Mississippi Valley Division,
Regional Planning and Environment Division South

Amite River and Tributaries East of the Mississippi River, Louisiana

Appendix B: Engineering

March 2025

TABLE OF CONTENTS

Section 1 1

General 1

Section 2 2

Structural Alternatives 2

2.1 Darlington Dry Dam/Darlington Reduced Wet Dam 2

2.2 Dry Dam on Sandy Creek 2

2.3 Dry Dam on Darlington, Lilley, and Bluff Creeks 2

Section 3 4

Geotechnical Investigations and Design 4

3.1 Darlington Dry Dam/Darlington Reduced Wet Dam 4

3.2 Dry Dam Alternatives 8

Section 4 9

Datum and Topography 9

Section 5 10

Civil Design 10

5.1 Darlington Dam 10

5.2 Dry Dam on Sandy creek 12

5.3 Dry Dam on Darlington, Lilley, and Bluff Creek 13

Section 6 16

Structural Design 16

6.1 Quantities 16

Section 7 20

Relocations 20

7.1 General 20

7.2 Roadway Relocations 25

7.3 Powerline and Telephone Relocations 26

7.4 Pipeline Relocations 26

7.5 Cemeteries and Church Relocations 27

7.6 Relocations cost 27

Section 8 29

Nonstructural Design 29

8.1 Geospatial Analysis 29

8.2 Geotechnical evaluation for non-structural 38

8.3 Residential Raisings (Structural) ... 46
8.4 Commercial FloodProofing Masonry construction ... 47
8.5 Industrial Metal building Floodproofing ... 50
Section 9 52
References ... 52
Section 10 53
List of Acronyms and Abbreviations ... 53
Annex 1: Residential Lift and DryProofing Structure Diagrams ... 54
Annex 2: Structure Raise Quantities ... 60
Summary ... 61
Pier Mobile Quantity 1507 SF ... 62
Pier 2 Story Quantity 1903 SF ... 64
Pier 1 Story Quantity 2291 SF ... 66
Slab-founded 1 Story Quantity 2338 SF ... 68
Slab-founded 2 Story Quantity 1932 SF ... 70

LIST OF TABLES

Table B:5-2.3. Sandy Creek Dam Dimensions ... 13
Table B:5-3.2a. Darlington Creek Dam Dimensions ... 14
Table B:5-3.2b. Lilley Creek Dam Dimensions ... 14
Table B:5-3.2c. Bluff Creek Dam Dimensions ... 15
Table B:6-1. Darlington Dam Quantities ... 17
Table B:8-3a. Estimated Weight per SF ... 46
Table B:8-3b. Inputs for Cost Analysis ... 47
Table B:8-4. Assumptions Inputs from EDS for Cost Estimate ... 48
Table B:8-5. Assumptions Inputs from EDS for Cost Estimate ... 50

LIST OF FIGURES

Figure B:2-1. Amite River Dry Retention Dams Focus Maps ... 3
Figure B:3-1.2. Boring Locations ... 6
Figure B:5-1.1. Typical Section-Darlington Dry Dam ... 11

Figure B:7-1a. Overall – Reduce Wet/Dry Reservoir Alternative 21
Figure B:7-1b. Darlington Dam – Reduce Wet/Dry Reservoir Alternative 22
Figure B:7-1c. Bluff Creek – Dry Dam Reservoir Alternative 23
Figure B:7-1d. Lilley Creek – Dry Dam Reservoir Alternative 24
Figure B:7-1e. Sandy Creek – Dry Dam Reservoir Alternative 25
Figure B:8-1a. Polygon Footprint Analysis 30
Figure B:8-1b. Statistical Analysis Summary 32
Figure B:8-1c. Spatial Join Between Point and Building Footprint 33
Figure B:8-1d. Spatial Drawing Cross Check 33
Figure B:8-1e. Apartment Building Statistical Analysis Image 34
Figure B:8-1f. Street View of Apartment Building 35
Figure B:8-1g. Tabular Comparison of Datasets. 34
Figure B:8-2a. Pleistocene Areas of Interest 38
Figure B:8-2b. Pleistocene Areas of Interest near Baton Rouge 39
Figure B:8-2c. Geologic Investigation Section, Near Baton Rouge, LA 40
Figure B:8-2d. Geologic Investigation Section Near White Castle, LA 41
Figure B:8-2e. Pleistocene Areas of Interest, Ascension Parish 42
Figure B:8-2f. Geologic Investigation Section Near White Castle, LA 43
Figure B:8-2g. Pleistocene Area of Interest - Mount Airy 44
Figure B:8-2h. Geologic Investigation Section Near Mount Airy, LA 45
Figure B:8-4. Dry Floodproofing Representative Section for Commercial Properties 49
Figure B:8-5. Dry Floodproofing Representative Section for Industrial Properties 51

