Upper Neuse River Basin Association
Special Study Plan
Date Issued: January 16, 2017

Special Study Name, ID# and Origination:

Bathymetry and Sediment Mapping, SS.LR.5

This Special Study was added to the Cardno FY 2017 monitoring contract to provide additional bathymetric and sediment mapping data for Falls Lake which is suitable for use in the lake response modeling effort.

Responsible Contractors:

Cardno – Planning, management and oversight, field sampling, and reporting

WaterCube, LLC[1] – Planning, field sampling, and data processing.

This study has also been developed in consultation with the US Army Corps of Engineers which is providing logistical support for this effort.

Purpose of Study:

This survey will be used to improve and gain confidence in the modeling and reexamination process for Falls Lake through a more complete understanding of the physical shape of the reservoir and the distribution and depth of accumulated sediments. Underwater topography (bathymetry) influences the retention and movement of water and thus partially controls the biological processing of nutrients that can affect the growth of chlorophyll *a* (algae). An accurate representation of underwater topography and flow restrictions is an essential element in understanding the volume of water within each segmented portion of the Falls Lake Reservoir and helps to determine the amount of time available within each segment to grow algae. Hydrodynamic models which aim to accurately represent the movement of water and its associated constituents such as suspended sediment, chlorophyll a, and nutrients are constructed using the most accurate measurements of the lake's morphological features as is possible to obtain. The lack of accurate lake morphology can impair a model's ability to accurately simulate water quality conditions across a range of flow regimes. DWR collected bathymetric data at 17 transects in 2006 and used these to inform grid development for their EFDC-based Falls Lake Nutrient Response Model. However just 17 transects over the entire 20+ mile length of Falls Lake and its coves does not provide a detailed picture of Falls Lake's bathymetry. Currently, there are no additional data on the bathymetry of Falls Lake other than pre-reservoir USGS topographic maps.

This study aims to significantly enhance the bathymetric data available to build a more robust hydrodynamic model for Falls Lake by collecting depth data on transects averaging every tenth of a mile throughout the reservoir (Figure 1). The data produced by this effort can be used to refine the grid development for any hydrodynamic model(s) developed, provide more accurate depths for each model grid cell, and calculate average water depths and thus retention time in each segment. Although not a

[1] WaterCube, LLC, based out of Charlotte, NC, provides cutting edge and cost effective hydrologic services for collecting and visualizing three-dimensional data on bathymetry and water velocities of rivers and reservoirs. WaterCube, LLC has already been engaged on UNRBA projects through support of the flow measurements for the constriction point study.

primary goal of the mapping effort, this survey can also provide a point of comparison with past and future surveys in order to estimate sedimentation rates.

This study also aims to provide data which will improve estimates of benthic nutrient flux to be used in model development by quantifying the spatial extent and relative thickness of accumulated sediments throughout the lake. The sediment flux study conducted in the summer of 2015 revealed significant nutrient flux from sediment cores, but also revealed some locations where cores could not be collected because the lake bed consisted of hard-packed clay or rock. These locations are not expected to have the same elevated flux of nutrients, however we do not know the spatial extent that these areas cover. Using a dual-frequency echo-sounder, the bathymetric survey can simultaneously identify the top of the sediment and the depth of any compact surface under loose sediment. Places where these two depths are the same identify areas which do not have an accumulation of loose sediment. This information will be useful in scaling up estimates of benthic flux obtained from sediment cores.

This Special Study supports these objectives of the UNRBA Monitoring Program:

- Lake response modeling,
- Support of regulatory options, and
- Source allocation and estimation of jurisdictional loading

Anticipated Field Schedule:

This study is targeted to occur in the spring of 2017 (March through May) subject to the reservoir being near to normal pool elevation at the time of sampling. Lower water levels reduce the surface area of the lake that can be accessed by boat and thus reduce the coverage of data collection. Spring is the optimal time for surveying for several reasons. First, the reservoir is most likely to be at or above normal pool at this time based on a review of the historical reservoir levels. Second, the cold water temperatures mean that methane production in the sediment should be low which minimizes the interference of methane bubbles in detecting the lower boundary of the soft sediment. Third, any areas that might typically have submerged aquatic vegetation (though not common in Falls Lake) should not be densely covered at this time of year which reduces the need to filter vegetation out of the depth sounding data. The actual field schedule will be determined in the spring based on reservoir water elevation. Once begun, the field effort is estimated to require 7 to 10 days in the field.

