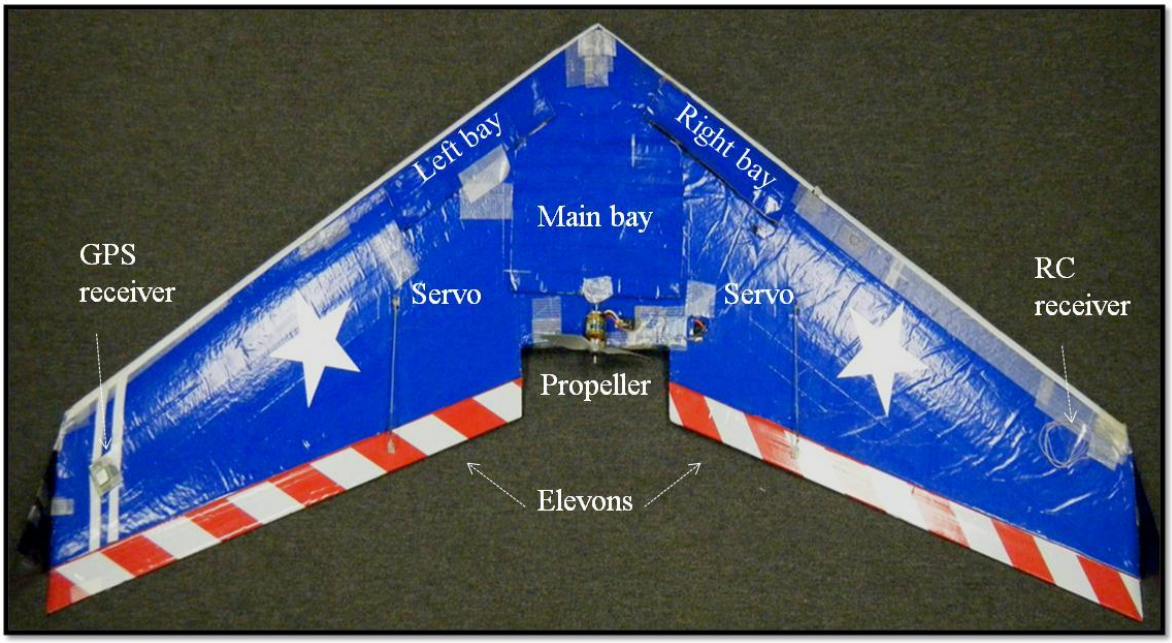

Figure 5. External view of UAV.

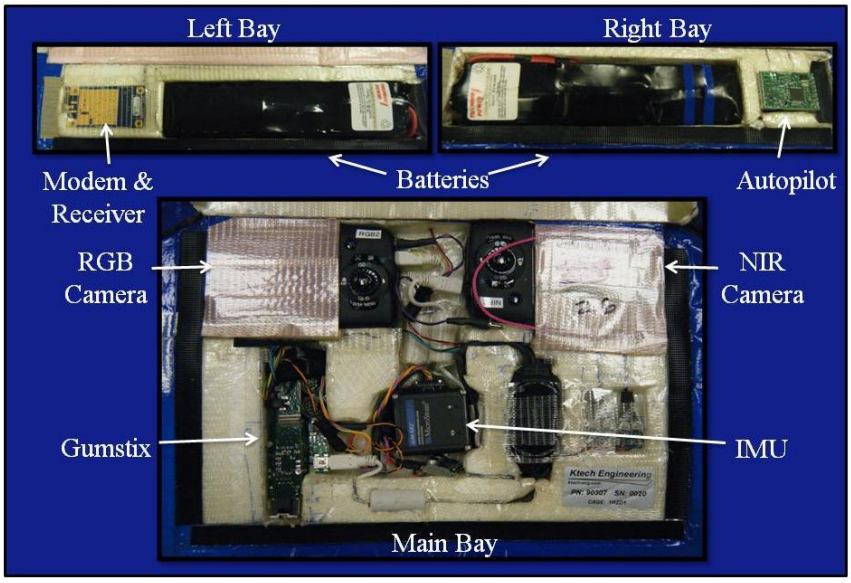

Figure 6. Internal view of UAV's components.

Study reaches on the Brazos River were flown during daylight hours March 10th and March 11th of 2011. Flights on the Blanco River were conducted during daylight hours September 12th and October 24th of 2011. Captured images and spatial data for each flight were downloaded for further processing. Images were processed using NASA World Wind software. Within NASA World Wind, images are paired with their spatial data recorded by the onboard computer. Distorted images (i.e., trapezoidal images) are deleted and remaining images are organized into flight lines to ensure sufficient overlap exists among images for the mosaicking process. Completed World Wind files are exported as trp and gps files for use in the mosaic software, EnsoMOSAIC (Fig. 7).

