DRAFT 8/27/2021

Lake Conway Canal Siltation Study

Technical Memorandum

August 2021

ORANGE COUNTY GOVERNMENT FLORIDA

Geosyntec consultants

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LAKE CONWAY CANAL SILTATION STUDY
TECHNICAL MEMORANDUM

Prepared for

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Project Number: FW7844

August 2021

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Lake Conway Canal Siltation Study
Technical Memorandum

The engineering material and data contained within the enclosed report was prepared by Geosyntec Consultants, Inc. for sole use by the Orange County Environmental Protection Division. This report was prepared under the supervision and direction of the respective undersigned, whose seal as a registered professional engineer is affixed below.

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ACRONYMS AND ABBREVIATIONS

Elev.	Elevation
EPD	Orange County Environmental Protection Division
Ft	Foot
lbs	Pounds
Min	Minimum
MNNE	Minimum Nominal Navigation Elevation
MSND	Minimum Safe Navigational Depth
Nav.	Navigability
NAVD88	North American Vertical Datum of 1988
NVGD29	National Geodetic Vertical Datum of 1929
S	Seconds
SJRWMD	St. John's River Water Management District
WS	Water Surface
Yr	Year

1. INTRODUCTION

This report represents the findings of the Lake Conway Canal Siltation Study. Geosyntec was tasked by the Orange County Environmental Protection Division (EPD) to perform this study. The work was performed under the Orange County Continuing Services Contract Y20-906B.

1.1 Project Location

The study area for the Lake Conway Chain of Lakes is located within the City of Belle Isle, the City of Orlando, and unincorporated areas of Orange County within Sections 24 and 25 of Township 23 South, Range 29 East, and Section 18, 19, 20, 29, 30 and 31 of Township 23 South, Range 30 East, see **Figure 1-1** for the Vicinity Map. The study area is located within the jurisdiction of the St. John's River Water Management District (SJRWMD) and just north of the South Florida Water Management District (SFWMD) jurisdiction. Included in the study are canals associated with Lake Gatlin, Little Lake Conway (Northwest Lobe and Northeast Lobe), Lake Conway Middle Lobe, and Lake Conway South Lobe, see **Figure 1-2** for the Site Map.

1.2 Background

Two studies, performed in 2005 and 2010, established and updated, respectively, readings on siltation levels for various canals throughout the Lake Conway Chain of Lakes. The baseline study in 2005 entitled *Lake Conway Canal Mud Removal Baseline Study*, established a set of baseline measurements determining the extent of siltation (i.e. muck thickness) of the canals in the Lake Conway Chain. A follow-up study was performed by TEC Engineering, Inc., in 2010 entitled *Lake Conway 2010 Canal Siltation Study* where measurements were collected to determine the extent of canal siltation and the approximate rate of siltation (see **Figure 1-2**). The following canals were evaluated in these studies:

- Barby Canal
- Landings Canal
- Willoughby Canal
- Backacre Canal
- Bayfront Canal
- Hoffner Canal
- Montmart Canal
- Overlake Canal
- Venice Canal
- Waterfront Canal
- Gatlin Canal
- Lisa Canal
- Harbor Oaks Canal
- Mandalay Canal
- Venetian Canal
- Daetwyler Canal

It is noted that, while included in the current study, prior to 2010 the Venetian and Lisa canals were de-mucked and were not included in the *Lake Conway 2010 Canal Siltation Study*.

A canal rating system was developed in the 2010 study based on data collected during the 2005 and 2010 studies. This rating system was used to evaluate the current canal conditions based on new measurements collected as part of this study. Based on this rating system, a canal rating that is near zero indicates that the canal would likely need maintenance sooner than a canal with a large, positive rating. The goal of this study was to assess the extent of siltation that has occurred within the canals since 2010, evaluate the navigability of each canal, and estimate the rate of siltation occurring in each canal.

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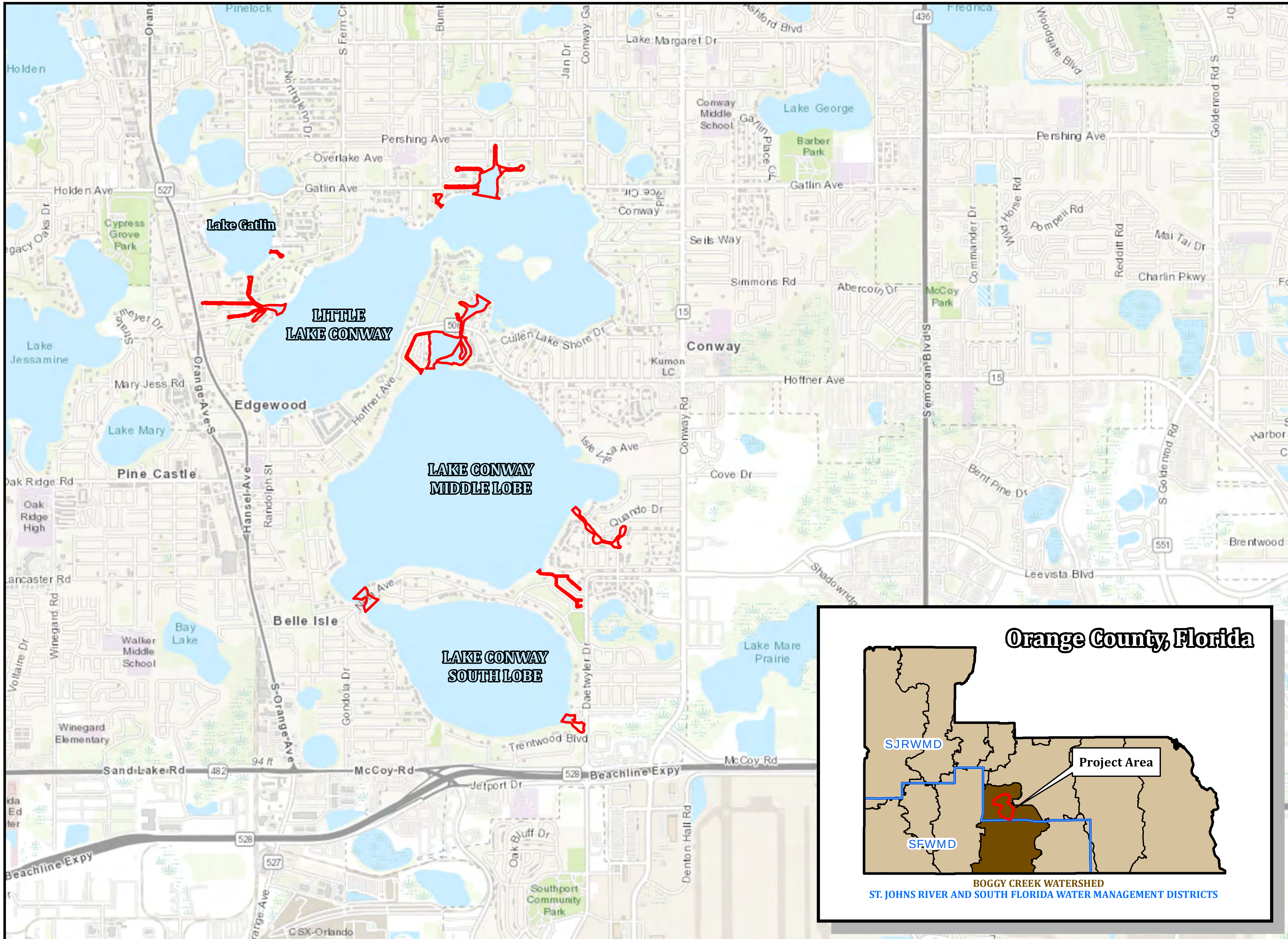

ORANGE COUNTY GOVERNMENT FLORIDA

N

0 1,500 3,000 Feet

Legend

Lake Conway Canals

Sources:
Basemap: ESRI, 2021
Jurisdictions: Orange County, 2013

Figure 1-1

Project Vicinity Map

Lake Conway Canal Siltation Study

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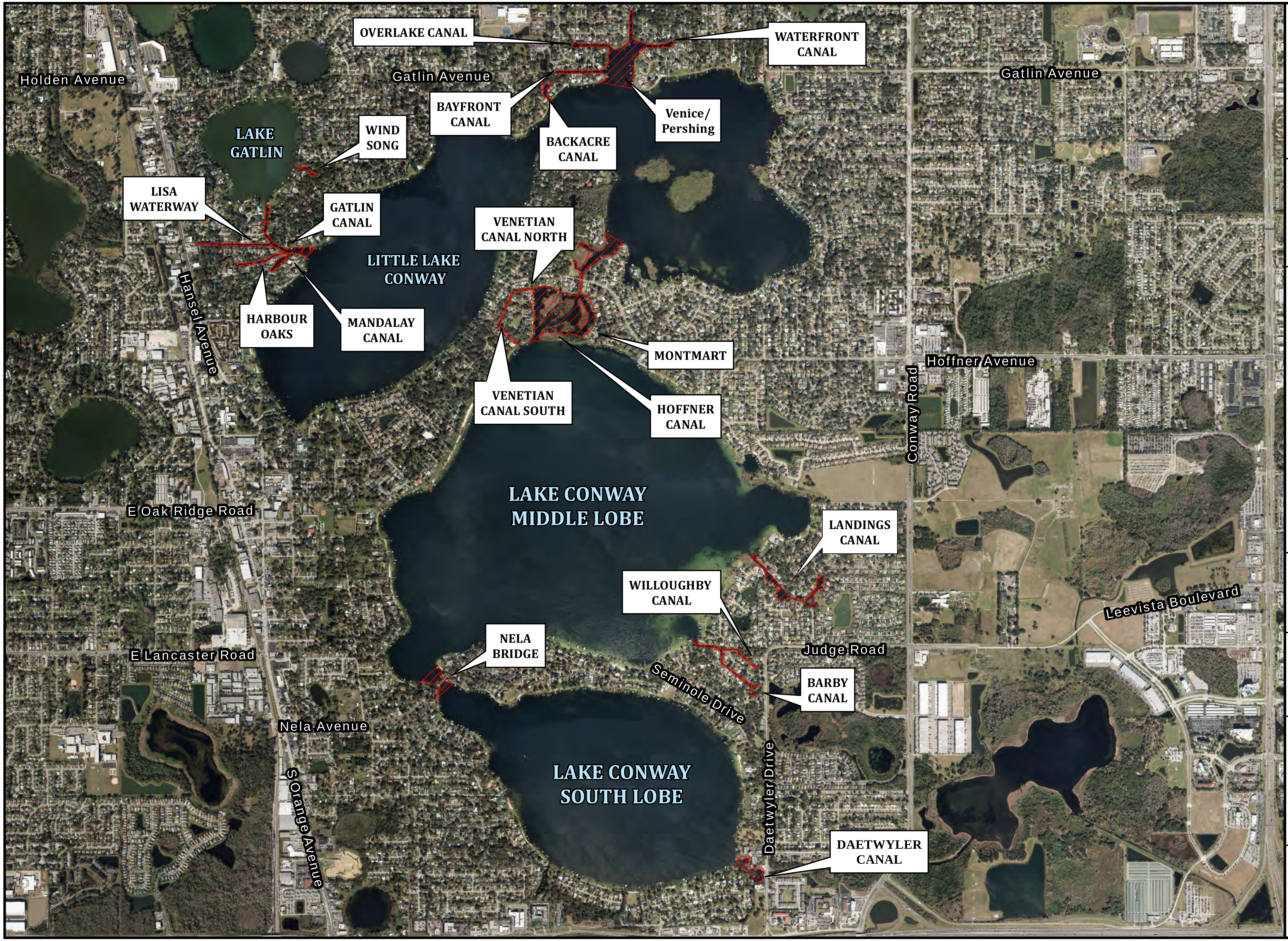

ORANGE COUNTY GOVERNMENT FLORIDA

N

0 1,000 2,000 Feet

Legend

Lake Conway Canals

Sources:
Aerial: Orange County, 2019
Roads: Orange County, 2015

Figure
1-2

Project Site Map

Lake Conway Canal Siltation Study

Geosyntec consultants

2. REVIEW OF PREVIOUS STUDIES

2.1 Background Data Collection

Orange County provided the 2005 and 2010 studies which were reviewed by Geosyntec and used as a guideline for the current study, see **Appendix A**. In addition, daily lake stage data were referenced from the Orange County Water Atlas, see **Appendix B**.

2.2 Previous Studies

The purpose of the previous studies was to assess the navigability of different lake canals, using field measurements and lake stage data. Navigability is defined as the percentage of time a point in a waterbody is likely to have a Minimum Safe Navigational Depth (MSND) of water above the top of an unconsolidated sediment layer – defined as muck in this report. The formula to find navigability at a sampling point is provided in **Equation 2-1**.

$$Navigability\ (\%) = 100\% - \alpha(\%) \qquad \textbf{Equation 2-1}$$

Where:

$$\alpha = Lake\ Stage\ Percentile\ (associated\ with\ the\ Top\ of\ Muck\ Elevation\ +\ the\ MSND)$$

The MSND used in the 2005 and 2010 studies is 3 feet. The top of muck elevation is one of the data points collected at each sample location. The summation of top of muck elevation and MSND equates to a water surface elevation that ensures a navigability of 3 feet. For the 2010 study, this elevation was compared to the historical lake stages collected from Lake Conway from 1981-2010 to determine the lake stage percentile associated with the MSND elevation, i.e., the percentage of observations where the lake stage was less than or equal to the MSND, see the 2010 report in **Appendix A**.

Lake stage data collected over time illustrates fluctuations in water elevation that occur as a result of natural cycles, such as drought and excess rainfall, or changes due to human activities, such as adding or adjusting a water control structure. Therefore, the navigability should consider these historic lake stage conditions to evaluate the navigability of canals associated with the lake system. For example, in the 2010 report, a top of muck elevation of 80.0 ft (NAVD88) plus the MSND equates to an elevation of 83.0 ft (NAVD88). This corresponds to a lake stage percentile of 19.72%, which means that the lake stage is less than or equal to 83.0 ft (NAVD88) 19.72% of the time on an average year. Therefore, based on **Equation 2-1**, the navigability is 80.28%, which means the lake stage is greater than or equal to the elevation 83.0 ft NAVD88 for 80.28% of the time for an average annual year, i.e., the waterbody is navigable approximately 293 days out of the year on average (assuming the future lake stages are similar to the historic lake stage data).

Based on a review of the 2010 report, 30-years of lake stage data was used, however no information was provided as to how often the lake stage was recorded, e.g., monthly, daily, etc. Based on a review of the historical lake stage data, there was a significant decrease in lake stage from 1999 to 2003, likely because of dewatering practices necessary to construct the Daetwyler weir improvements. Based on the *Lake Conway Stormwater Quality Management Master Plan, 2020*, this historic lake stage is presented in **Figure 2-1**. This figure illustrates the significant decrease in lake stage from 1999 to 2003 (shown in red). Based on a review of the 2010 report, there was no indication if the potential impact of the Daetwyler weir replacement on lake stage data was investigated/considered in calculations. Navigability and Navigability Ratings may have been influenced by the artificially low lake stages during this time because of construction activities. As further mentioned in **Section 4.2,** the lake stage calculated for the 2021 study used daily lake stage data from 2006 to 2021 from the Water Atlas, and therefore, does not include the lake stage during the construction of the Daetwyler weir.

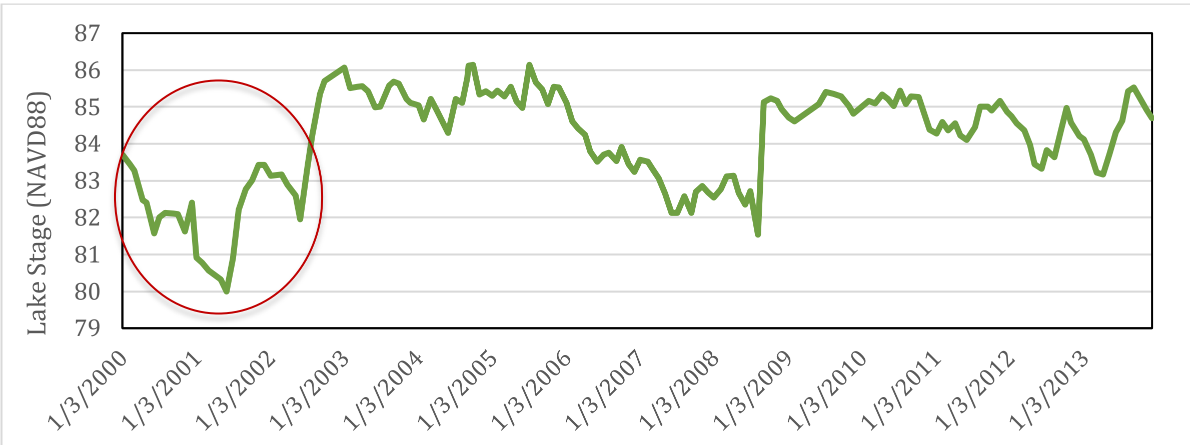

Figure 2-1: Historic Lake Stage for Lake Conway

The vertical datum used for the 2005 and 2010 studies was NGVD29; however, to remain consistent with the 2021 data collection, the data gathered in the 2005 and 2010 studies was converted to NAVD88. The conversion from NGVD29 to NAVD88 is the average value for the conversion factors for the Boggy Creek watershed gathered from the **Flood Insurance Study** for Orange County, Florida (see **Equation 2-2**).

$$\text{NAVD88} = \text{NVGD29} - 0.96\ \text{ft} \qquad \textbf{Equation 2-2}$$

The baseline study in 2005 contained 125 data points at approximately 200 ft intervals for 14 canals. Out of the 125 data points, 90 had a top of muck elevation with a navigability of 80% and higher. Three sample locations were not navigable at any lake stage observed during the study. The average canal summaries from the 2005 study are presented in this report for comparative purposes (see **Table 2-1)**. Complete results, including the minimum and maximum canal summaries, from the 2005 study are presented in **Appendix A.** The summary presented in **Table 2-1** uses the following convention: green shading indicates an acceptable navigability and yellow shading indicates an unacceptable navigability. Per the 2010 study, a navigability above 20% is considered acceptable.

Table 2-1: Average Canal Summary Results from the 2005 Study

Canal	Average Hard Bottom Elev. (ft NAVD88)	Average Muck Thickness (ft)	Average Top of muck Elev. (ft NAVD88)	Nav. (%)
Gatlin	78.59	1.20	79.79	84%
Harbour Oaks	77.96	1.44	79.40	89%
Lisa	80.10	1.56	81.66	45%
Mandalay	78.23	1.27	79.50	87%
Backacre	78.76	1.24	80.00	80%
Overlake	78.57	0.63	79.20	91%
Venice	79.18	0.55	79.73	84%
Waterfront	79.60	0.45	80.05	79%
Hoffner	75.31	1.18	76.49	92%
Montmart	71.78	2.38	74.16	100%
Venetian	78.43	1.16	79.59	67%
Landings	77.44	1.02	78.46	93%
Barby	80.37	0.94	81.31	54%
Willoughby	80.26	0.26	80.52	71%
Ave.	78.18	1.1	79.28	80%
Max.	80.37	2.4	81.66	45%
Min.	71.78	0.3	74.16	100%

Data presented is in the NAVD88 vertical datum.

The results of the 2010 canal siltation study are presented in **Table 2-2**. The canal summary from the 2010 study indicated that the average top of muck elevation for all the sampled canals equated to a navigability of 82%. The annual rate of change for navigability between the 2005 and 2010 studies was 1%, suggesting that muck thickness has slowly increased over the 5-year interval. The 2010 canal study evaluated the navigability of the canals through the development of a Navigability Rating, which represents the expected number of years it will take for the canal to become unnavigable (see **Equation 2-3**).

$$Navigability\ rating\ (years) = \frac{Minimum\ normal\ navigation\ elevation - Top\ of\ muck\ elevation}{Annual\ siltation\ rate}$$

Equation 2-3

The Navigability Rating is based upon the minimum normal navigation elevation (MNNE), top of muck elevation, and annual change in muck thickness. The MNNE equates to a navigability of 20% (lake stage percentile of 80%), meaning that at this elevation the lake is navigable 20% of the time based on the historical lake stage data. The MNNE was approximately 83.04 ft (NAVD88) for the 2010 study. The annual siltation rate is the annual rate of change of the muck thickness based on the muck measurements from 2005 to 2010.

The Navigability Rating is used to assess the long-term quality of the canal and is based on the navigability and rate of siltation. The rating represents the expected number of years it will take for the canal to silt in. For example, a Navigability Rating of 0 years would indicate that the canal is silted to the point where the top of muck is at an elevation that equates to a lake stage of 80%, i.e., a navigability of 20% or less.

The Navigability Ratings computed in the 2010 study varied from -74 to 1,161 years. Per the 2010 report, the negative value may indicate that the canal is getting deeper, and the large positive value may indicate that there is nearly no change in average top of muck elevation. **Table 2-2** includes the average results for each canal in 2010, as well as the change and annual change between the 2005 and 2010 average results. The complete 2010 study, including the maximum and minimum values, is found in **Appendix A.**

Table 2-2: Average Canal Summary Results from the 2010 Study

Canal	Average Absolute				Average Change from 2005				Average Annual Rate of Change				Navigability Rating (years)
	Hard Bottom Elev. (ft NAVD88)	Muck Thickness (ft)	Top of muck Elev. (ft NAVD88)	Nav. (%)	Hard Bottom Elev. (ft)	Muck Thickness (ft)	Top of muck Elev. (ft)	Nav. (%)	Hard Bottom Elev. (ft/ yr)	Muck Thickness (ft/ yr)	Top of muck Elev. (ft/ yr)	Nav. (%/ yr)	
Gatlin	79.16	0.7	79.81	83%	0.57	-0.55	0.02	-1%	0.09	-0.09	0.00	-0.1%	1161
Harbour Oaks	78.38	1.4	79.80	83%	0.42	-0.02	0.40	-6%	0.07	0.00	0.06	-1.0%	50.87
Lisa	79.74	0.9	80.64	70%	-0.36	-0.66	-1.02	25%	-0.06	-0.10	-0.16	3.9%	-14.8
Mandalay	78.55	1.0	79.55	86%	0.31	-0.27	0.05	-1%	0.05	-0.04	0.01	-0.1%	470.1
Backacre	79.12	0.9	80.04	80%	0.36	-0.32	0.04	0%	0.07	-0.06	0.01	-0.1%	412
Overlake	78.48	0.9	79.40	88%	-0.09	0.28	0.20	-3%	-0.02	0.05	0.04	-0.5%	102
Venice	78.96	0.4	79.40	88%	-0.15	-0.13	-0.27	3%	-0.03	-0.02	-0.05	0.6%	-74
Waterfront	79.65	0.5	80.15	78%	0.05	0.04	0.09	-2%	0.01	0.01	0.02	-0.3%	172
Hoffner	75.72	1.1	76.86	91%	0.08	0.04	0.12	0%	0.01	0.01	0.02	0.0%	281
Montmart	72.80	1.9	74.72	100%	1.02	-0.47	0.55	0%	0.19	-0.09	0.10	0.0%	82
Venetian	77.10	1.2	78.25	85%	-1.34	0.00	-1.34	19%	-0.22	0.00	-0.22	3.0%	-22.14
Landings	77.92	0.80	78.72	92%	0.49	-0.22	0.26	-2%	0.10	-0.05	0.05	-0.4%	79
Barby	80.47	1.04	81.52	49%	0.10	0.11	0.21	-5%	0.02	0.02	0.04	-1.1%	35
Willoughby	80.48	0.48	80.96	64%	0.22	0.22	0.44	-8%	0.05	0.05	0.09	-1.6%	23
Daetwyler[1]	78.41	1.00	81.33	88%	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Ave.	78.33	0.95	79.41	82%	0.12	-0.14	-0.02	0.01	0.02	-0.02	0.00	0.2%	197
Max.	80.48	1.92	81.52	49%	1.02	0.28	0.55	-0.08	0.19	0.05	0.10	-1.6%	1161
Min.	72.80	0.44	74.72	100%	-1.34	-0.66	-1.34	0.25	-0.22	-0.10	-0.22	3.9%	-74

Data presented is in the NAVD88 vertical datum.

[1] It is noted that the Daetwyler Canal was not evaluated during the 2005 study, so no siltation rate or Navigability Rating could be calculated.

3. FIELD SAMPLING

Data collection was performed by Geosyntec subconsultant Barnes, Ferland and Associates, Inc. (BFA). Sampling events occurred on the following dates:

- 4/22/2021
- 4/23/2021
- 4/28/2021
- 4/29/2021
- 5/4/2021
- 5/5/2021
- 6/9/2021

The field sampling effort included depth measurements to the top of the unconsolidated sediment layer and to the top of the hard bottom (consolidated sediment layer) relative to the lake stage at the time of measurement. The lake elevation was collected twice each day by surveying the shoreline top of water level based on nearby canal surroundings and Lake Conway gauge readings. The depth measurements were taken along the apparent centerline of each canal. A total of 142 data points were collected across all canals assessed. Relative to the 2010 study, two sample locations were added to the Lisa Waterway canal and one sample location was added to the Backacre canal. This was due to conditions being favorable to allow for additional measurements. Two new canals, Nela Bridge canal and Wind Song canal, were added to this study. Geosyntec developed sampling locations based on the methodologies of the previous studies, to as closely as possible match the previous coordinates for the purposes of comparison with the current data collection efforts (see **Appendix C)**. The specific sampling methodology used in this study is described below:

1. Arrive at sample location based on the sample locations provided in **Exhibit 1**. Recorded the GPS location at each sample location. Each data point was taken as close as possible to the latitude and longitude locations specified in **Exhibit 1**.
2. A Secchi disk was used to measure the depth of the top of the muck. This depth was recorded in the field form.
3. A calibrated survey rod was used to measure the depth to the hard bottom by pushing through the soft sediment until reaching the firm hard bottom. This depth was recorded in the field form.
4. The muck thickness was calculated as the difference between the top of muck elevation and the elevation of the hard bottom.

The top of muck elevation and depth to the hard bottom were collected relative to the NAVD88 datum. The detailed sample locations are provided in **Exhibit 1** and the project approved sampling plan is provided in **Appendix C**. The results of these measurements are provided in **Appendix D** and discussed further below.

4. RESULTS AND DISCUSSION

4.1 Canal Characteristics

As part of the current effort, the general characteristics of each canal was noted. The photographs provided below are intended to depict the general characteristics of each canal in this study. BFA provided pictures of each canal near the different sampling points. Most canals were described as narrow with some overhanging vegetation along the shoreline. Vegetation along the channel banks with the possibility to contribute to muck thickness (i.e., dead leaves falling into the channel) is reported as overhanging vegetation. Canal widths were approximated using measuring tools in ArcGIS. Heavy aquatic vegetation and manmade structures (boat docks and retaining walls) were noted in a few canals. The locations of each site photographed are illustrated in **Exhibit 1**.

Photo 4-1: Gatlin Canal (5/4/2021, 5/5/2021) - The canal had little vegetation near the bridge and no vegetation in most of the canal

Photo 4-2: Nela Bridge Canal (4/22/2021) - Minimal aquatic vegetation was observed

Photo 4-3: Wind Song Canal (5/5/2021) – Most of the canal is generally under 125 feet wide and contains significant aquatic and overhanging vegetation

Photo 4-4: Willoughby Canal (4/22/2021) – The canal is generally under 50 feet wide with no aquatic vegetation and some overhanging vegetation

Photo 4-5: Lisa Waterway Canal (5/4/2021, 5/5/2021) - The canal width is generally under 50 feet and contains significant overhanging and aquatic vegetation

Photo 4-6: Waterfront Canal (5/4/2021) – Most of the canal is open with little overhanging vegetation, the canal width varies with parts less than 75 feet wide

Photo 4-7: Venice/Pershing Canal (5/4/2021) – Most of the canal is generally over 250 feet wide with little overhanging vegetation

Photo 4-8: Venetian Canal South (4/28/2021) - The canal is generally under 50 feet wide, with significant overhanging and aquatic vegetation present

Photo 4-9: Venetian Canal North (4/28/2021) - The canal is generally under 50 feet wide with overhanging vegetation and retaining walls along the banks

Photo 4-10: Overlake Canal (5/4/2021) - Most of the canal is approximately 50 feet wide and has a retaining wall along the banks

Photo 4-11: Montmart Canal (4/29/2021) – Most of the canal is generally under 175 feet wide with some aquatic vegetation

Photo 4-12: Mandalay Canal (5/4/2021) - The canal is generally under 100 feet wide with no aquatic and little overhanging vegetation

Photo 4-13: Landings Canal (4/22/2021) - The canal width varied from under 75 feet to under 225 feet, with some overhanging vegetation


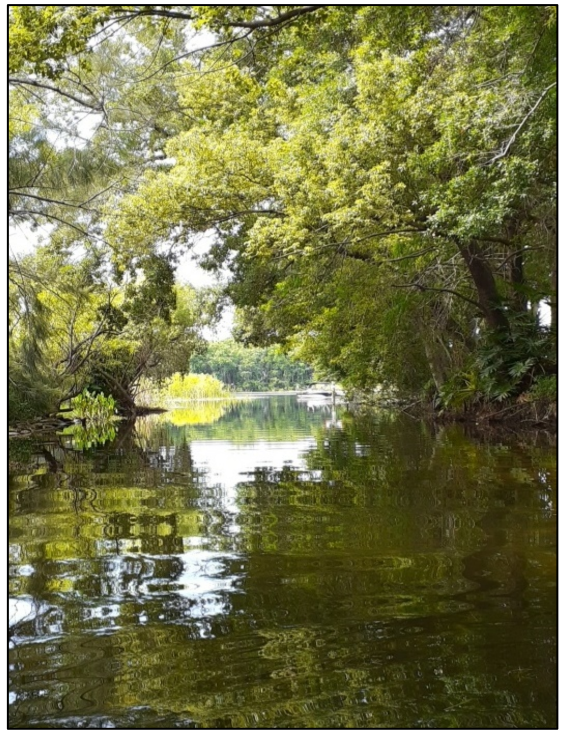

Photo 4-14: Hoffner Canal (4/23/2021, 4/28/2021) - The canal width varied from generally under 50 feet in certain parts of the canal to generally under 900 feet, with a large amount of overhanging vegetation


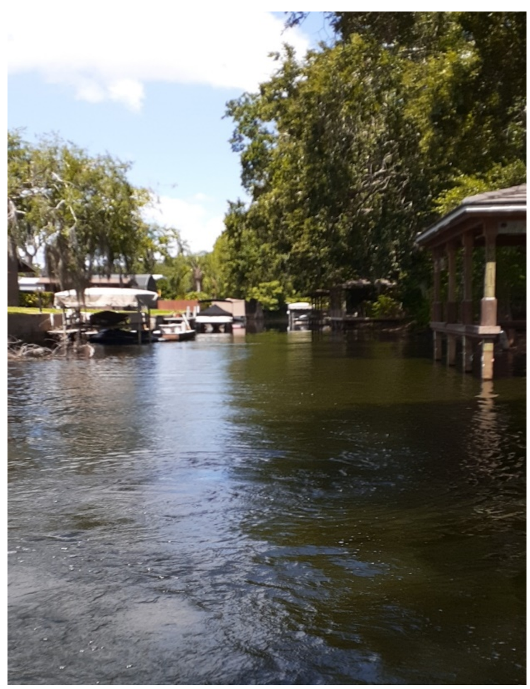

Photo 4-15: Harbour Oaks Canal (5/4/2021, 5/5/2021) - The canal is generally under 50 feet wide, with some overhanging vegetation

Photo 4-16: Daetwyler Canal (4/22/2021) – Most of the canal is generally under 200 feet with some areas less than 100 feet wide. The canal appears open with no aquatic nor overhanging vegetation but with some boat docks

Photo 4-17: Bayfront Canal (5/4/2021) – The canal is generally under 75 feet wide, with a large amount of overhanging vegetation but no aquatic vegetation

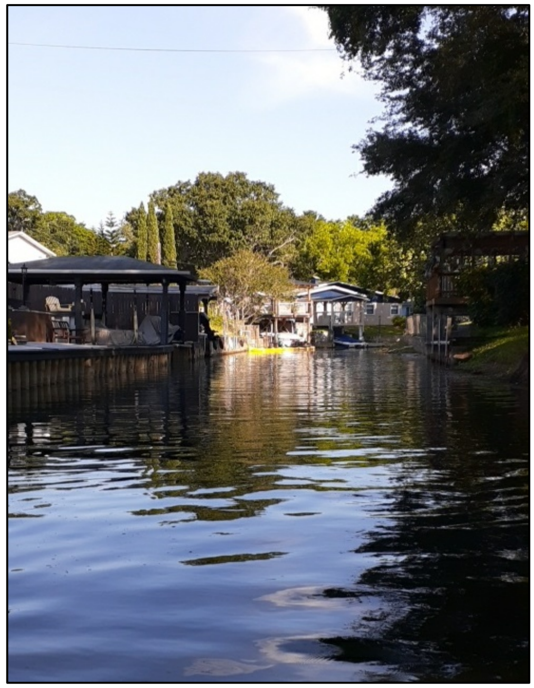

Photo 4-18: Barby Canal (4/22/2021) - The canal is generally under 50 feet wide, with a large amount of aquatic vegetation, some overhanging vegetation, and a retaining wall along the banks

Photo 4-19: Backacre Canal (5/4/2021, 6/9/2021) - The canal is generally under 50 feet wide in some areas and under 125 feet in the rest of the areas, with no significant overhanging nor aquatic vegetation

4.2 Navigability

Navigability was calculated using the same methodology from the 2005 and 2010 studies to maintain consistency in how the canal siltation assessment results are interpreted, i.e., using **Equation 2-1**. Navigability is related to the top of muck elevation and assumes a MSND of 3 feet, as recommended in the 2010 study. The lake stage percentile associated with the MSND is based on daily lake stage data obtained from the Orange County Water Atlas for the years 2006 to 2021, see **Appendix B**.

The previous studies evaluated the canal siltation three ways, based on average canal siltation conditions, maximum canal siltation conditions, and minimum canal siltation conditions. The average conditions represent the average conditions of each canal. This value is useful to understand the overall conditions within the canal but might miss problem areas. The maximum canal siltation conditions represent the worst-case conditions in each canal but will not provide information regarding the location of potential navigability issues. Finally, the minimum canal siltation conditions represent the best-case conditions in each canal.

The average canal siltation conditions are presented in **Table 4-1** and includes the average top of muck elevation, the average hard bottom elevation, the average muck thickness, the average minimum navigability water surface elevation (summation of the top of muck elevation and MSND), and the average navigability percentile for each canal. **Figure 4-1** presents these results for each canal. It is noted that the average in **Table 4-1** were determined by averaging the respective results for all the sampling points within each canal. As mentioned earlier, green shading indicates a canal with an acceptable average navigability (above 20%) and yellow shading indicates an unacceptable average navigability.

Table 4-1: Average Canal Conditions

Canal	Average Top of Muck Elev. (ft NAVD88)	Average Hard Bottom Elev. (ft NAVD88)	Average Muck Thickness (ft)	Average Min Nav. WS (ft NAVD88)	Average Nav. (%)
Backacre Canal	80.13	77.92	2.22	83.13	97.4%
Barby Canal	82.78	80.66	2.12	85.78	27.3%
Bayfront Canal	81.10	77.84	3.26	84.10	79.3%
Gatlin Canal	80.11	77.52	2.59	83.11	98.7%
Harbour Oaks Canal	80.10	77.35	2.76	83.10	97.7%
Hoffner Canal	77.04	73.03	4.01	80.04	99.2%
Landings Canal	79.14	76.94	2.21	82.14	98.4%
Lisa Waterway Canal	81.99	79.02	2.98	84.99	48.7%
Mandalay Canal	79.98	77.43	2.54	82.98	98.7%
Montmart Canal	74.43	68.05	6.39	77.43	100.0%
Overlake Canal	79.78	77.04	2.75	82.78	98.7%
Venetian Canal	80.25	77.40	2.86	83.25	78.7%
Venice/Pershing Canal	80.07	78.78	1.29	83.07	97.2%

Canal	Average Top of Muck Elev. (ft NAVD88)	Average Hard Bottom Elev. (ft NAVD88)	Average Muck Thickness (ft)	Average Min Nav. WS (ft NAVD88)	Average Nav. (%)
Waterfront Canal	80.55	77.88	2.67	83.55	97.1%
Willoughby Canal	80.95	78.65	2.29	83.95	86.7%
Daetwyler Canal	79.65	76.99	2.67	82.65	98.7%
Nela Bridge Canal	71.99	69.88	2.11	74.99	100.0%
Wind Song Canal	82.14	79.13	3.01	85.14	51.5%

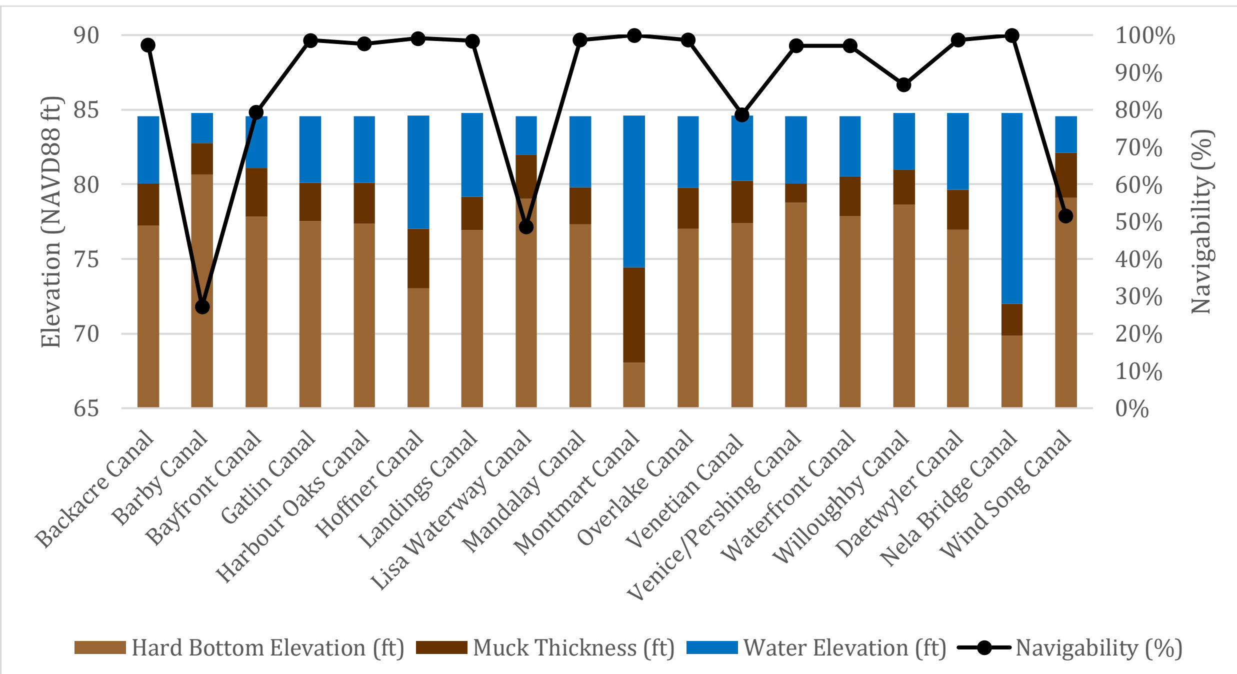

Figure 4-1: Average Canal Conditions

The minimum canal siltation conditions (best-case condition) are presented in **Table 4-2** and **Figure 4-2**. The top of muck elevation, muck thickness, and hard bottom elevation for the minimum canal siltation condition sample location in each canal are presented. The minimum canal siltation condition in the current study is similar to the results from the 2010 study. The sample locations representing each canal presented in **Table 4-2** all had an acceptable navigability. This suggests that at these locations, the canal is in an acceptable condition to permit navigation. These canal locations tended to have lower top of muck elevation due to lower hard bottom elevations and/or limited muck thickness. However, it is noted that the muck thickness for the Gatlin canal and Hoffner canal was significant at 7.66 and 7.77 feet, respectively. This suggests that dredging would further increase the navigability of these two canals as well as potentially provide a water quality benefit in the form of lake muck reduction.

Table 4-2: Minimum Canal Siltation Conditions (Best-Case)

Canal	Top of Muck Elev. (ft NAVD88)	Hard Bottom Elev. (ft NAVD88)	Muck Thickness (ft)	Min Nav. WS (ft NAVD88)	Nav. (%)
Backacre Canal	78.97	76.05	2.92	81.97	99.1%
Barby Canal	81.06	79.68	1.38	84.06	93.6%
Bayfront Canal	80.37	77.84	2.53	83.37	98.4%
Gatlin Canal	79.24	71.58	7.66	82.24	99.0%
Harbour Oaks Canal	79.39	75.87	3.52	82.39	98.9%
Hoffner Canal	73.31	65.54	7.77	76.31	100.0%
Landings Canal	78.05	76.64	1.41	81.05	100.0%
Lisa Waterway Canal	80.32	77.54	2.78	83.32	98.6%
Mandalay Canal	79.72	76.41	3.31	82.72	98.8%
Montmart Canal	70.07	68.82	1.25	73.07	100.0%
Overlake Canal	79.42	76.24	3.18	82.42	98.9%
Venetian Canal	78.39	76.16	2.23	81.39	100.0%
Venice/Pershing Canal	77.99	77.61	0.38	80.99	100.0%
Waterfront Canal	79.77	76.18	3.59	82.77	98.7%
Willoughby Canal	80.5	78.15	2.35	83.5	98.4%
Daetwyler Canal	78.76	73.52	5.24	81.76	99.1%
Nela Bridge Canal	69.71	67.76	1.95	72.71	100.0%
Wind Song Canal	81.59	78.62	2.97	84.59	86.4%

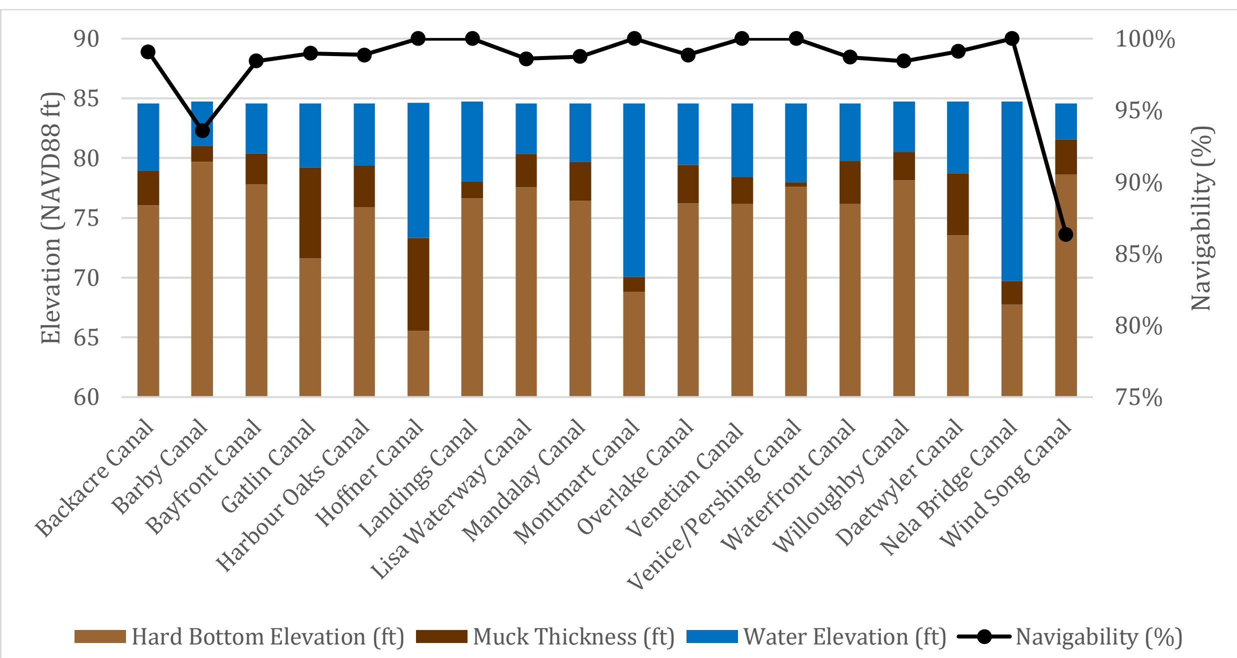

Figure 4-2: Minimum Canal Siltation Conditions (Best-Case)

It is noted that some canals contained multiple sample locations with the same best-case navigability. In these instances, the first sample location at that navigability is presented in **Table 4-2** and **Figure 4-2**. The following canals had multiple sample locations with the same best-case navigability:

- Hoffner canal (12 points)
- Landings canal (6 points)
- Montmart canal (6 points)
- Venetian canal (3 points)
- Nela Bridge canal (4 points)

The maximum canal siltation condition is presented in **Table 4-3** and **Figure 4-3**. The top of muck elevation, muck thickness, and hard bottom elevation for the sample location in each canal with the lowest navigability, which corresponds with the worst-case canal conditions. The maximum canal siltation condition (worst-case condition) is similar to the maximum siltation condition in the 2010 report. For the current study, six of the canals had unacceptable navigability conditions, which suggests that maintenance may be required to improve navigability, see **Table 4-3**. It is noted that, the results provided in this section are representative of one sample location in each canal. Inspection of the surrounding locations is recommended when evaluating maintenance or dredging activities.

Based on the results from this analysis, most of the canals that demonstrated unacceptable navigability conditions had greater muck thickness than the canals with acceptable navigability conditions. Therefore, removal of muck thickness appears to be warranted to improve the navigability of these canals. The remaining canals had a minimum navigability rating of 88% for the worst-case canal navigability, which suggests that these canals are sufficiently clear of muck to adversely impact navigability.