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 1
General

This Engineering Appendix documents the feasibility level engineering and design for the nonstructural Recommended Plan (RP) of residential structure raising and commercial structure floodproofing. Engineering Appendix B is supplemented by Appendix H, Hydraulics, Hydrology, and Coastal (HH&C); Appendix I, Implementation Plan; and Appendix C, Cost Engineering. Development of these appendices were in accordance with Engineering Regulation (ER) 1110-2-1150, "Engineering and Design for Civil Works Projects," dated 31 August 1999.

The study area is the Amite River Basin and Tributaries. The Amite River Basin begins in southwest Mississippi and flows southward, crossing the state line into southeastern Louisiana. The Amite River Basin includes 2,200 square miles flowing into the Amite River and its tributaries. It includes portions of Amite, Lincoln, Franklin, and Wilkinson Counties in Mississippi as well as East Feliciana, St. Helena, East Baton Rouge, Livingston, Iberville, St. James, St. John the Baptist, and Ascension Parishes in Louisiana.

The study area is similar to the US Army Corps of Engineers (USACE) 1984 Amite Rivers and Tributaries Flood Control Initial Evaluation Study; however, it was expanded to include areas that are impacted by backwater flooding to the southeast and east because they are hydraulically connected. The alternatives discussed within this study were analyzed by Hydraulics, Geotechnical, Civil, Relocations, Cost, Geospatial, and Structural disciplines within New Orleans District, Engineering Division, USACE (CEMVN-ED). **All structural alternatives were screened, and the RP is nonstructural as discussed in the following sections.**

SECTION 2
Structural Alternatives

2.1 DARLINGTON DRY DAM/DARLINGTON REDUCED WET DAM

Darlington Dry Dam/Darlington Reduced Wet Dam otherwise known as the “Darlington Dam alternative” consists of an earthen dam on the Amite River with the option of being a wet or dry dam. A dry dam only holds water during flood events. After the flood waters recede, the storage area drains completely dry again. This is opposed to a “wet” dam, where at least some water is permanently stored in what is typically called a full-sized conservation pool.

The dam would include an outlet feature (currently, three 10’ x 10’ box culverts) and a large spillway. The spillway would require a concrete base and walls. Because of the earthen base, the spillway would likely require anchor piles and a seepage cutoff. Structural components would also require flip bucket or baffle field, and there is potential that gate control towers would be needed. Other structures could include debris booms, trash racks, etc. Because this alternative was previously studied, data for analyzing it is available in the “Amite River and Tributaries, Darlington Reservoir Re-evaluation Study (Reconnaissance Scope),” dated September 1997. A reduced “wet” dam would function as a “wet” dam but would include a smaller sized conservation pool and spillway.

2.2 DRY DAM ON SANDY CREEK

The Dry Dam on the Sandy Creek alternative consists of an earthen dam on Sandy Creek, a tributary of the Amite River. Limited data is available during the feasibility phase due to funding constraints; therefore, many assumptions were made such as the geology of the area, the dam theoretical section, the outlet and spillway structure design, and borrow material and quantities.