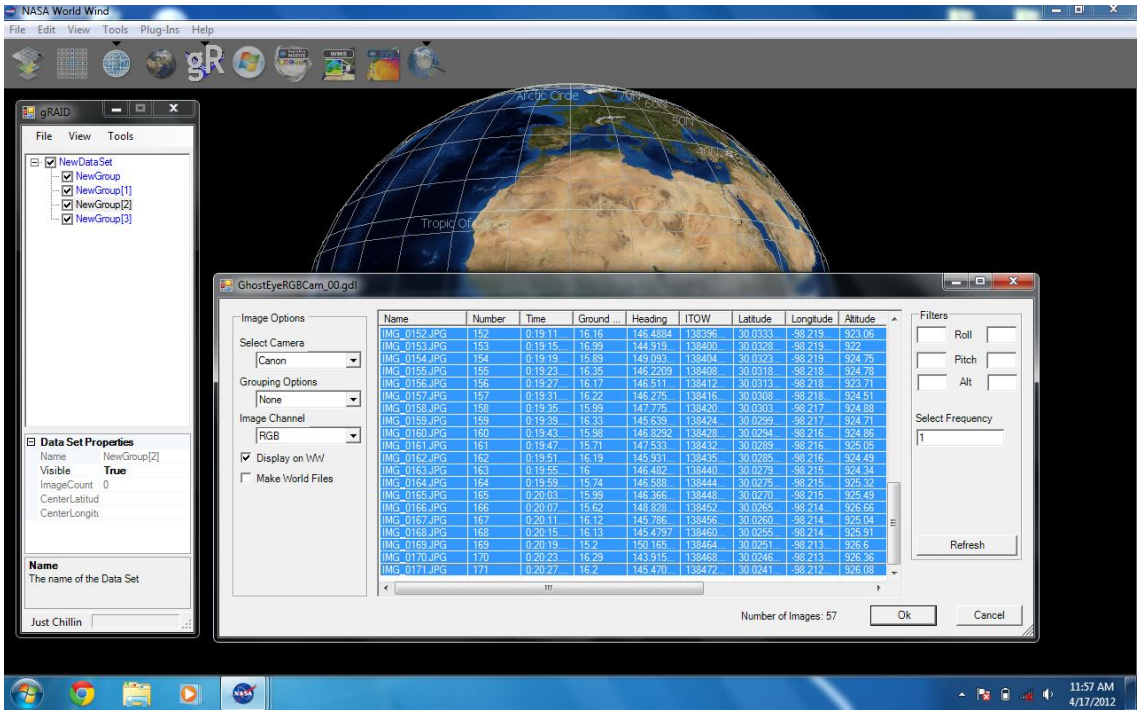

Figure 7. Example of Image preparation in NASA World Wind software.

EnsoMOSAIC is a proprietary mosaicking program developed by MosaicMill. Files required for processing are the: raw imagery, camera calibration, gps file, and ground control points that are typically extracted from reference imagery. EnsoMOSAIC performs a series of alternating steps that shift between assigning tie points to link images and converging tie points to reduce error (Fig. 8). The initial automatic aerial triangulation (AAT) generates tie points for every image based on overlapping features. After the initial AAT, the bundle block adjustment (BBA) converges tie points and checks the image orientation. This process is repeated until the final BBA converges. Ground control points are selected based on features found within reference NAIP imagery from TNRIS, Google Earth, as well as the UAV imagery. Additional BBA iterations are often needed to adjust points and reduce the level of error. Upon completion, a digital elevation model (DEM) is created and used as an input for the mosaicked image. Resolution of the mosaic is based on the altitude the UAV was flown and camera lens optics. All aerial orthorectified images were projected and assigned the WGS 1984 UTM zone 14 coordinate system.

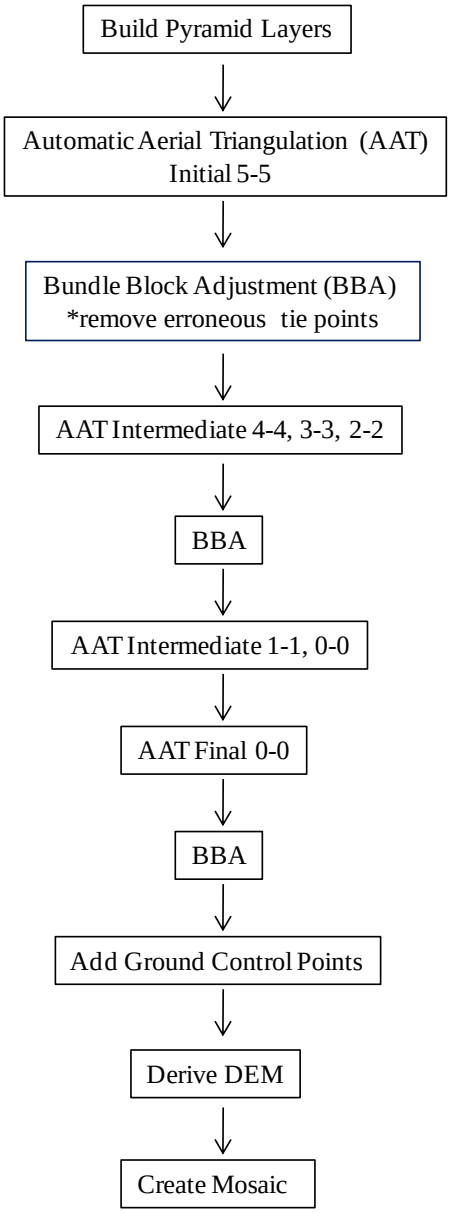

Figure 8. Organization flow chart for processes involved for generating mosaics with EnsoMOSAIC software.