Table 4-3: Maximum Canal Siltation Conditions (Worst-Case)

Canal	Top of Muck Elev. (ft NAVD88)	Hard Bottom Elev. (ft NAVD88)	Muck Thickness (ft)	Min Nav. WS (ft NAVD88)	Nav. (%)
Backacre Canal	81.17	78.69	2.48	84.17	92.7%
Barby Canal	83.75	81.13	2.62	86.75	0.0%
Bayfront Canal	82.62	78.72	3.9	85.62	10.6%
Gatlin Canal	80.52	78.59	1.93	83.52	98.4%
Harbour Oaks Canal	81.07	78.87	2.2	84.07	93.6%
Hoffner Canal	80.97	80	0.97	83.97	94.0%
Landings Canal	81.1	78.3	2.8	84.1	93.6%
Lisa Waterway	83.14	79.81	3.33	86.14	0.1%
Mandalay Canal	80.34	77.65	2.69	83.34	98.6%
Montmart Canal	70.07	68.82	1.25	73.07	100.0%
Overlake Canal	80.27	79.3	0.97	83.27	98.6%
Venetian Canal	83.44	78.65	4.79	86.44	0.0%
Venice/Pershing Canal	81.53	81.3	0.23	84.53	88.0%
Waterfront Canal	80.97	79.16	1.81	83.97	94.0%

Canal	Top of Muck Elev. (ft NAVD88)	Hard Bottom Elev. (ft NAVD88)	Muck Thickness (ft)	Min Nav. WS (ft NAVD88)	Nav. (%)
Willoughby Canal	82.65	80.35	2.3	85.65	6.5%
Daetwyler Canal	80.7	77.48	3.22	83.7	97.9%
Nela Bridge Canal	69.71	67.76	1.95	72.71	100.0%
Wind Song Canal	82.84	81.83	1.01	85.84	2.7%

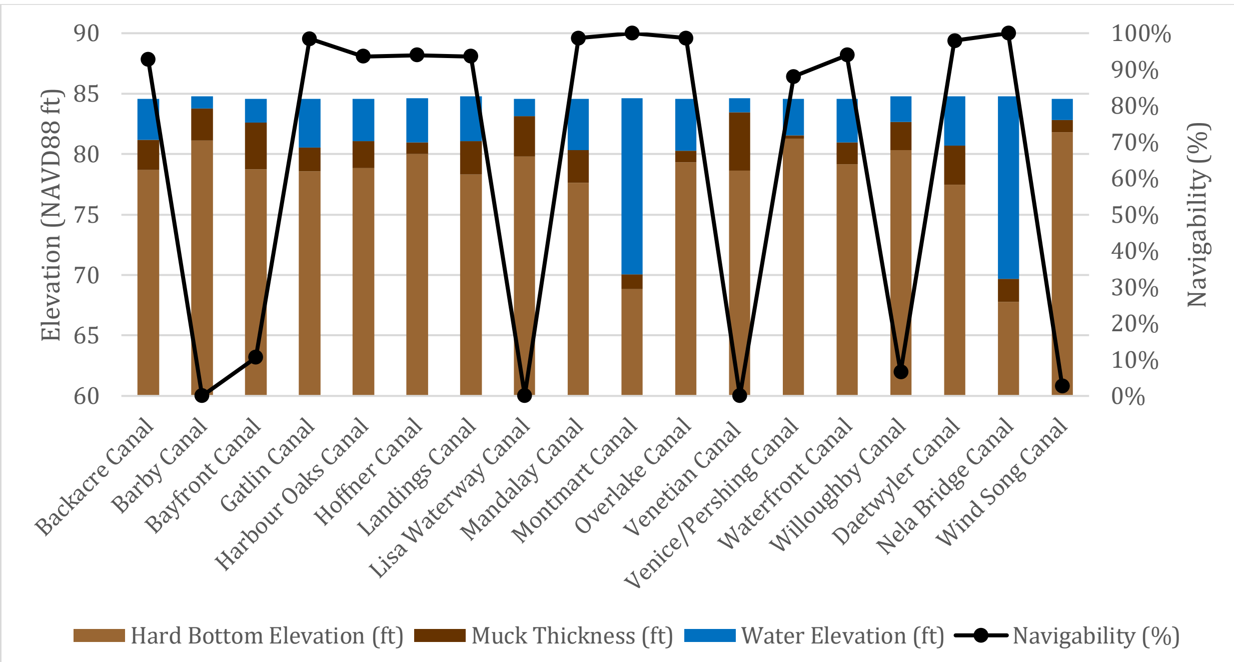

Figure 4-3: Maximum Canal Siltation Conditions (Worst-Case)

It is noted that some canals contained multiple sample locations with the same worst-case navigability. In these instances, the first sample location at that navigability is presented in **Table 4-3** and **Figure 4-3**. The following canals had multiple sample locations with the same worst-case navigability:

- Barby canal (4 points)
- Lisa Waterway canal (2 points)
- Venetian canal (2 points)
- Montmart canal (6 points)
- Nela Bridge canal (4 points)

All sample locations taken at the Montmart canal and Nela Bridge canals have a navigability of 100% indicating that dredging of these canals is not necessary at this time.

4.2.1 Areas of Interest

The information provided herein is intended to supplement dredging decisions that were based on the average canal condition and worst-case canal condition. A map of each sample location and the corresponding navigability, top of muck elevation, hard bottom elevation, and muck thickness is presented in **Exhibit 2** (see **Appendix E** for supplemental graphs showing the navigability for each measured location in each canal). The sample locations within a canal that are at or near an unacceptable navigability (20% or less) are presented in **Table 4-4**. Based on this information, the canals are typically navigable until towards the end of that canal. The Wind Song canal is an exception as the sample location with the lowest navigability is at the entrance to the canal, which is of particular concern as it could restrict ingress / egress from the canal.

Table 4-4: Summary Table for Areas of Interest

Canal	Sample Locations	Navigability (%)	Comments
Barby Canal	116	15.23%	The low navigability starts at the sample locations toward the middle of this canal and continues to the end of the canal. The sample locations at the end of this canal have a navigability of 0%.
	117	15.23%	
	118	6.51%	
	119	0.00%	
	120	0.00%	
	121	0.00%	
	122	0.00%	
Bayfront Canal	72	10.61%	The sample location is at the end of the canal, and the sample locations before sample location 72 had a high navigability, suggesting that most of the canal is navigable.
Lisa Waterway Canal	46	32.22%	The low navigability starts at a sample location toward the middle of the canal and continues to the end of the canal, which suggests most of the canal is or will be at an unnavigable value.
	47	0.25%	
	48	0.11%	
	165	0.11%	
	166	32.22%	
Venetian Canal North	135	0.00%	Sample location 135, is near sample location 133. The two sample locations are in the middle of the Venetian canal. The navigability is 0%, which suggests that navigating from one side of the canal to the other side is difficult toward the middle of the canal.
Venetian Canal South	133	0.00%	
Willoughby Canal	127	6.51%	The sample location is at the end of the canal, and the sample locations before sample location 127 had a high navigability, suggesting that most of the canal is navigable.
Wind Song Canal	158	2.75%	This sample location is at the entrance of the canal, however the sample locations within the canal have an acceptable navigability.

4.2.2 Boat Draft Discussion

The County desired some guidance on boat draft for different types of boats. For the purposes of this study, boat draft is defined as the distance between the water surface and the deepest point of the boat. Boat draft of common boat types was researched and is presented in **Table 4-5**. The typical boat draft provided in **Table 4-5** in conjunction with the lake stage and navigability readings should be reviewed and considered in determining what type of boats can safely navigate through the canals.

Table 4-5: Boat Draft for common boat types

Center Console		
Length* (ft)	Boat Draft* (ft)	 **Source:** https://chawkboats.net/welcome-2/product/23-center-console/
11 - 20	1 - 3	
22 - 40	1 - 8	
> 40	2 - 8	
Outboard		
Length* (ft)	Boat Draft* (ft)	 **Source:** https://crownline.com/the-advantages-of-outboard-engines/
11 - 20	1 - 3	
22 - 40	1 - 8	
> 40	2 - 8	
Inboard		
Length* (ft)	Boat Draft* (ft)	 **Source:** https://www.nauticexpo.com/boat-manufacturer/inboard-runabout-23539.html
11 - 75	1 - 3	

Day Cruiser		
Length* (ft)	Boat Draft* (ft)	 Source: https://yamarin.com/en/day-cruisers
15 - 36	1 - 3	

Source*: https://www.nauticexpo.com/

4.2.3 Depth to Disturbance

Depth to disturbance is defined as the vertical limit of erosion of the canal bottom due to boat propellers. It is a function of the velocity of the boat and diameter of the boat propellers. To calculate an approximate vertical depth of disturbance that corresponds with the flow velocity of a motor, the actuator disc theory is used (Froude, 1889). It assumes that the propeller jet is a submerged free jet discharging out of an orifice. The equations, from Albertson et al. (1950) and Pianc (2015), are presented below:

$$V_{axis} = \frac{1}{2C} * V_0 * \left(\frac{D}{x}\right)$$ **Equation 4-1**

Where:

$V_{axis} = flow\ velocity\ in\ the\ axis\ of\ the\ jet\ (\frac{ft}{s})$

$V_0 = efflux\ velocity\ (\frac{ft}{s})$

$D = jet\ diameter\ at\ the\ beginning\ of\ the\ jet\ (ft)$

$x = horizontal\ distance\ from\ the\ outflow\ of\ the\ jet\ (ft)$

$C = coefficient\ (unitless)$

$$\frac{V_{xy}}{V_{axis}} = e^{\left[-\frac{1}{2C^2}\frac{r^2}{x^2}\right]}$$ **Equation 4-2**

Where:

$V_{xy} = flow\ velocity\ in\ the\ jet\ at\ location\ x, y\ (\frac{ft}{s})$

$r = vertical\ distance\ (ft)$

$$V_0 = f * \left(\frac{Pthrust}{(\rho_w) * D^2}\right)^{\frac{1}{3}}$$ **Equation 4-3**

Where:

$f = percentage\ of\ maximum\ number\ of\ revolutions\ (unitless)$

$\rho_w = weight\ of\ water\ (\frac{lbs}{ft^3})$

$Pthrust = acceleration\ of\ boat\ produced\ by\ propellers\ turning\ (hp)$

It was assumed that the diameter of a typical boat propeller was approximately 15 inches, the boat thrust was 200 horsepower ($Pthrust = 150{,}000\ W$), the percentage of maximum number of revolutions was 1.15 and the coefficient (C) was 0.081. These assumptions are based on a typical boat motor for a lake and the actuator disc theory. The typical boat motor information was based on information found at https://www.nauticexpo.com. It is noted that the propeller diameter and boat thrust have little impact on the depth to disturbance. **Figure 4-4** depicts the relationship between vertical distance, horizontal distance, and flow velocity at location x,y. For a given horizontal distance away from the propellor, the maximum flow velocity occurs at half the vertical length of the propellor. As the horizontal distance away from the propellor increases, the maximum flow velocity decreases, but the vertical distance at which a flow velocity is present, increases.

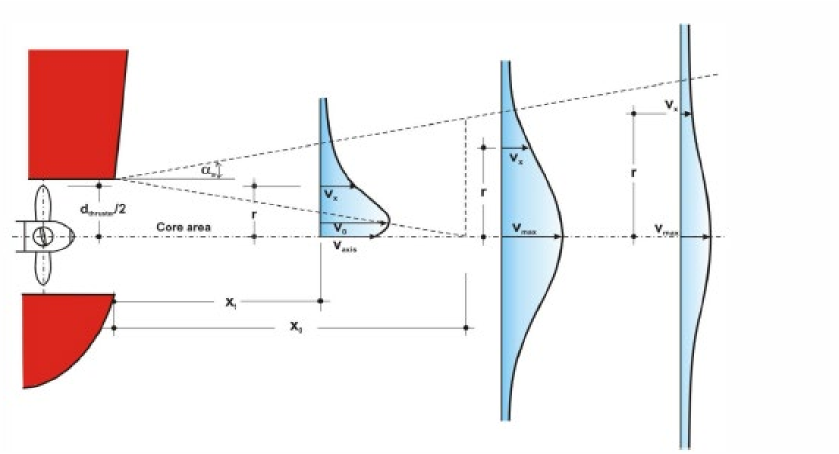

Figure 4-4: Flow velocity as horizontal distance away from propellor increases (Pianc, 2015)

Figure 4-5 illustrates the depth to disturbance for different horizontal distances (that starts from the back of the boat) and for different flow velocities in the jet at a location (x, y).

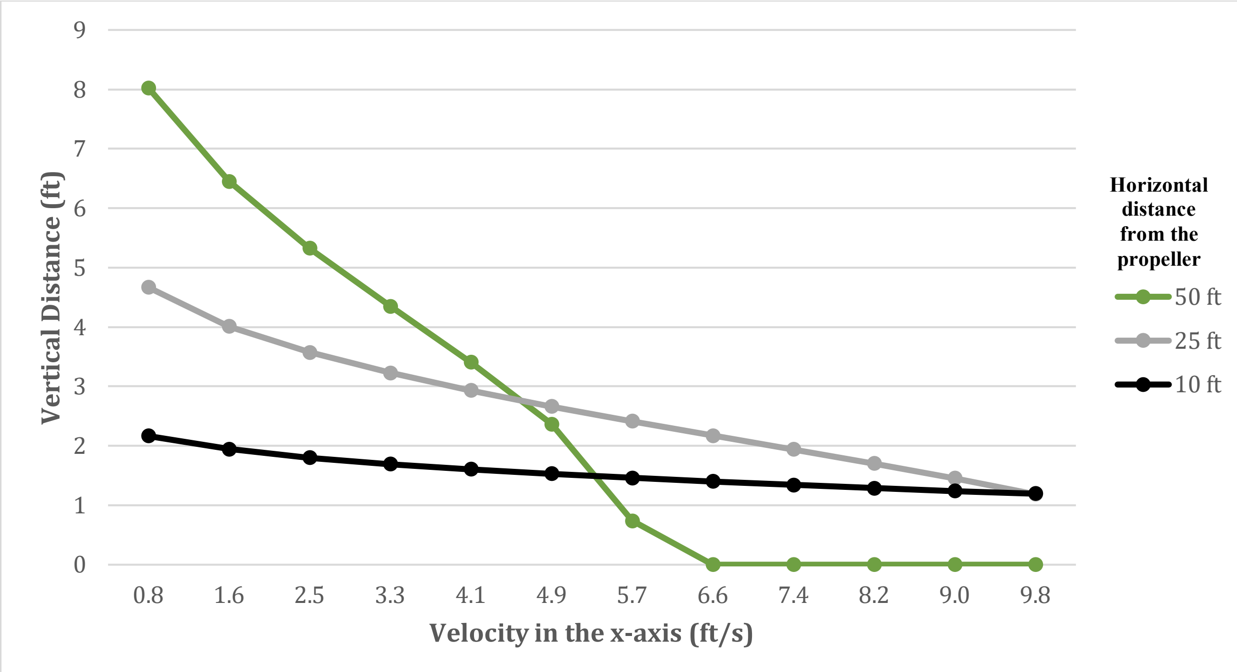

Figure 4-5: Depth to Disturbance for Different Horizontal Distances

Examination of **Figure 4-5** shows that when the flow velocity increases, the vertical distance of sediment disturbance decreases, which suggests that the velocity in the horizontal distance is greater than the velocity in the vertical distance. This may indicate that when the boat is travelling at a low speed, the vertical distance of disturbance may be near the maximum value. Understanding the relationship between boat speed and depth to disturbance is an important factor in understanding siltation characteristics in the canal.

4.3 Comparison with the 2010 Study

Navigability during the current study, 2021, was compared with the navigability in the 2010 study to determine the total change and average annual change of siltation conditions in each canal. It is noted that the total change and average annual rate of change of navigability may indicate the canal has become more navigable although the top of muck elevation has increased. This is likely because the lake stage used in the 2010 study and the current study are different due to the historical data used and the Daetwyler weir replacement. Total change and annual rate of change was calculated for the top of muck elevation, hard bottom elevation, and muck thickness. The total change is the difference between the 2021 and the 2010 findings. The average annual change was calculated by dividing the total change by the number of years between the readings. The best- and worst-case conditions for the 2010 study were calculated and compared with the best- and worst-case conditions for the current 2021 study results presented in **Section 4.2**.

The Navigability Ratings were calculated the same way as the 2010 canal study – using the MMNE, 2021 top of muck elevation, and the average annual change for the top of muck elevation from 2010 to 2021. The Navigability Rating is the range for which maintenance or dredging is recommended to be performed, i.e., the MNNE equates to a navigability of 20% (lake stage associated with the 80th percentile) or less, as suggested in the 2010 canal study. The MNNE for this study is approximately 84.75 feet NAVD88. **Table 4-6** illustrates the Navigability Ratings for each canal, as well as the average annual rate of change.

A positive change in navigability indicates that the canal has become more navigable; this may be due to a lessening amount of muck thickness or a deeper hard bottom elevation. For the total change and average annual change sections, unacceptable conditions (yellow shading) include the following:

- An increase (positive value) in hard bottom elevation, muck thickness or top of muck elevation
- A decrease (negative value) in navigability

Table 4-6: Average Canal Conditions Change Between 2021 and 2010

Canal	Total Change				Average Annual Change				Rating (years)
	Hard Bottom Elevation Total Change (ft)	Muck Thickness Total Change (ft)	Top of Muck Elev. Total Change (ft)	Nav.* (%)	Hard Bottom Elevation Change (ft / yr)	Muck Thickness Change (ft / yr)	Top of Muck Elevation Change (ft / yr)	Nav.* (%)	
Backacre Canal	-1.22	1.43	0.2	18.80%	-0.12	0.14	0.02	1.8%	237
Barby Canal	-0.44	1.25	0.81	-9.00%	-0.04	0.11	0.07	-0.8%	27
Bayfront Canal	-1.78	2.26	0.48	1.20%	-0.17	0.22	0.05	0.1%	81
Gatlin Canal	-1.64	1.94	0.30	16.64%	-0.17	0.20	0.03	1.7%	150
Harbour Oaks Canal	-1.03	1.34	0.30	16.40%	-0.11	0.14	0.03	1.7%	148
Hoffner Canal	-2.10	2.59	0.49	8.67%	-0.21	0.25	0.05	0.8%	163
Landings Canal	-0.99	1.41	0.42	7.46%	-0.09	0.13	0.04	0.7%	147
Lisa Waterway Canal	-1.46	2.62	1.16	-9.96%	-0.15	0.27	0.12	-1.0%	23
Mandalay Canal	-1.11	1.54	0.43	13.69%	-0.11	0.16	0.04	1.4%	108
Montmart Canal	-4.76	4.47	-0.28	0.00%	-0.45	0.43	-0.03	0.0%	-381
Overlake Canal	-1.07	1.50	0.43	11.51%	-0.10	0.14	0.04	1.1%	122
Venetian Canal	-1.21	2.27	1.06	-8.93%	-0.12	0.23	0.11	-0.9%	41
Venice/Pershing Canal	0.08	0.79	0.86	14.10%	0.01	0.08	0.08	1.3%	57
Waterfront Canal	-1.78	2.32	0.54	17.84%	-0.17	0.22	0.05	1.7%	82
Willoughby Canal	-1.13	1.37	0.24	20.76%	-0.10	0.12	0.02	1.9%	173
Daetwyler Canal	-1.78	2.26	0.48	1.20%	-0.17	0.22	0.05	0.1%	112

*The navigability for the 2010 and current study is based on different historic lake data.

Table 4-7 presents the best-case condition comparison between the 2010 and 2021 top of muck elevation, hard bottom elevation, muck thickness, and navigability that correspond with the sample location with the highest navigability in each canal. It is noted that the sample location with the highest navigability in 2010 for a given canal may not be the same sample location as in the current 2021 study.

Table 4-7: Best-case Canal Conditions Change Between 2021 and 2010

Canal	Change				Annual Change			
	Hard Bottom Elev. (ft)	Muck Thickness (ft)	Top of Muck Elev. (ft)	Nav.* (%)	Hard Bottom Elev. (ft / yr)	Muck Thickness (ft / yr)	Top of Muck Elev. (ft / yr)	Nav.* (%)
Backacre Canal	-1.89	2.18	0.29	28.52%	-0.18	0.21	0.03	2.7%
Barby Canal	-1.48	0.88	-0.60	48.04%	-0.13	0.08	-0.05	4.3%
Bayfront Canal	-1.95	2.04	0.09	28.69%	-0.19	0.19	0.01	2.7%
Gatlin Canal	-1.21	1.32	0.11	20.82%	-0.12	0.14	0.01	2.1%
Harbour Oaks Canal	-0.41	0.80	0.39	26.10%	-0.04	0.08	0.04	2.7%
Hoffner Canal	-2.33	1.75	-0.58	40.44%	-0.24	0.18	-0.06	4.2%
Landings Canal	-0.12	0.31	0.19	27.87%	-0.01	0.03	0.02	2.5%
Lisa Waterway Canal	-1.94	2.18	0.24	32.30%	-0.20	0.22	0.02	3.3%
Mandalay Canal	-0.84	0.83	-0.01	17.87%	-0.09	0.09	0.00	1.8%
Montmart Canal	0.32	-0.95	-0.63	0.00%	0.03	-0.09	-0.06	0.0%
Overlake Canal	-0.93	0.92	-0.01	16.49%	-0.09	0.09	0.00	1.6%
Venetian Canal	-0.52	0.54	0.02	34.31%	-0.05	0.06	0.00	3.5%
Venice/Pershing Canal	-0.08	0.02	-0.06	31.83%	-0.01	0.00	-0.01	3.0%
Waterfront Canal	-1.02	1.61	0.59	20.65%	-0.10	0.15	0.06	2.0%
Willoughby Canal	-1.54	0.84	-0.70	44.40%	-0.14	0.08	-0.06	4.0%
Daetwyler Canal	-1.07	0.00	-1.07	26.93%	-0.11	0.00	-0.11	2.8%

*The navigability for the 2010 and current study is based on different historic lake data.

Table 4-8 presents the worst-case condition comparison between the 2010 and 2021 top of muck elevation, hard bottom elevation, muck thickness, and navigability that correspond with the sample location with the lowest navigability in each canal. It is noted that the sample location with the lowest navigability in 2010 for a given canal may not be the same sample location as in the current 2021 study.

Table 4-8: Worst-Case Canal Conditions Change Between 2021 and 2010

Canal	Change				Annual Change			
	Hard Bottom Elev. (ft)	Muck Thickness (ft)	Top of Muck Elev. (ft)	Nav.* (%)	Hard Bottom Elev. (ft / yr)	Muck Thickness (ft / yr)	Top of Muck Elev. (ft / yr)	Nav.* (%)
Backacre Canal	-2.93	2.62	-0.31	10.76%	-0.28	0.25	-0.03	1.0%
Barby Canal	-0.91	2.07	1.16	-42.37%	-0.08	0.19	0.10	-3.8%
Bayfront Canal	-3.26	3.80	0.54	-20.50%	-0.31	0.36	0.05	-2.0%
Gatlin Canal	-4.60	4.66	0.06	8.98%	-0.47	0.48	0.01	0.9%
Harbour Oaks Canal	-1.21	1.72	0.51	5.54%	-0.12	0.18	0.05	0.6%
Hoffner Canal	-2.26	4.67	2.41	0.00%	-0.22	0.45	0.23	0.0%

Canal	Change				Annual Change			
	Hard Bottom Elev. (ft)	Muck Thickness (ft)	Top of Muck Elev. (ft)	Nav.* (%)	Hard Bottom Elev. (ft / yr)	Muck Thickness (ft / yr)	Top of Muck Elev. (ft / yr)	Nav.* (%)
Landings Canal	-1.15	1.44	0.29	0.00%	-0.10	0.13	0.03	0.0%
Lisa Waterway Canal	-2.28	4.36	2.08	-63.92%	-0.24	0.45	0.21	-6.6%
Mandalay Canal	-0.67	1.51	0.84	5.43%	-0.07	0.16	0.09	0.6%
Montmart Canal	0.32	-0.95	-0.63	0.00%	0.03	-0.09	-0.06	0.0%
Overlake Canal	-0.74	1.68	0.94	1.65%	-0.07	0.16	0.09	0.2%
Venetian Canal	0.01	4.39	4.40	-92.78%	0.00	0.45	0.45	-9.6%
Venice/Pershing Canal	-0.39	2.62	2.23	-0.20%	-0.04	0.25	0.21	0.0%
Waterfront Canal	-3.10	3.49	0.39	10.93%	-0.30	0.33	0.04	1.0%
Willoughby Canal	-1.21	2.20	0.99	-39.04%	-0.11	0.20	0.09	-3.5%
Daetwyler Canal	-0.45	1.21	0.76	5.99%	-0.05	0.13	0.08	0.6%

*The navigability for the 2010 and current study is based on different historic lake data.

The average navigability currently represents an acceptable condition for all the canals, however the annual change in average navigability for some canals currently represents an unacceptable condition. To further illustrate the change in average navigability between 2005, 2010, and 2021, a scatterplot is presented in **Figure 4-6**. In **Figure 4-6**, most of the canals had an improved average navigability from 2010 to 2021. This suggests that these canals would not immediately require dredging. However, some of the canals had a decrease in average navigability, which suggests these canals may require dredging or maintenance sooner as the canal may become unnavigable over time. For example, Lisa Waterway had an acceptable average navigability change between 2005 and 2010, which illustrates an improving canal condition. However, the canal had an unacceptable average navigability change between 2010 and 2021, which suggests that at the current average annual rate of change in navigability, the canal will need maintenance sooner than most other canals.

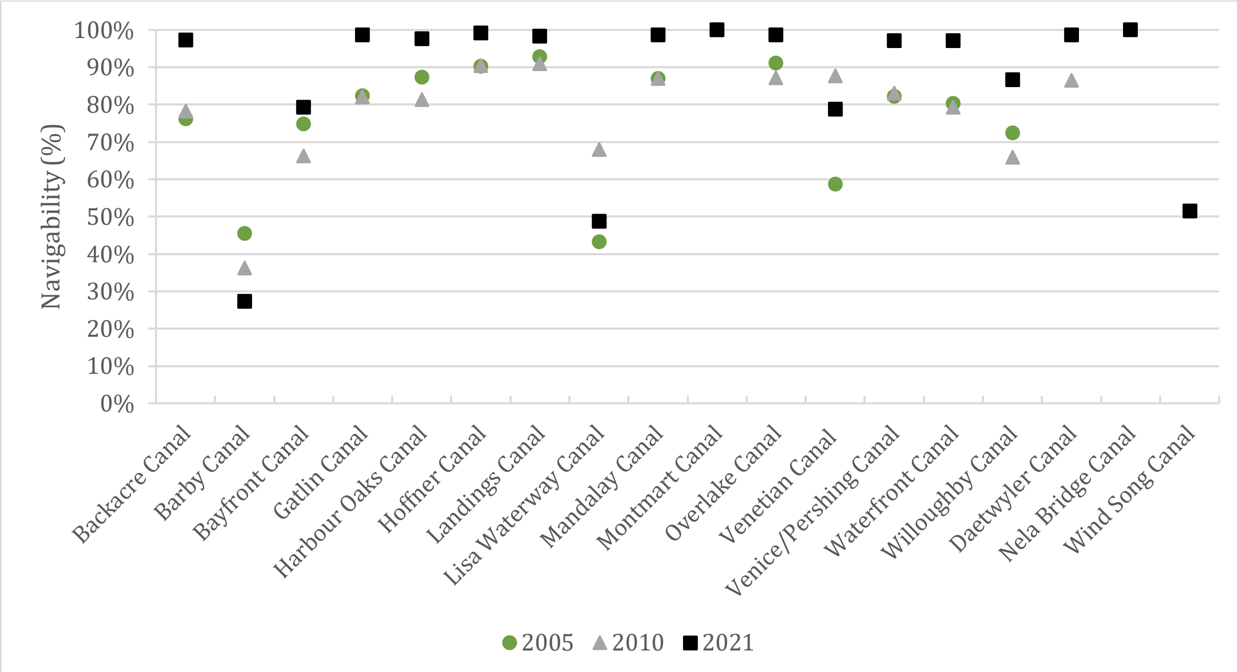

Figure 4-6: Scatterplot for the Average Conditions of Each Canal

5. DISCUSSION

The canals that have the lowest average navigability, Barby canal (27.3%), Lisa Waterway canal (48.7%), Wind Song canal (51.5%) and Venetian canal (78.7%), may be more difficult for boats to navigate through. For example, the average navigability for the Barby canal is 27.3% suggesting that 265 days of the year the canal may be unnavigable (assuming the lake stage of that year is similar to the historic lake stage collected). Further, the Venetian canal (0.23 feet per year) and Lisa Waterway canal (0.27 feet per year) have some of the highest average annual rate of muck thickness increase which may indicate maintenance or dredging might be more necessary to maintain and/or increase navigability of these canals. The Navigability Ratings determined during this study indicate that maintenance or dredging of these two canals may be required within the next 27 (Barby canal) to 41 (Venetian canal) years based on the average annual increase in top of muck elevation.

The Navigability Ratings are positive in most of the canals and range from 27 years to 237 years. The canals with Navigability Ratings that are higher will likely require less maintenance or dredging than the canals with lower positive ratings. Montmart canal has a negative Navigability Rating because the top of muck elevation has decreased. Per the 2010 report, the negative Navigability Rating indicates the canal is getting deeper over time. Because the canal is getting deeper and because the current navigability of this canal is 100%, it does not appear necessary to dredge this canal at this time.

From 2010 to 2021, the average annual rate of change of muck thickness in all the canals generally increased between 0.08 and 0.43 feet per year. The average annual rate of change for the hard bottom elevation was shown to decrease from between 0.04 and 0.45 feet per year for all the canals except the Venice/Pershing canal which showed an increase in hard bottom elevation at a rate of 0.01 feet per year. Although the average annual rate of change for the hard bottom elevation generally decreased, the muck thickness increased at a greater rate, causing the top of muck elevation to increase between 0.02 and 0.12 feet per year. The only canal that had a decrease in top of muck elevation was the Montmart canal at a rate of 0.03 feet per year. The average annual rate of change of most of the canals appeared to show an increase in navigability, however this may be partly the result of a change in the lake control elevation that occurred between 1999 to 2003 that was not specifically addressed in the 2010 report.

The 2021 canal ratings suggest that the canals may become unnavigable within the next 27 to 237 years, depending on the canal. The 2010 report recommended immediate dredging for a few canals and indicated that dredging would not be required for hundreds of years for most of the other canals. Although the Navigability Ratings are above 80 years in most of the canals, maintenance or dredging may be useful to reduce the muck thickness that has increased from 2010 to 2021, which might have ancillary water quality benefits to the lake due to the phenomenon of nutrient cycling between the muck and water interface.

Canals are recommended to be evaluated using two data sets to evaluate the need for dredging, the average navigability and review of the navigability at individual locations to evaluate potential problem areas that might impact navigability. The average navigability values are recommended to be used to provide an understanding of the overall, or average canal condition. The individual locations are recommended to identify potential problem areas that might affect specific residents' ability to access the lake from the canal. **Exhibit 2** shows the navigability results for specific locations within each canal. Due to the change in Navigability Ratings for the canals from the 2010 report to the current study, and as suggested in the 2010 report, collecting sample data in each of these canals on a 5-year interval is recommended to reevaluate siltation buildup conditions.

Information presented in **Section 4.2.1** can be referred to when basing dredging decisions for high priority areas. It is noted that the sample locations are not representative of the entire canal, however a low navigability at a sample location suggests that the surrounding area may exhibit similar navigable characteristics, and therefore would likely need maintenance. Based on the results of this study, the sample locations with low navigability were typically toward the end of the canal (i.e., the furthest distance from where the canal discharges to the lake). For example, the Barby canal and Lisa Waterway canal contained multiple sample locations with low navigability located toward the middle and end of the canal. The remaining canals listed in **Section 4.2.1** contained one sample location with an unacceptable navigability, which was typically at the end of the canal. However, the sample location with an unacceptable navigability in the Wind Song canal was at the entrance of the canal, which indicates it may be more difficult to navigate into/out of that canal.

6. CONCLUSION

The analysis performed and findings presented in this study are a continuation of the previous studies performed in 2005 and 2010. The 2010 canal study found that the Navigability Ratings ranged from -74 to 1,161 years. Navigability Ratings that were near zero or negative were recommended to be dredged immediately. The annual rate of change and total change of the top of muck elevation between the 2005 and 2010 indicated that the top of muck elevation had increased in most canals resulting in decreased navigability.

For this current 2021 effort, A total of 142 sample locations were evaluated, and 2 new canals (Nela Bridge canal and Wind Song canal) were included in this report. Sample locations for the current effort were based on those from the previous studies as well as two canals requested by the County. Measurements for hard bottom elevation and top of muck elevation were recorded at each sample location. The muck thickness was calculated as the difference between the two elevations.

The navigability of each sample location was defined as the percentage of time a location in a waterbody is likely to have an MSND of 3 feet above the top of muck elevation and was found using **Equation 2-1**. The percentage of time is based on daily historic lake stage data from 2006 to 2021 used to calculate the lake stage percentiles provided in **Appendix B**.

Based on the results of the analysis presented in **Section 4.3**, the average annual rate of change for navigability demonstrated that most of the canals exhibited acceptable navigability conditions (except for Lisa Waterway canal, Barby canal, and Venetian canal). However, this may be due to a significant difference in lake stage used in this study and the 2010 study (which appear to be affected by the Daetwyler weir replacement but may be the use of monthly lake stage data in the 2010 study as opposed to daily lake stage data in the current study). Nearly all the canals had a positive top of muck elevation annual change, a positive muck thickness annual change, and a negative hard bottom elevation annual change, suggesting that the canals were getting deeper at a slower rate than the increase in muck thickness. This indicates that the canals are generally becoming slightly more shallow over time.

Based on the results of the current study, the Navigability Ratings have decreased since 2010. However, the Navigability Rating indicated that canals would remain navigable within the next 27 to 237 years for most of the canals evaluated in this study. The average annual change in navigability increased by approximately two percentage points each year in most canals, however in some locations (Barby canal, Lisa Waterway canal, Venetian canal) the annual change in navigability decreased. These canals had the lowest Navigability Ratings, had some of the lowest navigability values, and contained sample locations with unacceptable navigability values as defined in this study. Most of the canals had a high navigability, indicating the canals were safe to navigate through. Analysis of the results from the worst-case condition and analysis of individual sample locations with unacceptable navigability indicated there may exist localized areas within each canal that are less navigable when compared to the average canal conditions. **Table 6-1** presents the canals that are recommended to be inspected and/or dredged based on the findings in this study.

Table 6-1: Canal Recommendations

Canal	Comments	Action Recommended
Backacre Canal	Because the Navigability Rating is at 237 years it is not recommended to dredge this canal at this time.	No
Barby Canal	The canal contained sample locations with an unacceptable navigability from toward the middle of the canal to the end of the canal. Dredging at these sample locations appears warranted as the muck thickness is larger than the sample locations with an acceptable navigability value. The average navigability is at 27.3% likely due to the greater muck thickness at the sample locations with an unacceptable navigability and because the bottom elevation is higher than most other canals. Therefore, dredging of portions of this canal is recommended.	Yes
Bayfront Canal	The average canal navigability is close to 80% which suggests the canal is likely in good shape. Based on the analysis of individual sample locations, one sample location (72) at the end of the canal has an unacceptable navigability. Since this location is at the end of the canal and doesn't appear to impact residents access to the lake, it does not appear that dredging of this canal is warranted at this time.	No
Gatlin Canal	Based on the findings presented in this report, it is not recommended to dredge the entirety of this canal at this time. It is recommended to inspect the area surrounding sample location 34 in the future, as the muck thickness is approximately 7.66 feet; however, the navigability is still 98.98%.	No
Harbour Oaks Canal	Because the Navigability Rating is at 148 years, it does not appear that dredging is necessary at this canal at this time.	No
Hoffner Canal	Based on the findings presented in this report, dredging does not appear to be necessary for the entirety of this canal at this time. It is recommended to inspect the areas surrounding sample locations 20, 26, 31, 140, 141, and 143 in the future, as the muck thickness is over 7 feet; however, the navigability is still above 98%.	No
Landings Canal	Because the Navigability Rating is at 147 years, dredging does not appear to be necessary at this time.	No

Canal	Comments	Action Recommended
Lisa Waterway Canal	The canal contained sample locations with an unacceptable navigability from toward the middle of the canal to the end of the canal. The average navigability of the canal is 48.7% and the average muck thickness is nearly 3 feet. Sample locations 45, 46, and 47 have a muck thickness near or greater than 3 feet, therefore dredging to remove accumulated muck appears to be warranted at these locations. However, at sample locations 165 and 166 the muck thickness is low, and dredging may not significantly improve the navigability unless hard bottom sediments are removed. It is noted that sample locations 165 and 166 are at the end of the canal. Based on this, dredging is recommended for this canal.	Yes
Mandalay Canal	Because the average navigability is 98.7%, it is not recommended to dredge this canal at this time.	No
Montmart Canal	Based on the findings in this study, dredging does not appear to be warranted for this canal as the average navigability is 100%. It is noted that this recommendation is despite a negative Navigability Rating for this canal. It is recommended to continue to monitor the conditions in the areas surrounding sample locations 145, 146, 148, and 149 in the future as the muck thickness at these locations is above or near 7 feet.	No
Overlake Canal	Because the Navigability Rating is at 121 years, dredging does not appear to be warranted at this time.	No
Venetian Canal	The overall condition of the canal is good as the average navigability is 78.7%. However, two sample locations (133, 135) have an unacceptable navigability value due to the significant amount of muck thickness (4.79 and 5.69 ft). The canal has two entrances, and the location of these two sample locations is at the middle of the canal. The accumulation of muck may make navigating from one entrance to the other more difficult, therefore dredging is recommended for the locations with unacceptable navigability to remove accumulated muck.	Yes
Venice/ Pershing Canal	Based on the findings in this study, dredging does not appear warranted at this time. However, because this canal had an increase in average annual hard bottom elevation (0.01 ft/yr) and a low Navigability Rating of 57 years, it is recommended to continue to assess this canal in the future.	No
Waterfront Canal	Because the Navigability Rating is 81 years, dredging does not appear to be warranted at this time.	No

Canal	Comments	Action Recommended
Willoughby Canal	The overall condition of the canal is good as the average navigability is 86.7%. However, one sample location (127) at the end of the canal had unacceptable navigability. Based on this, dredging does not appear to be warranted at this time.	No
Daetwyler Canal	Because the Navigability Rating is 112 years, dredging does not appear to be warranted at this time.	No
Nela Bridge Canal	Because the average top of muck elevation is 71.99 ft, and the average navigability is 100%, dredging does not appear to be warranted at this time. It is noted that this is the first measurement for this canal, so future monitoring is recommended for a better understanding of how conditions change at this location.	No
Wind Song Canal	The canal contained one sample location with an unacceptable navigability, which is at the entrance of the canal. The muck thickness at this sample location is 1.01 ft, therefore dredging may not significantly improve the navigability unless hard bottom sediments are also removed. Based on this, it appears that dredging may be warranted in this location to maintain lake access for the residents living on this canal. It is noted that this is the first measurement for this canal, so future monitoring is recommended for a better understanding of how conditions change at this location.	Yes

The following are recommendations based on the findings in this study:

1. Perform future assessments on a 5-year interval.
2. It is recommended that future studies maintain consistent assumptions with the previous studies, including using an MSND of 3 feet and using an MNNE of 20%.
3. It is recommended to use the average canal conditions to provide overall assessments of the entire canal.
4. It is recommended to review the location specific data, e.g., **Exhibit 2**, when making decisions for high priority locations in a canal.
5. It is recommended to perform dredging for the following canals:
    a. Barby Canal
    b. Lisa Waterway Canal
    c. Venetian Canal
    d. Wind Song Canal

7. REFERENCES

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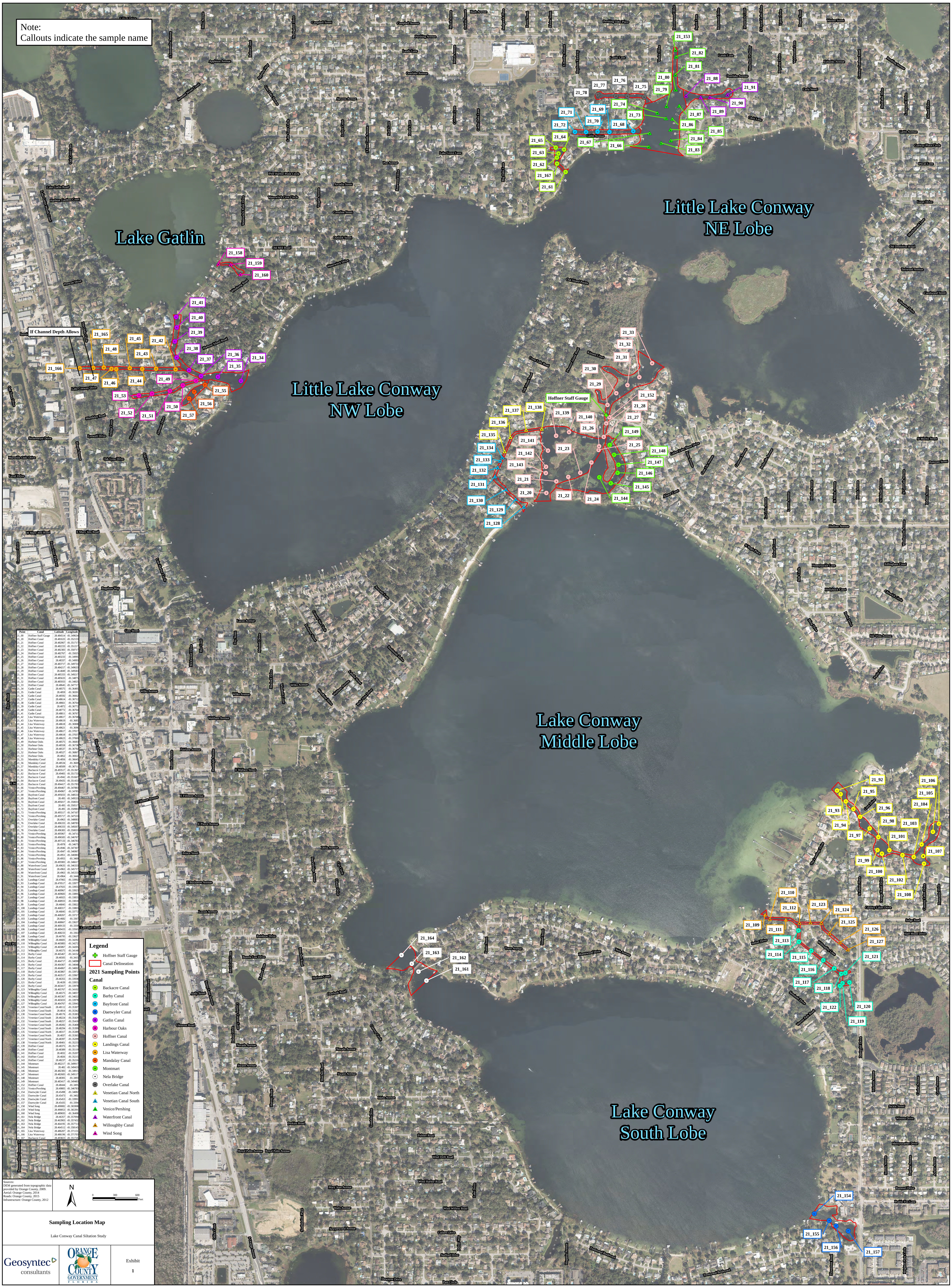
Exhibits

DRAFT 8/27/2021



Point	Canal	Latitude	Longitude
21_00	Hoffner Staff Gauge	28.484514	-81.349634
21_20	Hoffner Canal	28.481633	-81.352133
21_21	Hoffner Canal	28.482067	-81.351717
21_22	Hoffner Canal	28.482233	-81.351217
21_23	Hoffner Canal	28.482383	-81.350717
21_24	Hoffner Canal	28.482767	-81.35025
21_25	Hoffner Canal	28.483233	-81.34995
21_26	Hoffner Canal	28.48337	-81.34993
21_27	Hoffner Canal	28.483717	-81.349733
21_28	Hoffner Canal	28.484217	-81.349633
21_29	Hoffner Canal	28.4849	-81.349583
21_30	Hoffner Canal	28.485333	-81.349217
21_31	Hoffner Canal	28.485633	-81.34875
21_32	Hoffner Canal	28.485933	-81.34825
21_33	Hoffner Canal	28.48645	-81.347717
21_34	Gatlin Canal	28.48575	-81.36495
21_35	Gatlin Canal	28.4859	-81.36591
21_36	Gatlin Canal	28.48592	-81.36662
21_37	Gatlin Canal	28.48614	-81.36712
21_38	Gatlin Canal	28.48661	-81.36764
21_39	Gatlin Canal	28.4872	-81.36772
21_40	Gatlin Canal	28.48772	-81.36764
21_41	Gatlin Canal	28.48811	-81.36767
21_42	Lisa Waterway	28.48617	-81.36768
21_43	Lisa Waterway	28.48619	-81.3685
21_44	Lisa Waterway	28.48618	-81.36908
21_45	Lisa Waterway	28.48621	-81.3696
21_46	Lisa Waterway	28.48617	-81.37017
21_47	Lisa Waterway	28.48618	-81.37037
21_48	Lisa Waterway	28.48623	-81.37069
21_49	Harbour Oaks	28.48575	-81.36683
21_50	Harbour Oaks	28.48558	-81.36738
21_51	Harbour Oaks	28.48537	-81.36792
21_52	Harbour Oaks	28.48527	-81.36867
21_53	Harbour Oaks	28.4852	-81.36922
21_55	Mandalay Canal	28.4856	-81.36645
21_56	Mandalay Canal	28.48534	-81.3669
21_57	Mandalay Canal	28.48509	-81.36711
21_61	Backacre Canal	28.493517	-81.351367
21_62	Backacre Canal	28.49405	-81.351733
21_63	Backacre Canal	28.4942	-81.351667
21_64	Backacre Canal	28.49435	-81.351433
21_65	Backacre Canal	28.494417	-81.351783
21_66	Venice/Pershing	28.494467	-81.347883
21_67	Venice/Pershing	28.494967	-81.34785
21_68	Bayfront Canal	28.495033	-81.348533
21_69	Bayfront Canal	28.495	-81.349533
21_70	Bayfront Canal	28.495017	-81.350033
21_71	Bayfront Canal	28.495	-81.350517
21_72	Bayfront Canal	28.495	-81.350983
21_73	Venice/Pershing	28.495517	-81.347167
21_74	Venice/Pershing	28.495717	-81.347533
21_75	Overlake Canal	28.4963	-81.348083
21_76	Overlake Canal	28.496333	-81.348783
21_77	Overlake Canal	28.496333	-81.349267
21_78	Overlake Canal	28.496383	-81.350033
21_79	Venice/Pershing	28.495967	-81.34715
21_80	Venice/Pershing	28.496583	-81.346767
21_81	Venice/Pershing	28.497133	-81.346783
21_82	Venice/Pershing	28.4978	-81.34675
21_83	Venice/Pershing	28.4946	-81.347367
21_84	Venice/Pershing	28.4947	-81.346967
21_85	Venice/Pershing	28.4951	-81.346983
21_86	Venice/Pershing	28.4955	-81.3469
21_87	Venice/Pershing	28.495983	-81.346617
21_88	Waterfront Canal	28.49635	-81.346333
21_89	Waterfront Canal	28.4963	-81.345717
21_90	Waterfront Canal	28.4963	-81.345333
21_91	Waterfront Canal	28.4964	-81.3446
21_92	Landings Canal	28.47065	-81.33992
21_93	Landings Canal	28.470517	-81.33977
21_94	Landings Canal	28.47025	-81.33955
21_95	Landings Canal	28.469967	-81.33923
21_96	Landings Canal	28.469683	-81.33895
21_97	Landings Canal	28.46925	-81.33855
21_98	Landings Canal	28.468933	-81.33818
21_99	Landings Canal	28.46845	-81.33822
21_100	Landings Canal	28.468317	-81.33803
21_101	Landings Canal	28.46845	-81.33772
21_102	Landings Canal	28.468267	-81.33717
21_103	Landings Canal	28.4682	-81.3367
21_104	Landings Canal	28.468667	-81.33637
21_105	Landings Canal	28.469133	-81.3359
21_106	Landings Canal	28.469433	-81.33565
21_107	Landings Canal	28.468233	-81.3363
21_108	Landings Canal	28.46795	-81.33627
21_109	Willoughby Canal	28.46605	-81.34292
21_110	Willoughby Canal	28.465883	-81.34272
21_111	Willoughby Canal	28.465867	-81.34205
21_112	Willoughby Canal	28.46575	-81.34148
21_113	Barby Canal	28.465467	-81.34152
21_114	Barby Canal	28.46505	-81.3415
21_115	Barby Canal	28.464717	-81.34098
21_116	Barby Canal	28.464367	-81.34048
21_117	Barby Canal	28.464067	-81.34002
21_118	Barby Canal	28.463867	-81.33972
21_119	Barby Canal	28.463517	-81.33967
21_120	Barby Canal	28.46355	-81.33938
21_121	Barby Canal	28.4639	-81.33955
21_122	Barby Canal	28.463417	-81.33978
21_123	Willoughby Canal	28.465767	-81.34102
21_124	Willoughby Canal	28.46575	-81.34057
21_125	Willoughby Canal	28.465367	-81.34022
21_126	Willoughby Canal	28.465033	-81.33978
21_127	Willoughby Canal	28.464767	-81.33945
21_128	Venetian Canal South	28.48112	-81.35307
21_129	Venetian Canal South	28.4814	-81.35342
21_130	Venetian Canal South	28.48176	-81.35383
21_131	Venetian Canal South	28.48224	-81.35429
21_132	Venetian Canal South	28.48257	-81.35418
21_133	Venetian Canal South	28.48282	-81.35408
21_134	Venetian Canal South	28.48294	-81.35399
21_135	Venetian Canal North	28.48317	-81.35389
21_136	Venetian Canal North	28.4837	-81.35365
21_137	Venetian Canal North	28.48397	-81.35299
21_138	Venetian Canal North	28.48401	-81.35233
21_139	Hoffner Canal	28.48375	-81.35173
21_140	Hoffner Canal	28.48389	-81.35119
21_141	Hoffner Canal	28.4832	-81.35207
21_142	Hoffner Canal	28.4826	-81.35215
21_143	Hoffner Canal	28.48237	-81.35216
21_144	Montmart	28.482217	-81.349917
21_145	Montmart	28.482	-81.349433
21_146	Montmart	28.482383	-81.34915
21_147	Montmart	28.482683	-81.349117
21_148	Montmart	28.48305	-81.3493
21_149	Montmart	28.483417	-81.349483
21_152	Hoffner Canal	28.48444	-81.3495
21_153	Venice/Pershing	28.49805	-81.346783
21_154	Daetwyler Canal	28.45498	-81.34082
21_155	Daetwyler Canal	28.45473	-81.3402
21_156	Daetwyler Canal	28.45453	-81.33991
21_157	Daetwyler Canal	28.45435	-81.3394
21_158	Wind Song	28.490082	-81.365908
21_159	Wind Song	28.490053	-81.365391
21_160	Wind Song	28.489693	-81.36498
21_161	Nela Bridge	28.46357	-81.357094
21_162	Nela Bridge	28.463903	-81.357432
21_163	Nela Bridge	28.464195	-81.357713
21_164	Nela Bridge	28.464512	-81.358145
21_165	Lisa Waterway	28.486207	-81.371131
21_166	Lisa Waterway	28.486196	-81.371703
21_167	Backacre Canal	28.493823	-81.351726