2.3 DRY DAM ON DARLINGTON, LILLEY, AND BLUFF CREEKS

The dry dams for the Darlington, Lilley, and Bluff Creek alternative consists of three earthen dams on Darlington Creek, Lilley Creek, and Bluff Creek, all tributaries of the Amite River.

Likewise, limited data was available due to funding constraints. Therefore, many assumptions were necessary in design development and corresponding quantities and costs.

A map showing the locations of all four dry retention dams is provided in Figure B:2-1.

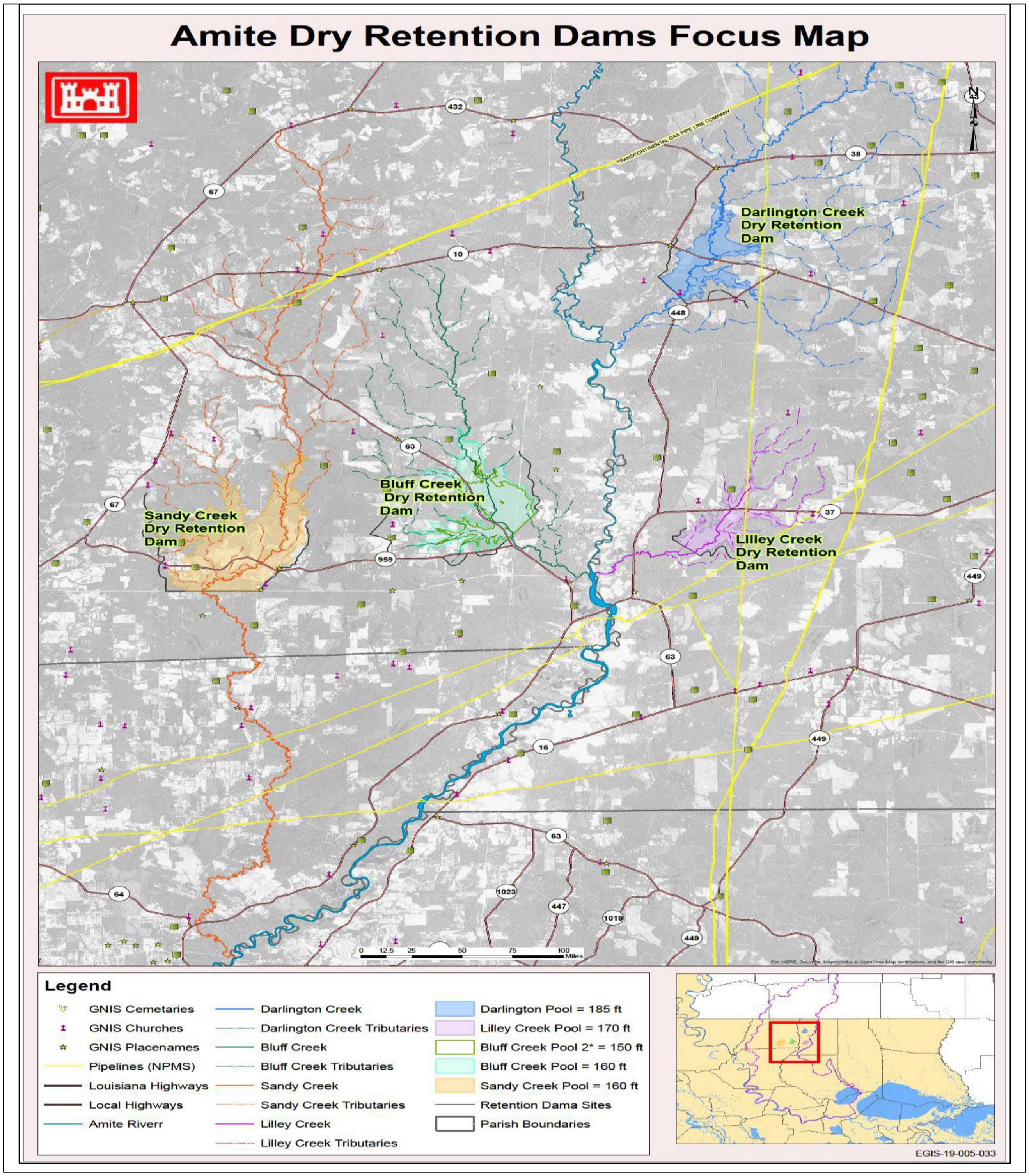


Figure B:2-1. Amite River Dry Retention Dams Focus Map

SECTION 3
Geotechnical Investigations and Design

This portion of the report contains the initial feasibility level geotechnical review performed for the Amite River and Tributaries Study. Alternatives assessed within this study include:

- Darlington Dry Dam/Darlington Reduced Wet Dam alternative.
- Dry Dam on Sandy Creek alternative.
- Dry Dams on Darlington Creek, Lilley Creek, and Bluff Creek alternative.

3.1 DARLINGTON DRY DAM/DARLINGTON REDUCED WET DAM

An initial feasibility level study for the Darlington Dam was conducted in 1992 and revised in 1997. Findings are documented in the "Amite River and Tributaries, Darlington Reservoir Feasibility Study," dated September 1992 and the "Amite River and Tributaries, Darlington Reservoir Re-evaluation Study (Reconnaissance Scope)," dated September 1997.

Updated geotechnical designs were not performed because no additional sub surface investigations were performed. To assess technical feasibility and update cost estimates, existing geotechnical data and analyses were re-evaluated for compliance with current design requirements.

The Darlington Dam alternative was analyzed using the design section developed in the 1997 report. The dry dam crown elevation was one foot lower than the reduced wet dam alternative. The dam would consist of a clay core with a random fill outer layer. The design section would consist of a reservoir with a 24 feet wide crown at elevation 202.8 feet North American Vertical Datum of 1988 (NAVD 88) (2009.55). Side slopes of 1 vertical on 3 horizontal would connect to the flood control pool at elevation 172.8 feet NAVD 88 (2009.55). On the flood side, from the flood control pool elevation to the