Results

All eleven sites on the Brazos River and Blanco River were successfully flown and mosaicked. Combined reaches on the Brazos River equaled 36.2 river kilometers with a total of 1,206 images selected for processing. Blanco River reaches totaled 26.2 kilometers and 729 images were used for processing. Image resolution ranged from 13 cm to 25 cm (Table 1).

Table 1. Location, reach length (km), date, AGL (m), total images captured, images used for mosaicking, and mosaic resolution (cm) for each UAV flight completed on the Brazos River and Blanco River.

Location	River	Reach Length (km)	Date	AGL (m)	Total Images	# of images used for mosaic	Resolution (cm) RGB/NIR
12087*	Brazos	9.5	3/10/2011	500	600	235	18/20
12080	Brazos	7.0	3/10/2011	500	468	244	15/15
12030	Brazos	5.5	3/10/2011	500	281	166	15/15
12020 Nursery	Brazos	7.2	3/11/2011	500	437	274	25/25
12020 Wildcat	Brazos	7.0	3/11/2011	600	651	287	15/20
Upper Blanco*	Blanco	10.3	9/12/2011	600	566	345	20/20
Craft Ranch	Blanco	4.4	10/24/2011	600	149	102	13/18
Canyon Creek 1	Blanco	6.3	10/24/2011	600	313	152	15/15
Canyon Creek 2	Blanco	5.3	10/24/2011	600	259	130	18/18

* Two flights merged for Mosaic

Completed mosaics for each location can be obtained on Texas State University – San Marcos TRACS site at: https://tracs.txstate.edu:443.

Imagery applications by Texas Parks and Wildlife

Imagery captured using the UAV was used to identify isolated pools in the Blanco River downstream of the City of Blanco for the purpose of facilitating removal of non native smallmouth bass. The UAV was successful in capturing imagery in areas inaccessible by road or bordered by private landowners. Identified isolated pools were delineated in Google Earth (Fig. 8) and used to guide field crews during non native smallmouth bass depletion efforts.

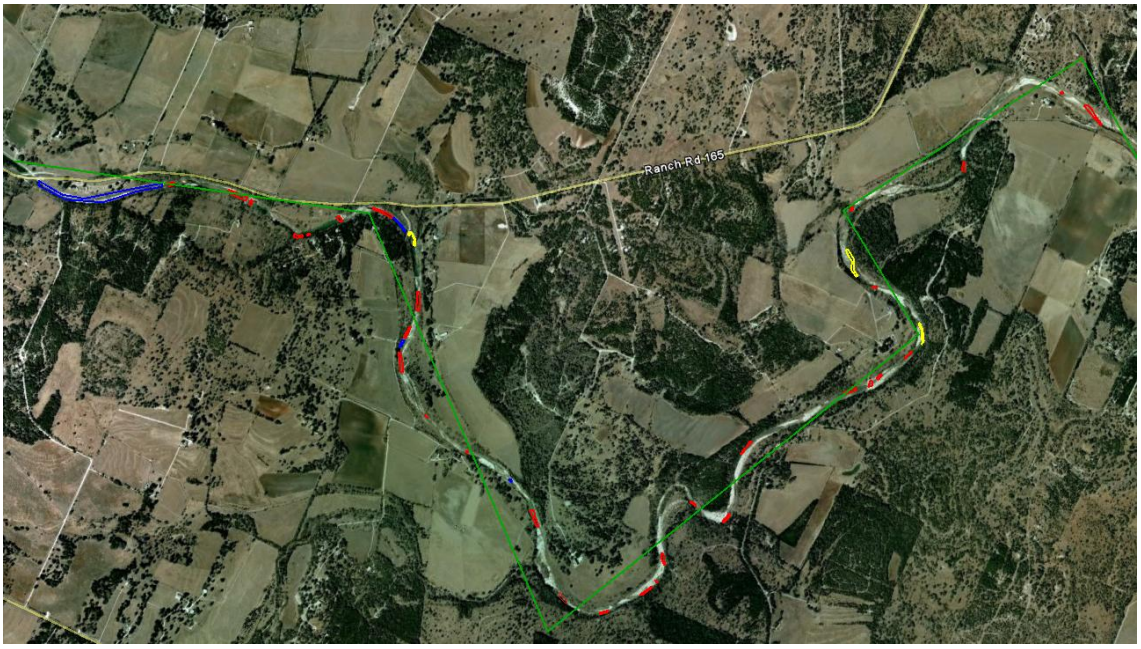

Figure 8. Isolated pools in the Blanco River delineated in Google Earth using imagery captured from the UAV.

Literature Cited

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