Canal	Sample Points	Hard Bottom Elevation (ft)	Top of Muck Elevation (ft)	Muck Thickness (ft)	Navigability (%)	Water Elevation (ft)
Backacre Canal	61	78.69	81.17	2.48	92.69%	84.57
Backacre Canal	62	76.2	79.57	3.37	98.82%	84.57
Backacre Canal	63	76.05	78.97	2.92	99.09%	84.57
Backacre Canal	64	76.92	80.86	3.94	94.80%	84.57
Backacre Canal	65	79.99	80.52	0.53	98.43%	84.57
Backacre Canal	167	77.58	79.32	1.74	98.96%	84.57
Barby Canal	113	79.1	81.76	2.66	76.77%	84.76
Barby Canal	114	80	81.96	1.96	65.48%	84.76
Barby Canal	115	79.68	81.06	1.38	93.60%	84.76
Barby Canal	116	80.04	82.45	2.41	15.23%	84.76
Barby Canal	117	80.42	82.48	2.06	15.23%	84.76
Barby Canal	118	80.55	82.72	2.17	6.51%	84.76
Barby Canal	119	81.13	83.75	2.62	0.00%	84.76
Barby Canal	120	83.68	83.68	0	0.00%	84.76
Barby Canal	121	80.26	83.35	3.09	0.00%	84.76
Barby Canal	122	81.75	84.6	2.85	0.00%	84.76
Bayfront Canal	68	77.84	80.37	2.53	98.43%	84.57
Bayfront Canal	69	78.28	80.8	2.52	96.34%	84.57
Bayfront Canal	70	77.12	80.82	3.7	96.34%	84.57
Bayfront Canal	71	77.23	80.87	3.64	94.80%	84.57
Bayfront Canal	72	78.72	82.62	3.9	10.61%	84.57
Daetwyler Canal	154	79.41	79.41	0	98.87%	84.76
Daetwyler Canal	155	77.53	79.74	2.21	98.76%	84.76
Daetwyler Canal	156	77.48	80.7	3.22	97.94%	84.76
Daetwyler Canal	157	73.52	78.76	5.24	99.12%	84.76
Gatlin Canal	34	71.58	79.24	7.66	98.98%	84.57
Gatlin Canal	35	77.3	80.02	2.72	98.71%	84.57
Gatlin Canal	36	77.76	79.92	2.16	98.71%	84.57
Gatlin Canal	37	77.84	80.21	2.37	98.63%	84.57
Gatlin Canal	38	78.28	80.32	2.04	98.60%	84.57
Gatlin Canal	39	79.83	80.32	0.49	98.60%	84.57
Gatlin Canal	40	78.59	80.52	1.93	98.43%	84.57
Gatlin Canal	41	78.97	80.29	1.32	98.60%	84.57
Harbour Oaks Canal	49	78.87	81.07	2.2	93.60%	84.57
Harbour Oaks Canal	50	78.48	80.47	1.99	98.43%	84.57
Harbour Oaks Canal	51	78.13	79.7	1.57	98.76%	84.57
Harbour Oaks Canal	52	75.87	79.39	3.52	98.87%	84.57
Harbour Oaks Canal	53	75.38	79.89	4.51	98.71%	84.57
Hoffner Canal	20	65.54	73.31	7.77	100.00%	84.6
Hoffner Canal	21	79.7	80.19	0.49	98.63%	84.6
Hoffner Canal	22	79.8	80.14	0.34	98.68%	84.6
Hoffner Canal	23	66.86	72.44	5.58	100.00%	84.6
Hoffner Canal	24	79.12	79.39	0.27	98.87%	84.6
Hoffner Canal	25	66.48	72.74	6.26	100.00%	84.6
Hoffner Canal	26	65.66	73.14	7.48	100.00%	84.6
Hoffner Canal	27	78.59	80.29	1.7	98.60%	84.6
Hoffner Canal	28	80.38	80.59	0.21	98.30%	84.6
Hoffner Canal	29	75.62	80.09	4.47	98.68%	84.64
Hoffner Canal	30	73.09	77.19	4.1	100.00%	84.64
Hoffner Canal	31	66.57	74.74	8.17	100.00%	84.64
Hoffner Canal	32	76.29	77.79	1.5	100.00%	84.64
Hoffner Canal	33	76	78.19	2.19	100.00%	84.64
Hoffner Canal	139	75.54	76.64	1.1	100.00%	84.6
Hoffner Canal	140	62.85	74.79	11.94	100.00%	84.6
Hoffner Canal	141	66.17	72.69	6.52	100.00%	84.6
Hoffner Canal	142	78.71	80.66	1.95	97.94%	84.6
Hoffner Canal	143	67.64	74.74	7.1	100.00%	84.6
Hoffner Canal	152	80	80.97	0.97	93.98%	84.64
Landings Canal	92	80.64	81	0.36	93.98%	84.76
Landings Canal	93	78.3	81.1	2.8	93.60%	84.76
Landings Canal	94	79.25	81	1.75	93.98%	84.76
Landings Canal	95	74.43	79.55	5.12	98.82%	84.76
Landings Canal	96	76.64	78.05	1.41	100.00%	84.76
Landings Canal	97	75.11	77.05	1.94	100.00%	84.76
Landings Canal	98	75.01	78.05	3.04	100.00%	84.76
Landings Canal	99	77.28	78.95	1.67	99.09%	84.76
Landings Canal	100	76.39	78.1	1.71	100.00%	84.76
Landings Canal	101	78	79.35	1.35	98.87%	84.76
Landings Canal	102	78.09	80.22	2.13	98.63%	84.76
Landings Canal	103	77.37	78.82	1.45	99.12%	84.76
Landings Canal	104	76.04	78.95	2.91	99.09%	84.76
Landings Canal	105	77.25	78.92	1.67	99.12%	84.76
Landings Canal	106	78.25	79.28	1.03	98.96%	84.76
Landings Canal	107	73.21	78.6	5.39	100.00%	84.76
Landings Canal	108	76.67	78.45	1.78	100.00%	84.76
Lisa Waterway Canal	42	77.54	80.32	2.78	98.60%	84.57
Lisa Waterway Canal	43	77.85	81.12	3.27	93.60%	84.57
Lisa Waterway Canal	44	77.87	81.42	3.55	89.80%	84.57
Lisa Waterway Canal	45	78.67	81.32	2.65	91.81%	84.57
Lisa Waterway Canal	46	78.81	82.32	3.51	32.22%	84.57
Lisa Waterway Canal	47	77.4	82.96	5.56	0.25%	84.57
Lisa Waterway Canal	48	79.81	83.14	3.33	0.11%	84.57
Lisa Waterway Canal	165	81.31	83.07	1.76	0.11%	84.57
Lisa Waterway Canal	166	81.88	82.27	0.39	32.22%	84.57
Mandalay Canal	55	77.65	80.34	2.69	98.60%	84.57
Mandalay Canal	56	78.24	79.87	1.63	98.71%	84.57
Mandalay Canal	57	76.41	79.72	3.31	98.76%	84.57
Montmart Canal	144	68.82	70.07	1.25	100.00%	84.6
Montmart Canal	145	67.26	75.24	7.98	100.00%	84.6
Montmart Canal	146	67.64	74.47	6.83	100.00%	84.6
Montmart Canal	147	73	76.29	3.29	100.00%	84.6
Montmart Canal	148	66.36	74.99	8.63	100.00%	84.6
Montmart Canal	149	65.19	75.54	10.35	100.00%	84.6
Nela Bridge Canal	161	67.76	69.71	1.95	100.00%	84.76
Nela Bridge Canal	162	76.78	78.11	1.33	100.00%	84.76
Nela Bridge Canal	163	75.62	76.81	1.19	100.00%	84.76
Nela Bridge Canal	164	59.34	63.33	3.99	100.00%	84.76
Overlake Canal	75	76.45	79.77	3.32	98.71%	84.57
Overlake Canal	76	76.15	79.67	3.52	98.76%	84.57
Overlake Canal	77	76.24	79.42	3.18	98.87%	84.57
Overlake Canal	78	79.3	80.27	0.97	98.60%	84.57
Venetian Canal North	135	78.65	83.44	4.79	0.00%	84.6
Venetian Canal North	136	76.98	79.59	2.61	98.82%	84.6
Venetian Canal North	137	76.16	78.39	2.23	100.00%	84.6
Venetian Canal North	138	77.59	80.24	2.65	98.63%	84.6
Venetian Canal South	128	80.62	81.26	0.64	91.81%	84.6
Venetian Canal South	129	75.06	78.74	3.68	100.00%	84.6
Venetian Canal South	130	77.12	79.34	2.22	98.96%	84.6
Venetian Canal South	131	77.11	78.49	1.38	100.00%	84.6
Venetian Canal South	132	76.66	79.36	2.7	98.87%	84.6
Venetian Canal South	133	78	83.69	5.69	0.00%	84.6
Venice/Pershing Canal	66	77.61	77.99	0.38	100.00%	84.57
Venice/Pershing Canal	67	77.68	79.34	1.66	98.96%	84.57
Venice/Pershing Canal	73	78.99	79.37	0.38	98.87%	84.57
Venice/Pershing Canal	74	78.99	79.47	0.48	98.87%	84.57
Venice/Pershing Canal	79	78.4	79.57	1.17	98.82%	84.57
Venice/Pershing Canal	80	78.56	80.72	2.16	97.94%	84.57
Venice/Pershing Canal	81	77.5	80.77	3.27	96.34%	84.57
Venice/Pershing Canal	82	78.1	80.52	2.42	98.43%	84.57
Venice/Pershing Canal	83	78.34	79.04	0.7	99.09%	84.57
Venice/Pershing Canal	84	81.3	81.53	0.23	88.04%	84.57
Venice/Pershing Canal	85	79.31	80.37	1.06	98.43%	84.57
Venice/Pershing Canal	86	80.3	80.72	0.42	97.94%	84.57
Venice/Pershing Canal	87	79.61	80.17	0.56	98.63%	84.57
Venice/Pershing Canal	153	78.29	81.41	3.12	89.80%	84.57
Waterfront Canal	88	79.16	80.97	1.81	93.98%	84.57
Waterfront Canal	89	78.37	80.72	2.35	97.94%	84.57
Waterfront Canal	90	77.8	80.72	2.92	97.94%	84.57
Waterfront Canal	91	76.18	79.77	3.59	98.71%	84.57
Willoughby Canal	109	78.72	80.61	1.89	98.30%	84.76
Willoughby Canal	110	77.96	80.96	3	93.98%	84.76
Willoughby Canal	111	78.13	80.66	2.53	97.94%	84.76
Willoughby Canal	112	78.52	80.76	2.24	96.34%	84.76
Willoughby Canal	123	77.8	80.56	2.76	98.30%	84.76
Willoughby Canal	124	78.15	80.5	2.35	98.43%	84.76
Willoughby Canal	125	79.39	80.68	1.29	97.94%	84.76
Willoughby Canal	126	78.86	81.15	2.29	92.69%	84.76
Willoughby Canal	127	80.35	82.65	2.3	6.51%	84.76
Wind Song Canal	158	81.83	82.84	1.01	2.75%	84.57
Wind Song Canal	159	78.62	81.59	2.97	86.37%	84.57
Wind Song Canal	160	76.93	81.99	5.06	65.48%	84.57

Sources:
DEM generated from topographic data provided by Orange County, 2009.
Aerial: Orange County, 2014
Roads: Orange County, 2015

Sampling Locations Navigability Results

Lake Conway Canal Siltation Study

Geosyntec consultants

Orange County Government Florida

Exhibit 2

APPENDIX A
2010 Study by TEC Engineering, Inc.

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Lake Conway 2010 Canal Siltation Study

(Including All Canals)

Publication Date: September, 13, 2011

Prepared for:

Orange County Lake Conway Water and Navigation Control District Advisory Board
Orange County Environmental Protection Division
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Lake Conway 2010 Canal Siltation Study (Including All Canals)

Summary

A baseline study, "**Lake Conway Canal Mud Removal Baseline Study**" was performed in 2005 to establish baseline data for future studies to determine the rate of siltation of the canals of the Lake Conway chain. In May 2010 the "**Lake Conway 2010 Canal Siltation Study**" reported updated readings from the Barby, Landings, and Willoughby Canals. In December 2010 the "**Lake Conway 2010 Canal Siltation Study**" was updated to include readings from the Backacre, Bayfront, Hoffner, Montmart, Overlake, Venice, and Waterfront Canals to estimate the amount and rate of siltation in these canals over the past 5 years. This report completes the study by including Gatlin, Lisa, Harbor Oaks, Mandalay, Venetian, and Daetwyler canals. Since 2005 two canals (Venetian and Lisa) have been de-mucked. Excluding these the results show siltation has occurred. On the average the bottom elevation has raised 0.28 feet. The result is an average reduction in the navigability (using the 2010 30 Year Lake Stage profile) from 83% to 80%.

To evaluate the need for maintenance, a canal rating system was developed which divides the current average depth of the canal less the navigability depth by its rate of siltation to yield an approximate number of years until the 20% navigability point is reached. Negative numbers indicate the depth of the canal has improved. Large positive numbers indicate there has been little decrease in depth. These ratings were between -74 and 1161 years with an average of 197 years (including de-mucked canals). This means the canals are in fairly good shape. The Barby and Wiloughby Canals are in poor shape with ratings of 35 and 23 years, respectively.

Data Collection

In the 2005 study bottom depth and mud depth measurements were mechanically obtained at 125 locations near the centerline of the Conway canals at approximately 200' intervals. The nature of the data collection method necessarily misses some deep areas and shallow areas. It was observed that there are many fluctuations in the canal depth that did not show up in this data for some canals (particularly Hoffner).

The results were tabulated and compiled on a base map from the County GIS system to aid in the visual relocation of the probe locations. To assist in relocating points at some distance from shore navigational level GPS (with WAAS enhancement) coordinates were obtained for all probe locations. The results were compared to the 2010 - 30 Year Lake Stage data to assess the navigability at each location. This project returns to those data points in the remaining canals to sample the data again for the purpose of determining the changes which have occurred. Daetwyler Lagoon baseline data was added with this survey.

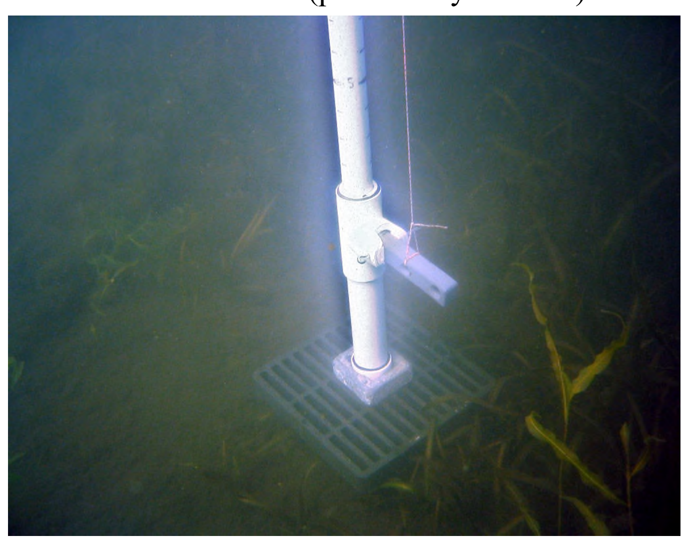

Figure 1 Depth Probe with Mud Plate

The depth information was collected at each probe location using mechanical means to eliminate interference experienced by digital depth indicators. The sand probe was a 20' long 1" diameter capped PVC pipe calibrated in 0.1' intervals. To reach the theoretical sand bottom it was pushed down into the bottom until it stopped with approximately 20 pounds force. The mud probe was a 9" square plastic grate weighted to have approximately 2 pounds of negative buoyancy when submerged resulting in a contact pressure of 0.025 pounds per square inch. It was found this was sufficient to push through the aquatic growth but would only penetrate the mud surface about 1/2 inch. The mud pad was arranged to freely slide over the sand probe with its gauge measuring indicator one foot above the mud pad. Therefore, each mud pad reading was reduced by 1 foot to obtain the actual mud thickness. A cam lever operated by a lifting line would lock the mud pad to the sand probe for extraction and reading (Figure 1). Due to the awkwardness of this arrangement the entire mechanism was supported by a 10' high 2" diameter PVC mast arranged vertically on the study boat (Figure 2).

Within canals, probes were taken when aligned with property lines and as near as practical to the middle of the canal. Comments in the data tables indicate which property lines were used. When no location comment was present the GPS coordinate and visual location on the map was used to re-locate the point. To further improve future probe re-locations, at least two annotated digital images were taken of the surrounding area from each probe location. These images are provided with this report on CD.

It was found that over time a fixed location could be reported by the GPS receiver anywhere within a 40' diameter circle. This equates to a tolerance of +/- 20'. To reduce the relative imprecision of the navigational GPS readings, they were taken as an average of at least 10 readings over about as many seconds, plotted on the drawing, adjusted to better fit the map and recalculated for display in the tables. The averaging of the readings does not actually resolve the coordinate shift but it does reduce the possibility of a seriously stray reading. The resulting coordinates appear to be at a tolerance of +/- 10' when combined with visual location on the water. Improved relocation precision is anticipated for the 2015 survey since two photographs have been taken for each probe location in this survey.

Figure 2 Study Boat with Probe Support

All data was collected in the calmest conditions practical. Each reading was taken as a depth from the water surface. The water surface elevation was determined from reading the attenuated lake gauge located at 3042 Hoffner Road. This gauge has been calibrated to correspond with benchmark L-1058-005 (elev. 92.22) located on the west headwall of the Lake Conway Discharge at Daetwyler Road. On 3/22/2010 it was determined this benchmark may have settled about 0.05’ due to erosion of the headwall foundation. From this date forward, OC benchmark L-1058-006 (elev. 92.287, NGVD 29) located on the east headwall of the Lake Conway Discharge at Daetwyler Road will be used. Elevations take this adjustment into account.

Data Tables

Data Tables 1 and 3 are summaries of the data contained in the Excel spreadsheets on the included CD. The following information is provided within the data tables:

Point - The point number of the probe location which should be used to correlate the table data to the maps.

GPS – The waypoint number placed on the GPS to record the present location and time of probe.

Depth - The depth from the water surface to the hard bottom (bottom of mud).

Raw Mud - The physical rod reading taken at the top of the mud. This number is 1 foot greater than the actual mud thickness.

Mud - The actual mud thickness above the bottom elevation

Comments - Information peculiar to the data point including physical conditions and location reference information.

Elevation - The calculated hard bottom elevation based on the water surface elevation on the data collection date.

Canal - The name of the canal system where the point is located.

Time – The time of the probe. This is used to coordinate the probe locations with the digital images.

Latitude - The adjusted GPS Latitude in decimal degrees (see discussion above).

Longitude - The adjusted GPS Longitude in decimal degrees (see discussion above).

Navigability - This represents the percentage of time this location is likely to have a Minimum Safe Navigational Depth (MSND) of 3 feet of water above the top of the mud for the purpose of navigating a boat. Using the 2010 - 30 Year Lake Stage data as the basis for comparison the expected usability of each location for navigation was determined. For example 100% indicates it is expected there will always be at least 3' of water above the mud at this location. A value of 33% would indicate that in the past 30 years there were 10 years with at least 3 feet of water above the top of the mud as it is today. More specific information is given in Discussion below.

Map Sheets 2 – 9 show the adjusted locations of the probes on County GIS maps. Each probe location shows the point number (top number), the 2010 hard bottom elevation (descending the list), mud thickness above the hard bottom elevation, the change in bottom elevation from 2005, and change in mud thickness from 2005. Daetwyler Lagoon data only contains the first three data types since no 2005 data exists. These maps should be used whenever reestablishing these probe locations for future studies.

The accompanying CD also contains images taken from each probe location. They were taken to assist in relocating the probe location for the next survey. They also serve to give a visual indication of the conditions in the canals. Each image is labeled with the point number, date, and water surface elevation. The file names are structured in this format:

PPP YYYYMMDD SS CCCC.jpg

Where:
PPP = Probe Number
YYYY = Year number (ie. 2010)

MM = Month number
DD = Day of month number
SS = Series number (the order in which the images were taken on that day)
CCCC = Canal name (variable length)

The images are in directories organized by the date of the survey. Other files in the directories include Orange County GIS aerial images of the canals.

Discussion

2005

The original 2005 project resulted in 125 data points. It was found the median top of mud elevation was 80.16 which equates to a navigability of 79%. 35 points had a top of mud elevation below 81.0 meaning that 72% of the areas are considered navigable 80% of the time. Only 3 probe locations were not navigable at any lake stage. **Table 1, 2005 Canal Summary Data,** contains summary data for all canals in 2005. The canals are organized according to those which are either connected or adjacent to each other. The horizontal dividing lines illustrate which canals can be found on the same sheet of the point maps.

Key to the analysis is the Navigability which is based on Lake Stage as shown in **Table 2, Lake Conway Lake Stage 1981 - 2010**. The derivation of Lake Stage was done in the TEC Engineering 2001 report "Lake Conway Water Level Analysis as Related to Recreational Use." Lake Stage illustrates the percentage of months the water level is below a particular level over the course of a 30 year period. Navigability is essentially the inverse of the Lake Stage. Navigability is concerned with the percentage of months the water is above the elevation, and Lake Stage is concerned with the number of months the water is below the elevation. In tables 1 and 3 Navigability above 20% is shown in green and below 20% is shown in yellow.

Navigability (Figure 3) is related to the bottom elevation and assumes a Minimum Safe Navigational Depth (MSND) of 3 feet to safely operate a boat. A Navigability of 10% occurs at a bottom elevation of 83.65 (water surface elevation 86.65) and is the same as a Lake Stage of 90% which occurs at a water surface elevation 86.65. With the lake 90% full (Lake Stage) and a bottom elevation just 3 feet below that surface, at 83.65, it would only be possible to navigate for the 10% (Navigability) of the time the lake is above that elevation. A key element in Navigability is the MSND which for this study has been chosen to be 3 feet. The Navigability is found by adding the MSND of 3 feet to the top of mud elevation for a point, looking up the corresponding Lake Stage in

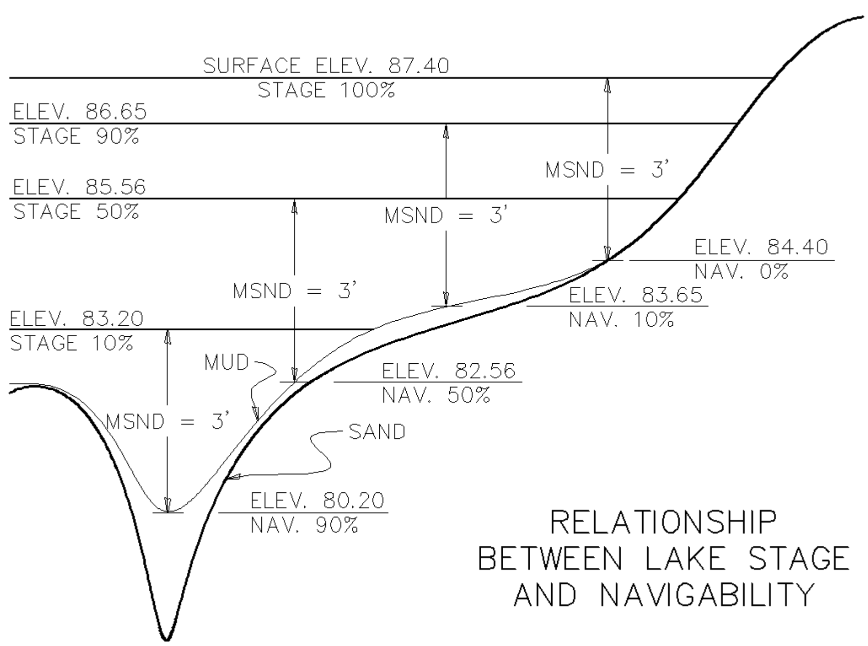

Figure 3

Table 2 then subtracting it from 100%.

Navigability = 100% - Lake Stage of (Mud Elevation + MSND)

Table 1 is broken into three groups: Average, Maximum, and Minimum. The Average section shows the average for all the points within each canal. The average Navigability does not match the Navigability as calculated above of the average Top of Mud since average Navigability is the average of the Navigabilities of each probe location in the canal. Since Navigability is not a linear function of elevation the individual average will not match the group average. This average Navigability does not truly represent the access to the canal. It is simply used to give an indication of the quality of the canal as a whole. It was found that there is often a shallow restriction near the entrance of each canal. This would, of course, prevent access to the deeper parts of the canal in a low water situation. Conversely some canals have very shallow terminal ends which will also skew the overall result for the canal.

The Maximum section shows the highest bottom point elevation, thickest mud, and highest top of mud elevation for each canal. You may note the bottom elevations and mud thicknesses do not add up. It is rare that the thickest mud is at the highest bottom elevation. Mud usually accumulates in the low points (as shown in Figure 3) while it is usually cleared from the high points by boat movement. Here the Navigability is directly related to the associated elevation. This is because each is a single number rather than a composite of many. The minimum elevation is related to the maximum Navigability which explains why the largest Navigability is shown in the minimum row.

The Minimum section shows the lowest bottom point elevations and least mud thicknesses. The data relationships are similar to how they were described in the previous paragraph.

A summary of the average state of the canals in 2005 and 2010 is shown visually in Figures 4 and 5 respectively. These show the average bottom elevation of each canal with the average mud thickness stacked on top. Here the Navigability (read off the right hand scale) is an average of the Navigability of each probe location in the canal. These are the best charts to quickly compare the condition of each canal.

The highest canal elevations and thickest mud for each canal in both 2005 and 2010 is illustrated in Figures 6 and 7 respectively. These charts are a reasonable second check for potential restricted points in the canals. The sand bars illustrate the highest hard bottom in the canals. The mud bar on top of them illustrates the thickest mud in each canal. The top of the mud bar does not represent a real elevation in the canal since the thickest mud usually occurs in the deeper parts of the canal while the thinnest mud usually occurs at the shallowest locations (shown in this chart). The Navigability for this chart was determined from the actual shallowest mud elevation. For the most part the shallow areas occur at either the entrance or the end of the canals.

The lowest canal elevations and thinnest mud for each canal in 2005 and 2010 is illustrated in Figures 8 and 9 respectively. These charts show the elevation of the deepest holes in each canal. The Navigability shown here is for these deep locations only. To see the true relationship of the mud and bottom elevation at each probe location use the Canal Profiles described in the next section.

Canal Profiles

To get a good understanding of the true navigability of the canals it is best to look at the individual profiles of the canal bottom. To the right is a listing of the Canals, the Dates of data collection, the Map Sheets on which they are shown, and the Figure numbers where you may see each profile. The bottom of each chart shows the probe location number which can be found on the Map Sheet as referenced below the figure title. The probe point numbers are arranged so the lowest point number (left end of chart) is at the entrance to the canal and the highest point number is at the closed end of the canal. Exceptions to this rule are Hoffner, Montmart, and Venetian canals which have an entrance at each end.

Canal Profile Figure Listing

Canal	Date		Map Sheet	Figure
	Original	Re-visit		
Gatlin	5/12/2005	8/23/2011	2	11
Harbour Oaks	5/12/2005	8/23/2011	2	12
Lisa	5/12/2005	8/23/2011	2	13
Mandalay	5/12/2005	8/23/2011	2	14
Backacre	5/12/2005	11/10/10	3	15
Bayfront	5/12/2005	11/10/10	3	16
Overlake	5/12/2005	11/10/10	3	17
Venice	5/12/2005	11/10/10	4	18
Waterfront	5/12/2005	11/10/10	4	19
Hoffner	5/12/2005	11/9/10	6, 5	20
Montmart	6/8/2005	11/9/10	6	21
Venetian	6/8/2005	8/17/2011	6	22
Landings	5/23/2005	3/31/2010	7	23
Barby	5/23/2005	3/31/2010	8	24
Willoughby	5/23/2005	3/31/2010	8	25
Daetwyler	N/A	8/23/2011	9	26

The figures show the sand elevation, top of mud elevation, and Navigability for each probe location on each canal. Heavier lines show the same data for the re-visited probe locations. All of these charts are set up with the same vertical scale making visual comparison possible. With some of the larger canals, such as Hoffner, Landings, and Venetian, the probe locations are not entirely in order of the line of natural travel. Some points were interspersed from lobes to avoid the necessity of additional charts with few data points. Using the map sheets as a reference one can connect the points of interest on the charts to get an approximate profile. Remember, these probes only represent depths a particular locations and do not show all of the variations in canal depths.

In 2005 the median mud thickness was 1.06 feet, and only 10 readings showed mud thicknesses greater than 2.8 feet. None of these occur at a bottom elevation that would have restricted navigation at any expected water level. In general, greater mud depths occur in greater water depths and consequently have no effect on the navigability of the water body.

In 2005 the Lisa, Harbour Oaks, Mandaly Shores, and Waterfront canals were very heavy in weed growth even though the mud depths were not extraordinary.

2010

The 2010 data was actually collected over a period of time from March 2010 to August 2011. Table 3, 2010 Canal Summary Data, contains the summary data. It shows the average, maximum and minimum elevation data for each canal. These data items are as described earlier for Table 1. Additionally, the absolute change in these parameters and the annual rate of change is also reported. A summary chart of the absolute change can be found in Figure 10. The annual rate of change was derived by dividing the absolute change by the number of years between the readings.

The rate of change in Navigability is not directly proportional to the rate of change of top of mud elevation. Navigability is a statistical number based on 30 years of lake elevation data and its rate of change depends on what absolute elevation is being considered. Elevation differences at either end of the Navigability scale will result in small changes in the actual Navigability. In the center of the scale a small elevation change will have a greater effect. On this basis it is not possible to predict future navigability simply by multiplying the Navigability rate of change by a number of years. The proper way to predict a future Navigability is to multiply the rate of change of top of mud by the number of years of interest then add that to the original top of mud elevation. With that new elevation use Table 2 to find the Lake Stage and use the Navigability formula on page 5 to find the new Navigability value.

The Nav. Rating was developed to create a single number which assesses the long term quality of the canal based on Navigability and rate of degradation. It is shown as the right-most column in Table 3. This value represents the expected number of years it will take for the canal to silt in (based on the current annual rate of siltation) to the point that it will have a Navigability of 20% (Min. Normal Navigation Elevation).

Nav. Rating = (Top of Mud Elevation – Min. Normal Navigation Elevation)/Annual Siltation Rate

This means a canal with a Nav. Rating of zero (0) years would already be silted in to the point where the top of the mud is at an elevation of 83.35 (based on the 2010 Lake Stage of 80%). This is where the mud is at a level 3 feet (MSND) below the water surface when the lake is at a level of 86.35. Given the lake water surface elevation of 85.74 (as it was at on 11/10/2010 during this study) a canal in this same condition would not be considered passable since the water depth would only be 2.39 feet.

The Nav. Ratings of the 16 canals tested varied widely from -74 years for Venice to 1161 years for Gatlin with an average rating of 197 years. Venice Canal's negative Nav. Rating indicates the canal is actually getting deeper. This is understandable since it was de-mucked in 2009 resulting in the lower bottom elevations and improved navigability. Unfortunately, no data was collected immediately prior to the de-mucking so it is not possible to determine the actual siltation rate of that canal. Backacre's unusually high Nav. Rating is a result of virtually no change in average top of mud elevation. Barbie and Willoughby canals have low Nav. Ratings since they are relatively shallow and have relatively high siltation rates.

It was found the GPS positions were not nearly as reliable as visual alignment with property lines. Over all the average accuracy of the positions was about four feet by four feet. However, the variance was as much as 50 feet. On that basis visual orientation is considered the more reliable method. The GPS points were a second check to avoid blunders such as alignment with the wrong property line. Most of the GPS "error" can be attributed to satellite timing variances intentionally entered into the public GPS signals at the system level. These effectively make it impossible to reacquire an exact point without extremely long observation times or a differential GPS system using a known base point. In the future the use of photographic alignment evidence will make re-acquisition of the probe locations more consistent. Based on the narrowness of the canals and the usage of property lines as alignment points it is estimated the points were re-acquired to within less than 3 feet along the axis of the canal and about 5 feet laterally in the canal.

The imprecision of the re-acquired points could lead one to conclude the data is not reliable. The fact that some probe points showed a deeper bottom reading supports this. However, the average difference of all bottom elevation points for 2005 and 2010 is 0.28 feet indicating an overall reasonable correlation. Since the objective is simply to get a handle on the siltation rate it is not necessary to have absolute accuracy in the locations. With sufficient data points the errors of location average out. Also photo records of each probe location transmitted with this report will improve the locational accuracy of future studies.

Specific Probe Issues

Anomalies in some of the data points indicate possible probe location errors. These are listed according to the canal order used for the profiles.

Lisa – Probes 42-45 – This area was not dredged in 2010 but appears to have had substantial siltation.
Lisa – Probes 45-48 – This area was dredged in 2010.
Lisa – Probe 48 – This location does not have any associated location photos.
Venice – Probes 79-82 – This canal was de-mucked in 2009.
Venice – Probes 153 – This is a new probe location created in 2010.
Waterfront – Probe 90 – This is a new probe location created in 2010.
Hoffner – Probe 152 – This is a new probe location created in 2010. It is directly under the Hoffner Bridge.
Montmart – Probes 144-149 – This canal is fairly wide with an irregular bottom created by dredging when the subdivision was built. It is suspected most of the variation in elevations was due to error of location. This is the deepest canal in the system and is 100% navigable.
Venetian – Probes 129-137 – This canal was dredged in 2009.
Venetian – Probe 134 – This is only 8’ from the headwall at the end of the canal.
Venetian – Probe 139 – This is apparently a poor replication of the 2005 location. 2011 photographs should make it easier to relocate in 2015.
Venetian – Probe 140 – This was relocated to a more meaningful and easier to relocate location in 2011.
Landings – Probes 99, 104-106 – These are probably poorly relocated in 2010. Photographic information should improve location in 2015.
Barby – Probe 110 – This area appears to have been scoured by propeller wash during a period of low water (2007) between measurements. This canal is in the poorest overall condition of those surveyed.

Conclusion

In general it was found the mud levels in the canals were an average of 0.93’ which is less than the 2005 average of 1.01’ for the same canals in 2005. Since the thicker mud was found in the deeper sections this number somewhat overstates the mud in the shallower reaches of the canals. The average siltation rate was found to be about 0.04’ (or ½”) per year for sand and -0.01’ (or 1/8”) per year for the mud. This effectively results in the top of mud rising 0.03’ per year. This indicates the mud is not really the issue but it is the sand being washed in from the canal sides.

The only canals which improved in the last 5 years are those which have been de-mucked or dredged. The others have, on the average, decreased their navigability by only 2.3%. The de-mucked canals have navigability which has improved by 25% for Lisa, 3% for Venice, and 19% for Venetian. Gatlin canal is virtually unchanged. The canals in the poorest condition are Barby and Willoughby.

It is known deeper canals allow water to pass more slowly around boats traveling in them. Slower moving water decreases the scour rate and reduces the rate of erosion of the canal side walls. As a consequence, slow travel speed in canals will serve to extend the canals’ serviceable life.

Recommendations

1. It is recommended that this study be repeated every five years to provide a consistent gauge of quality of the canals.

2. It is recommended two digital photographs be taken from each probe location in future studies to document the visual state of the canals and more precisely define the probe point. To maintain consistency these images should be 1600x1200 pixel resolution and be taken from the probe location toward aligning landmarks at approximately 90° to each other in a clockwise order. Each photo should be clearly marked with the probe number, date, and water surface elevation.

3. In the event of a canal cleaning or de-mucking it is recommended supplementary data is collected within a year both before and after the cleaning to provide siltation rate data and new baseline data for that canal.

4. Boaters should travel at minimum speed in canals to reduce the rate of sidewall erosion.

5. Property owners can slow the rate of canal degradation by keeping yard debris out of the canals.

6. In order to maintain consistency in analysis and decision making it is recommended the Orange County Lake Conway Water and Navigation Control District Advisory Board (Nav. Board) consider the ramifications of the base values which lead to the indicators used in this report. The key base values are:

    a. Minimum Safe Navigational Depth (MSND) – This is the minimum distance from the surface to the bottom of a body of water necessary to allow navigation of most watercraft without endangering people or wildlife and without causing damage to either the vessel or habitat. This could be broken down further to MSNDs for various vessel speeds. It is recommended this be established at a depth of between 3.0 and 3.5 feet.

    b. Normal Minimum Navigability% - This is the percentage of time it would be expected over the course of 30 years that it would not be possible to operate a vessel with at least the Minimum Safe Navigational Depth. This value needs to be established as a balance between the cost of maintaining the MSND compared to the inconvenience of the vessel operators. It is not possible to set this at 100% as it would necessitate dredging and installation of new seawalls in many of the canals at a cost far in excess of the tax revenue available. It is recommended this value be set between 20% and 30%.

7. The Orange County Lake Conway Water and Navigation Control District Advisory Board should consider the use of Nav. Ratings as described in this document as a method of determining which canals may be in need of maintenance.

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Tables

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Table 1, 2005 Canal Summary Data

2005 Canal Summary Data

	Average				Maximum				Minimum			
Canal	Bottom Elev.	Mud Thick.	Top Mud	Nav.	Bottom Elev.	Mud Thick.	Top Mud	Nav.	Bottom Elev.	Mud Thick.	Top Mud	Nav.
Gatlin	79.55	1.2	80.75	84%	80.96	5.6	81.06	80%	74.56	0.1	80.16	91%
Harbour Oaks	78.92	1.4	80.36	89%	80.06	3.0	80.76	84%	77.06	0.7	79.96	93%
Lisa	81.06	1.6	82.62	45%	84.56	2.6	85.06	0%	78.06	0.2	80.66	85%
Mandalay	79.19	1.3	80.46	87%	80.26	2.1	81.16	78%	77.56	0.3	79.66	97%
Backacre	79.72	1.2	80.96	80%	81.36	2.0	81.86	66%	78.46	0.1	80.16	91%
Overlake	79.53	0.6	80.16	91%	80.16	1.6	80.46	88%	78.66	0.3	79.56	97%
Venice	80.14	0.6	80.69	84%	80.46	0.7	80.96	81%	79.66	0.5	80.16	91%
Waterfront	80.56	0.5	81.01	79%	82.16	0.9	82.16	59%	79.26	0.0	79.66	97%
Hoffner	76.27	1.2	77.45	92%	81.26	3.7	81.26	78%	68.06	0.0	71.46	100%
Montmart	72.74	2.4	75.12	100%	77.09	4.2	77.29	100%	68.79	0.2	70.79	100%
Venetian	79.39	1.2	80.55	67%	82.79	5.7	83.39	22%	68.56	0.0	72.89	100%
Landings	78.40	1.0	79.42	93%	81.67	2.9	81.77	68%	75.57	0.1	77.37	100%
Barby	81.33	0.9	82.27	54%	82.72	3.9	84.41	0%	77.92	0.0	80.92	81%
Willoughby	81.22	0.3	81.48	71%	82.02	0.8	82.12	59%	80.12	0.0	80.92	81%
Ave.	79.14	1.1	80.24	80%	81.25	2.8	81.69	62%	75.88	0.2	78.17	93%
Max.	81.33	2.4	82.62	45%	84.56	5.7	85.06	0%	80.12	0.7	80.92	81%
Min.	72.74	0.3	75.12	100%	77.09	0.7	77.29	100%	68.06	0.0	70.79	100%

Canals are arranged by display sheet
Navigatibility is based on 1979 - 2010 Lake Stage criteria.

Color Legend
- Acceptable
- Unacceptable

Table 2, Lake Conway Lake Stage 1981 - 2010

Elev.	Stage	Elev.	Stage	Elev.	Stage	Elev.	Stage
		83.0	7.22%	85.0	38.33%	87.0	98.61%
		83.1	9.44%	85.1	40.56%	87.1	98.61%
81.2	0.00%	83.2	10.00%	85.2	42.50%	87.2	99.44%
81.3	0.28%	83.3	11.67%	85.3	44.72%	87.3	99.72%
81.4	0.56%	83.4	12.22%	85.4	46.39%	87.4	100.00%
81.5	0.56%	83.5	14.17%	85.5	48.06%		
81.6	1.11%	83.6	15.00%	85.6	51.11%		
81.7	1.39%	83.7	16.39%	85.7	54.44%		
81.8	1.67%	83.8	17.78%	85.8	58.89%		
81.9	1.67%	83.9	19.17%	85.9	62.22%		
82.0	1.67%	84.0	19.72%	86.0	65.83%		
82.1	1.67%	84.1	21.67%	86.1	68.89%		
82.2	1.94%	84.2	22.22%	86.2	72.50%		
82.3	1.94%	84.3	24.72%	86.3	77.78%		
82.4	1.94%	84.4	26.67%	86.4	81.94%		
82.5	2.78%	84.5	28.06%	86.5	85.28%		
82.6	3.06%	84.6	31.67%	86.6	88.61%		
82.7	3.61%	84.7	32.50%	86.7	91.67%		
82.8	5.00%	84.8	33.89%	86.8	94.72%		
82.9	6.67%	84.9	35.83%	86.9	98.06%		

The percentages shown are the percent of time during the referenced 30 years where water surface was below the specified elevation.
The range in green represents "normal" water levels.
The Orange County Normal High Water is shown in dark pink.
The nominal weir elevation is 86.4.

Table 3, 2010 Canal Summary Data

Canal	Absolute				Change				Annual Rate of Change				Rating
	Bottom Elev.	Mud Thick.	Top Mud	Nav.	Elev.	Mud	Top Mud	Nav.	Elev.	Mud	Top Mud	Nav.	
Average													
Gatlin	80.12	0.7	80.77	83%	0.57	-0.55	0.02	-1%	0.09	-0.09	0.00	-0.1%	1161
Harbour Oaks	79.34	1.4	80.76	83%	0.42	-0.02	0.40	-6%	0.07	0.00	0.06	-1.0%	50.87
Lisa	80.70	0.9	81.60	70%	-0.36	-0.66	-1.02	25%	-0.06	-0.10	-0.16	3.9%	-14.8
Mandalay	79.51	1.0	80.51	86%	0.31	-0.27	0.05	-1%	0.05	-0.04	0.01	-0.1%	470.1
Backacre	80.08	0.9	81.00	80%	0.36	-0.32	0.04	0%	0.07	-0.06	0.01	-0.1%	412
Overlake	79.44	0.9	80.36	88%	-0.09	0.28	0.20	-3%	-0.02	0.05	0.04	-0.5%	102
Venice	79.92	0.4	80.36	88%	-0.15	-0.13	-0.27	3%	-0.03	-0.02	-0.05	0.6%	-74
Waterfront	80.61	0.5	81.11	78%	0.05	0.04	0.09	-2%	0.01	0.01	0.02	-0.3%	172
Hoffner	76.68	1.1	77.82	91%	0.08	0.04	0.12	0%	0.01	0.01	0.02	0.0%	281
Montmart	73.76	1.9	75.68	100%	1.02	-0.47	0.55	0%	0.19	-0.09	0.10	0.0%	82
Venetian	78.06	1.2	79.21	85%	-1.34	0.00	-1.34	19%	-0.22	0.00	-0.22	3.0%	-22.14
Landings	78.88	0.80	79.68	92%	0.49	-0.22	0.26	-2%	0.10	-0.05	0.05	-0.4%	79
Barby	81.43	1.04	82.48	49%	0.10	0.11	0.21	-5%	0.02	0.02	0.04	-1.1%	35
Willoughby	81.44	0.48	81.92	64%	0.22	0.22	0.44	-8%	0.05	0.05	0.09	-1.6%	23
Daetwyler	79.37	1.00	80.37	88%									
Ave.	79.29	0.95	80.24	82%	0.12	-0.14	-0.02	1%	0.02	-0.02	0.00	0.2%	197
Max.	81.44	1.92	82.48	49%	1.02	0.28	0.55	-8%	0.19	0.05	0.10	-1.6%	1161
Min.	73.76	0.44	75.68	100%	-1.34	-0.66	-1.34	25%	-0.22	-0.10	-0.22	3.9%	-74
Maximum													
Gatlin	81.14	3.0	81.14	78%	2.58	0.20	0.28	5%	0.41	0.03	0.04	0.8%	
Harbour Oaks	80.24	1.8	81.64	68%	1.28	0.70	0.88	2%	0.20	0.11	0.14	0.4%	
Lisa	81.94	1.5	82.44	54%	2.38	1.00	1.28	66%	0.38	0.16	0.20	10.5%	
Mandalay	80.44	1.8	80.84	82%	0.48	0.10	0.28	4%	0.08	0.02	0.04	0.6%	
Backacre	81.54	2.0	81.84	66%	0.88	0.20	0.38	12%	0.16	0.04	0.07	2.2%	
Overlake	80.24	2.4	80.74	84%	0.38	0.80	0.58	1%	0.07	0.15	0.11	0.2%	
Venice	80.34	0.8	80.94	81%	0.08	0.30	0.38	10%	0.01	0.05	0.07	1.8%	
Waterfront	82.04	1.4	82.14	59%	1.08	1.10	0.68	9%	0.20	0.20	0.12	1.7%	
Hoffner	81.34	3.9	81.34	75%	2.48	0.50	1.78	3%	0.45	0.09	0.32	0.5%	
Montmart	77.86	3.0	77.96	100%	5.67	2.70	1.67	0%	1.05	0.50	0.31	0.0%	
Venetian	82.10	3.9	83.10	31%	4.21	3.20	4.81	57%	0.68	0.52	0.78	9.2%	
Landings	81.72	2.6	81.77	68%	1.95	0.60	0.95	7%	0.40	0.12	0.20	1.4%	
Barby	82.72	2.3	84.32	0%	1.00	1.70	1.40	18%	0.21	0.35	0.29	3.6%	
Willoughby	82.52	0.8	82.62	49%	0.80	0.60	0.80	-2%	0.17	0.12	0.17	-0.5%	
Daetwyler	81.44	2.4	81.44	73%									
Ave.	81.17	2.2	81.62	65%	1.80	0.98	1.15	14%	0.32	0.18	0.20	2.3%	
Max.	82.72	3.9	84.32	0%	5.67	3.20	4.81	-2%	1.05	0.52	0.78	-0.5%	
Min.	77.86	0.8	77.96	100%	0.08	0.10	0.28	66%	0.01	0.02	0.04	10.5%	
Minimum													
Gatlin	77.14	0.0	80.14	91%	-0.32	-2.60	-0.42	-4%	-0.05	-0.41	-0.07	-0.7%	
Harbour Oaks	78.04	0.7	79.84	95%	-0.22	-1.20	-0.22	-15%	-0.04	-0.19	-0.04	-2.4%	
Lisa	80.14	0.5	80.74	84%	-3.92	-2.00	-2.92	-23%	-0.62	-0.32	-0.46	-3.6%	
Mandalay	78.04	0.4	79.84	95%	0.18	-0.60	-0.32	-4%	0.03	-0.10	-0.05	-0.6%	
Backacre	78.64	0.3	80.24	90%	0.18	-0.90	-0.72	-7%	0.03	-0.16	-0.13	-1.3%	
Overlake	77.94	0.2	79.44	98%	-0.82	-0.10	-0.12	-7%	-0.15	-0.02	-0.02	-1.3%	
Venice	79.64	0.0	79.94	93%	-0.42	-0.70	-0.82	-5%	-0.08	-0.13	-0.15	-0.9%	
Waterfront	79.14	0.1	79.54	97%	-1.52	-0.40	-0.42	-13%	-0.28	-0.07	-0.08	-2.3%	
Hoffner	67.65	0.0	71.55	100%	-2.10	-0.80	-1.70	-3%	-0.38	-0.15	-0.31	-0.6%	
Montmart	69.46	0.1	71.66	100%	-4.33	-4.10	-1.63	0%	-0.80	-0.76	-0.30	0.0%	
Venetian	70.10	0.0	74.00	100%	-11.49	-2.90	-8.29	-21%	-1.86	-0.47	-1.34	-3.4%	
Landings	75.82	0.1	77.72	100%	-0.45	-1.90	-0.45	-13%	-0.09	-0.39	-0.09	-2.6%	
Barby	78.42	0.1	80.72	84%	-0.69	-1.60	-1.10	-27%	-0.14	-0.33	-0.23	-5.6%	
Willoughby	80.92	0.1	81.52	72%	-0.10	0.00	0.20	-13%	-0.02	0.00	0.04	-2.8%	
Daetwyler	77.64	0.0	79.94	93%									
Ave.	76.51	0.2	78.35	93%	-1.86	-1.41	-1.35	-11%	-0.32	-0.25	-0.23	-2.0%	
Max.	80.92	0.7	81.52	72%	0.18	0.00	0.20	-27%	0.03	0.00	0.04	-5.6%	
Min.	67.65	0.0	71.55	100%	-11.49	-4.10	-8.29	0%	-1.86	-0.76	-1.34	0.0%	

Canals are arranged by display sheet.
Navigability is based on 1979 - 2010 Lake Stage criteria.