conservation pool elevation, the slope would be 1 vertical on 6 horizontal. The flatter slope is to reduce the chances of sudden drawdown failures that tend to occur in this zone. Below the conservation pool elevation, the slope would be 1 vertical on 4 horizontal. On the protected side, the slope would be 1 vertical on 5 horizontal from the flood control pool elevation to the conservation pool. The flatter slope in this area would increase stability and would resist seepage forces that may concentrate in the lower portion of the dam. Below the conservation pool, the slope would be 1 vertical on 3 horizontal. The outlet structure for the dam consists of three 10'x10' foot box culverts with an emergency spillway.

3.1.1 Geology

The 1992 study describes the geology in the project area as:

> "The study area is in the Southern Pine Hills of the Eastern Gulf Coastal Plain. Topography in the northern portion of the basin is dominated by plateaus and

ridgetops underlain by the Citronelle Formation. The southern portion is dominated by gently sloping Pleistocene terrace surfaces.

The maximum elevation within the basin is approximately 500 feet MSL. Elevations are between 35 feet and 40 feet MSL near the junction of the Comite River and Amite River near Denham Springs. Minimum elevations are between 0 and 5 feet in the lower part of the basin near Lake Maurepas.

Although older sediments are found at depth in the study area, only the Plio-Pleistocene and Holocene sediments exposed at the surface and found near the surface are discussed. Four distinct geologic units are found within the basin: the Citronelle Formation, the Pleistocene terraces, the loess deposits, and Holocene alluvium. The Citronelle Formation, which varies in age from late Pliocene to Pleistocene, generally consists of a gradational sequence of fluvial gravels, cross bedded sands, silts, and clays with the coarser grained material occurring at the base of this sequence. On the southside of the outcrop of the Citronelle Formation, are found the relatively flat Pleistocene terraces of less variable lithology than that of the Citronelle Formation. Generally, these terraces are comprised of sediments consisting of silt and sandy clay which grade downward into a fine to coarse grained sand with some gravel.