Study Methods:

Overview: Depth-sounding data will be collected using a boat-mounted echo-sounder coupled with a GPS device which will be navigated along parallel transect lines spaced approximately 500 feet apart over the surface of Falls Lake. In addition, data along several lines from the upstream to downstream end of the reservoir will be collected as cross-checks to the transect data. In total, up to 200 miles of track lines will be sampled over a period of several days. Data from this survey effort will be processed to produce tables and graphics showing the relationship between stage and both water volume and surface area as well as maps showing depth contours and locations of sediment accumulation.

Equipment: A CEE HydroSystems dual-frequency single-beam echo-sounder integrated with a Hemisphere AtlasLink Multi-GNSS GPS (+/- 10cm accuracy) will be used to collect geo-referenced depth data. The echo-sounder operates at 33 and 200 kHz with up to 20 soundings per second. The higher frequency data identifies the soft bottom while the lower frequency follows the more compact surface

underneath. This system is designed for its robustness for sampling over a wide range of bottom conditions including submerged aquatic vegetation and loose organic sediments.

Lake coverage: Depth soundings will be collected by following a cross hatch pattern covering the surface area of all navigable sections of the lake. Parallel tracks perpendicular to the direction of flow will be collected at an average spacing of approximately 500 feet (Figure 1). Areas identified in the field with very steep relief may be sampled with a somewhat tighter spacing while areas with very gradual relief may be sampled at a coarser spacing. In addition, several tracks will be run parallel to the direction of flow as a cross-check on the perpendicular track lines. Navigation tracks will be guided in real time by hydrographic survey software which is connected to the sampling and GPS equipment.

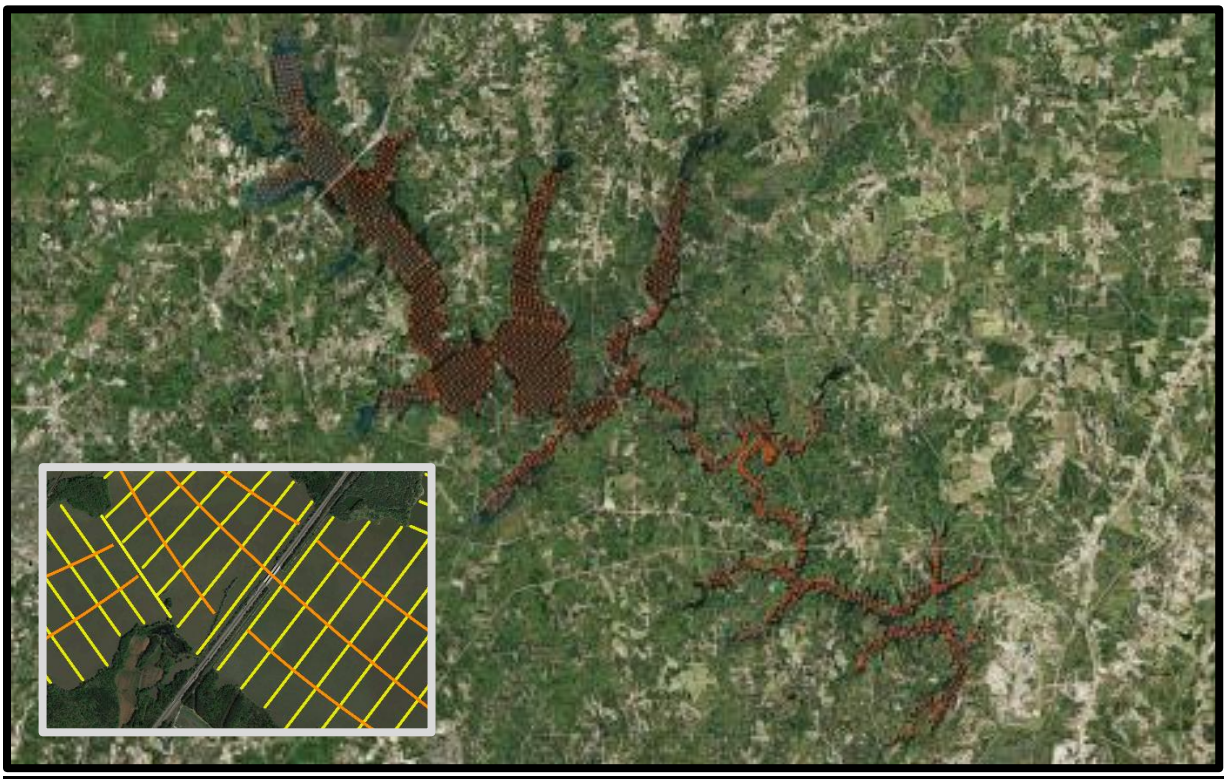

Figure 1. Aerial view of Falls Lake showing approximate track line positions and patterns. A close-up of the area around Highway I-85 is shown in the inset.