Color Legend: Acceptable/Improved; Unacceptable/Degraded

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Figures

Lake Conway 2005 Average Canal Bottom Elevations

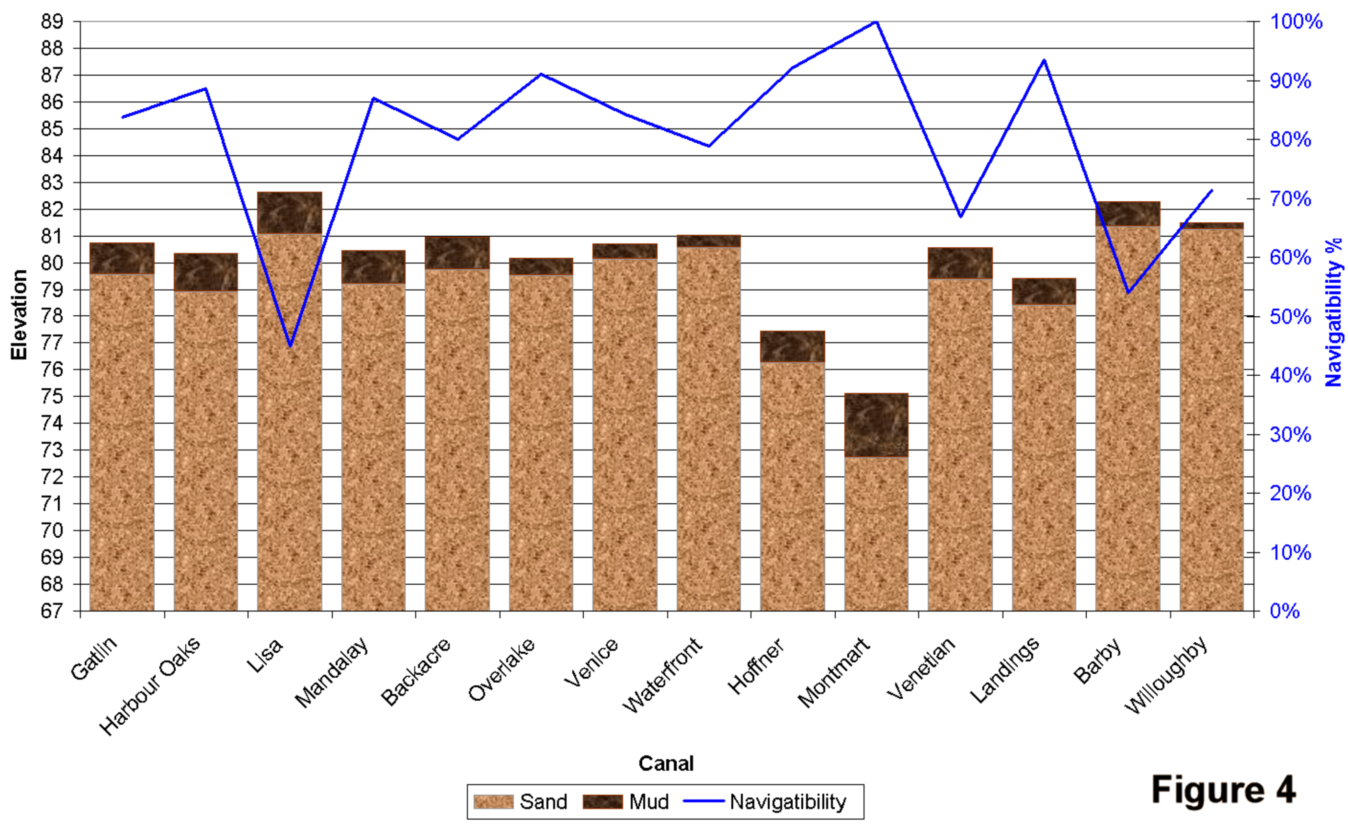

Figure 4

Lake Conway 2010 Average Canal Bottom Elevations

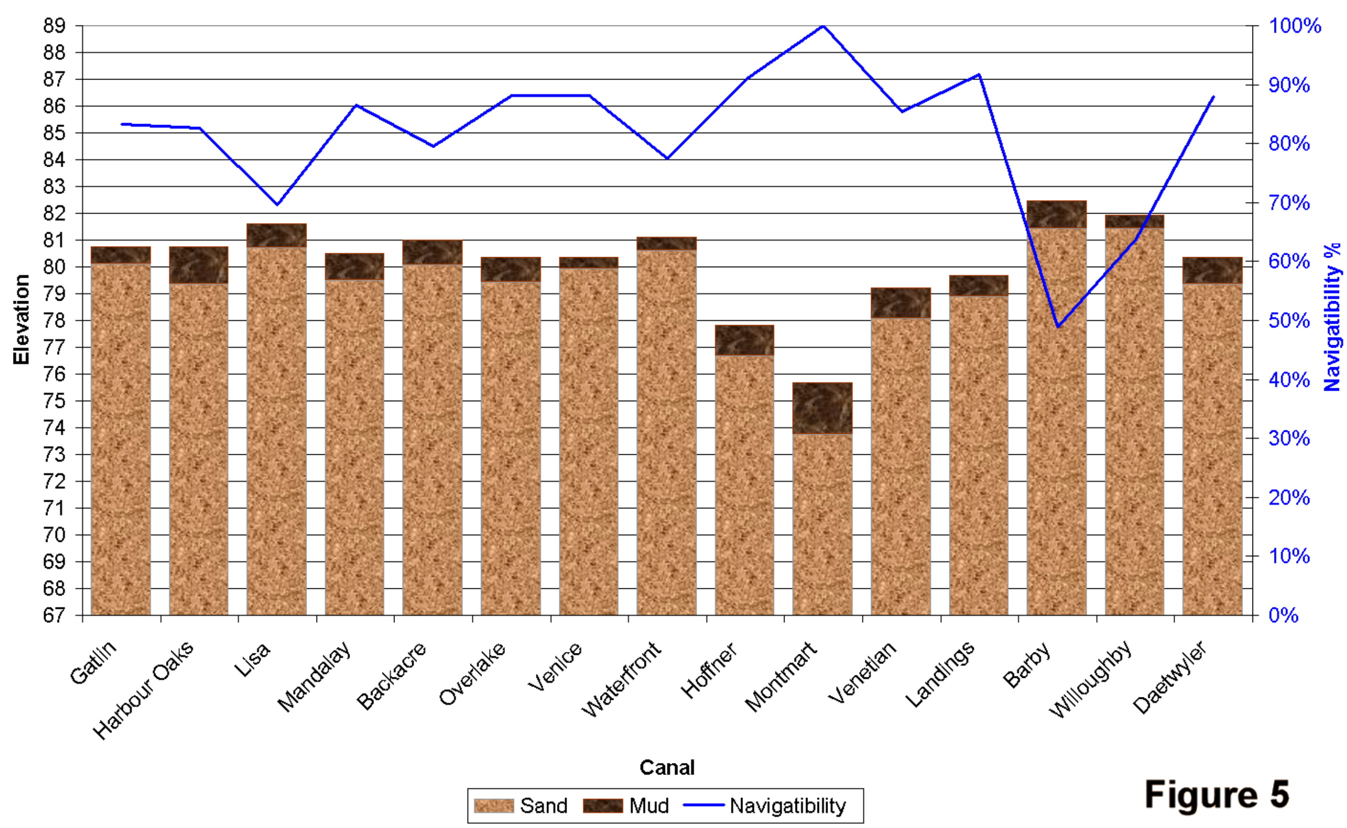

Figure 5

Lake Conway 2005 Highest Canal Bottom Elevations

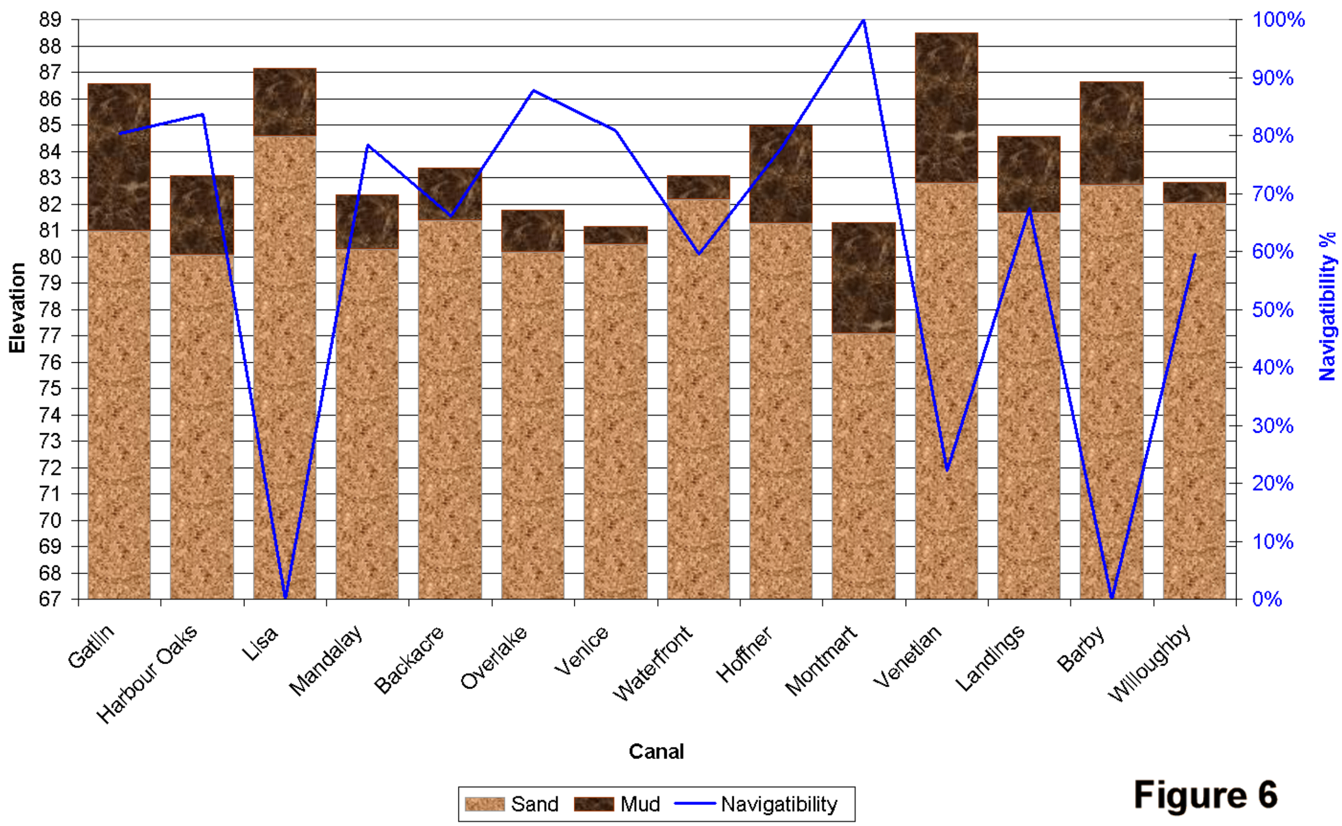

Figure 6

Lake Conway 2010 Maximum Canal Bottom Elevations

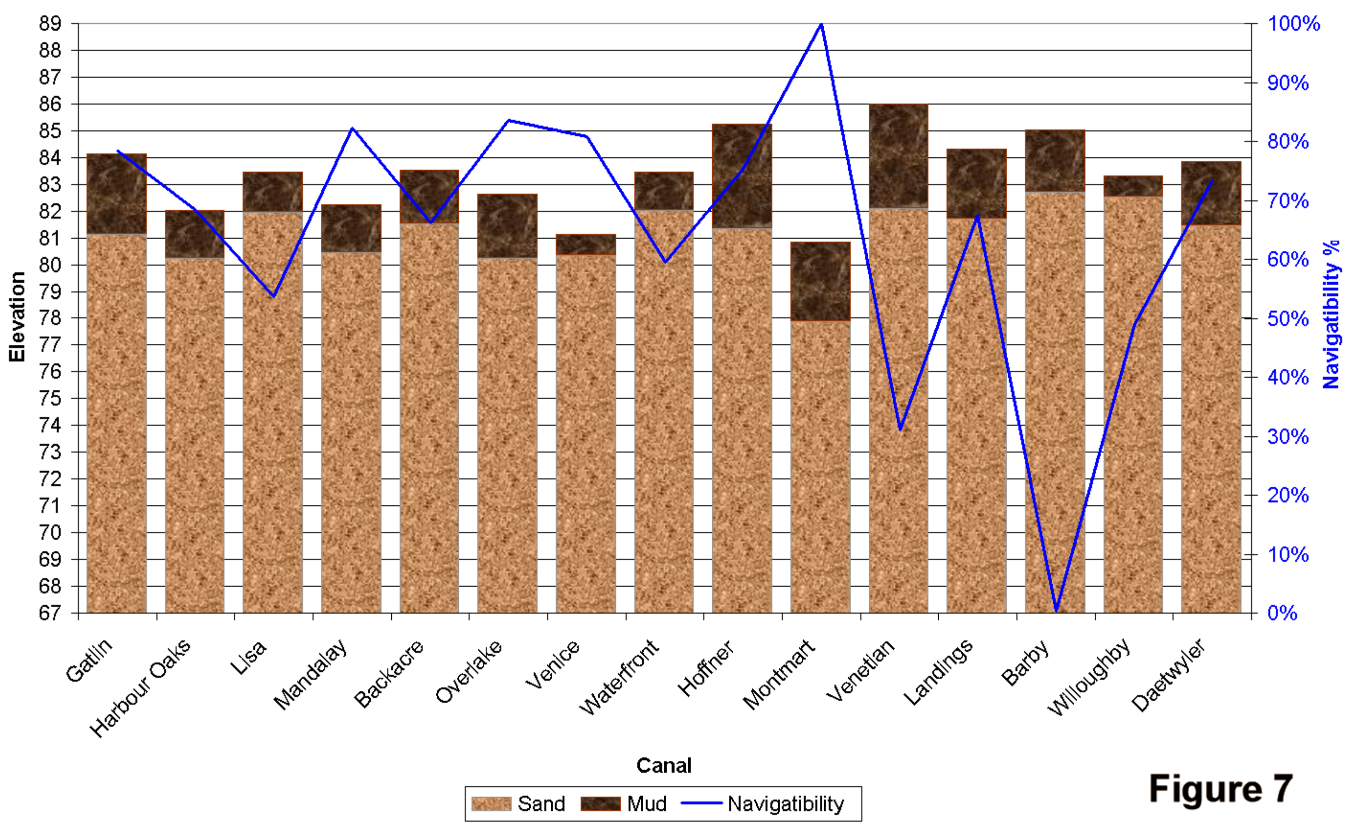

Figure 7

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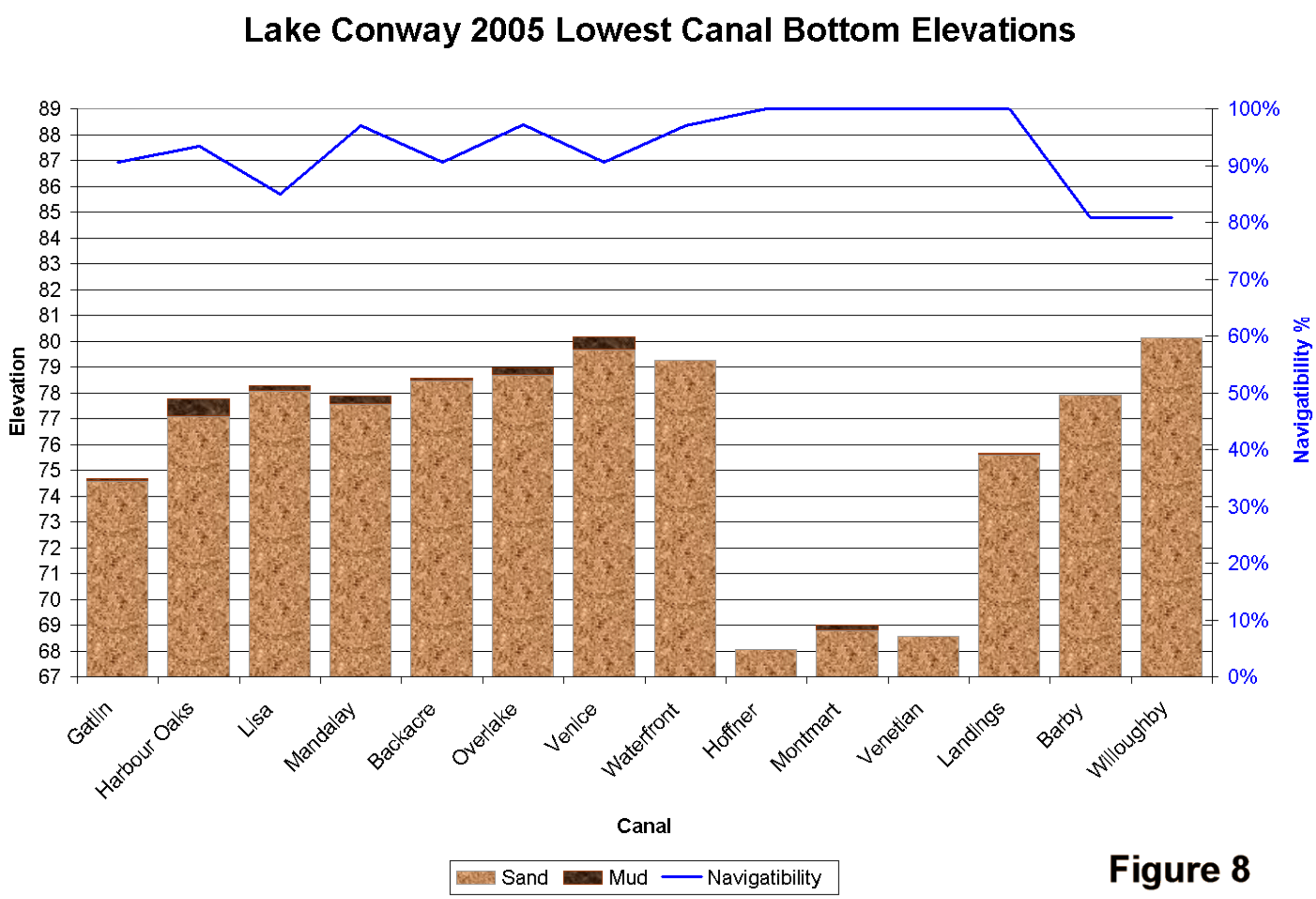

Figure 8

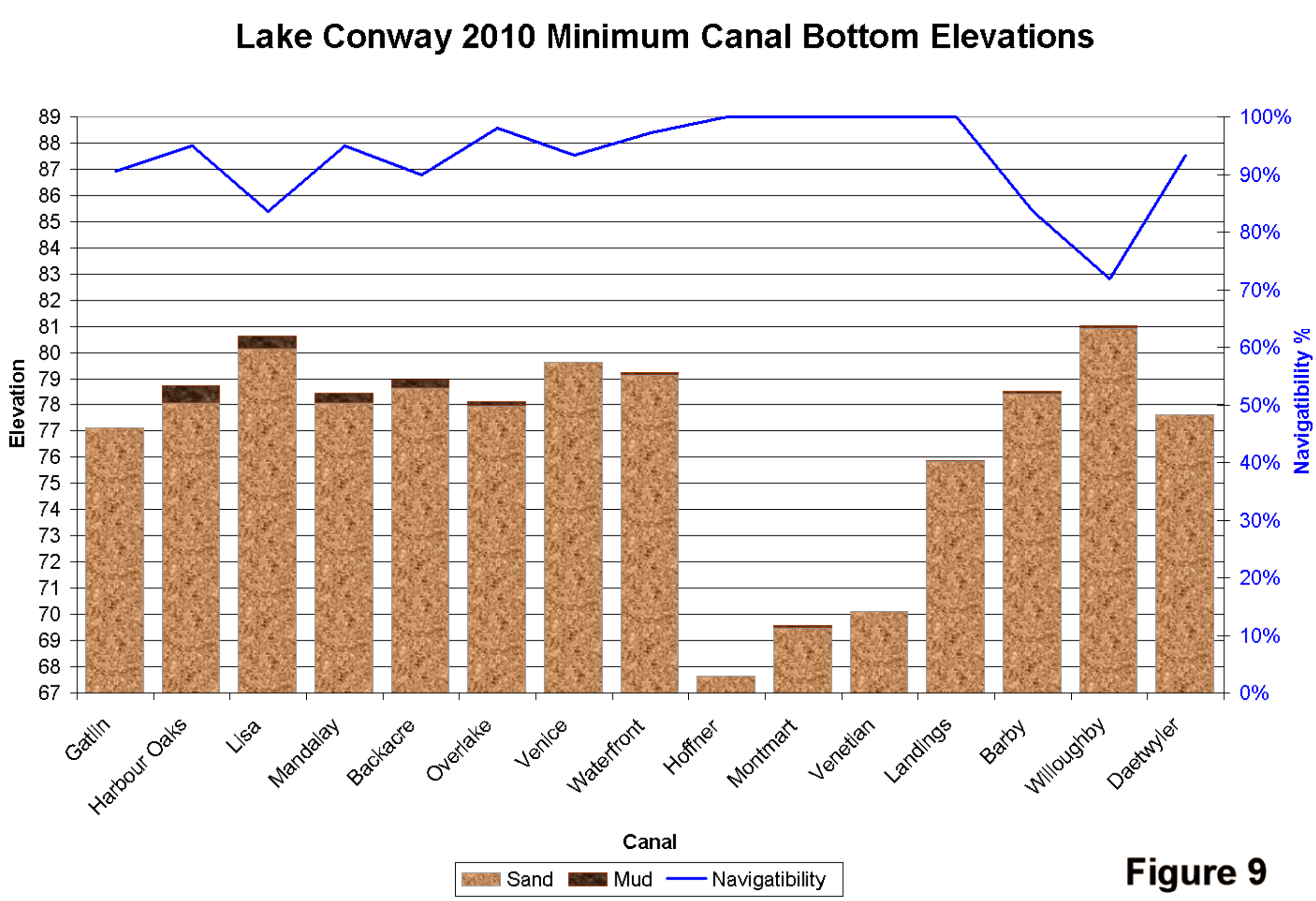

Figure 9

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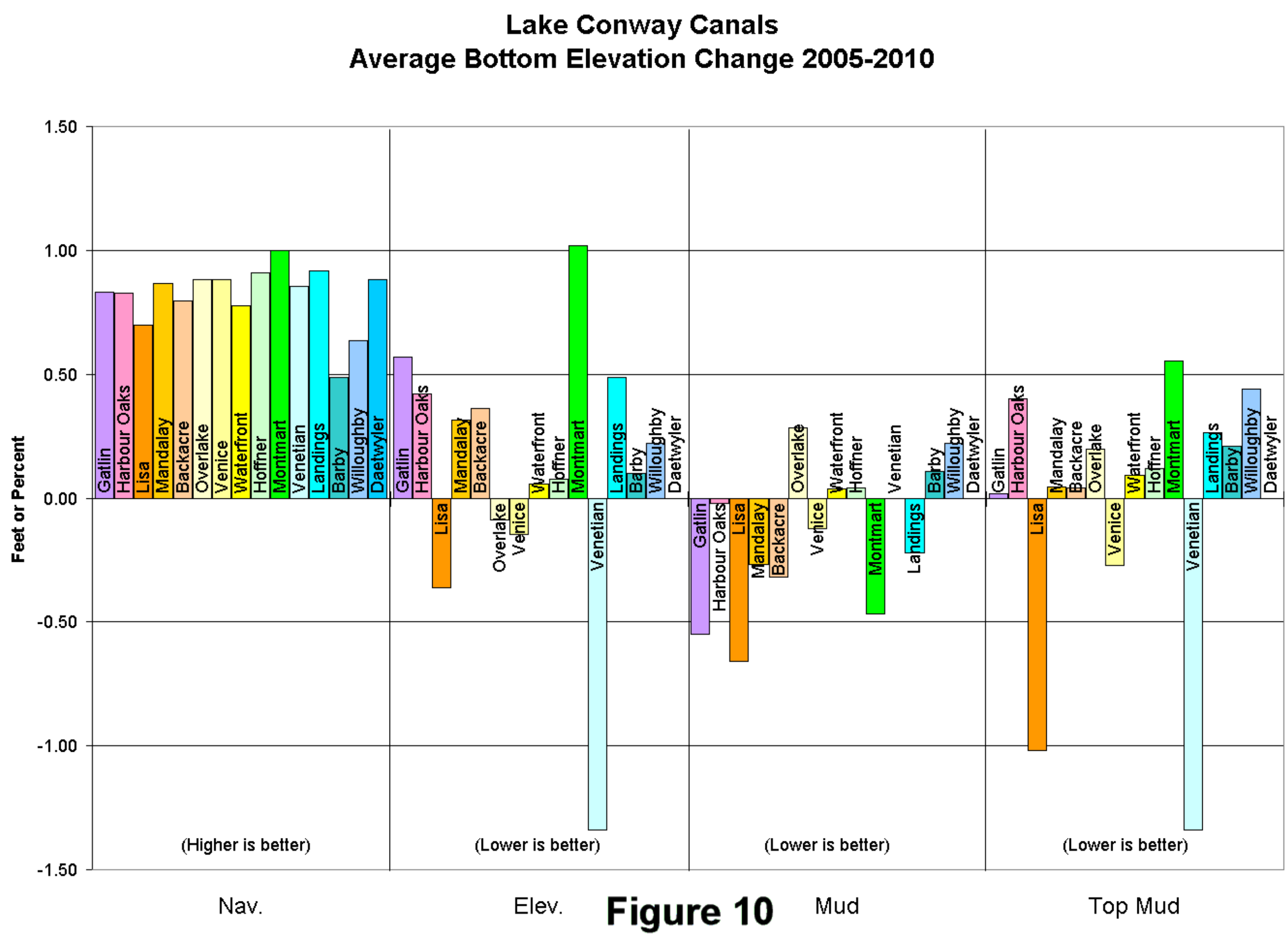