The study area is in a stable area of low seismicity. Earthquake activity is relatively rare and is usually less severe than average. Resulting damage to structures and levees (dikes) in the project area would be expected to be minor." (USACE, 1992)

Seismic effects continue to be required considerations in current structure design regulations including:

- EM 1110-2-2300, "General Design and Construction Considerations for Earth and Rock-Fill Dam", dated 30 July 2004
- ER 1110-2-1156, "Safety of Dams – Policy and Procedures", dated 31 March 2014
- ER 1110-2-1806, "Earthquake Design and Evaluation for Civil Works Projects", dated 31 May 2016

However, a great portion of Louisiana is considered to have "Low" seismic hazard (Appendix C, ER 1110-2-1156). While Louisiana has had several quakes, they were minor as the local faults are not the type to typically produce earthquakes, especially not deep and forceful ones.

3.1.2 Geotechnical Data Available for Assessment

This assessment was based on borings and soil testing performed in the 1992 and 1997 studies. Seven undisturbed borings (DD-1U to DD-7U) were taken for the 1992 study, one on each dam abutment and five along the center of the dam. Four additional undisturbed borings (DD-8U, DD-9U, DD-10U, and DD-11U) were taken during the 1997 study (see Figure B:3-1), as well as two exploratory trench excavations. The earth core material data obtained from two exploratory trench excavations is considered adequate for embankment fill construction. There are gaps where no boring information is available along the east and west terraces. In addition, consolidation test data was limited to two borings (DD-9U and DD-10U) located at the center of the dam. It is recommended that additional boring data be taken to supplement existing borings used during the feasibility study.

Figure B:3-1. Boring Locations

3.1.3 Shear Strength Data

Shear strength tests, including unconsolidated undrained, consolidated undrained, direct shear, and consolidation, were performed on selected samples to obtain design values at MVN during the 1997 study. The shear strength values selected for design (i.e., clay core, embankment soils, and foundation clays, and granular foundation soils) are consistent with current design criteria requirements.

3.1.4 Stability Analyses

In the 1992 and 1997 studies, stability analyses were performed for the dam section, as per USACE EM 1110-2-1902, *Engineering and Design Stability of Earth and Rock-Fill Dams*, dated 1 April 1970. As part of the 1992 study, stability analyses were performed for seven separate reaches along the length of the dam: the east abutment terrace, east abutment, river closure, east river terrace, west abutment terrace, west river terrace, and west abutment. Stability analyses for these runs included end of construction analyses (required Factor of Safety [FOS] of 1.3, long-term analysis (required FOS of 1.5), and a sudden draw-down analysis (required FOS of 1.0)). In all cases analyzed in 1992, the construction case (short-term) governed the design cross-section of the dam. The scope of the 1997 study's stability analyses was limited to using new boring and strength data to determine if a reduced dam cross section is feasible to reduce cost of the structure. Analysis in the 1997 study was limited to the East River Terrace reach, which was chosen because it has clay strata closer to the ground surface and is more critical from a stability viewpoint. The 1997 study analyzed the critical end of construction analysis (both upstream and downstream) for this reach, but did not look at long-term, maximum surcharge pool, or sudden draw-down cases. The end of construction analyses resulted in a safety factor greater than 1.4. Several additional end of construction analyses were assessed using modified parameters to simulate a direct shear value for the core and strain softening of the foundation clay.

The current EM 1110-2-1902, *Slope Stability,* dated 31 October 2003, specifies a minimum FOS 1.3 (for end-of-construction including stage construction for both upstream and downstream), 1.5 (Long-term for steady seepage, maximum storage pool, spillway crest or top of gates at downstream), 1.4 (maximum surcharge pool at downstream), and 1.1-1.3 (Rapid drawdown from maximum surcharge pool and storage pool, respectively at upstream). The analyses run for the 1997 study are adequate for cost estimation purposes for the Darlington Dam alternative. To comply with the current EM 1110-2-1902, the full range of stability analyses are required for final design and construction. USACE Method of Planes using the Stability with Uplift program and Spencer's method using the Slope/W program are recommended for stability analyses.