Lake boundary: The shoreline boundary represents the extent of the lake at a constant reference elevation and is used to determine the volume of the lake at that elevation. The lake boundary will be determined by digitizing geo-referenced satellite images when the lake is very near guide curve (251.5 feet). This digitized boundary will be provided by the US Army Corps of Engineers.

Water surface elevation: The soundings provide the depth of the reservoir relative to the surface elevation of the lake. The water depth measurements need to be converted to absolute elevation and this will be done using the time series of water surface elevation collected at the dam by the USGS and US Army Corps of Engineers (USGS Gage Number 02087182).

Data processing: Data acquisition and processing will be completed using hydrographic survey software including Hypack (Xylem Inc.) and Hydromagic (Eye4Software). This software allows real-time quality

control during field collection, advanced tools for post-collection editing and filtering of raw echogram data, and tools for exporting gridded depth data and water elevation-volume relationships.

The sediment accumulation depths, volumes, and locations will be estimated by computing the difference between the top of sediment measured by the high frequency transducer and the maximum penetration depth measured by the low frequency transducer**.** These results will then be processed, gridded, and compared to determine the locations of sediment accumulation (see example in Figure 2).

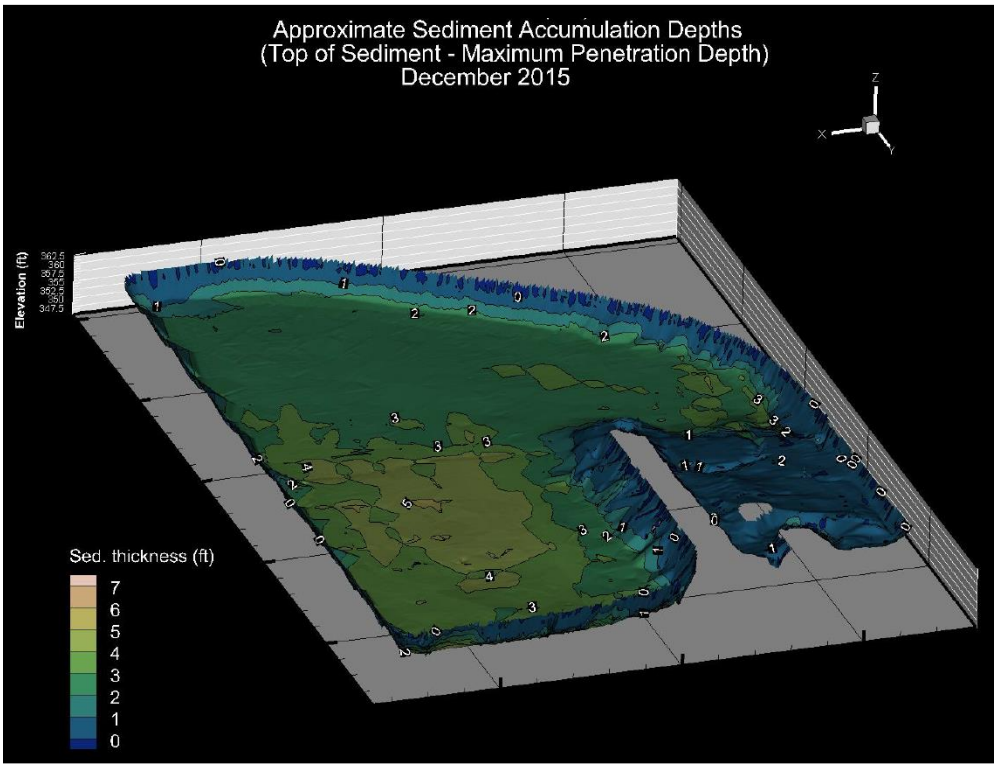

Figure 2. Example depth-of-sediment map.

Reporting/Deliverables:

Cardno will communicate with the UNRBA Executive Director on a regular basis on the progress of this Special Study. Status updates and an overview of results will be provided to the UNRBA Path Forward Committee and the Board of Directors at their regular meetings.

Deliverables from this special study include the gridded depth data for both top-of-sediment and bottom-of-sediment soundings and tables of the stage, surface area, and volume relationships. Graphics including the survey ship tracks and contour plots of depth and sediment accumulation along with a narrative overview of the effort will be provided in the Annual Report which follows the completion of the study. All processing of field data will be completed within 4 weeks of the end of the data collection effort.