Figure 10

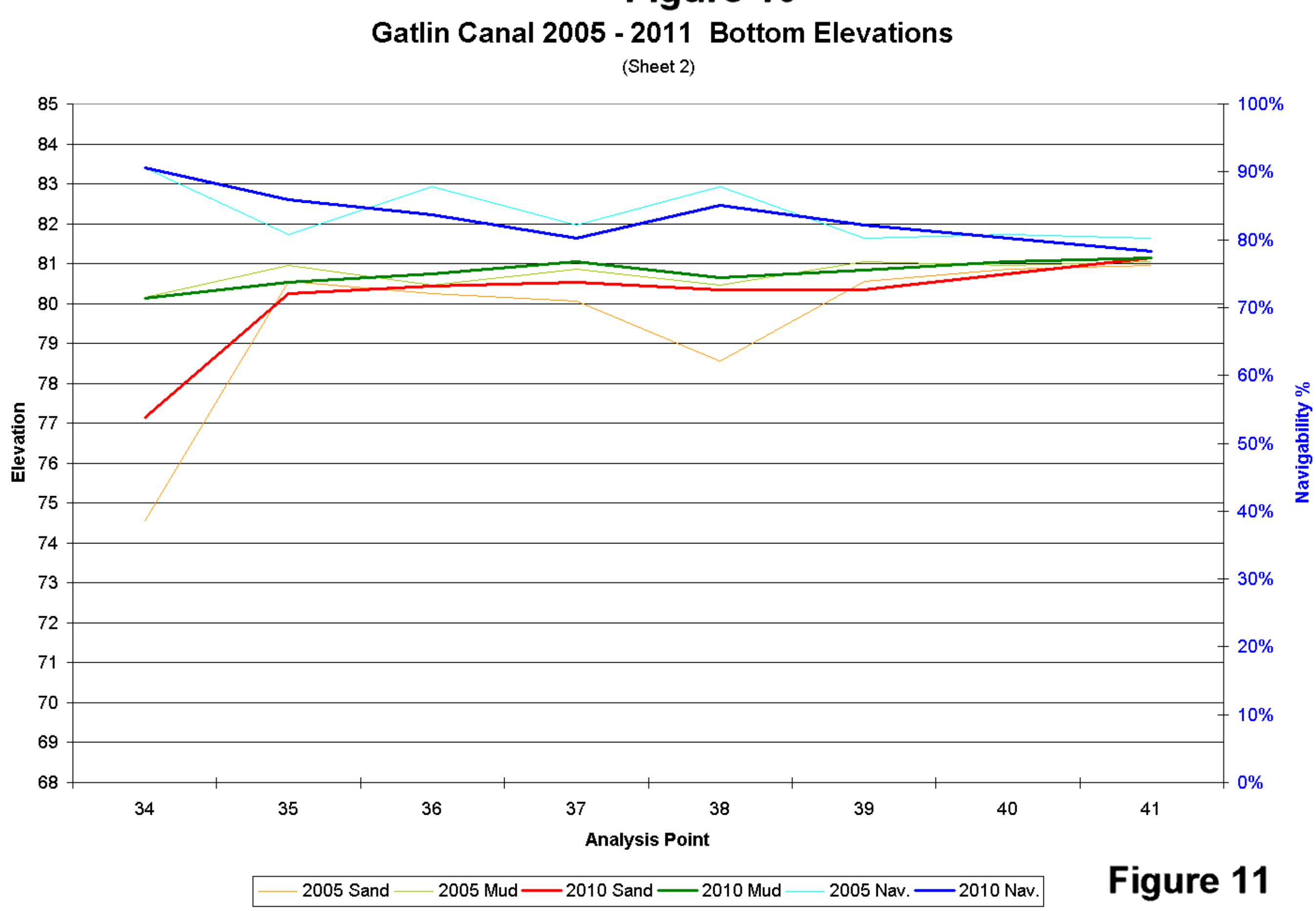

Figure 11

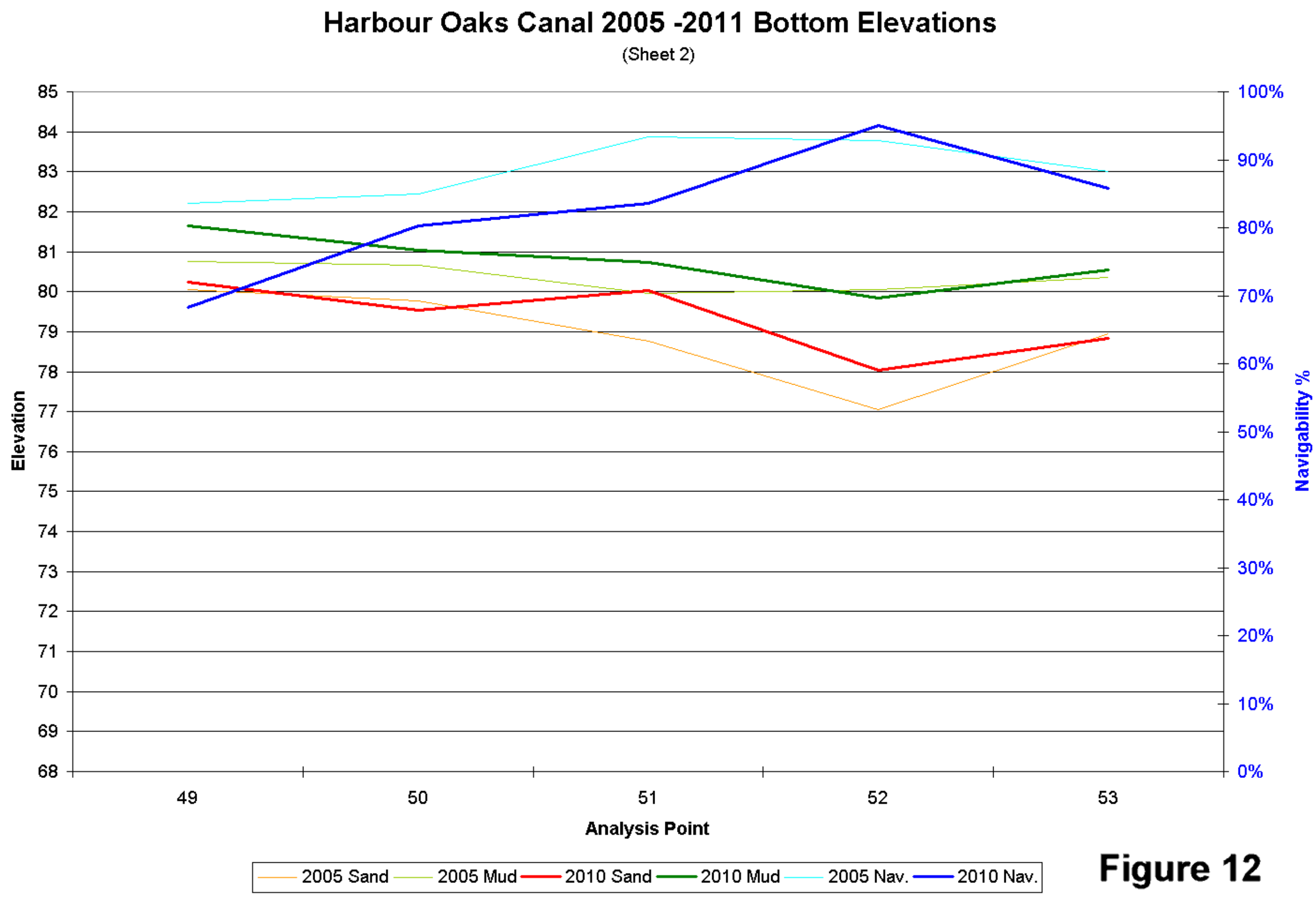

Figure 12

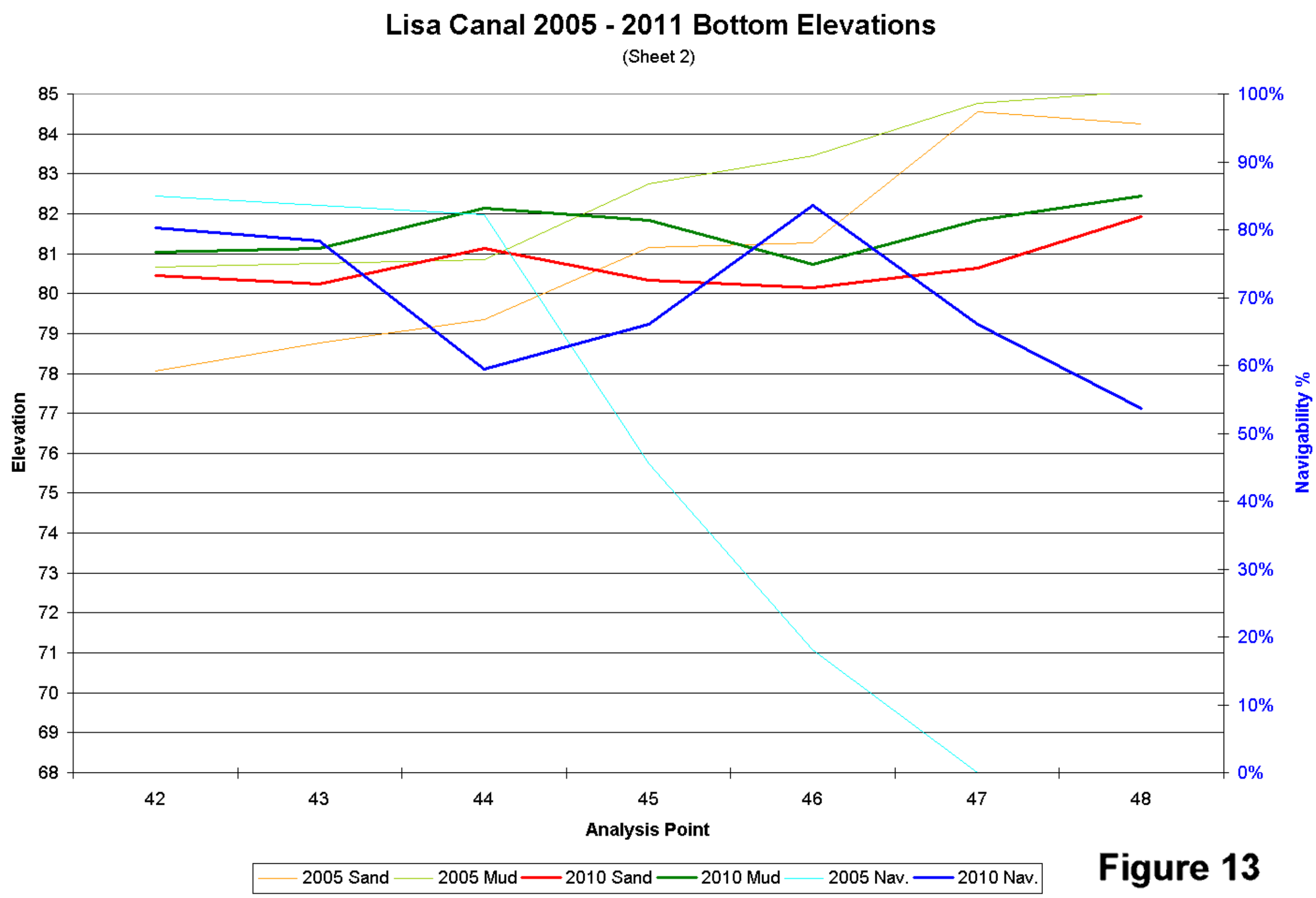

Figure 13

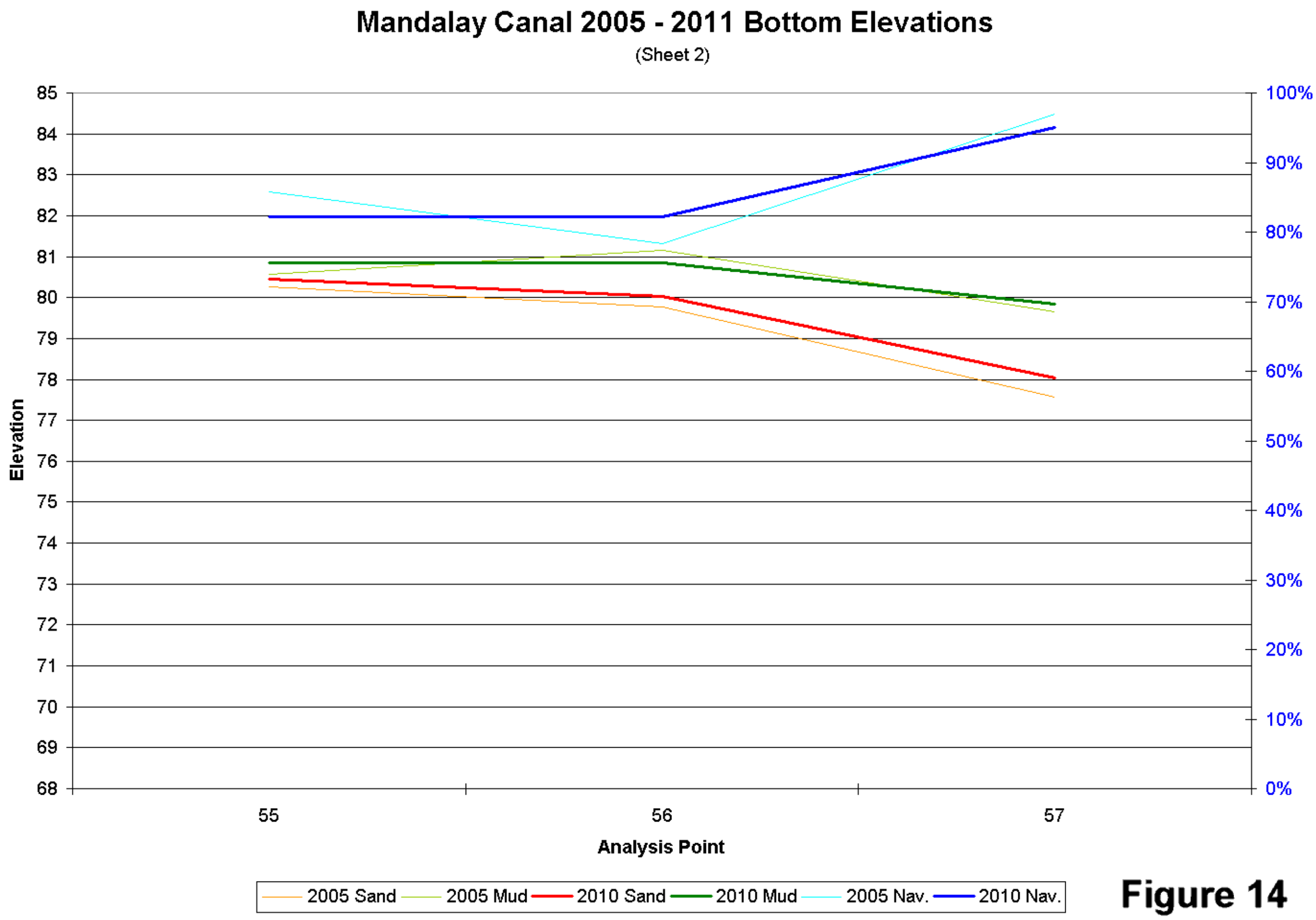

Figure 14

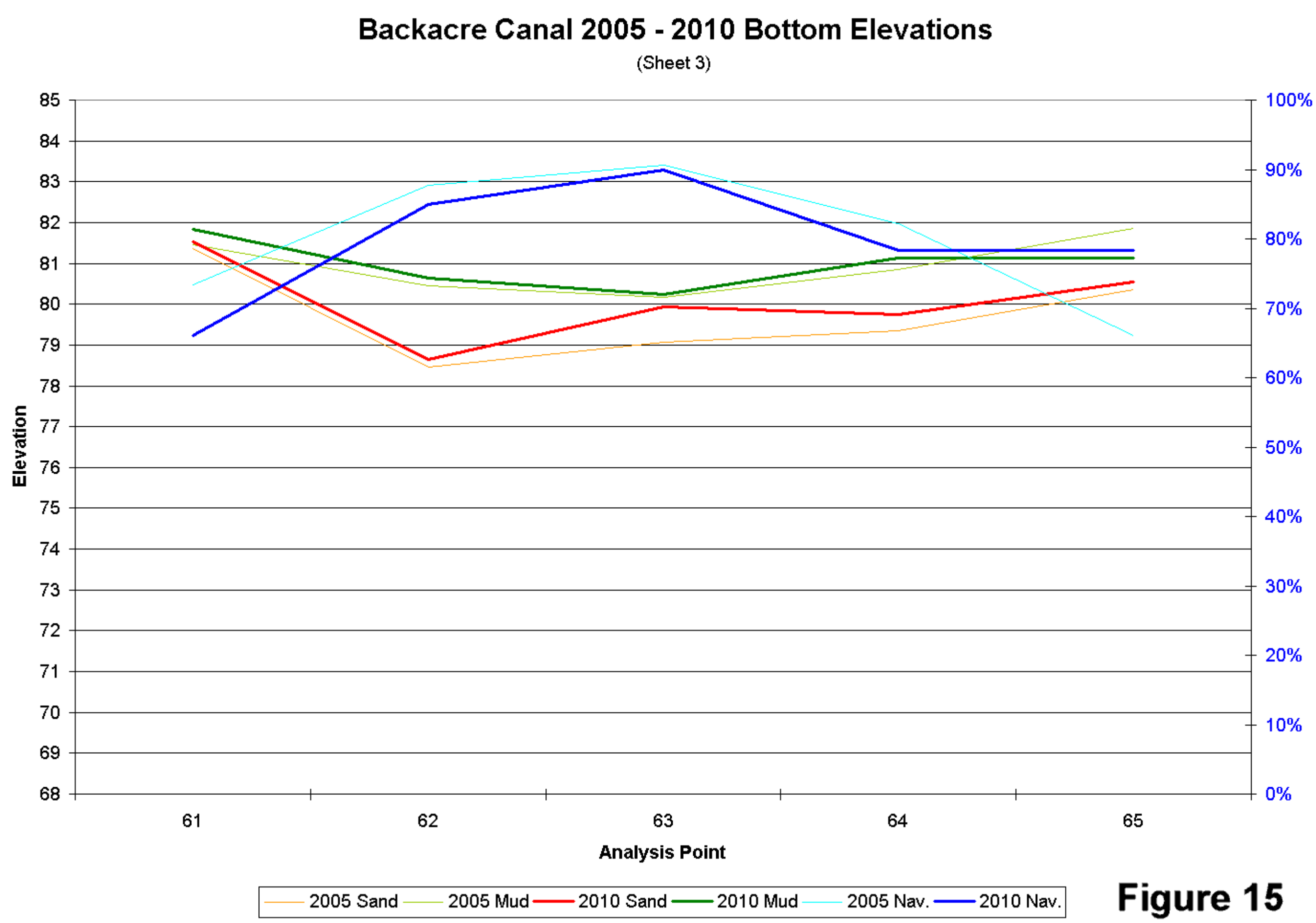

Figure 15

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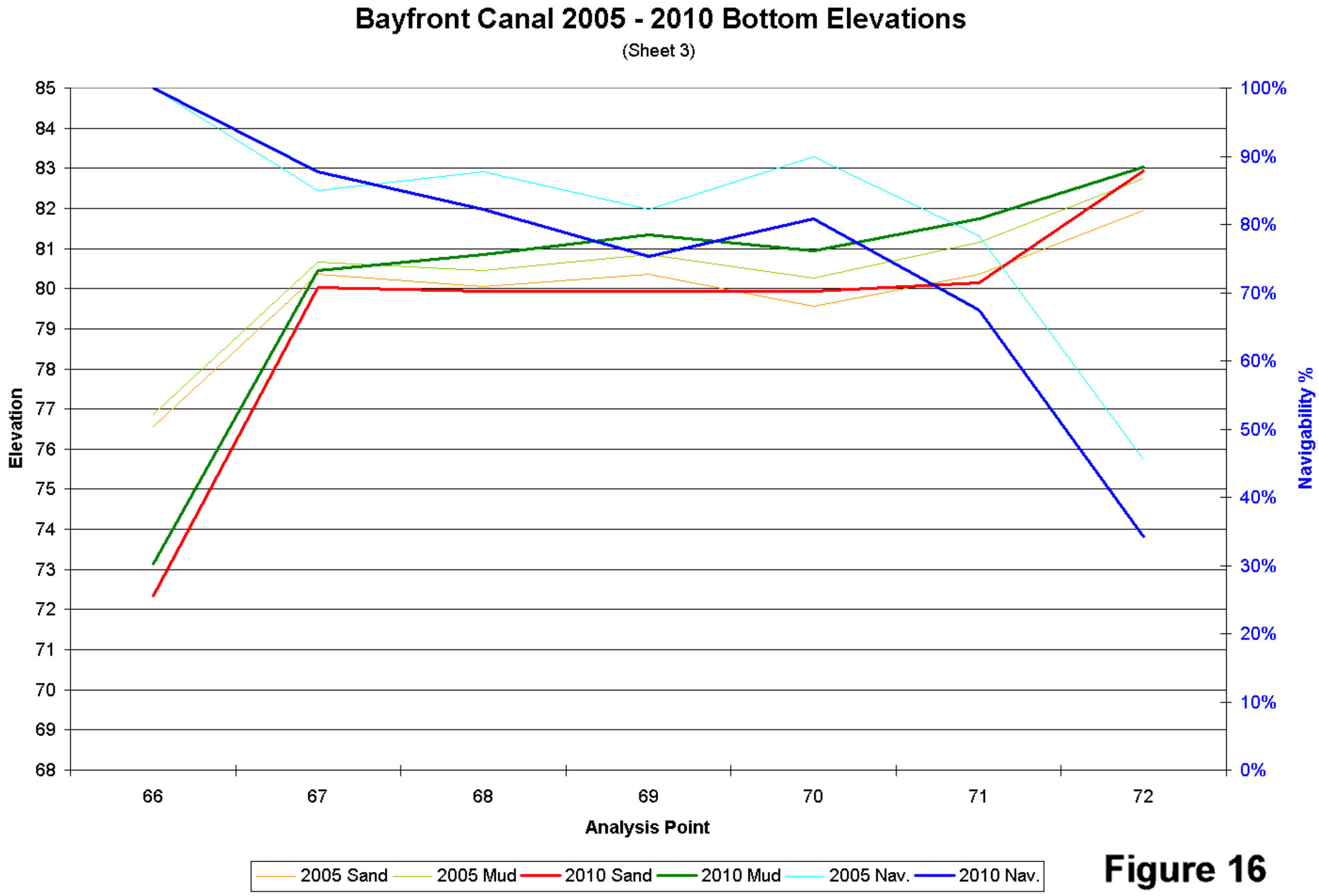
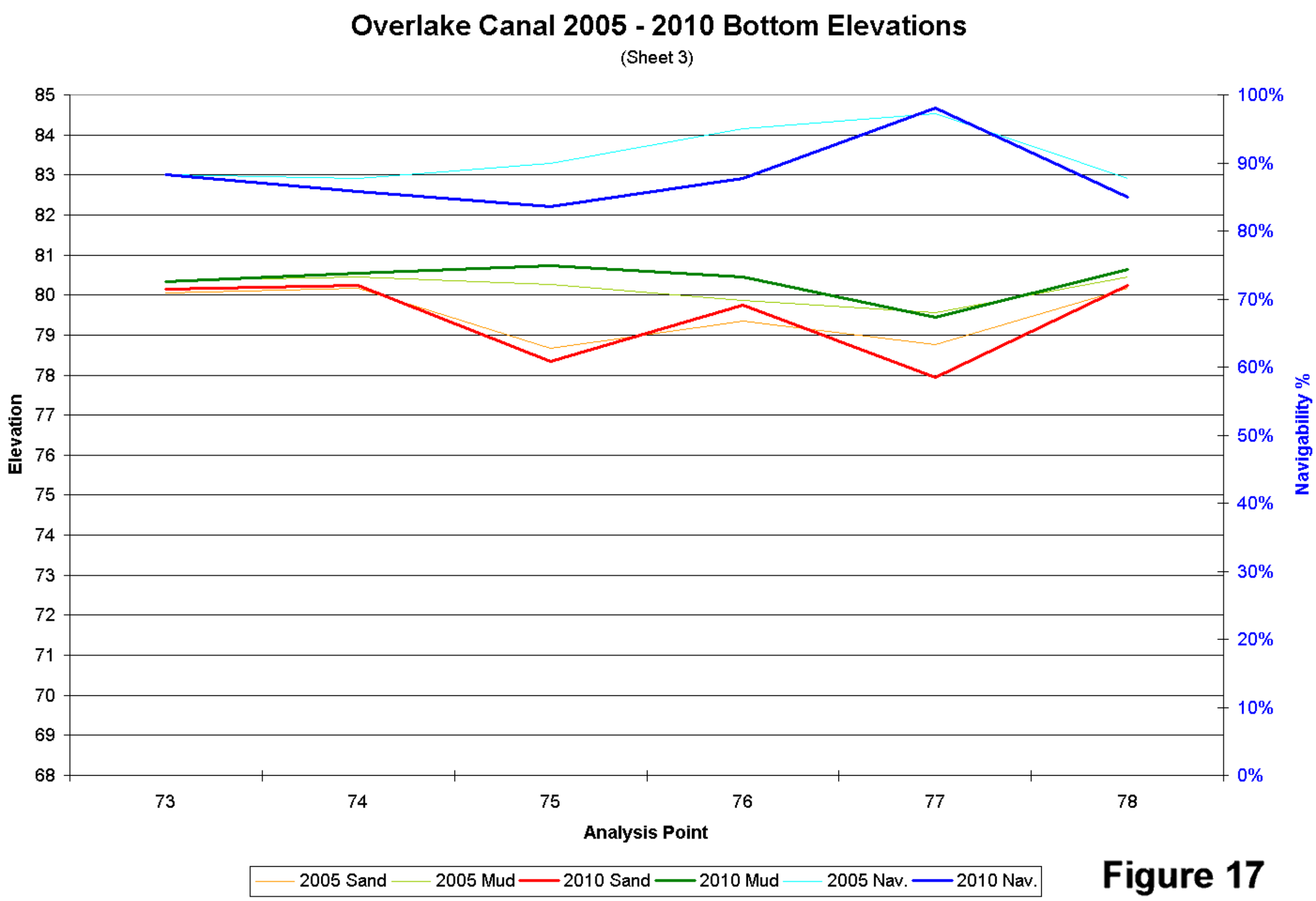


Figure 16



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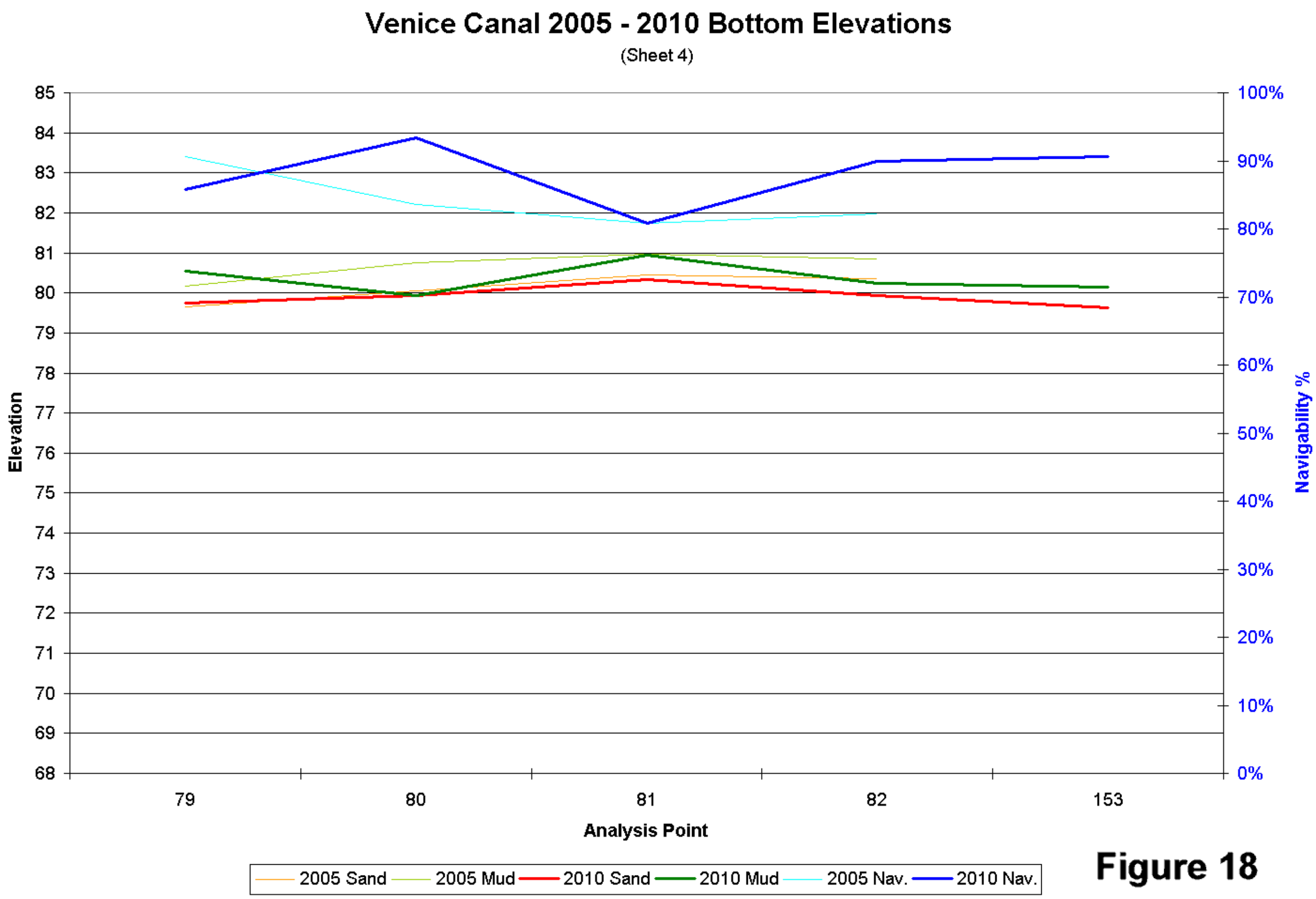

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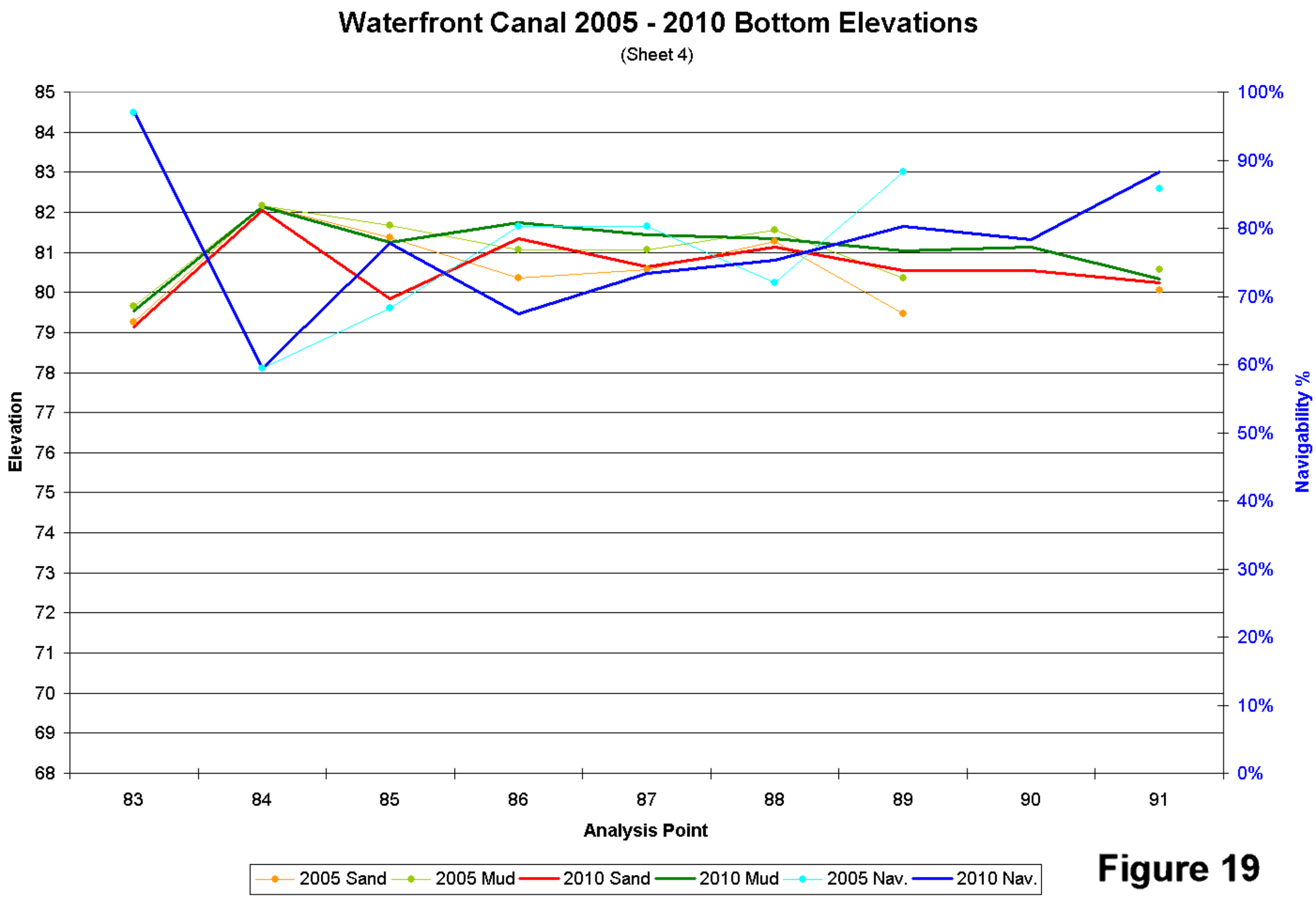
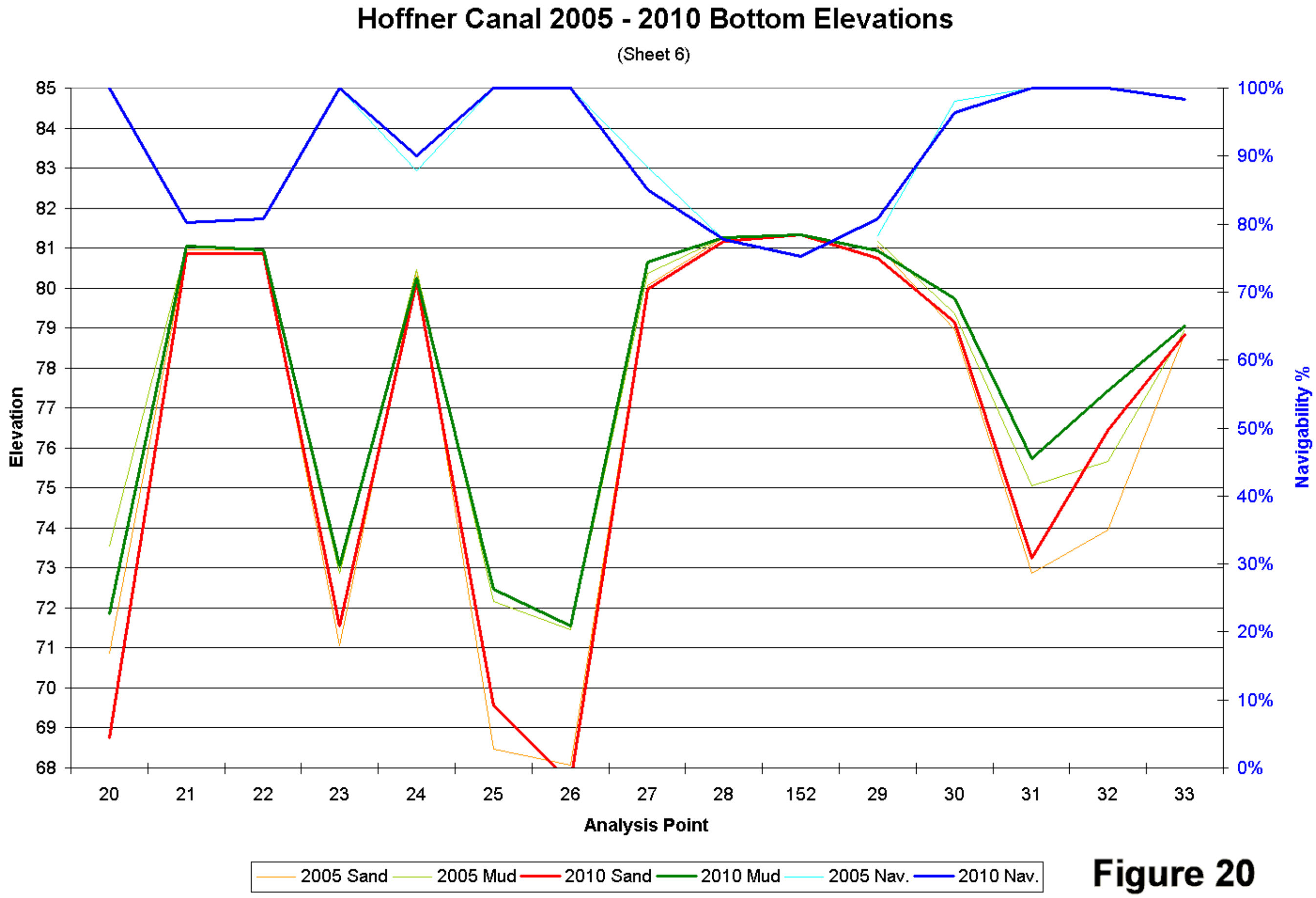


Figure 19

DRAFT 8/27/2021



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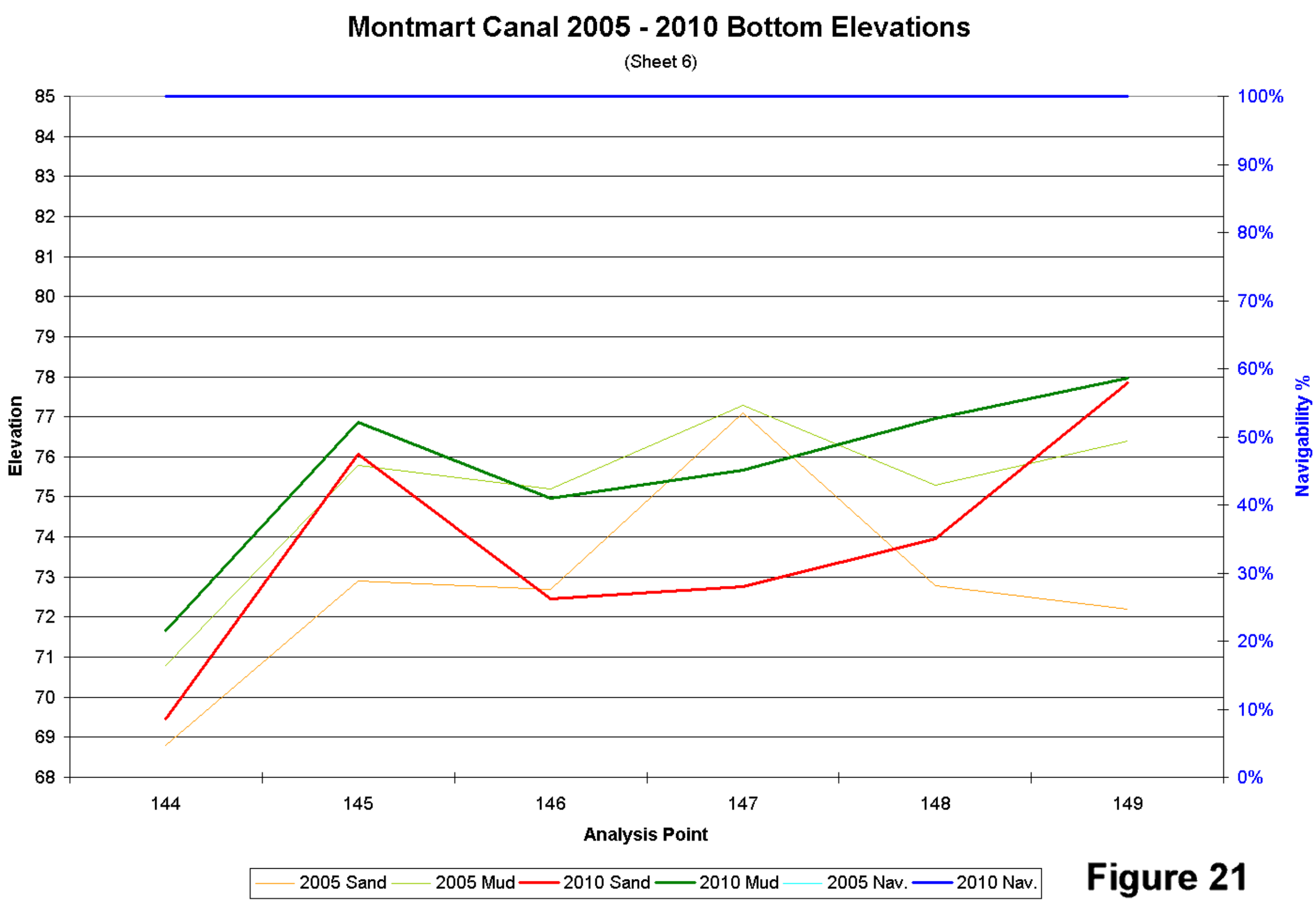

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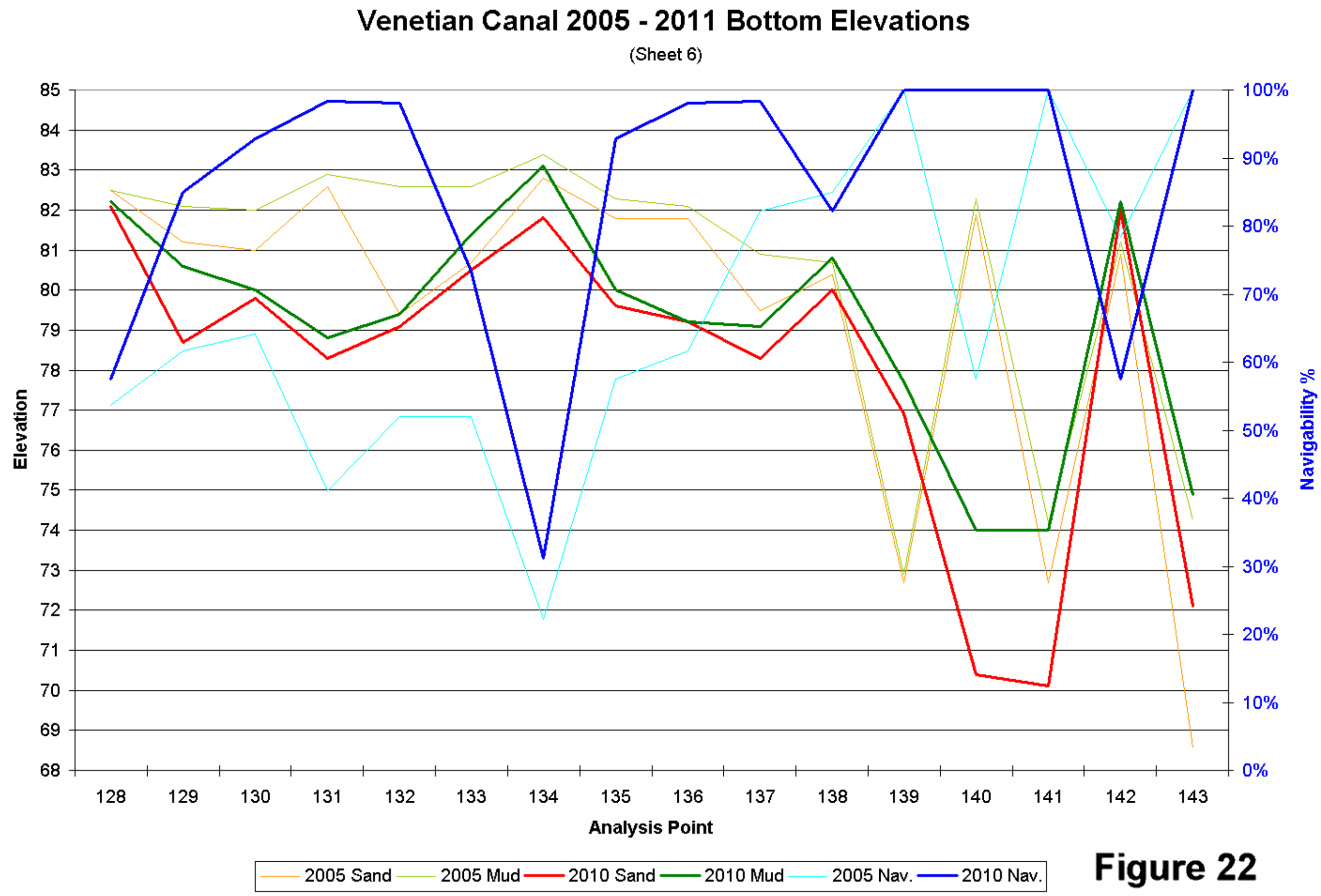

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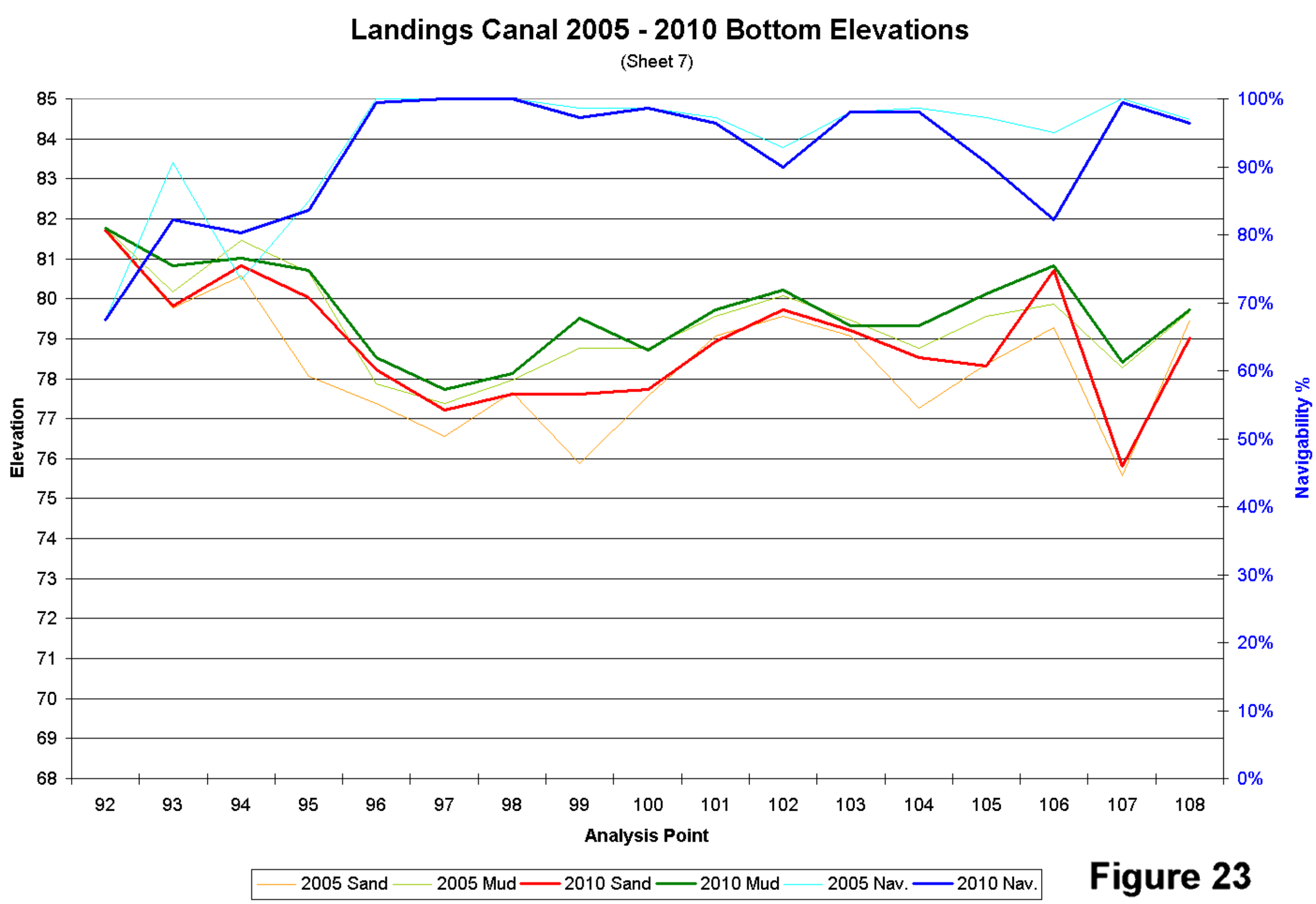

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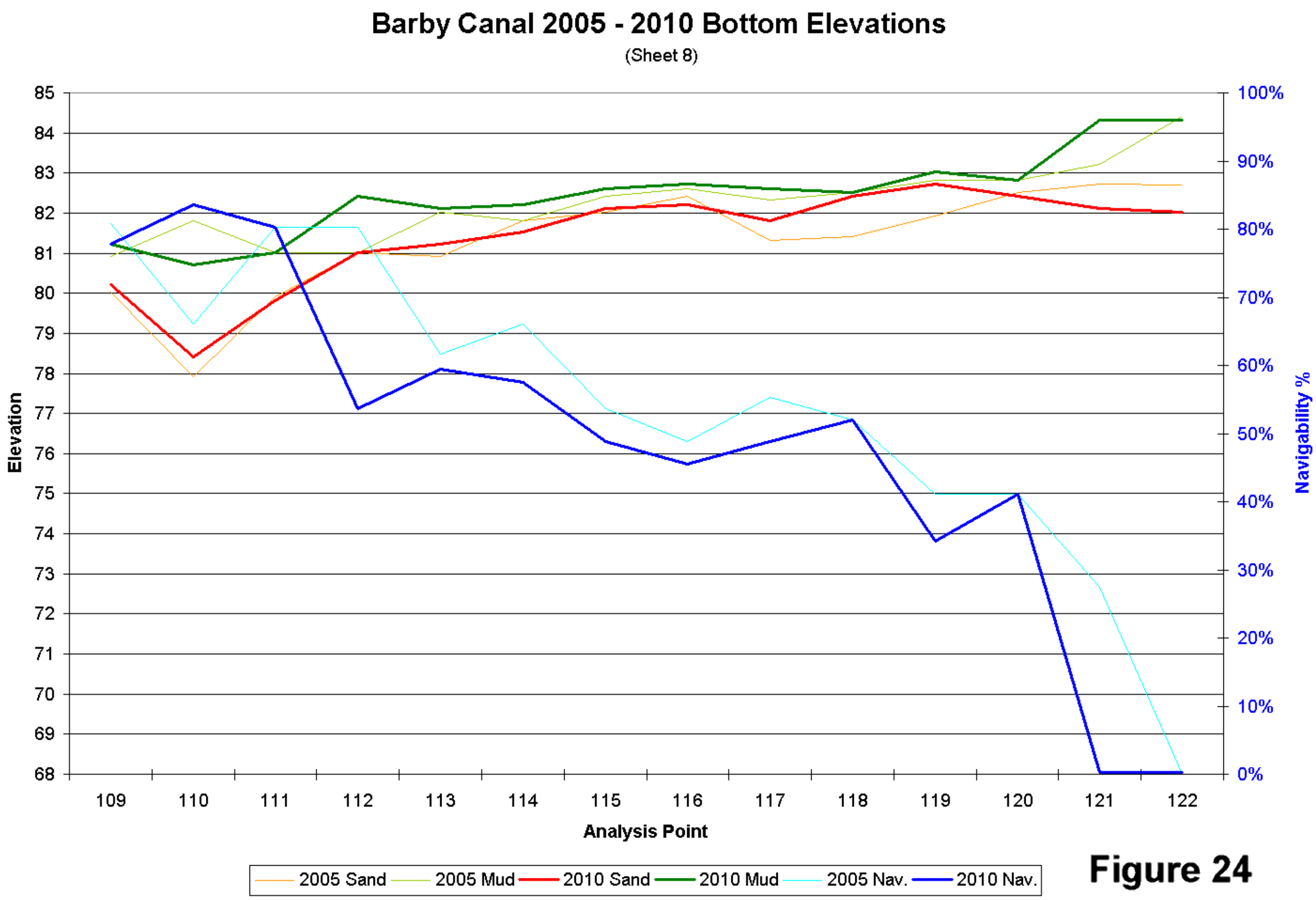

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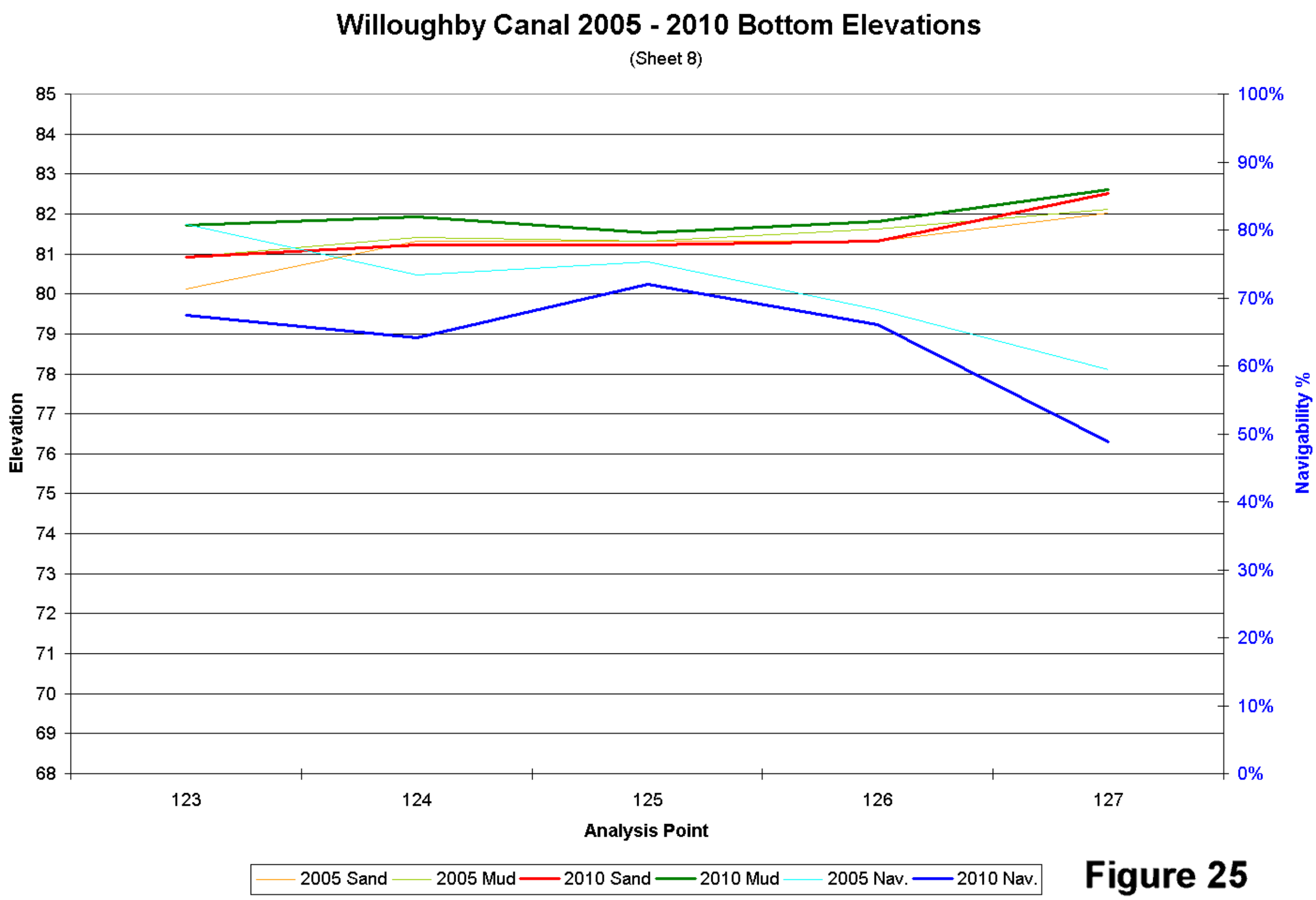


Figure 25

DRAFT 8/27/2021

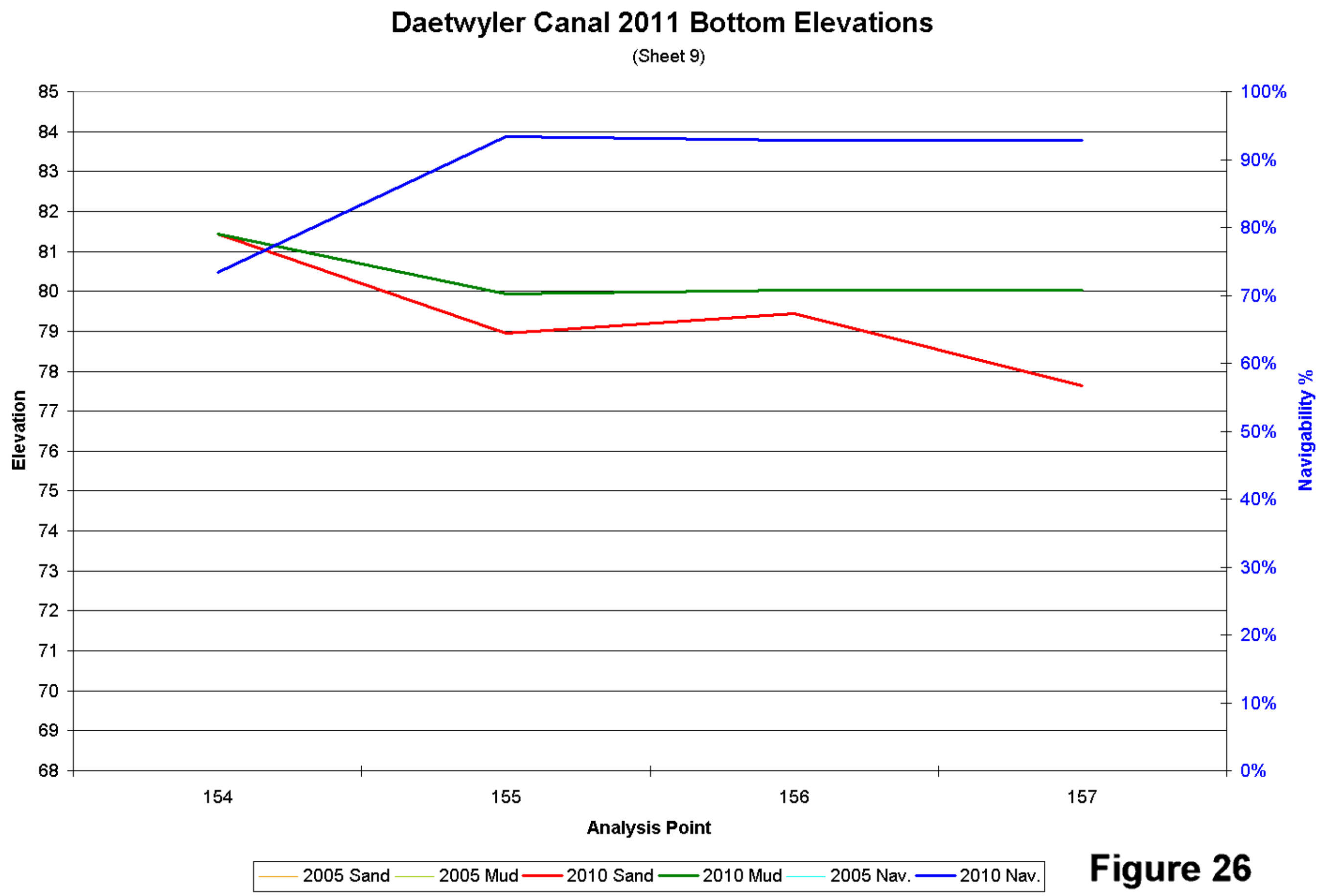


Figure 26

DRAFT 8/27/2021

Sheets

DRAFT 8/27/2021

LAKE CONWAY
2010 CANAL SILTATION STUDY

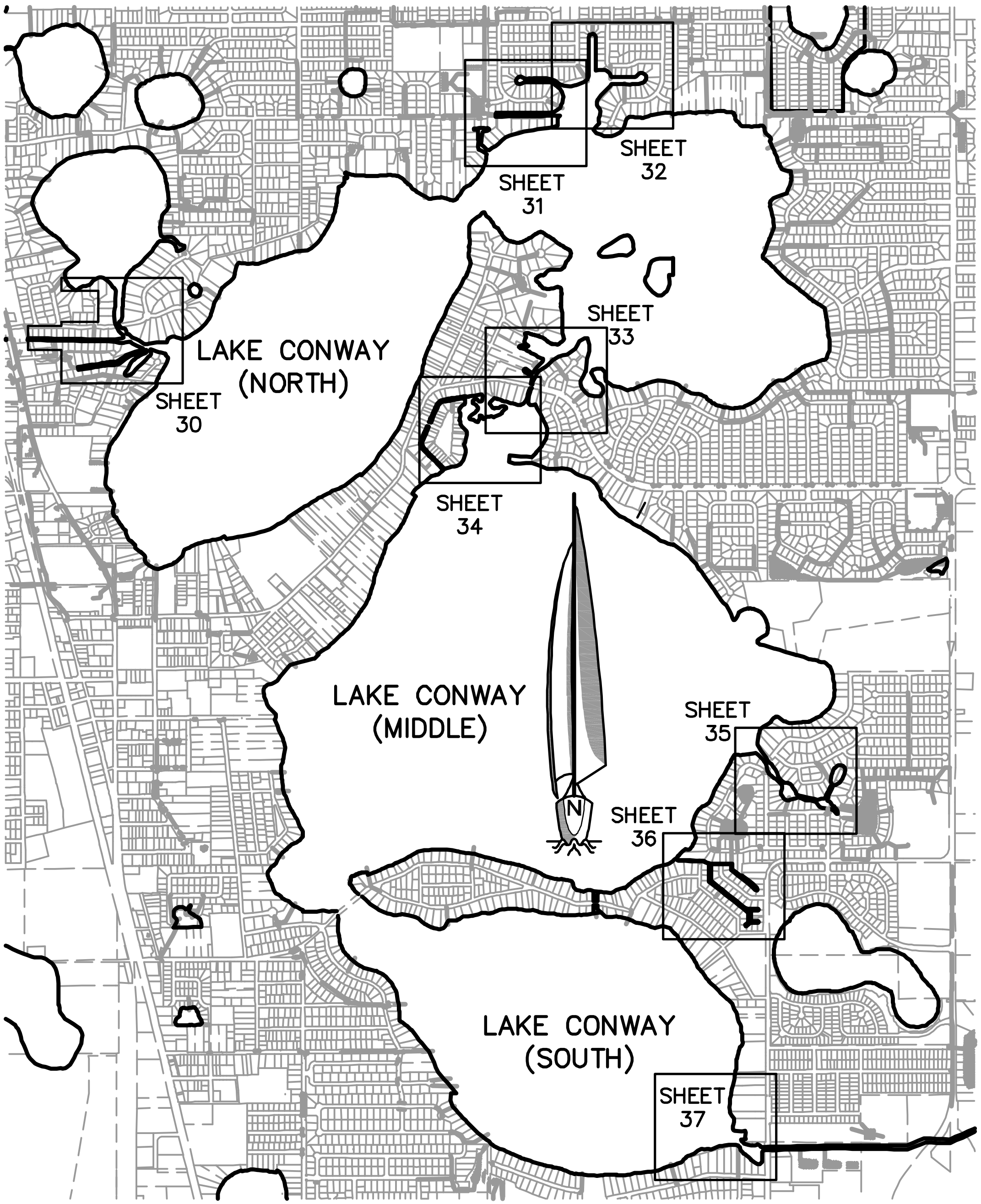


TABLE OF CONTENTS

SHEET	SUBJECT
29.	TITLE SHEET
30.	HARBOUR ISLAND/LISA CANALS
31.	BACKACHERS & WATERFRONT CANALS
32.	WATERFRONT CANALS
33.	HOFFNER CANAL
34.	VENETIAN & HOFFNER CANALS
35.	THE LANDINGS CANAL
36.	BARBY/WILLOUGHBY CANALS
37.	DAETWYLER LAGOON

GENERAL NOTES

1. THIS STUDY IS TO TRACK AND ESTIMATE THE RATES OF SILTATION OF THE CANALS ON THE LAKE CONWAY CHAIN.
2. THE BASE MAP FOR THIS STUDY WAS PROVIDED BY THE PROFESSIONAL ENGINEERING CONSULTANTS IN 2005.
3. THE HORIZONTAL LOCATION OF THE SPOT ELEVATIONS ARE APPROXIMATE TO WITHIN ±10' AND ARE BASED ON VISUAL OBSERVATION AND NAVIGATIONAL QUALITY GPS DATA.
4. BASELINE FIELD OBSERVATIONS WERE MADE BETWEEN 5/12/05 AND 6/8/05.
5. SECONDARY OBSERVATION DATES FOR EACH CANAL ARE SHOWN ON THE INDIVIDUAL SHEETS.
6. BOTTOM ELEVATIONS WERE ESTABLISHED BASED ON DEPTHS FROM THE DAILY LAKE SURFACE ELEVATION ACCORDING TO ORANGE COUNTY DATUM NGVD 29.

APPROVED:

DAVID W. WOODS, PE
FLA REG 36902

TEC ENGINEERING, INC.
DAVID W. WOODS P.E.
3042 HOFFNER AVE., ORLANDO, FL 32812-1062
PH. (407) 859-8737 FAX (407) 859-7476
EMAIL: DWoodsTEC@cfl.rr.com

CONWAY CANAL SILTATION STUDY

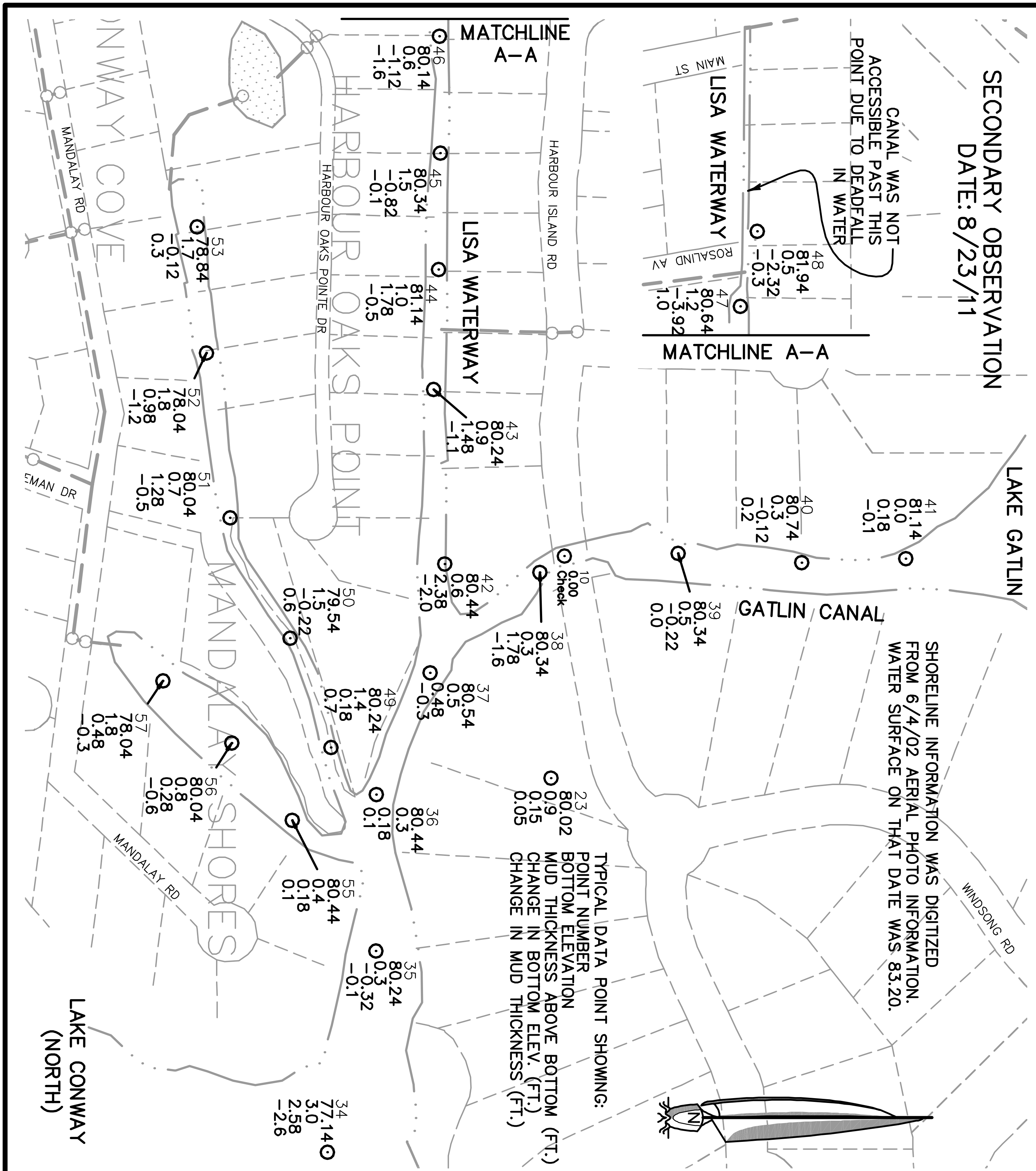
TITLE SHEET

FOR: O. C. LAKE CONWAY NAVIGATION ADVISORY BOARD

SCALE: 1"=2500'	DATE: 9/13/2011	FILENAME: CNBCNL04
SHEET 29 OF 37	DESIGNED BY: DWW	DRAWN BY: DWW

CNB

DRAFT 8/27/2021



CONWAY CANAL SILTATION STUDY		
HARBOUR ISLAND / LISA WATERWAY CANALS		
FOR: O. C. LAKE CONWAY NAVIGATION ADVISORY BOARD		
SCALE: 1"=200'	DATE: 9/13/2011	FILENAME: CNBCNL04
SHEET 30 OF 37	DESIGNED BY: DWW	DRAWN BY: DWW

TEC ENGINEERING, INC.
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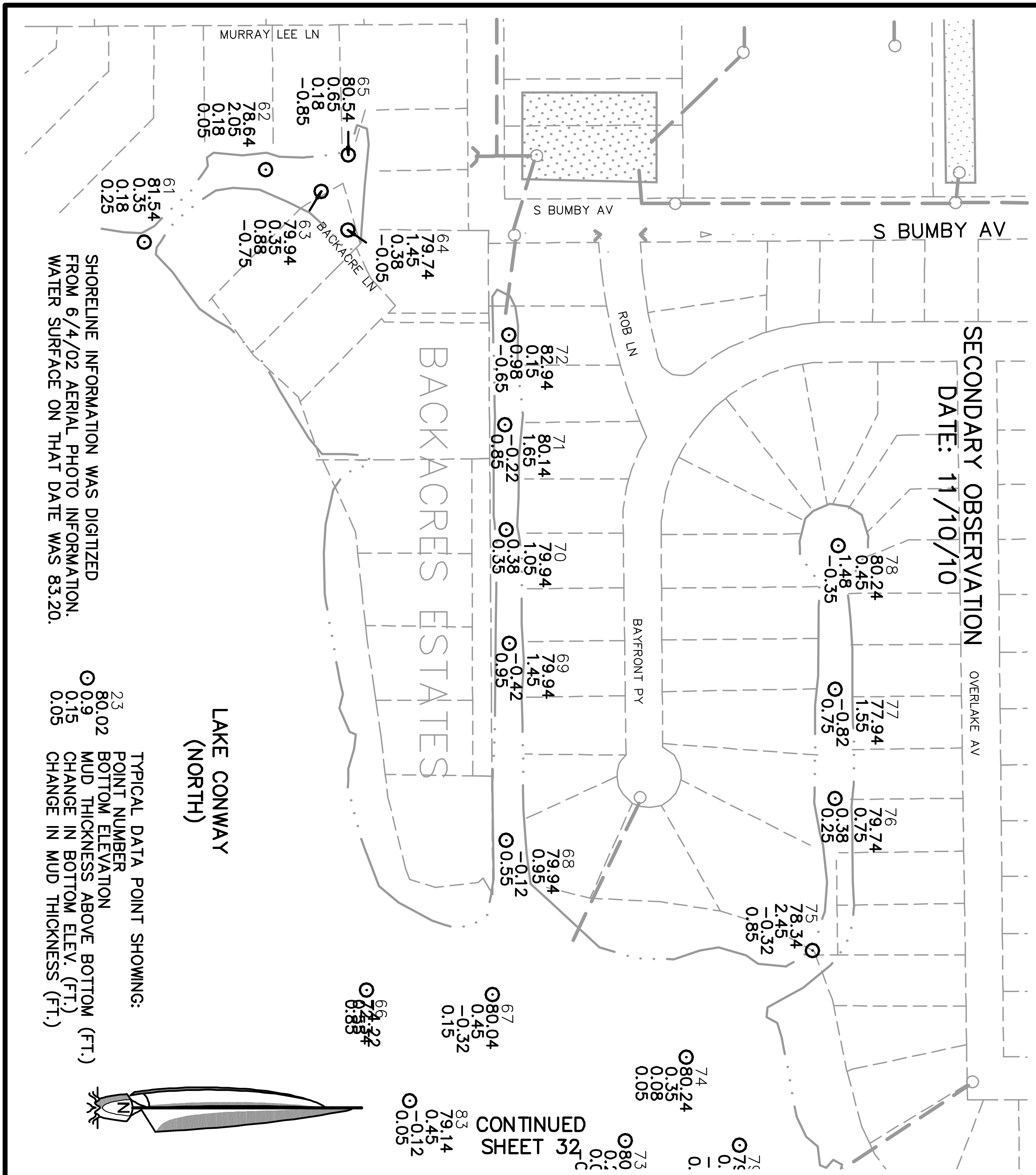

CONTINUED
SHEET 32

CONWAY CANAL SILTATION STUDY

BACKACRES & WATERFRONT CANALS

FOR: O. C. LAKE CONWAY NAVIGATION ADVISORY BOARD

SCALE: 1"=200'	DATE: 9/13/2011	FILENAME: CNBCNL04
SHEET 31 OF 37	DESIGNED BY: DWW	DRAWN BY: DWW

TEC ENGINEERING, INC.
TEC ENGINEERING, INC.
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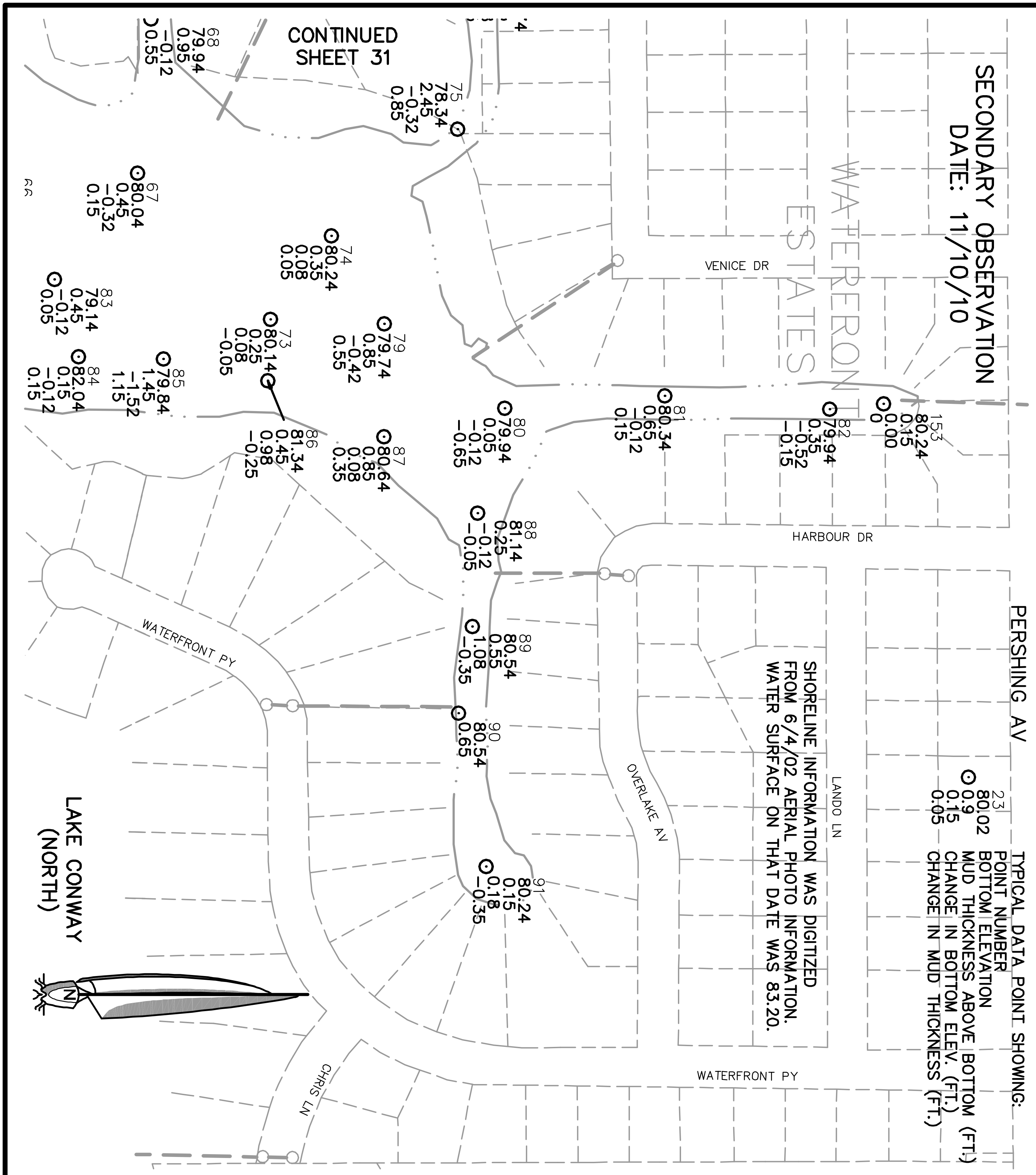

CONWAY CANAL SILTATION STUDY

WATERFRONT CANALS

FOR: O. C. LAKE CONWAY NAVIGATION ADVISORY BOARD

SCALE: 1"=200'	DATE: 9/13/2011	FILENAME: CNBCNL04
SHEET 32 OF 37	DESIGNED BY: DWW	DRAWN BY: DWW

TEC ENGINEERING, INC.
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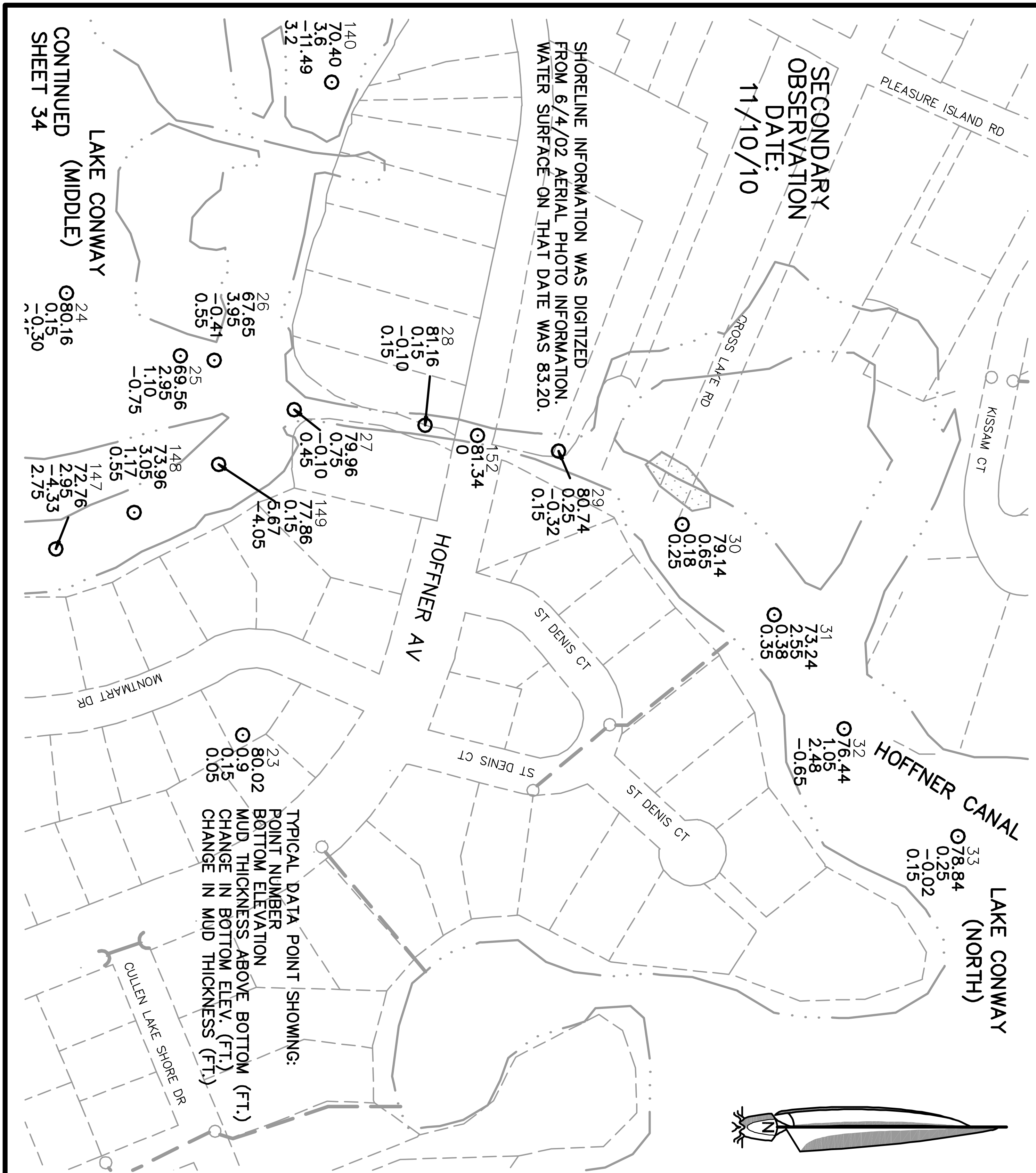

CONWAY CANAL SILTATION STUDY

HOFFNER CANAL

FOR: O. C. LAKE CONWAY NAVIGATION ADVISORY BOARD

SCALE: 1"=200' | DATE: 9/13/2011 | FILENAME: CNBCNL04

SHEET 33 OF 37 | DESIGNED BY: DWW | DRAWN BY: DWW

TEC ENGINEERING, INC.
DAVID W. WOODS P.E.
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EMAIL: DWoodsTEC@cfl.rr.com

APPROVED:

DAVID W. WOODS, PE
FLA REG 36902

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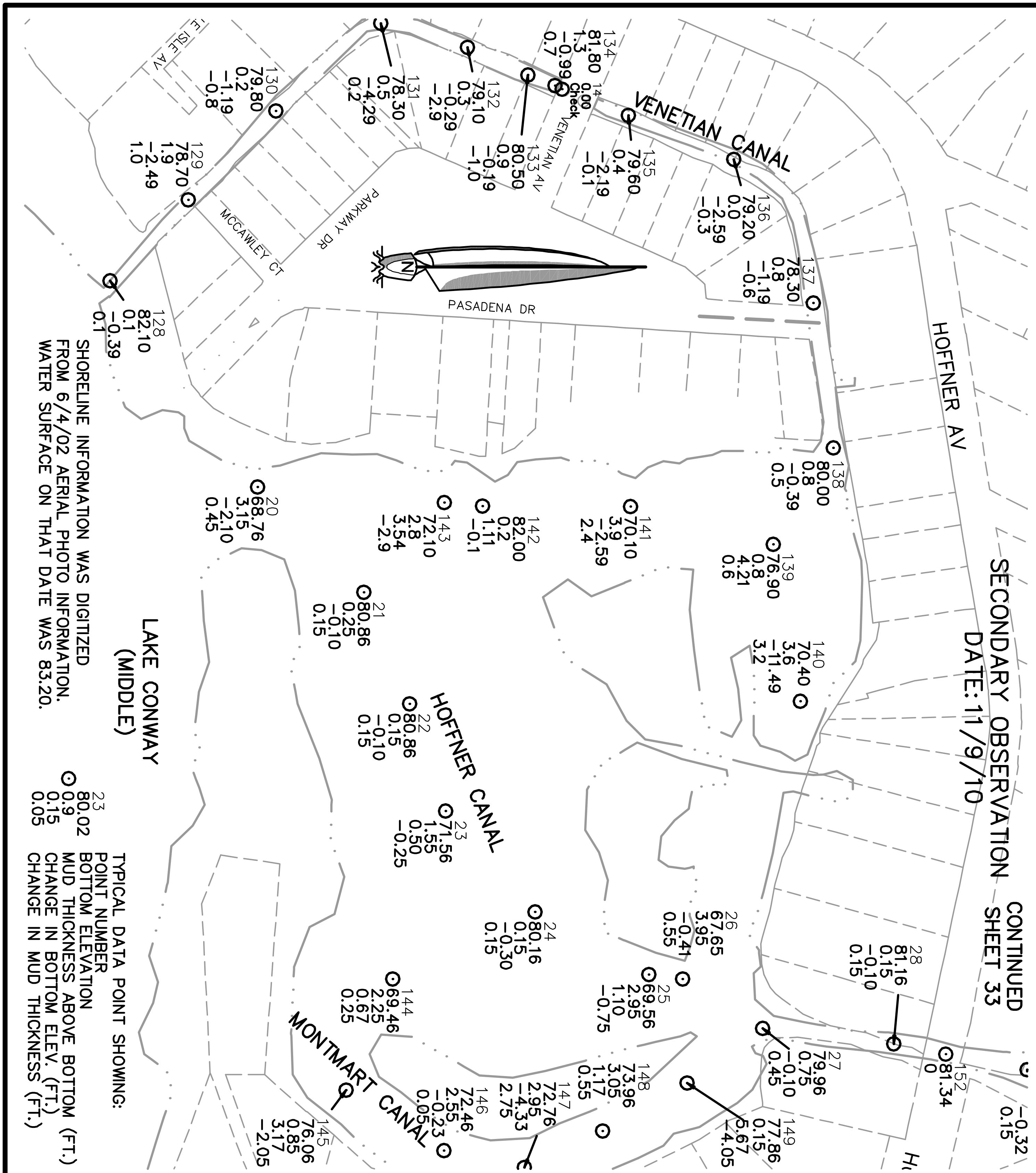

CONWAY CANAL SILTATION STUDY			
VENETIAN & HOFFNER CANALS			
FOR: O. C. LAKE CONWAY NAVIGATION ADVISORY BOARD			
SCALE: 1"=200'	DATE: 9/13/2011	FILENAME: CNBCNL04	
SHEET 34 OF 37	DESIGNED BY: DWW	DRAWN BY: DWW	

TEC ENGINEERING, INC.
TEC ENGINEERING, INC.
DAVID W. WOODS P.E.
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APPROVED:

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FLA REG 36902

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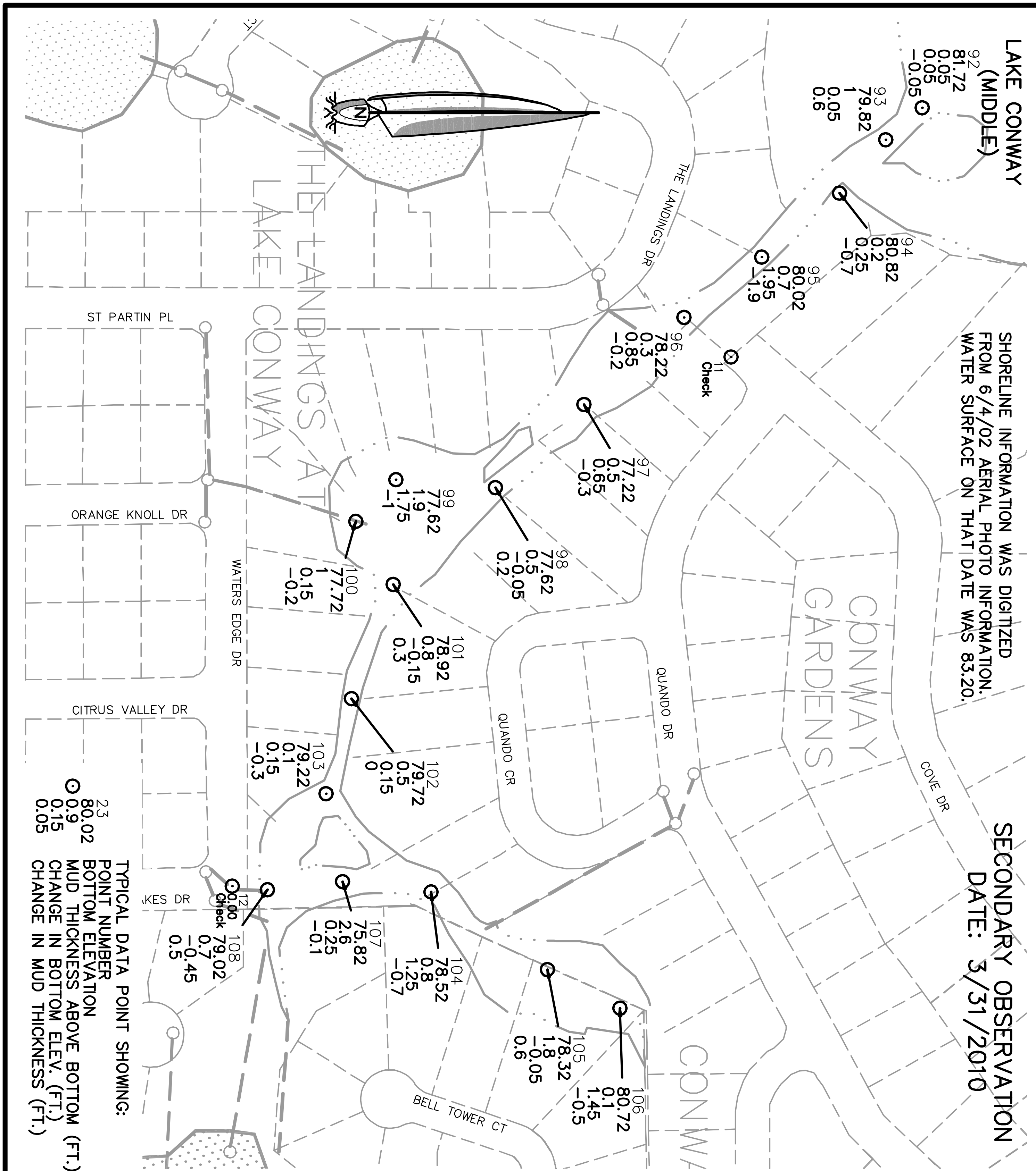

CONWAY CANAL SILTATION STUDY

THE LANDINGS CANAL 2010

FOR: O. C. LAKE CONWAY NAVIGATION ADVISORY BOARD

SCALE: 1"=200'	DATE: 9/13/2011	FILENAME: CNBCNL04
SHEET 35 OF 37	DESIGNED BY: DWW	DRAWN BY: DWW

TEC ENGINEERING, INC.

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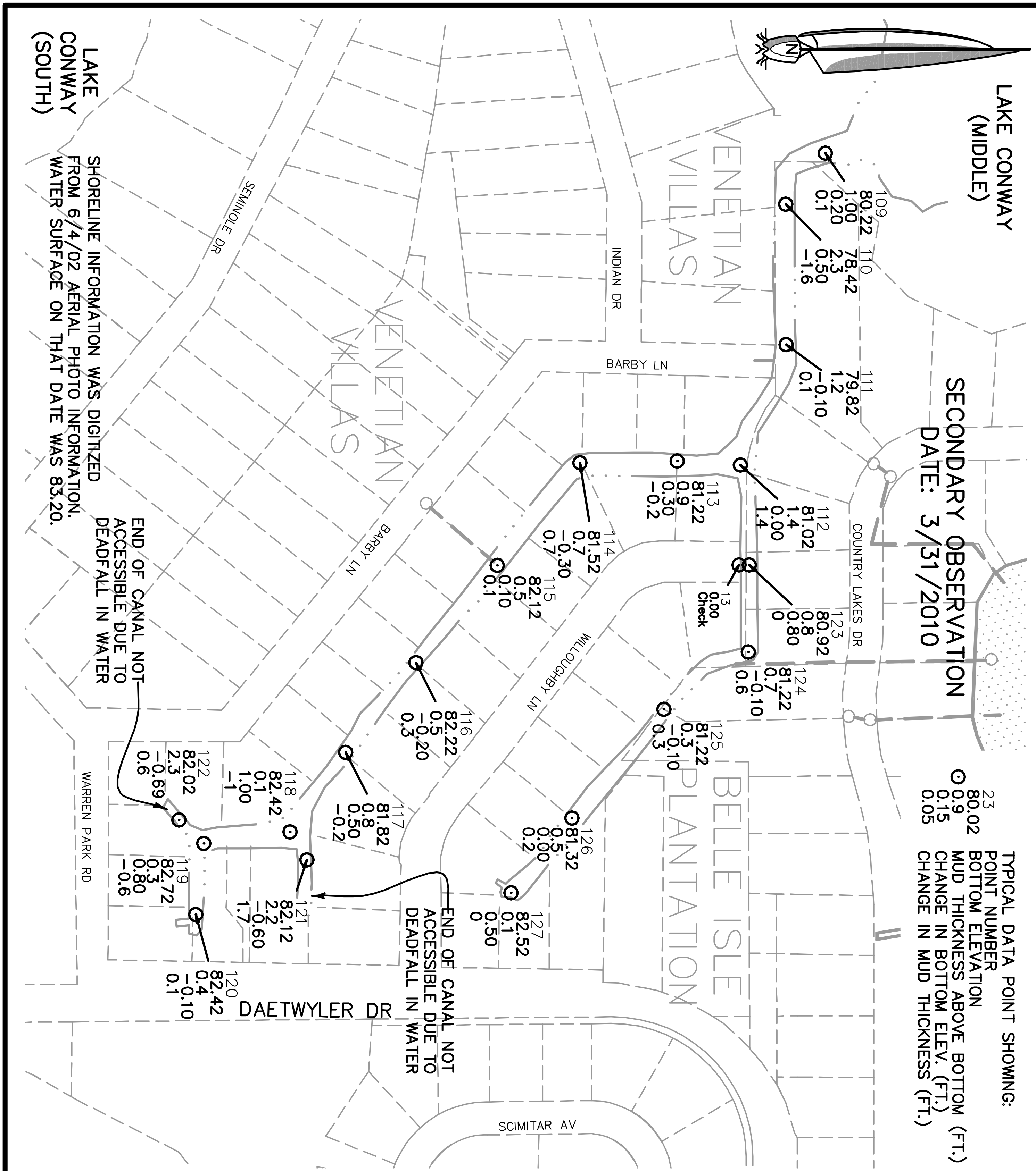

CONWAY CANAL SILTATION STUDY		
BARBY / WILLOUGHBY CANALS		
FOR: O. C. LAKE CONWAY NAVIGATION ADVISORY BOARD		
SCALE: 1"=200'	DATE: 9/13/2011	FILENAME: CNBCNL04
SHEET 36 OF 37	DESIGNED BY: DWW	DRAWN BY: DWW

TEC ENGINEERING, INC.
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APPROVED:

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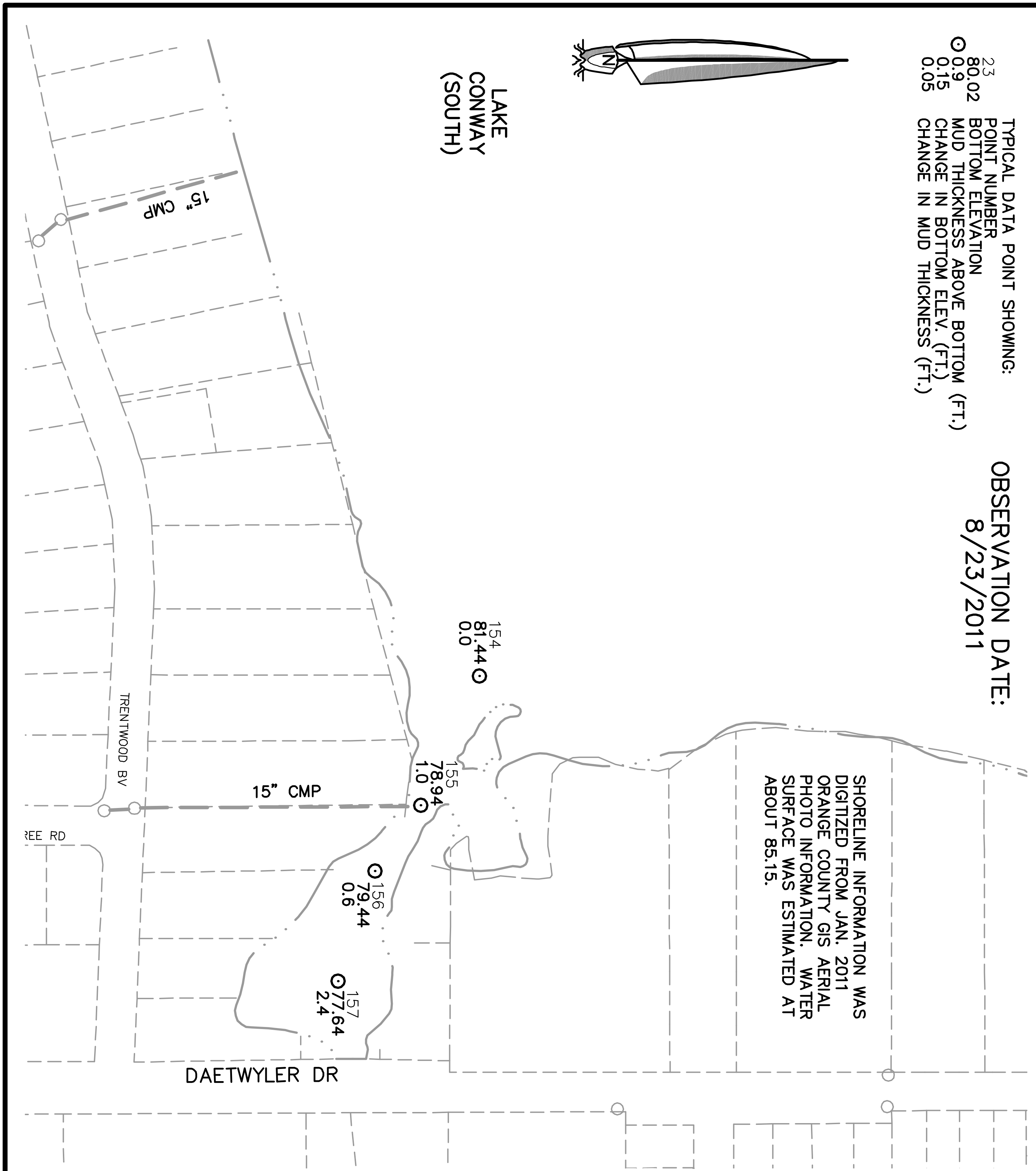

CONWAY CANAL SILTATION STUDY

DAETWYLER LAGOON

FOR: O. C. LAKE CONWAY NAVIGATION ADVISORY BOARD

SCALE: 1"=200'	DATE: 9/13/2011	FILENAME: CNBCNL04
SHEET 37 OF 37	DESIGNED BY: DWW	DRAWN BY: DWW

TEC ENGINEERING, INC.
TEC ENGINEERING, INC.
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APPROVED:

DAVID W. WOODS, PE
FLA REG 36902

APPENDIX B
Compiled Lake Stage Data

Elevation [ft, NAVD88]	Stage Percentile [%]
49.11	0.00%
80.31	0.00%
80.41	0.00%
80.51	0.00%
80.61	0.00%
80.71	0.00%
80.81	0.00%
80.91	0.85%
81.01	0.85%
81.11	0.85%
81.21	0.85%
81.31	0.85%
81.41	0.85%
81.51	0.85%
81.61	0.85%
81.71	0.85%
81.81	0.88%
81.91	0.88%
82.01	0.91%
82.11	0.96%
82.21	1.02%
82.31	1.04%
82.41	1.13%
82.51	1.13%
82.61	1.18%
82.71	1.24%
82.81	1.29%
82.91	1.29%
83.01	1.29%
83.11	1.32%
83.21	1.37%
83.31	1.40%
83.41	1.57%
83.51	1.57%
83.61	1.70%
83.71	2.06%
83.81	3.66%
83.91	5.20%
84.01	6.02%
84.11	6.40%

Elevation [ft, NAVD88]	Stage Percentile [%]
84.21	7.31%
84.31	8.19%
84.41	10.20%
84.51	11.96%
84.61	13.63%
84.71	16.85%
84.81	23.23%
84.91	28.04%
85.01	34.52%
85.11	42.91%
85.21	53.11%
85.31	67.78%
85.41	77.71%
85.51	84.77%
85.61	89.39%
85.71	93.49%
85.81	97.25%
85.91	99.40%
86.01	99.75%
86.11	99.89%
86.21	99.97%
86.31	100.00%
86.41	100.00%
86.51	100.00%

APPENDIX C
Approved Project Sampling Plan

BFA Environmental Consultants
Barnes, Ferland and Associates, Inc.

March 19, 2021

Mike Hardin, PhD, PE, CFM
Senior Water Resources Engineer
Geosyntec Consultants
3504 Lake Lynda Drive, Suite 155
Orlando, FL 32817

Re: Field Data Collection Standard Operating Procedure for the Lake Conway Canal Siltation Study.

Dear Mike,

Barnes Ferland and Associates, Inc. (BFA) surveyors will perform manual soundings to determine the depth to the top of the unconsolidated sediment layer and depth to the top of the hard bottom (consolidated sediment layer) relative to lake stage at the time of measurement along the canals that join the Lake Conway chain of lakes. The following is intended to satisfy Task 1 Field Data Collection Standard Operating Procedure (SOP) described below:

> *Task 1 - BFA will prepare a draft data collection SOP for approval by Geosyntec prior to collecting any field data. The SOP will include descriptions of manual soundings to determine the top of the unconsolidated sediment and top of the hard bottom sediment depths along canals. This is to include methods and materials to be used in collecting the data. BFA will make editorial changes and provide a final copy of the SOP to Geosyntec.*

Lake Access - The City of Belle Isle will provide a ramp pass to allow BFA access to the City's boat ramps for the duration of the study. The Venetian (middle) and Perkins (south) will require a pass for use. The Randolph boat ramp (Little Lake Conway) does not require a pass.

Horizontal and Vertical Controls - The horizontal control data shall be relative to the Florida State Plane Coordinate system, East Zone, North American Datum of 1983/1990 adjustment. All vertical control shall be established from benchmarks published by Orange County or other governmental agencies utilizing the North American Vertical Datum 1988 adjustment.

The survey will be conducted utilizing GPS Sokkia GRX3 base/rover, a Topcon AT-B3A Auto Level 28x, Windows 10 Rugged Tablet and Magnet Field Solutions, conventional instrumentation will also be utilized when needed.

Survey will be performed in accordance with the Standards of Practice as set forth by the Florida Board of Professional Surveyors and Mappers, Chapter 5J-17, Florida Administrative Code, Pursuant to Section 472.027, Florida Statutes.

Water Surface Elevation - The lake elevation will be determined twice daily by surveying the shoreline top of water level based on nearby canal soundings and benchmarks utilizing NAVD88. Additionally, the Lake Conway staff gauge will be read daily.

Depth Measurement Methodology - Depth measurements will be taken along the canal's apparent centerline in approximately 130 different locations throughout the canals, approximately every 200 ft (see attached sampling map). Each depth measurement will be taken as close as possible to the latitude/longitude locations listed on attached sampling map. Then the actual GPS reading will be taken at each sampling location. These data will be recorded in a data collector being a Windows Rugged Tablet utilizing Magnet Field Solutions.

Soundings to the top of the sediment will be made with a Secchi disk and the depth to hard bottom will be measured using a calibrated survey rod pushed to firm bottom/refusal. The lake elevation will then be used to determine the top of sediment elevation and the elevation of the hard bottom. The difference between the two elevations will define the soft sediment thickness.

Deliverables - BFA surveyors will create a bathymetry map using manual soundings evenly distributed through the canals approximately every 200 feet. Bathymetric survey data will be provided in CAD format. Sediment volume and water volume at the time of survey will be calculated and provided on the map. The survey will be delivered in Autocad format Version 19 or 20, and pdf format of the final map.

If you should have any questions or need more information, please give me a call at (321) 332-1101.

Sincerely,
Barnes, Ferland and Associates, Inc.

John Watson

John Watson, P.H.
Project Manager

Cc: Jay Sturgeon, PSM / BFA
Ben Stormont, P.G. / BFA

Standard Operation Plan for the Lake Conway Canal Siltation Study

This Standard Operation Plan (SOP) was prepared to detail the sampling procedures, methodologies, equipment, and requirements for the Lake Conway Canal Siltation Study. This project is being performed for Orange County Environmental Protection Division.

Approving Signatures and Dates:

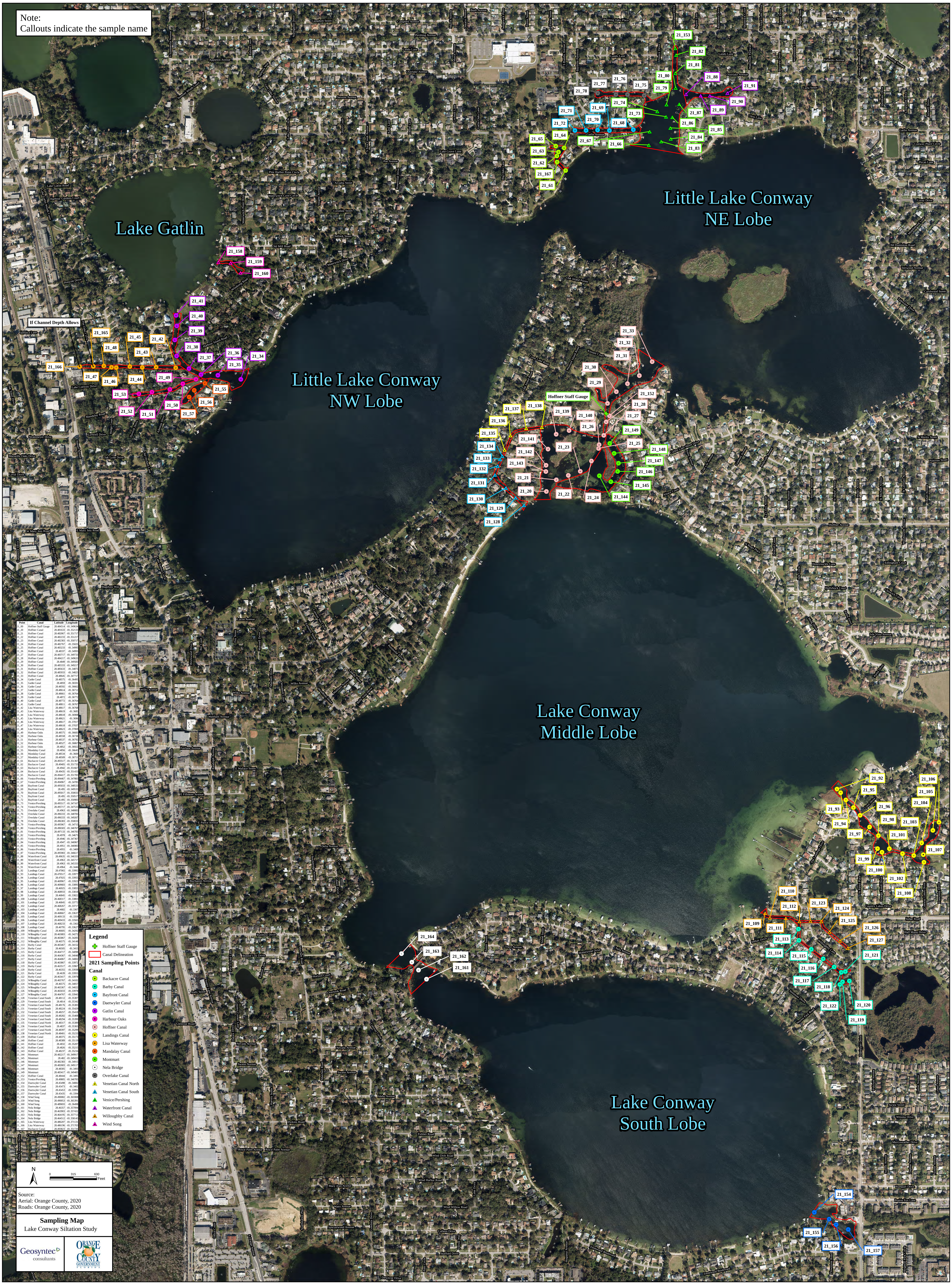
APPROVED
By Tara Urbanik at 10:50 am, Mar 22, 2021

Orange County Project Manager: Signature________ Date________

Geosyntec Project Manager: Mike Hardin Signature [signature] Date 3-22-2021

BFA Project Manager: John Watson Signature [signature] Date 3-22-2021

DRAFT 8/27/2021



Point	Canal	Latitude	Longitude
21_00	Hoffner Staff Gauge	28.484514	-81.349634
21_20	Hoffner Canal	28.481633	-81.352133
21_21	Hoffner Canal	28.482067	-81.351717
21_22	Hoffner Canal	28.482233	-81.351217
21_23	Hoffner Canal	28.482383	-81.350717
21_24	Hoffner Canal	28.482767	-81.35025
21_25	Hoffner Canal	28.483233	-81.34995
21_26	Hoffner Canal	28.48337	-81.34993
21_27	Hoffner Canal	28.483717	-81.349733
21_28	Hoffner Canal	28.484217	-81.349633
21_29	Hoffner Canal	28.4849	-81.349583
21_30	Hoffner Canal	28.485333	-81.349217
21_31	Hoffner Canal	28.485633	-81.34875
21_32	Hoffner Canal	28.485933	-81.34825
21_33	Hoffner Canal	28.48645	-81.347717
21_34	Gatlin Canal	28.48575	-81.36495
21_35	Gatlin Canal	28.4859	-81.36591
21_36	Gatlin Canal	28.48592	-81.36662
21_37	Gatlin Canal	28.48614	-81.36712
21_38	Gatlin Canal	28.48661	-81.36764
21_39	Gatlin Canal	28.4872	-81.36772
21_40	Gatlin Canal	28.48772	-81.36764
21_41	Gatlin Canal	28.48811	-81.36767
21_42	Lisa Waterway	28.48617	-81.36768
21_43	Lisa Waterway	28.48619	-81.3685
21_44	Lisa Waterway	28.48618	-81.36908
21_45	Lisa Waterway	28.48621	-81.3696
21_46	Lisa Waterway	28.48617	-81.37017
21_47	Lisa Waterway	28.48618	-81.37037
21_48	Lisa Waterway	28.48623	-81.37069
21_49	Harbour Oaks	28.48575	-81.36683
21_50	Harbour Oaks	28.48558	-81.36738
21_51	Harbour Oaks	28.48537	-81.36792
21_52	Harbour Oaks	28.48527	-81.36867
21_53	Harbour Oaks	28.4852	-81.36922
21_55	Mandalay Canal	28.4856	-81.36645
21_56	Mandalay Canal	28.48534	-81.3669
21_57	Mandalay Canal	28.48509	-81.36711
21_61	Backacre Canal	28.493517	-81.351367
21_62	Backacre Canal	28.49405	-81.351733
21_63	Backacre Canal	28.4942	-81.351667
21_64	Backacre Canal	28.49435	-81.351433
21_65	Backacre Canal	28.494417	-81.351783
21_66	Venice/Pershing	28.494467	-81.347883
21_67	Venice/Pershing	28.494967	-81.34785
21_68	Bayfront Canal	28.495033	-81.348533
21_69	Bayfront Canal	28.495	-81.349533
21_70	Bayfront Canal	28.495017	-81.350033
21_71	Bayfront Canal	28.495	-81.350517
21_72	Bayfront Canal	28.495	-81.350983
21_73	Venice/Pershing	28.495517	-81.347167
21_74	Venice/Pershing	28.495717	-81.347533
21_75	Overlake Canal	28.4963	-81.348083
21_76	Overlake Canal	28.496333	-81.348783
21_77	Overlake Canal	28.496333	-81.349267
21_78	Overlake Canal	28.496383	-81.350033
21_79	Venice/Pershing	28.495967	-81.34715
21_80	Venice/Pershing	28.496583	-81.346767
21_81	Venice/Pershing	28.497133	-81.346783
21_82	Venice/Pershing	28.4978	-81.34675
21_83	Venice/Pershing	28.4946	-81.347367
21_84	Venice/Pershing	28.4947	-81.346967
21_85	Venice/Pershing	28.4951	-81.346983
21_86	Venice/Pershing	28.4955	-81.3469
21_87	Venice/Pershing	28.495983	-81.346617
21_88	Waterfront Canal	28.49635	-81.346333
21_89	Waterfront Canal	28.4963	-81.345717
21_90	Waterfront Canal	28.4963	-81.345333
21_91	Waterfront Canal	28.4964	-81.3446
21_92	Landings Canal	28.47065	-81.33992
21_93	Landings Canal	28.470517	-81.33977
21_94	Landings Canal	28.47025	-81.33955
21_95	Landings Canal	28.469967	-81.33923
21_96	Landings Canal	28.469683	-81.33895
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21_98	Landings Canal	28.468933	-81.33818
21_99	Landings Canal	28.46845	-81.33822
21_100	Landings Canal	28.468317	-81.33803
21_101	Landings Canal	28.46845	-81.33772
21_102	Landings Canal	28.468267	-81.33717
21_103	Landings Canal	28.4682	-81.3367
21_104	Landings Canal	28.468667	-81.33637
21_105	Landings Canal	28.469133	-81.3359
21_106	Landings Canal	28.469433	-81.33565
21_107	Landings Canal	28.468233	-81.3363
21_108	Landings Canal	28.46795	-81.33627
21_109	Willoughby Canal	28.46605	-81.34292
21_110	Willoughby Canal	28.465883	-81.34272
21_111	Willoughby Canal	28.465867	-81.34205
21_112	Willoughby Canal	28.46575	-81.34148
21_113	Barby Canal	28.465467	-81.34152
21_114	Barby Canal	28.46505	-81.3415
21_115	Barby Canal	28.464717	-81.34098
21_116	Barby Canal	28.464367	-81.34048
21_117	Barby Canal	28.464067	-81.34002
21_118	Barby Canal	28.463867	-81.33972
21_119	Barby Canal	28.463517	-81.33967
21_120	Barby Canal	28.46355	-81.33938
21_121	Barby Canal	28.4639	-81.33955
21_122	Barby Canal	28.463417	-81.33978
21_123	Willoughby Canal	28.465767	-81.34102
21_124	Willoughby Canal	28.46575	-81.34057
21_125	Willoughby Canal	28.465367	-81.34022
21_126	Willoughby Canal	28.465033	-81.33978
21_127	Willoughby Canal	28.464767	-81.33945
21_128	Venetian Canal South	28.48112	-81.35307
21_129	Venetian Canal South	28.4814	-81.35342
21_130	Venetian Canal South	28.48176	-81.35383
21_131	Venetian Canal South	28.48224	-81.35429
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21_133	Venetian Canal South	28.48282	-81.35408
21_134	Venetian Canal South	28.48294	-81.35399
21_135	Venetian Canal North	28.48317	-81.35389
21_136	Venetian Canal North	28.4837	-81.35365
21_137	Venetian Canal North	28.48397	-81.35299
21_138	Venetian Canal North	28.48401	-81.35233
21_139	Hoffner Canal	28.48375	-81.35173
21_140	Hoffner Canal	28.48389	-81.35119
21_141	Hoffner Canal	28.4832	-81.35207
21_142	Hoffner Canal	28.4826	-81.35215
21_143	Hoffner Canal	28.48237	-81.35216
21_144	Montmart	28.482217	-81.349917
21_145	Montmart	28.482	-81.349433
21_146	Montmart	28.482383	-81.34915
21_147	Montmart	28.482683	-81.349117
21_148	Montmart	28.48305	-81.3493
21_149	Montmart	28.483417	-81.349483
21_152	Hoffner Canal	28.48444	-81.3495
21_153	Venice/Pershing	28.49805	-81.346783
21_154	Daetwyler Canal	28.45498	-81.34082
21_155	Daetwyler Canal	28.45473	-81.3402
21_156	Daetwyler Canal	28.45453	-81.33991
21_157	Daetwyler Canal	28.45435	-81.3394
21_158	Wind Song	28.490082	-81.365908
21_159	Wind Song	28.490053	-81.365391
21_160	Wind Song	28.489693	-81.36498
21_161	Nela Bridge	28.46357	-81.357094
21_162	Nela Bridge	28.463903	-81.357432
21_163	Nela Bridge	28.464195	-81.357713
21_164	Nela Bridge	28.464512	-81.358145
21_165	Lisa Waterway	28.486207	-81.371131
21_166	Lisa Waterway	28.486196	-81.371703
21_167	Backacre Canal	28.493823	-81.351726

APPENDIX D
2021 Sample Results

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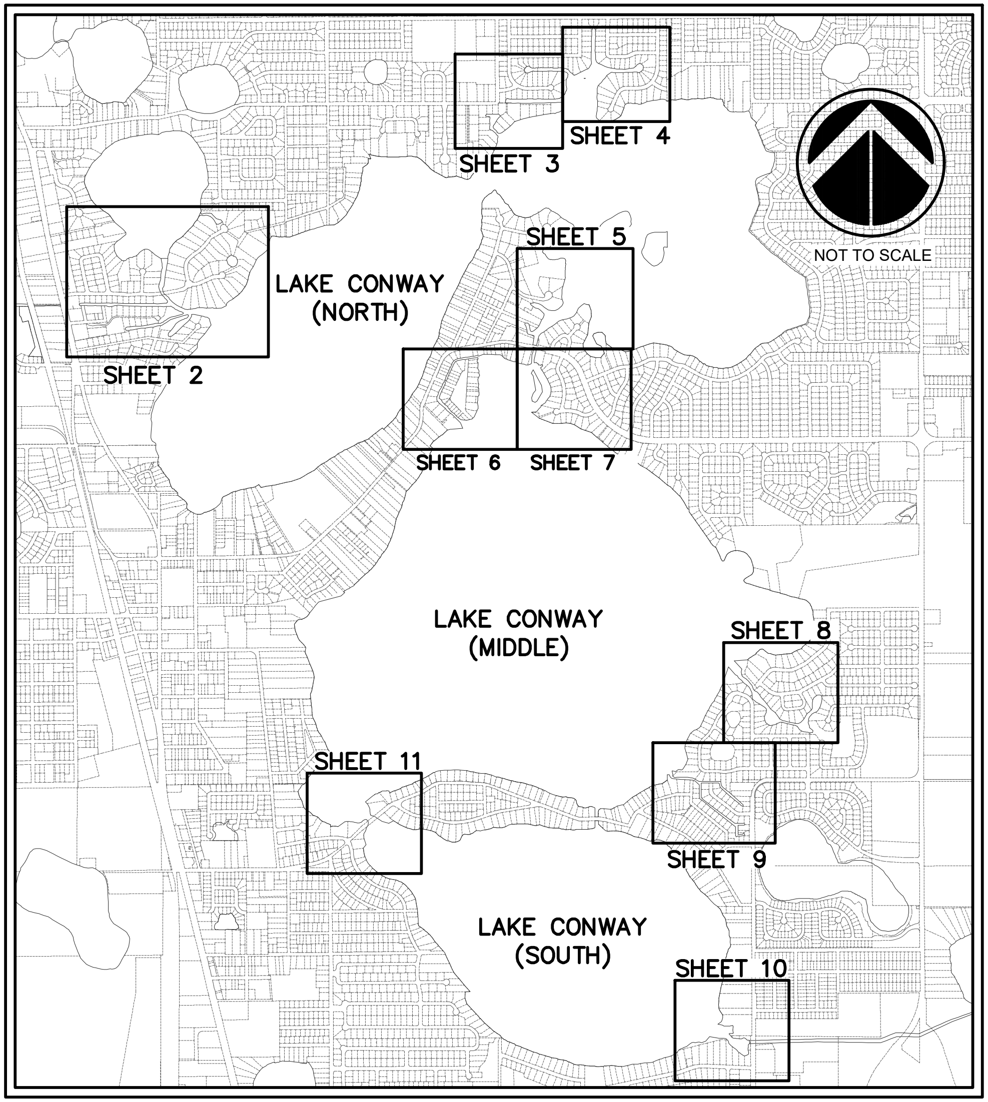
LAKE CONWAY
2021 CANAL SILTATION STUDY



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2.	HARBOUR ISLAND & LISA CANALS
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4.	WATERFRONT CANALS
5.	HOFFNER CANAL
6.	VENETIAN & HOFFNER CANALS
7.	VENETIAN & HOFFNER CANALS
8.	THE LANDINGS CANAL
9.	BARBY & WILLOUGHBY CANALS
10.	DAETWYLER LAGOON
11.	NELA AVE

GENERAL NOTES

1. THIS STUDY IS TO TRACK AND ESTIMATE THE RATES OF SILTATION OF THE CANALS ON THE LAKE CONWAY CHAIN.
2. THE BASE MAP FOR THIS STUDY WAS PROVIDED BY THE PROFESSIONAL ENGINEERING CONSULTANTS IN 2005.
3. THE HORIZONTAL LOCATION OF THE SPOT ELEVATIONS ARE APPROXIMATE TO WITHIN ±10' AND ARE BASED ON VISUAL OBSERVATION AND NAVIGATIONAL QUALITY GPS DATA.
4. BASELINE FIELD OBSERVATIONS WERE MADE BETWEEN 5/12/05 AND 6/8/05.
5. SECONDARY OBSERVATION DATES FOR EACH CANAL ARE SHOWN ON THE INDIVIDUAL SHEETS.
6. BOTTOM ELEVATIONS WERE ESTABLISHED BASED ON DEPTHS FROM THE DAILY LAKE SURFACE ELEVATION ACCORDING TO NAVD 88.

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COVER SHEET
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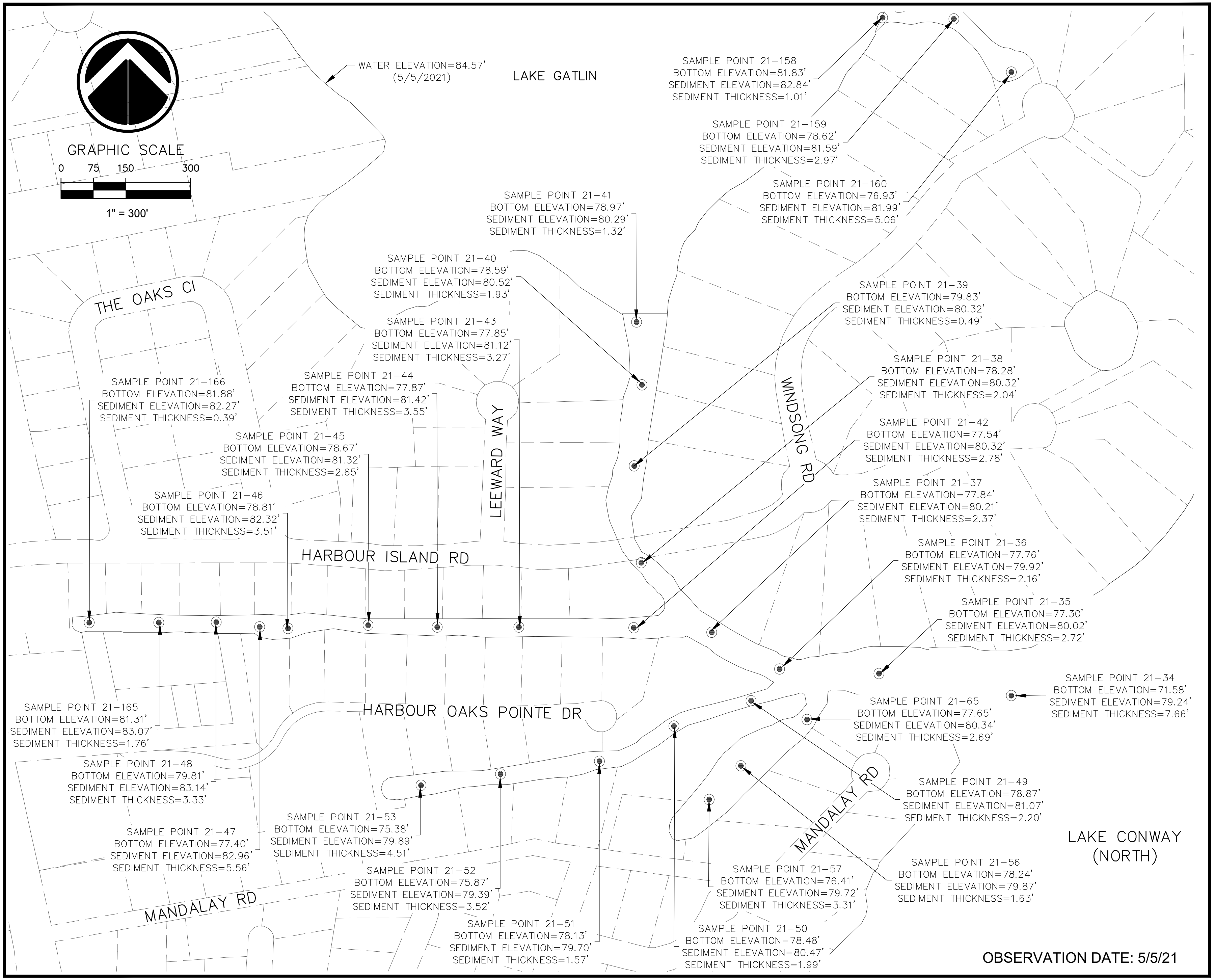

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CONWAY CANAL SILTATION STUDY
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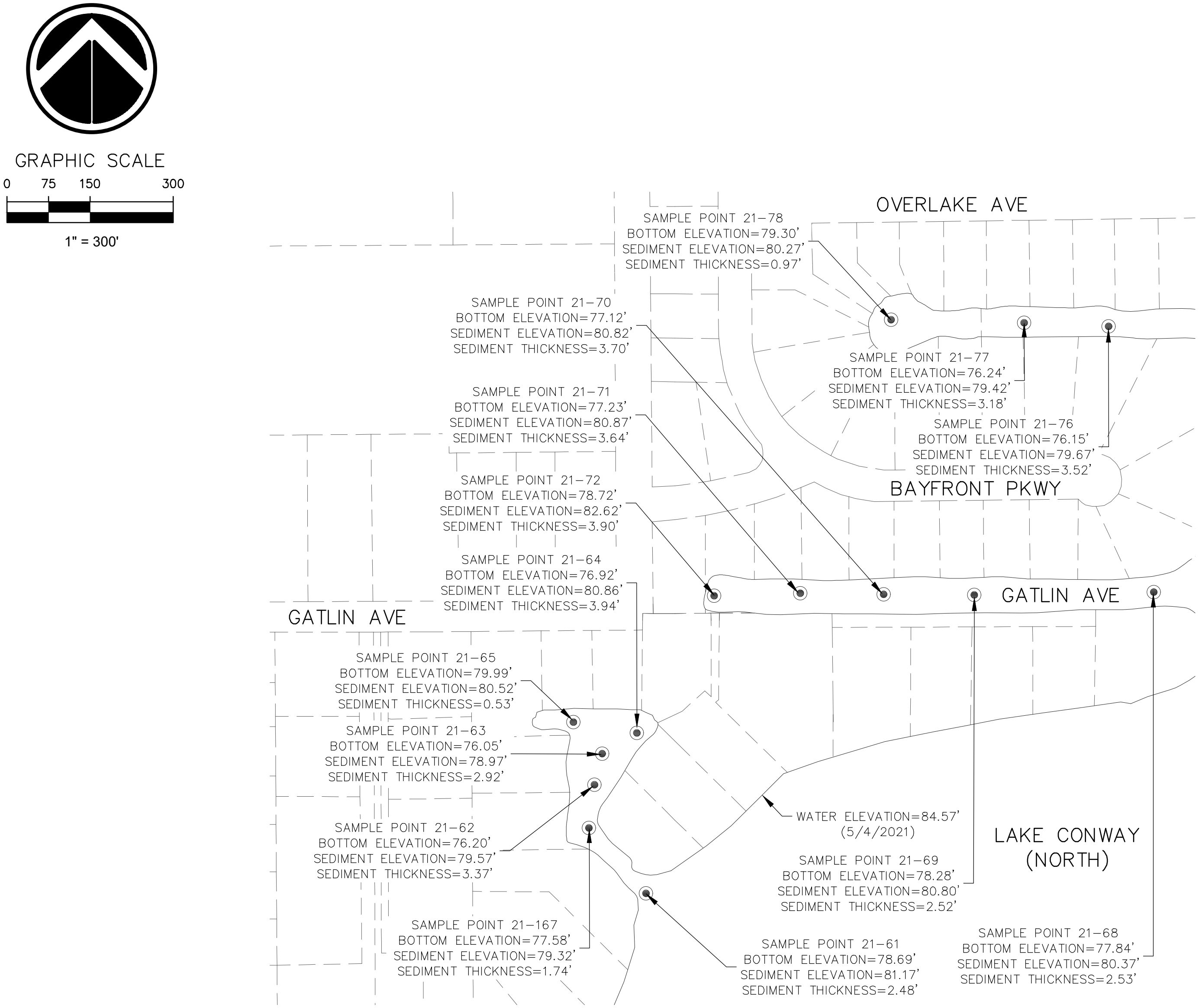

OBSERVATION DATE: 5/4/21

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CONWAY CANAL SILTATION STUDY
BACKACHERS & WATERFRONT CANALS
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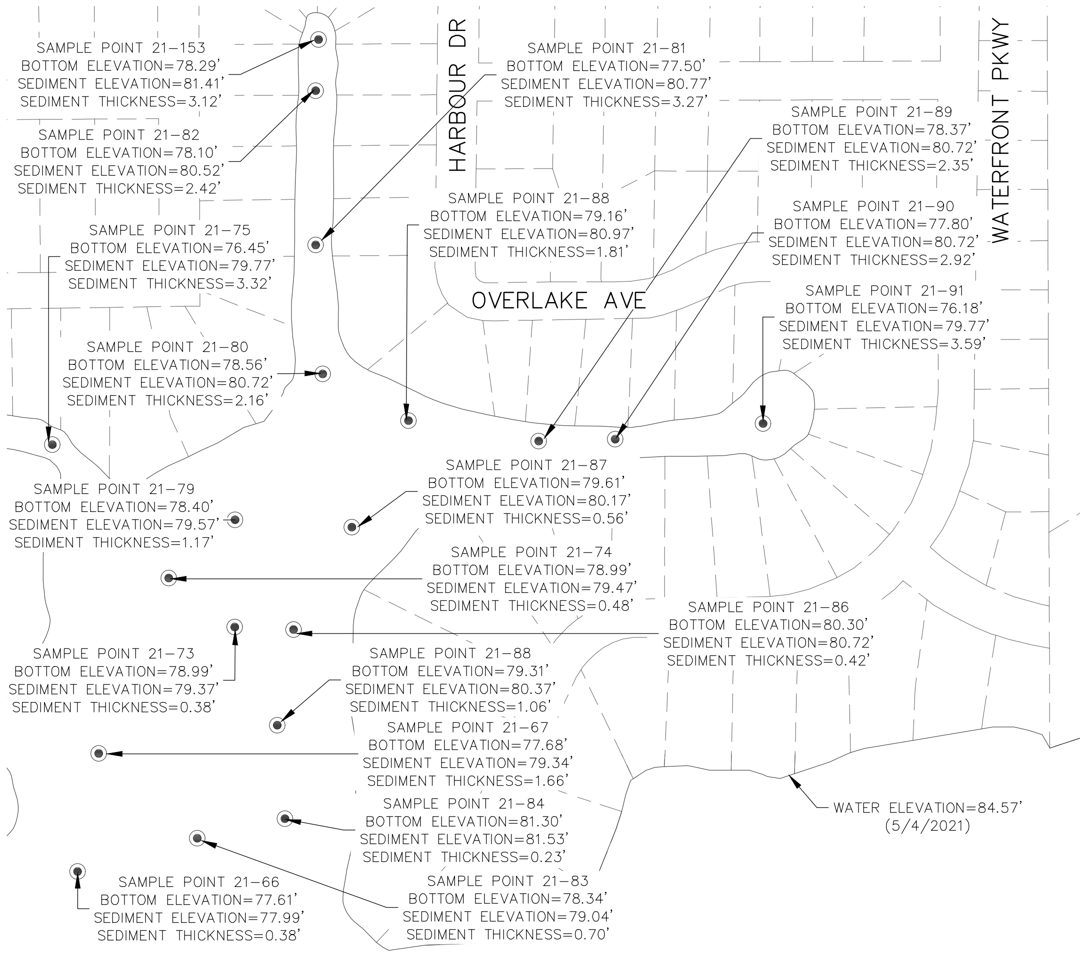
GRAPHIC SCALE

0 75 150 300

1" = 300'



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CONWAY CANAL SILTATION STUDY
WATERFRON CANALS
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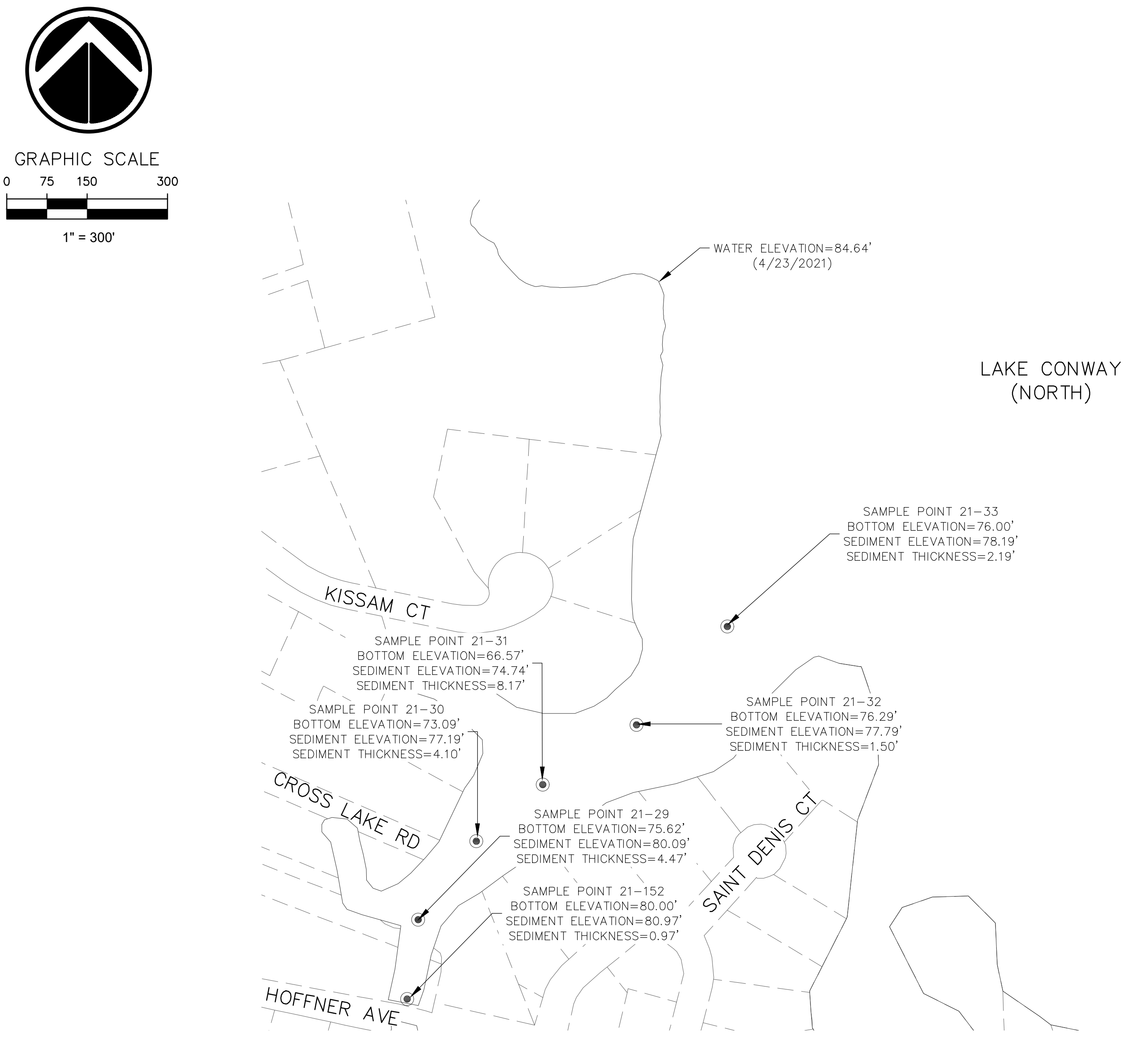

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CONWAY CANAL SILTATION STUDY
HOFFNER CANAL
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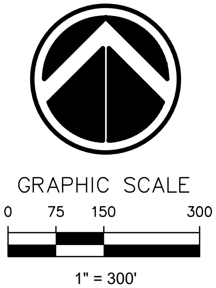

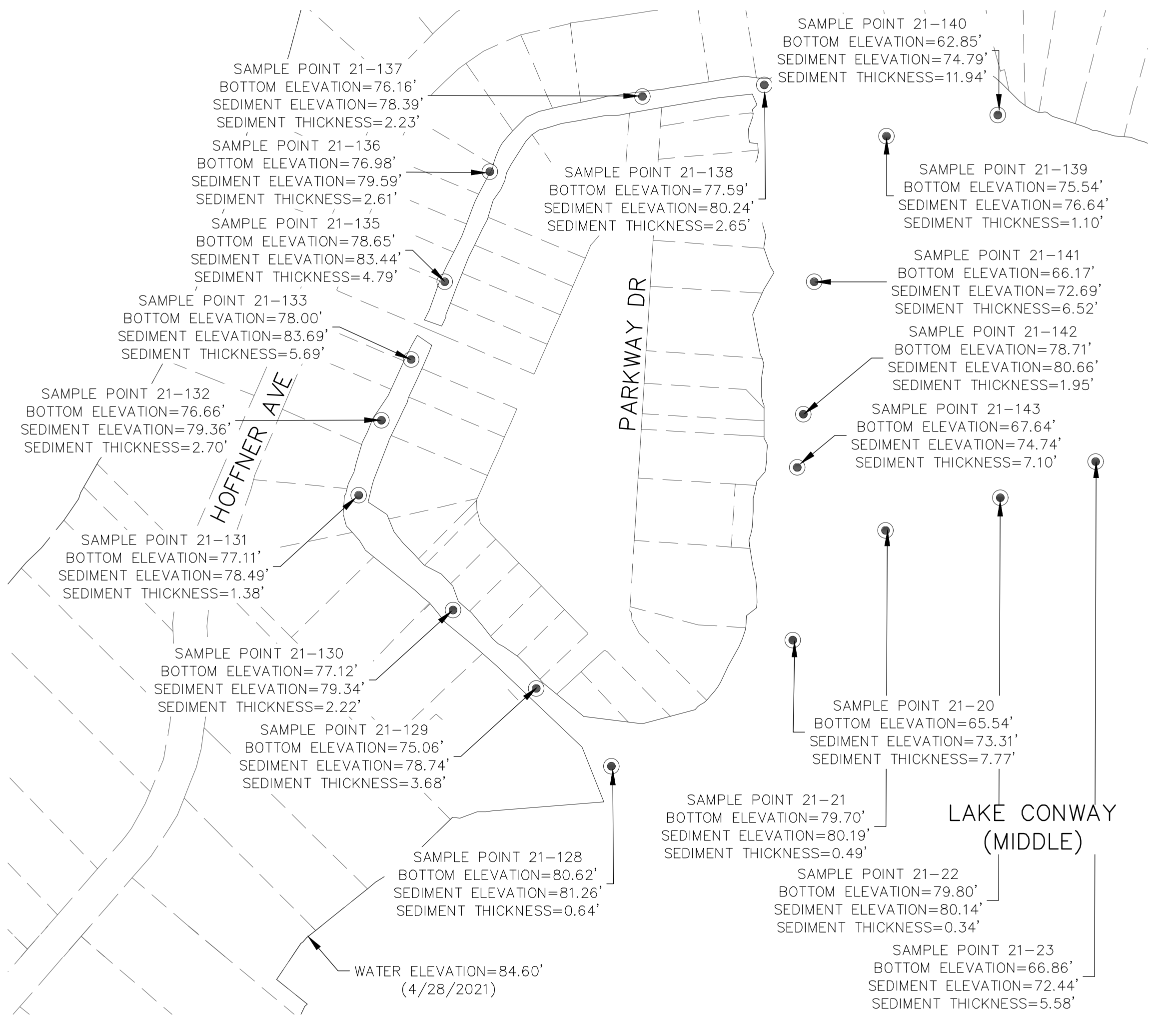

OBSERVATION DATE: 4/28/21

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CONWAY CANAL SILTATION STUDY

VENETIAN & HOFFNER CANALS

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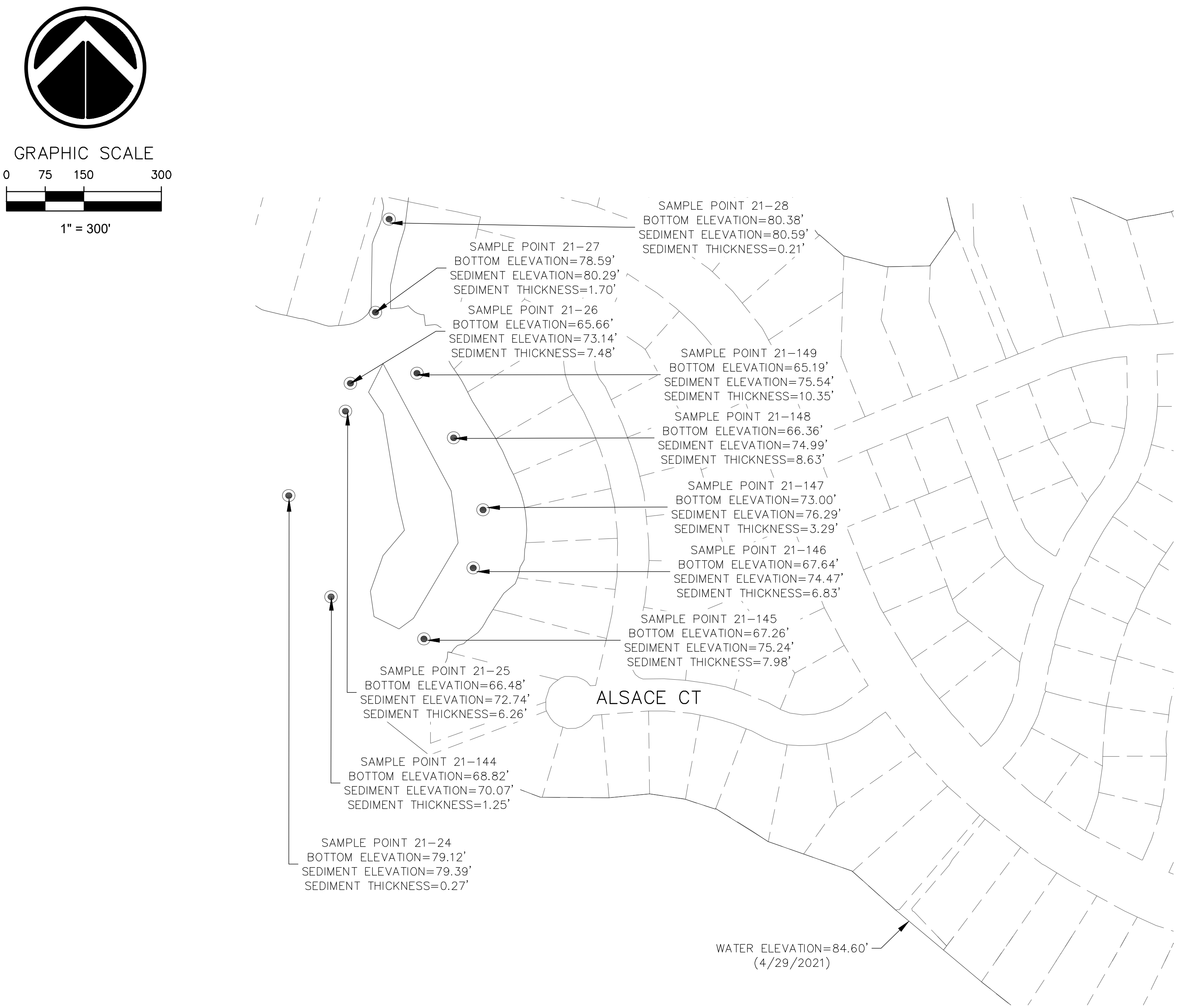

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CONWAY CANAL SILTATION STUDY
VENETIAN & HOFFNER CANALS
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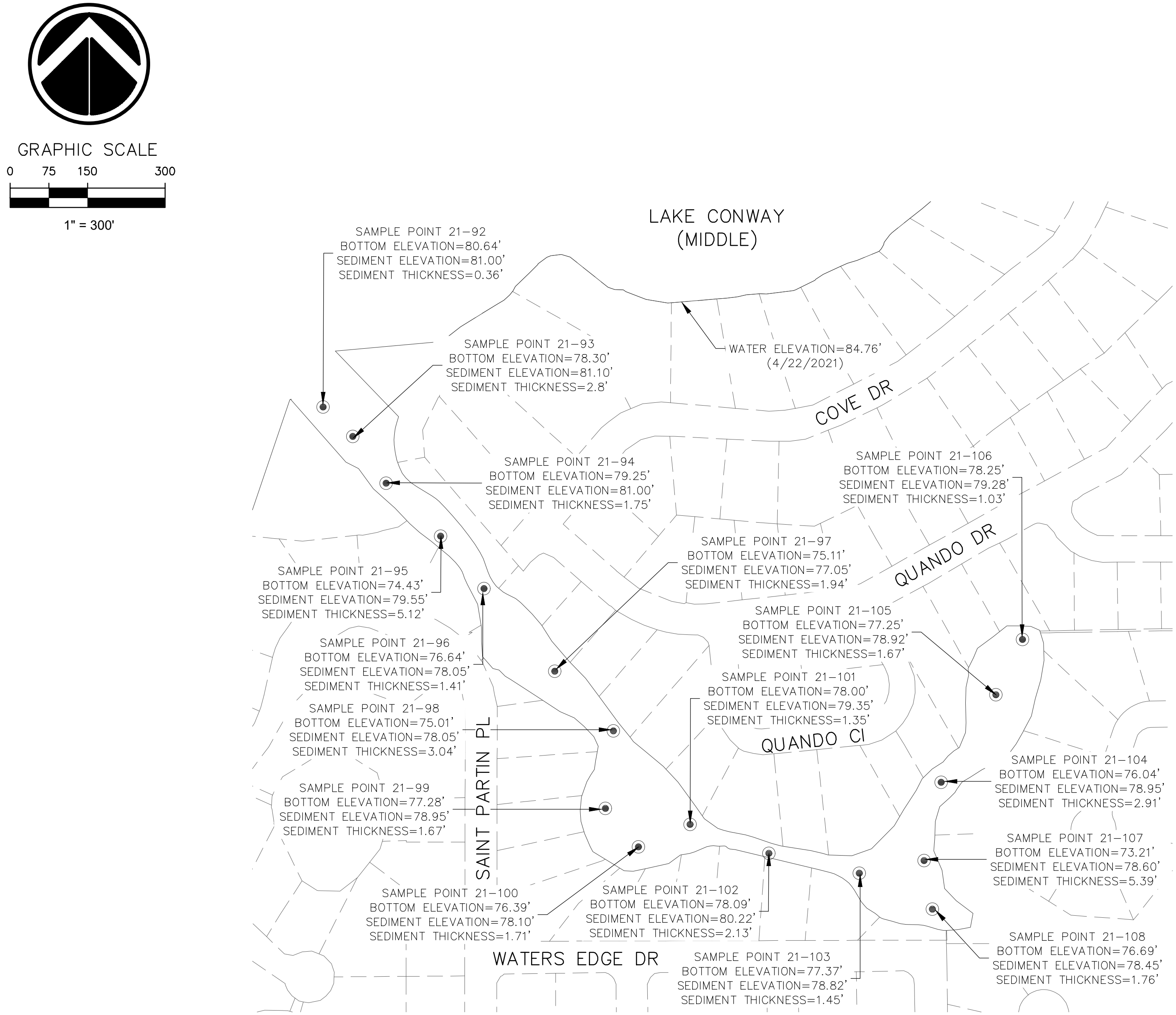

OBSERVATION DATE: 4/22/2021

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CONWAY CANAL SILTATION STUDY
THE LANDINGS CANAL
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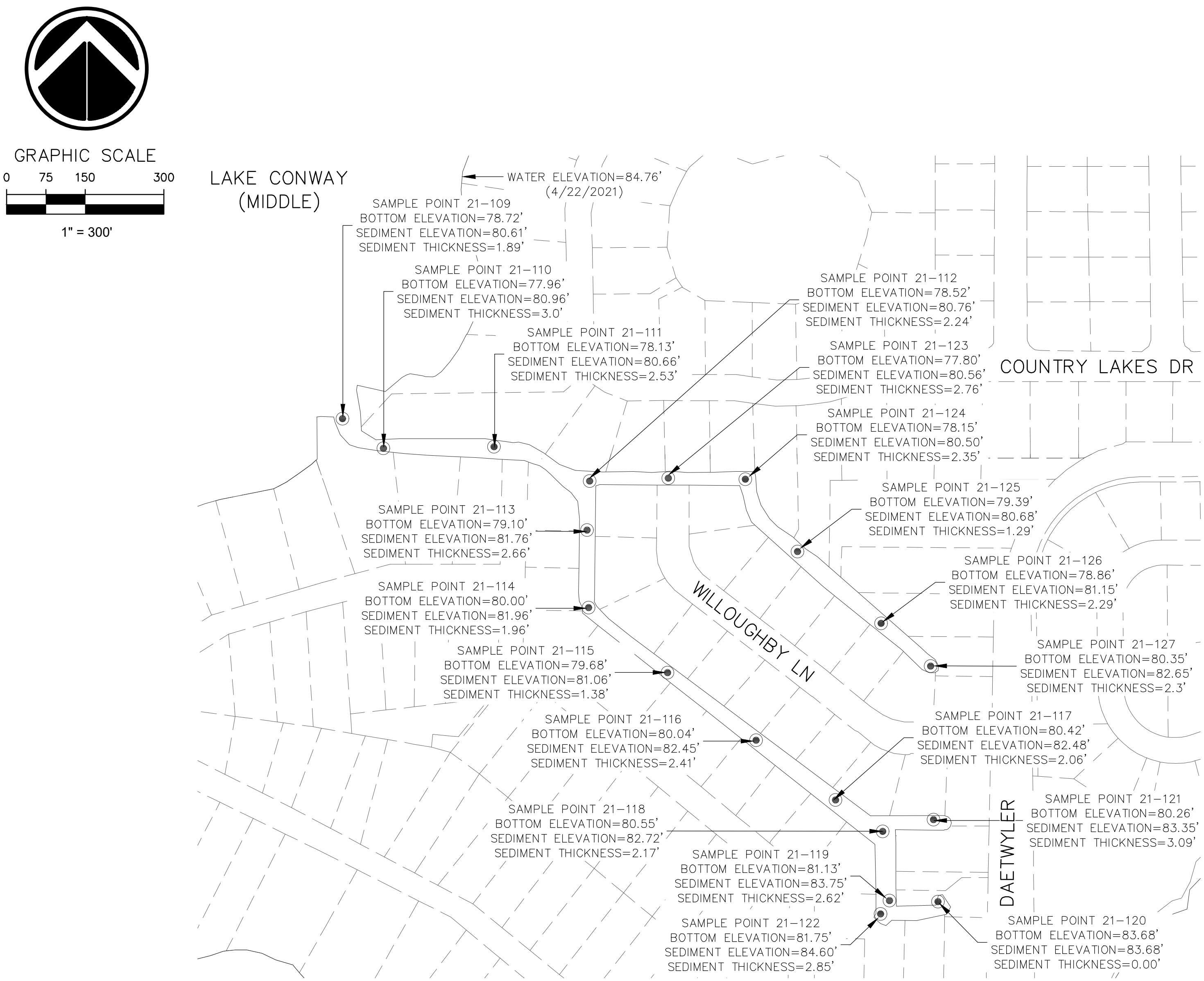

OBSERVATION DATE: 4/22/21

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CONWAY CANAL SILTATION STUDY
DARBY & WILLOUGHBY CANALS
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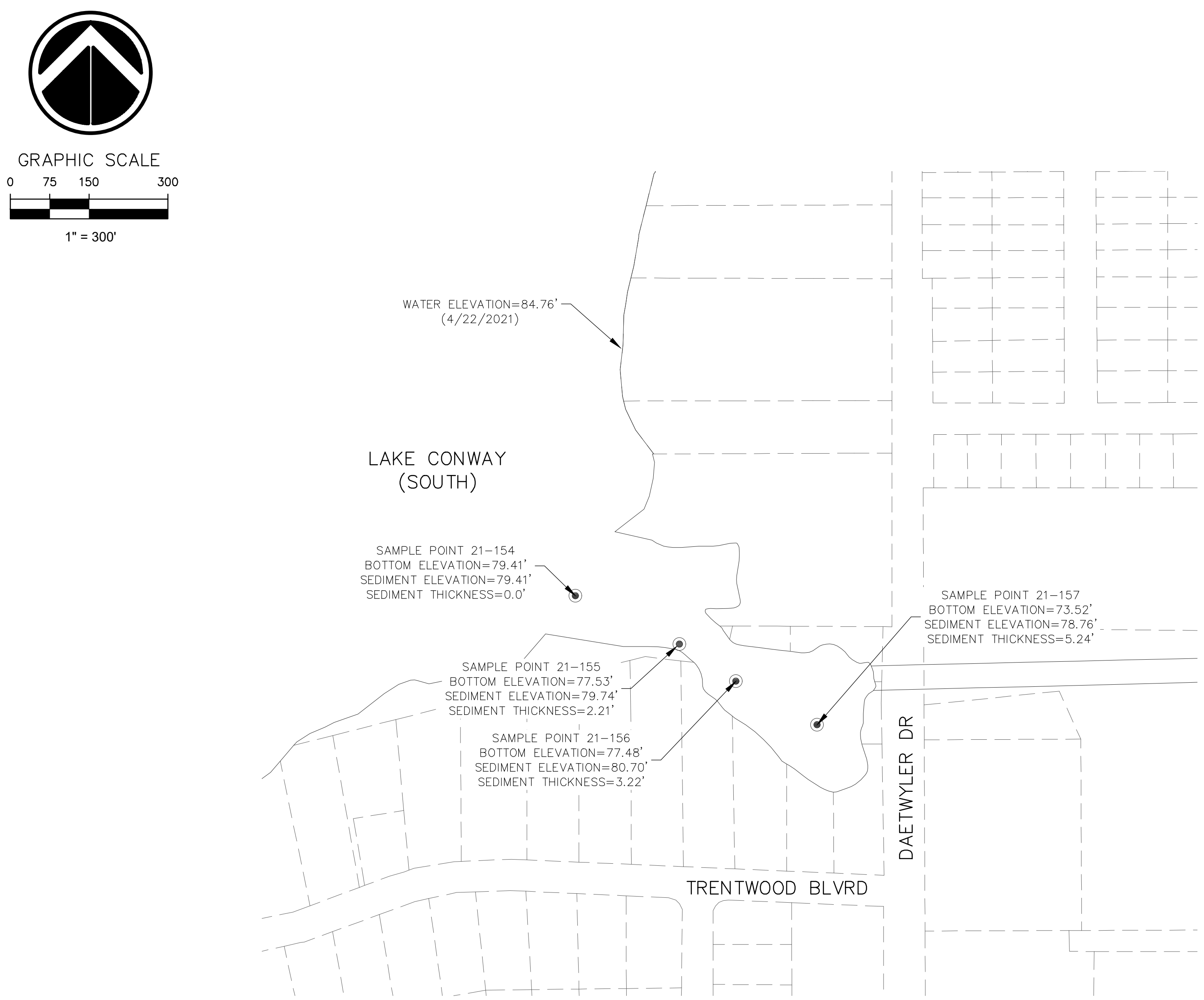

OBSERVATION DATE: 4/22/2021

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CONWAY CANAL SILTATION STUDY
DAETWYLER LAGOON
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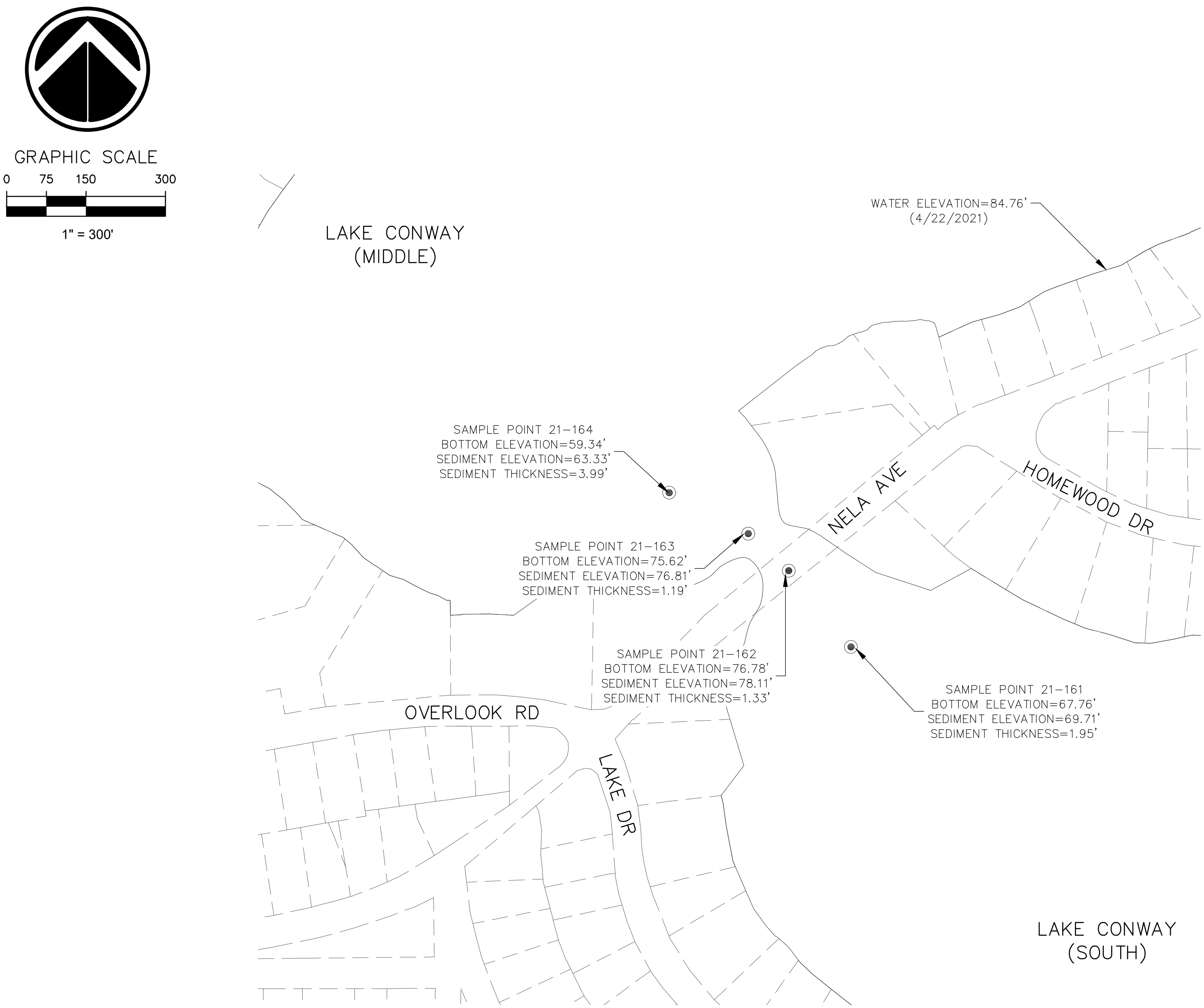

OBSERVATION DATE: 4/22/2021

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CONWAY CANAL SILTATION STUDY
NELA AVE
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APPENDIX E
Supplemental Graphs

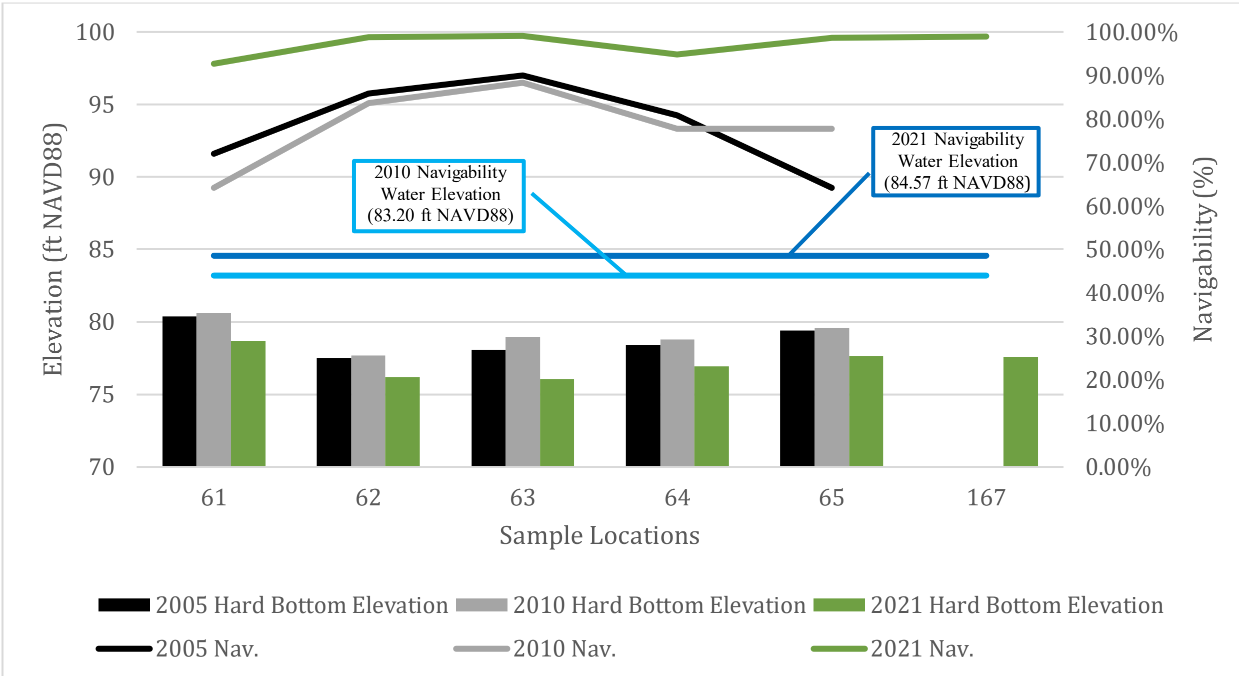

Figure E-1: Backacre Canal

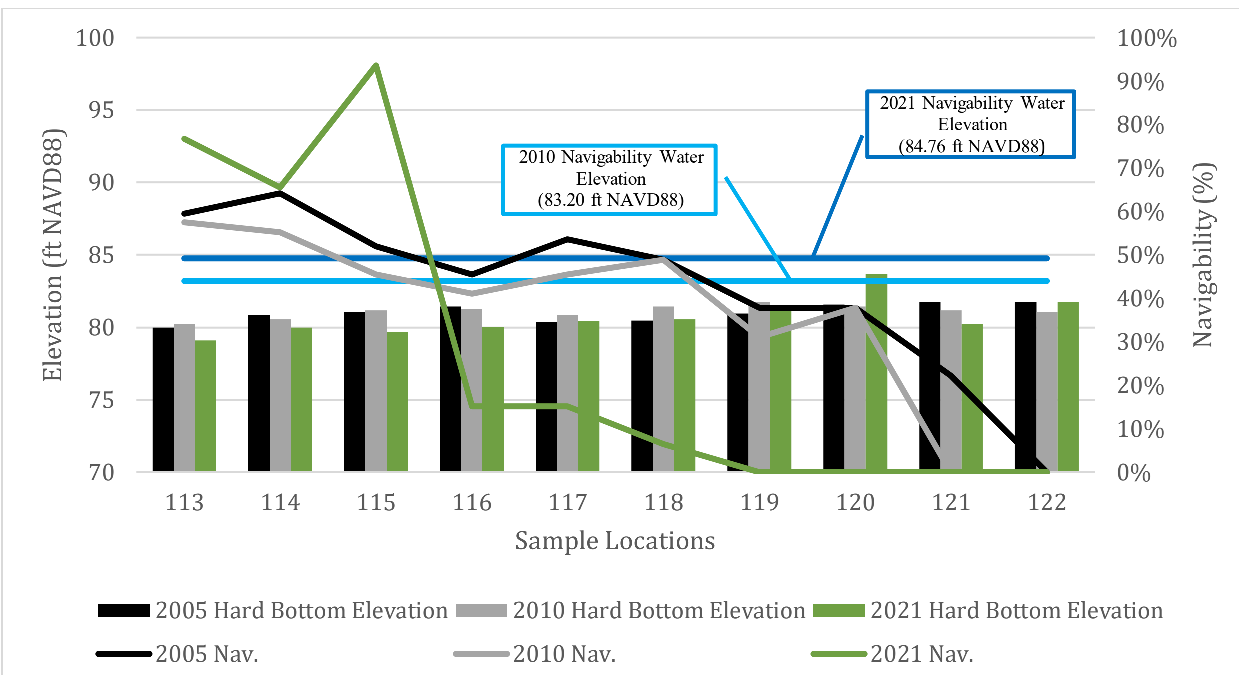

Figure E-2: Barby Canal

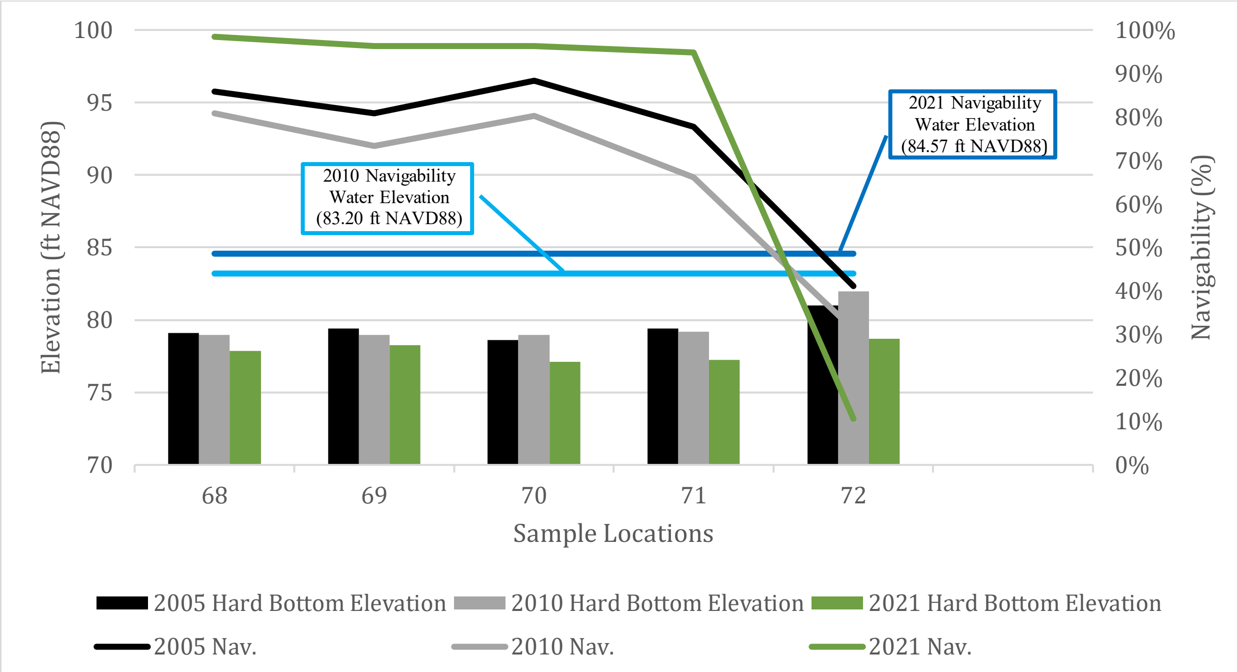

Figure E-3: Bayfront Canal

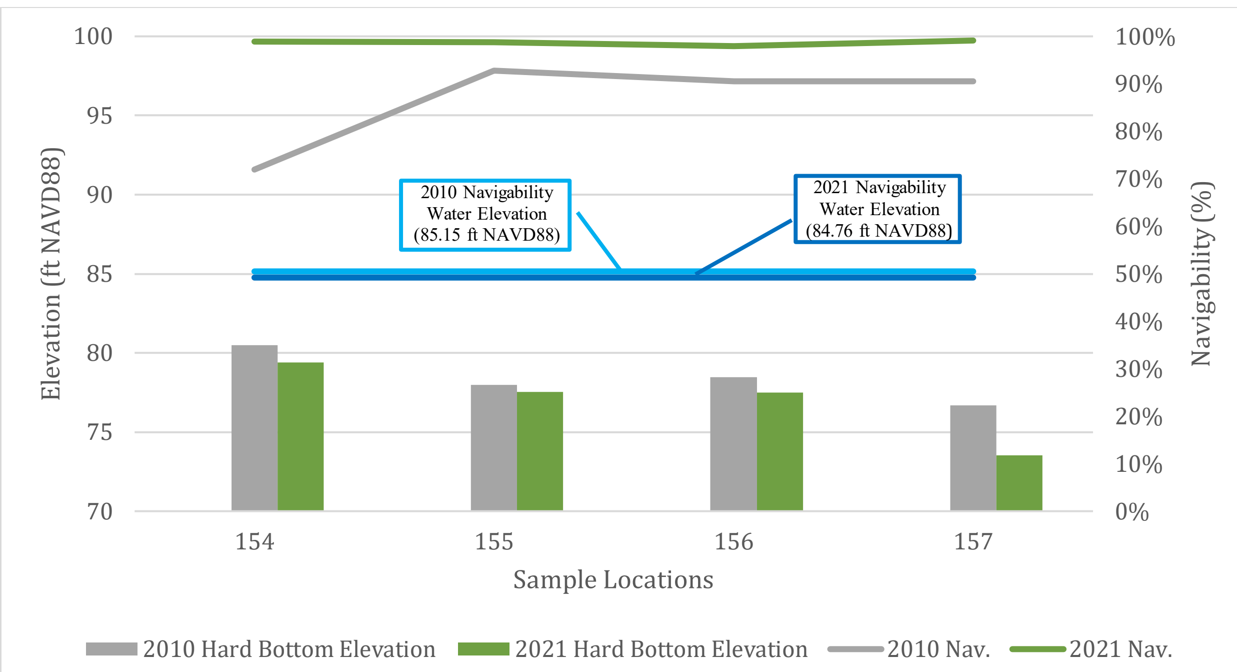

Figure E-4: Daetwyler Canal (no data for 2005)

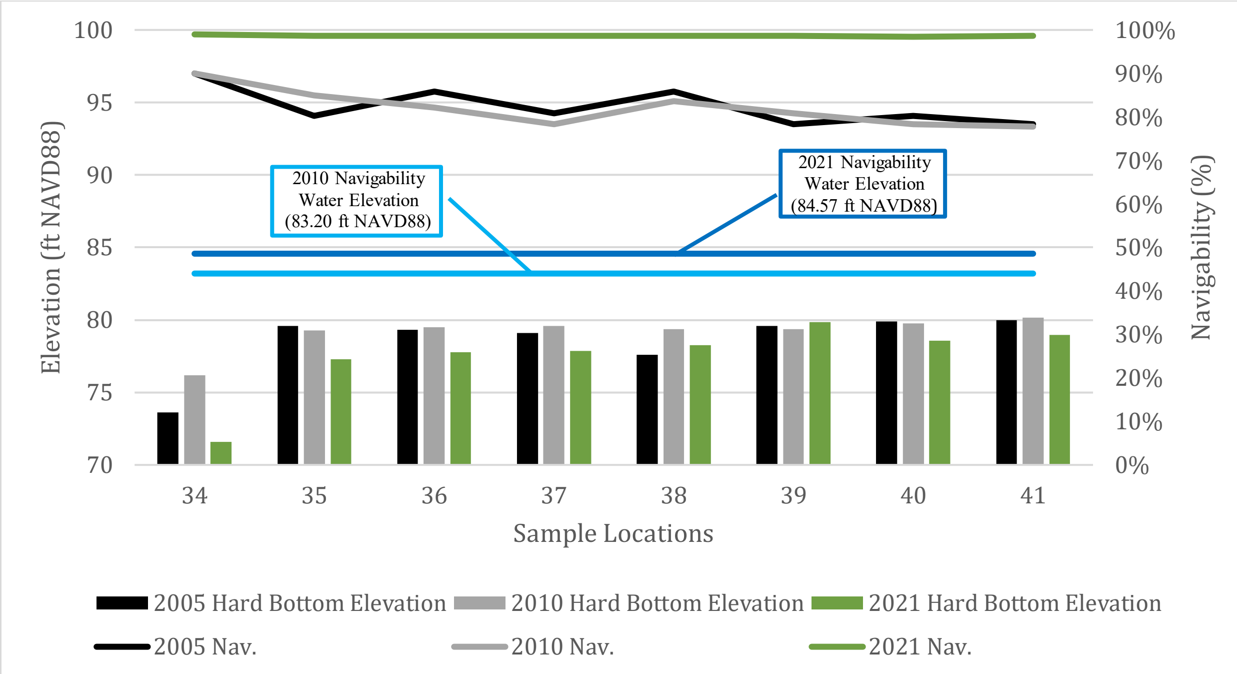

Figure E-5: Gatlin Canal

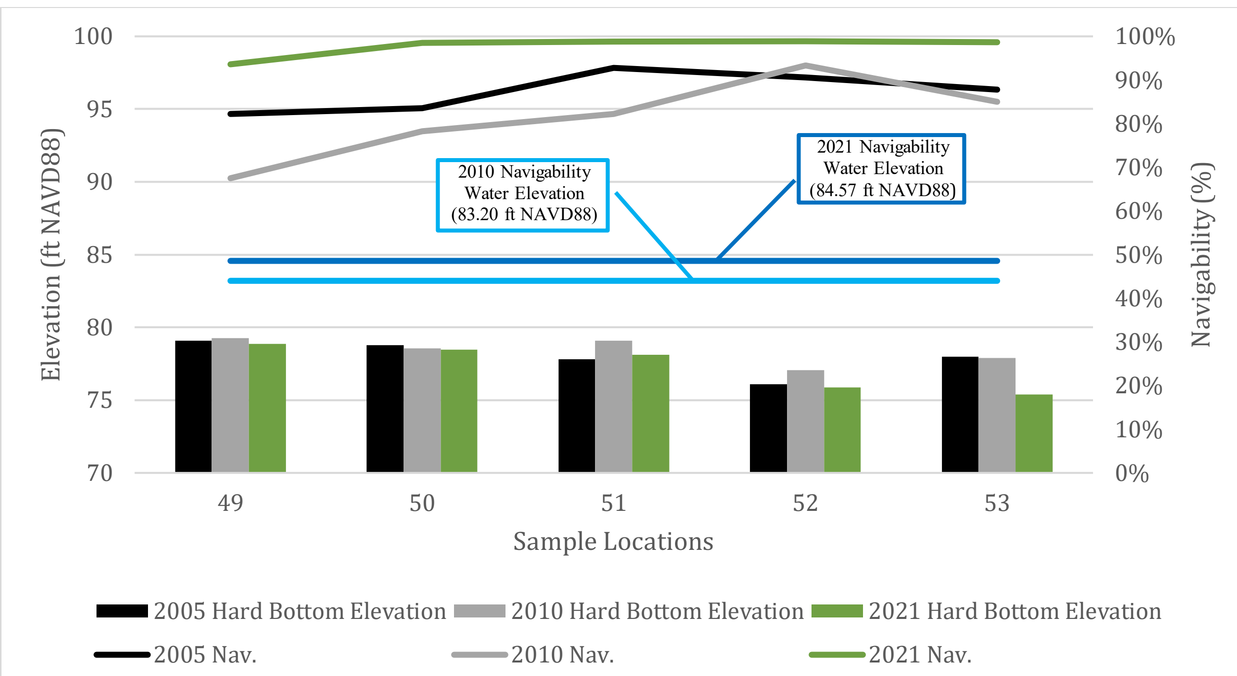

Figure E-6: Harbour Oaks

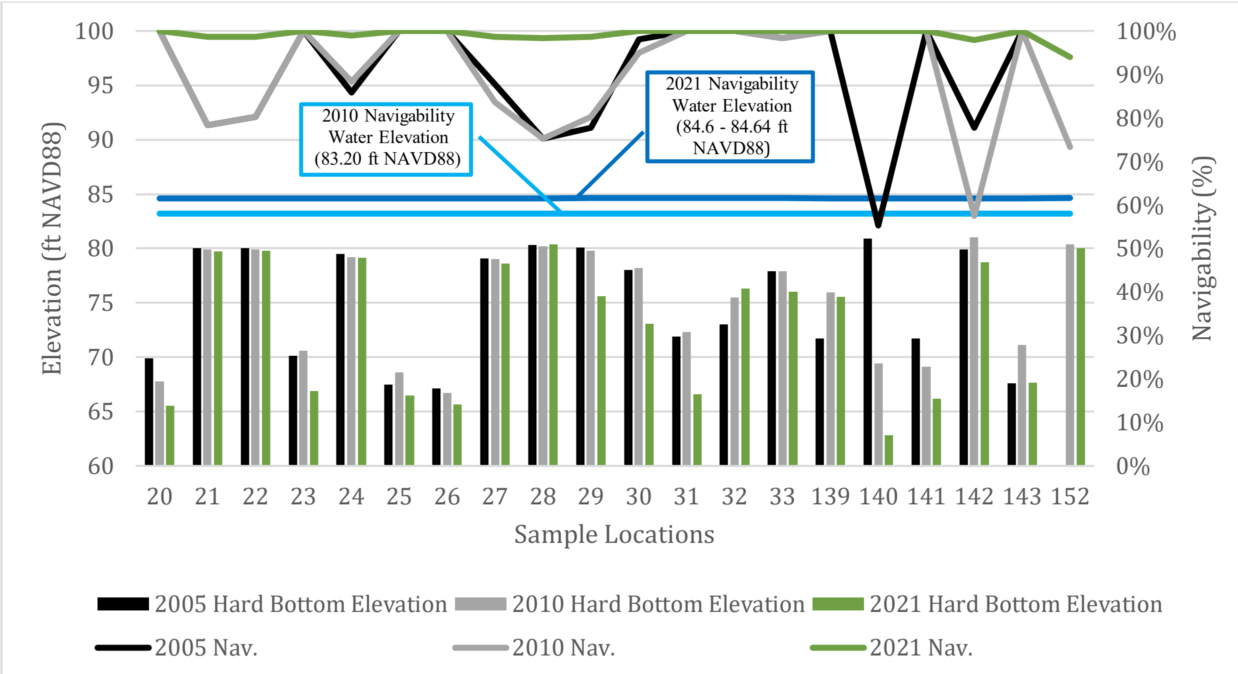

Figure E-7: Hoffner Canal

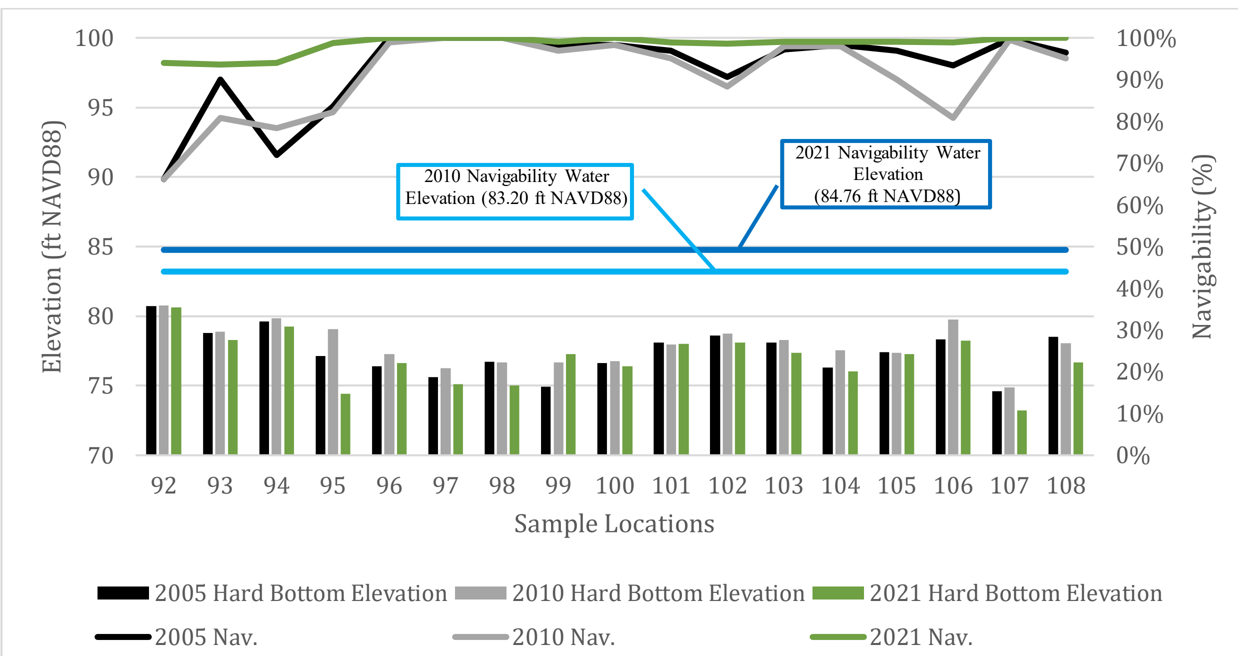

Figure E-8: Landings Canal

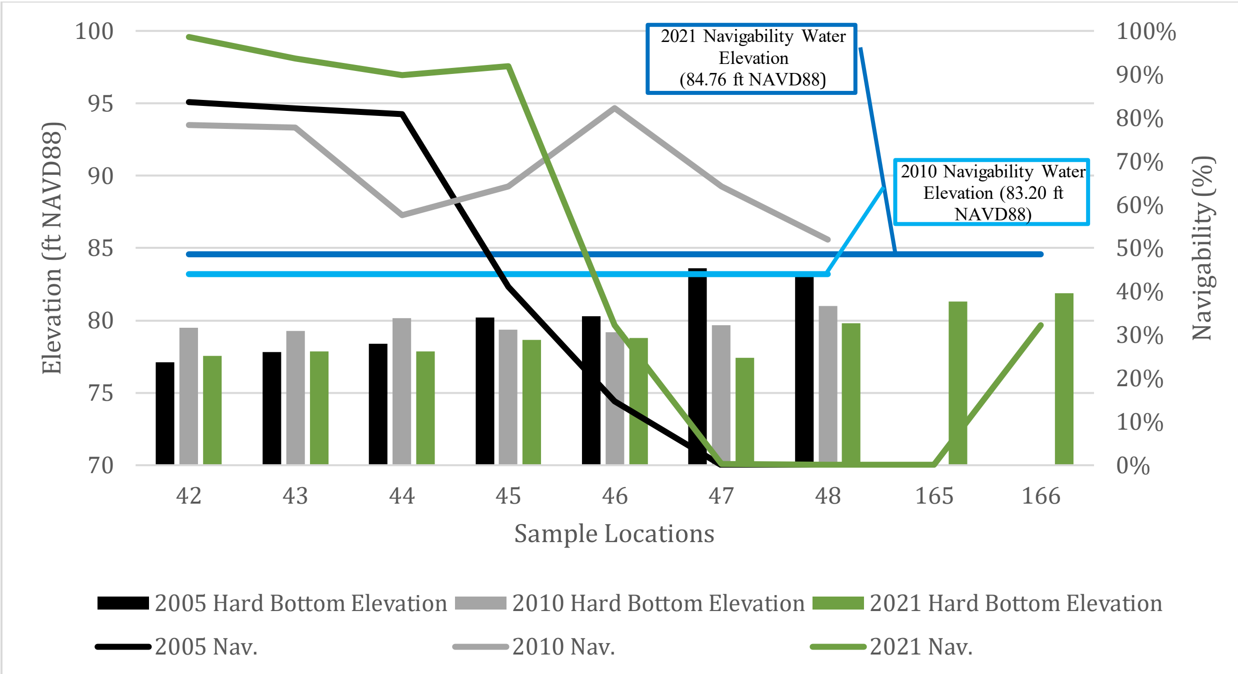

Figure E-9: Lisa Waterway

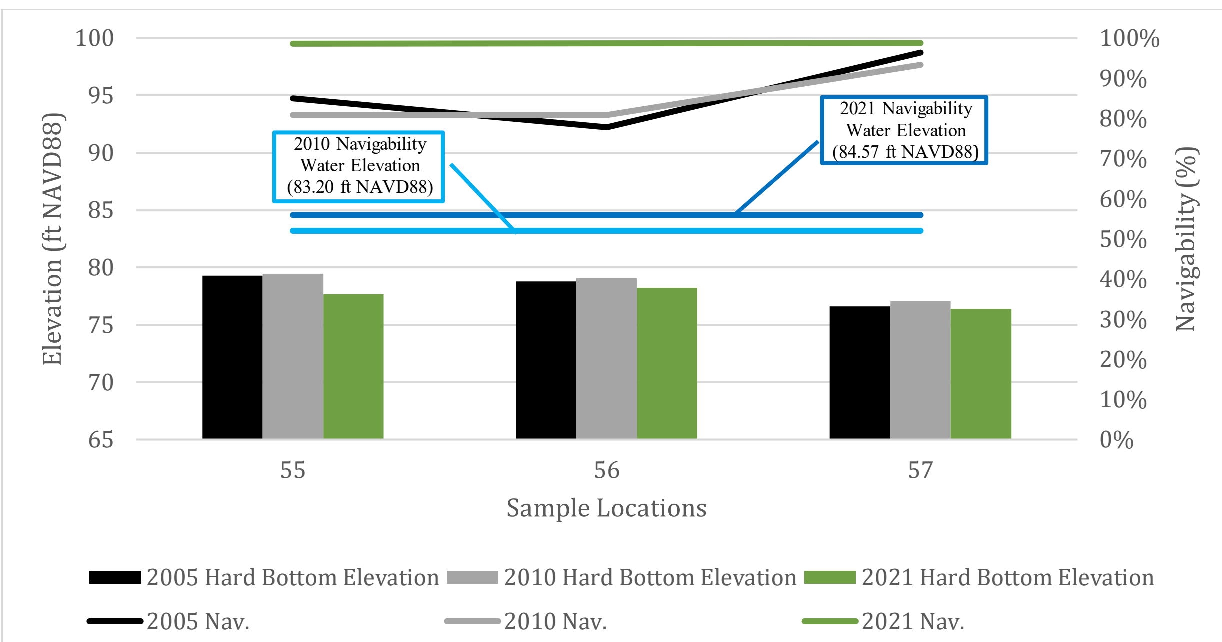

Figure E-10: Mandalay Canal

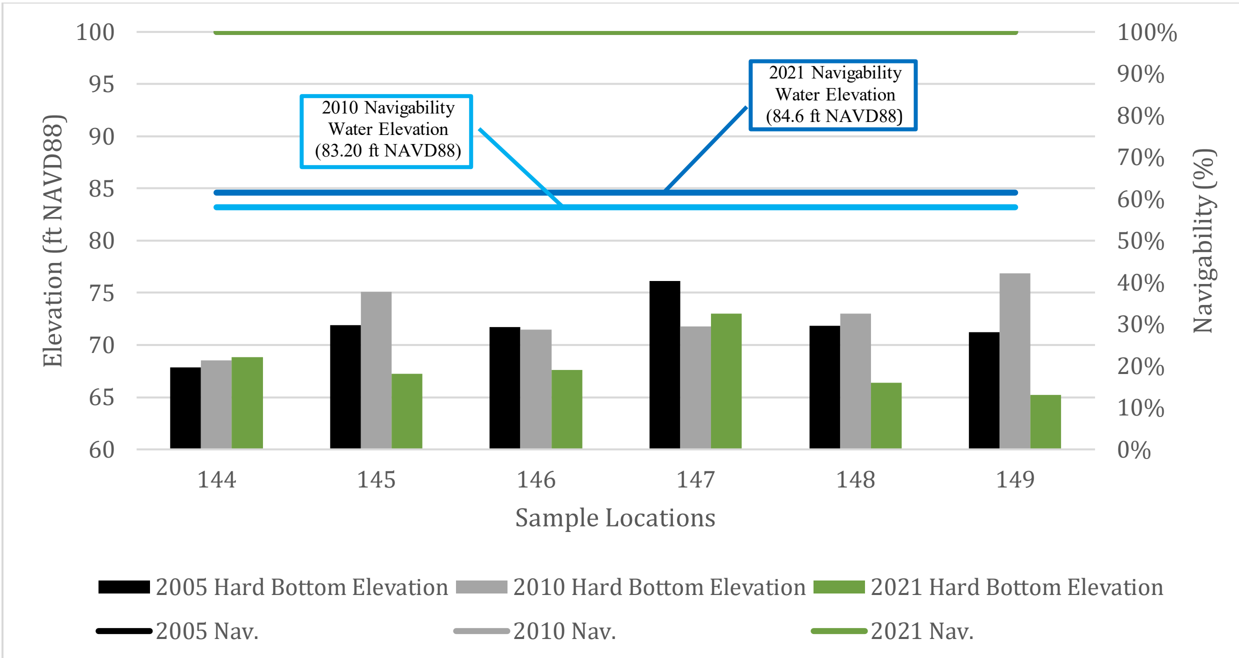

Figure E-11: Montmart Canal (the Navigability for 2005, 2010 and 2021 sample locations is 100%)

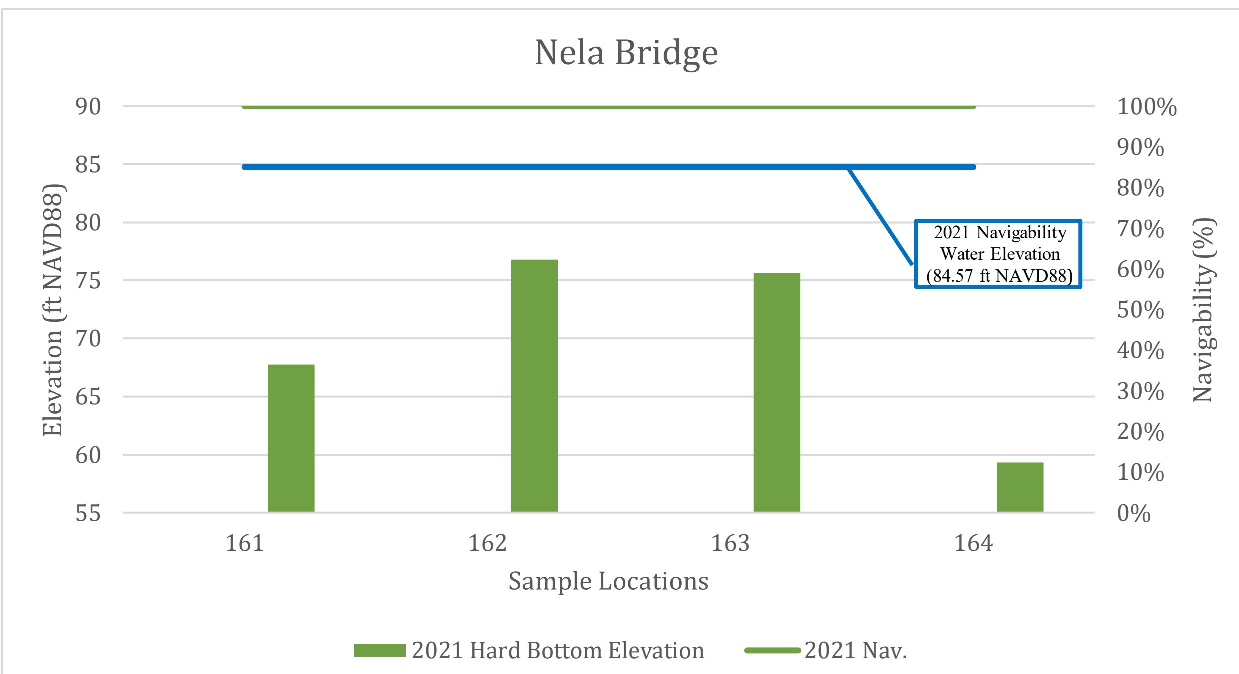

Figure E-12: Nela Bridge (no data for 2005, 2010)

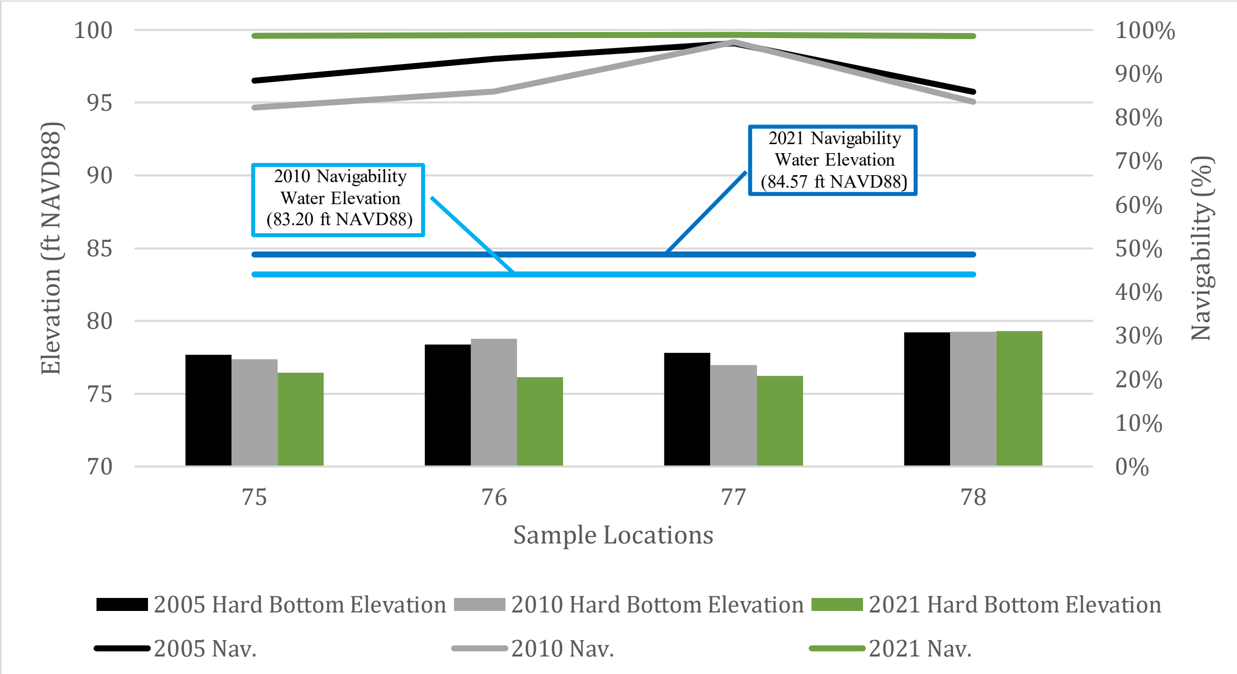

Figure E-13: Overlake Canal

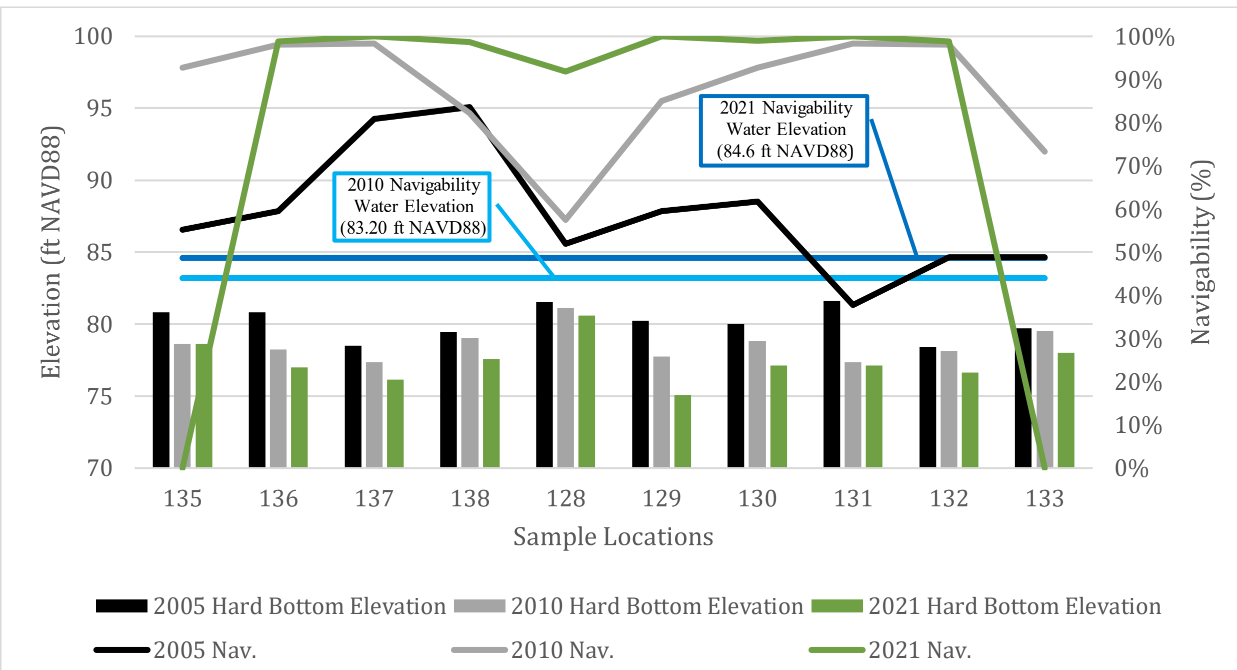

Figure E-14: Venetian Canal

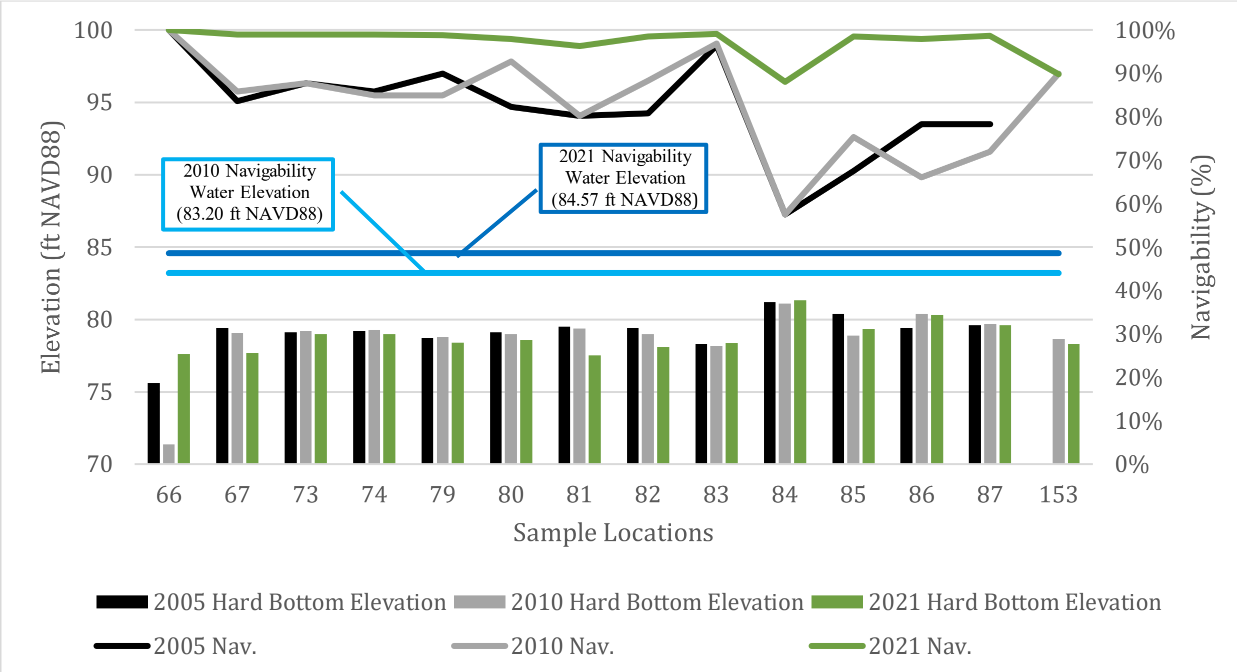

Figure E-15: Venice/Pershing

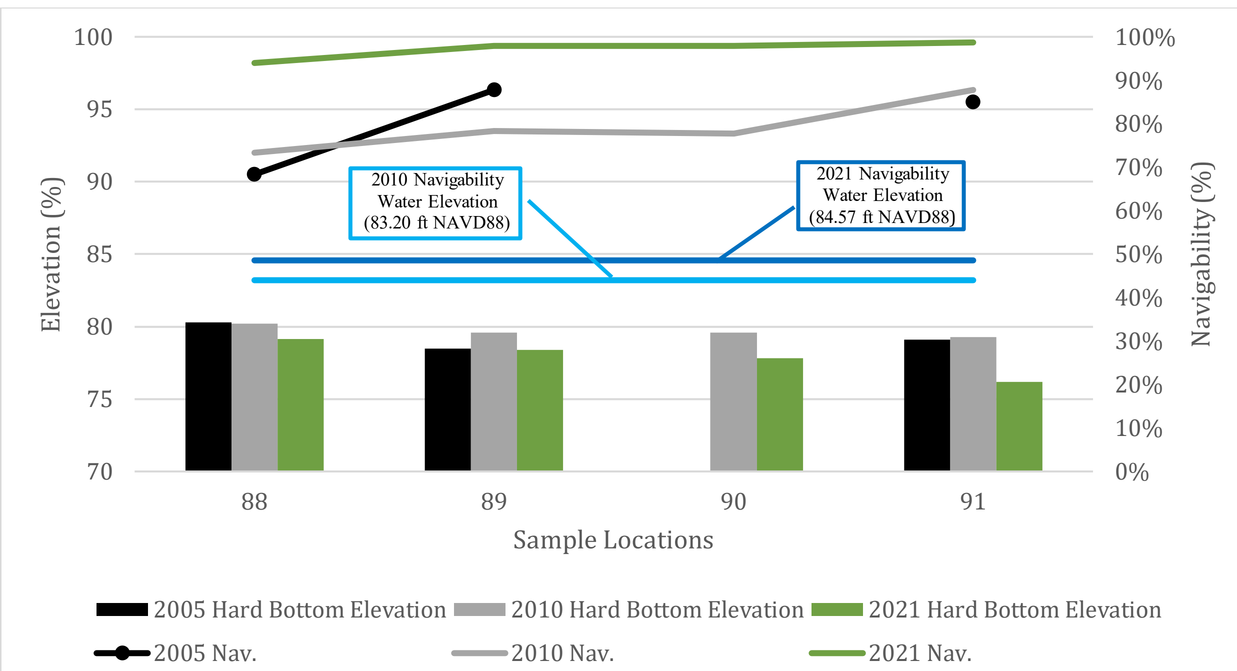

Figure E-16: Waterfront Canal

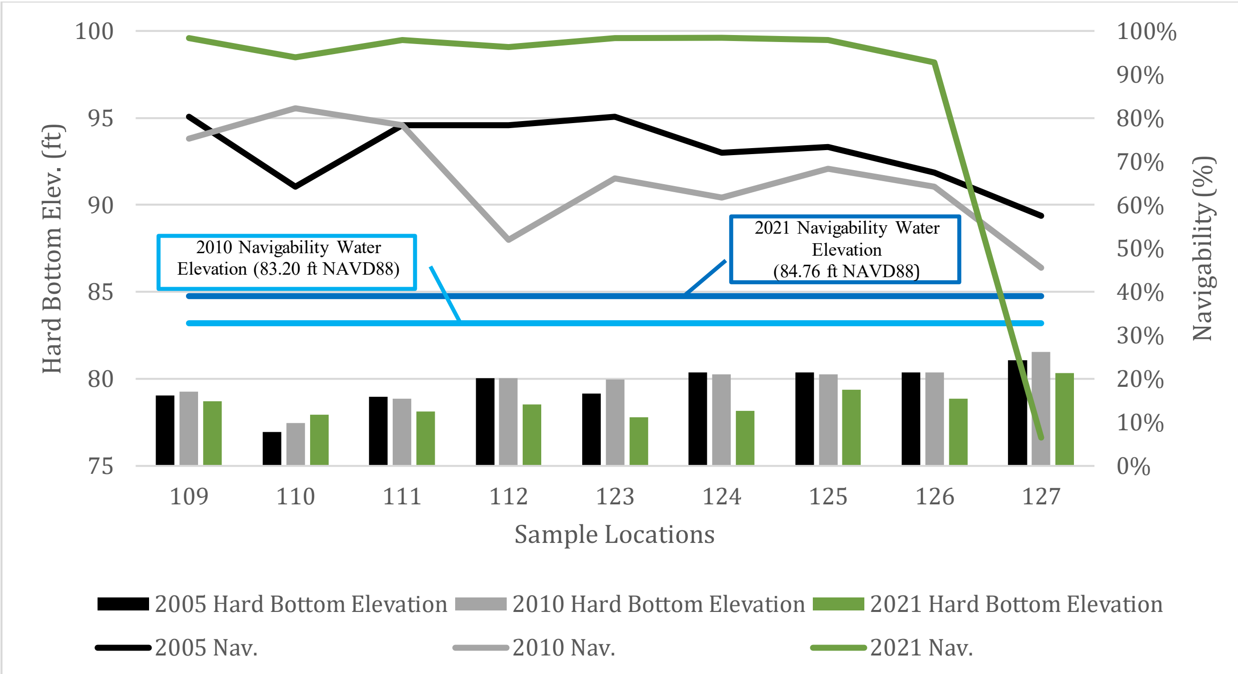

Figure E-17: Willoughby Canal

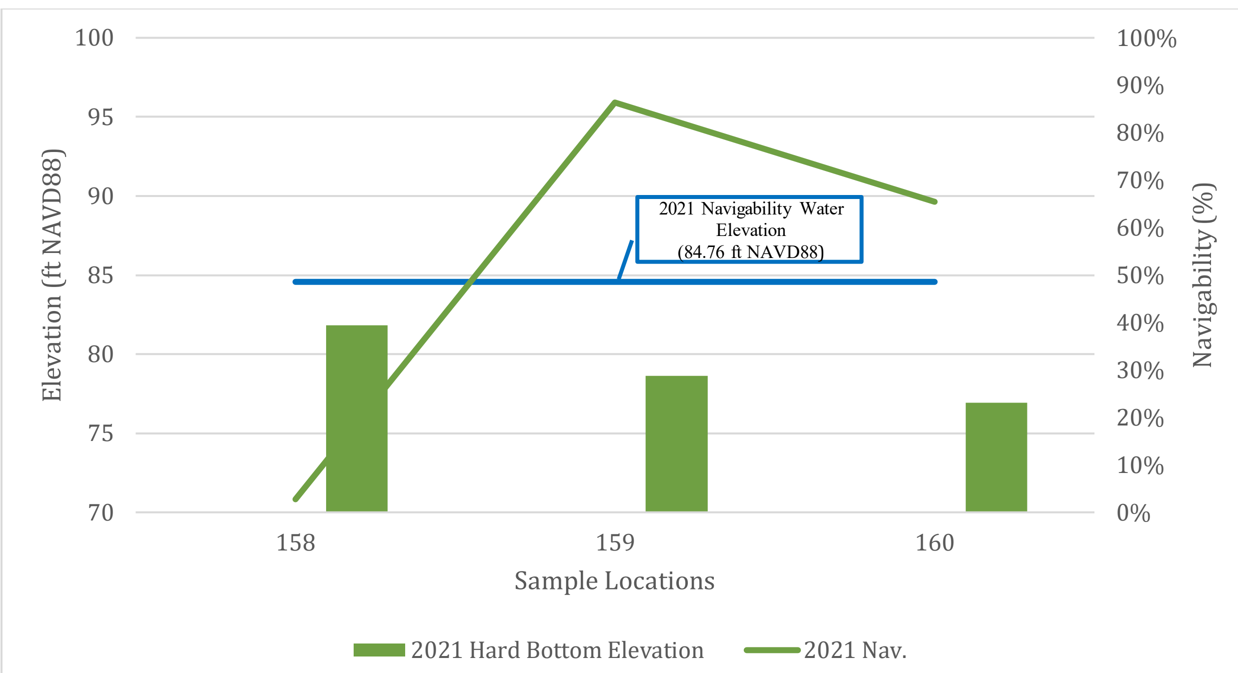

Figure E-18: Wind Song (no data for 2005, 2010)

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