3.1.5 Seepage Analysis

Seepage analyses were not performed in the 1997 study due to lack of information. However, the following seepage control methods were recommended for embankment, foundation, abutments, and spillway section areas. A clay core with a 4-foot crest width at elevation 192, and 30-foot width at the ground surface was proposed to control seepage through the embankment. A 70-foot-deep slurry trench was proposed to control seepage through the foundation. An upstream drainage control blanket was recommended to control seepage at abutment areas. The spillway section (i.e., see in the Plate 12 in 1997 study report) with sheet pile at upstream and downstream were proposed to control the seepage. Boring DD-11U, taken near the location of the spillway, shows a clay layer of approximately 20-foot thick. The 20-foot clay layer, in combination with the clay core of the dam, were assumed to reduce seepage in spillway areas. To comply with EM 1110-2-1901, Seepage Analysis and Control for Dams, a thorough seepage analysis to include mitigation features, including proposed cutoffs and upstream blanket, is recommended to adequately assess and design seepage control measures for embankment, foundation, abutments, and spillway section areas.

3.1.6 Foundation Settlement

Settlement analyses were not performed in the 1997 study due to a limited scope and funding constraints. Consolidation tests revealed a stiff clay deposit with high pre-consolidation values; thus, it was assumed that only 1 percent foundation settlement would occur. However, consolidation testing was only available in two of the 11 borings taken through the length of the dam. For this current assessment, an additional 15 percent of embankment fill, and 25 percent of compacted clay core fill was included in cost estimates to account for construction and foundation settlement. It is recommended that additional borings be taken, and a complete settlement analysis be conducted during engineering design, to adequately assess settlement conditions.

3.1.7 Conclusion

It was determined that the 1997 study's limited analyses are considered adequate for cost estimating purposes. However, complete stability designs on all reaches should be conducted for all cases as specified in EM 1110-2-1902. It is recommended that a seepage analysis be performed based on EM 1110-2-1901, to better assess seepage conditions and accurately define seepage mitigation measures. A complete settlement analyses is recommended during PED phase to adequately assess settlement conditions.

3.2 DRY DAM ALTERNATIVES

Two additional dry dam alternatives were considered as part of this study, the Dry Dam on Sandy Creek alternative and the Dry Dam on Darlington, Lilley, and Bluff Creek alternative. These dry dams would be placed on tributaries along the Amite River as conceptual alternatives. Foundation conditions are unknown within the proposed alignments as no existing data was available and no subsurface investigations were conducted in these locations. For cost estimating purposes, a scaled down dam cross section was derived from the Darlington Dam cross section. The design sections are conceptually based on site specific assumptions used in the 1997 report.

SECTION 4
Datum and Topography

Light Detection and Ranging (LIDAR) data was obtained for this study from the Louisiana Department of Transportation (LADOTD). The data source was LADOTD LIDAR for Amite Watershed, Louisiana. The LIDAR data acquisition occurred from January to March 2018.

- 2-foot LIDAR; Digital Elevation Model (DEM) grid developed by LADOTD
- Vertical Control = NAVD 88 (2009.55) GEOID12B
- LA SOUTH 1702 NAD83 map projection

In addition to the LIDAR data, LADOTD and USACE obtained bathymetric data within the main channel of the Amite River, Comite River, and Amite River Diversion Canal using high detail surveys in 2017 and 2018. This bathymetric data was used in the hydraulic model terrain.

The geographic information system (GIS) software tool, ArcGIS, was used to extract raster data around the Amite Dam and dry dam sites and generate contours at 1-foot intervals for all sites.

SECTION 5
Civil Design

5.1 DARLINGTON DAM

5.1.1 Two Options: Dry Dam and Reduced-Wet Dam

The design section described in Section 3.1 (see Figure B:5-1) was taken from the 1997 report.

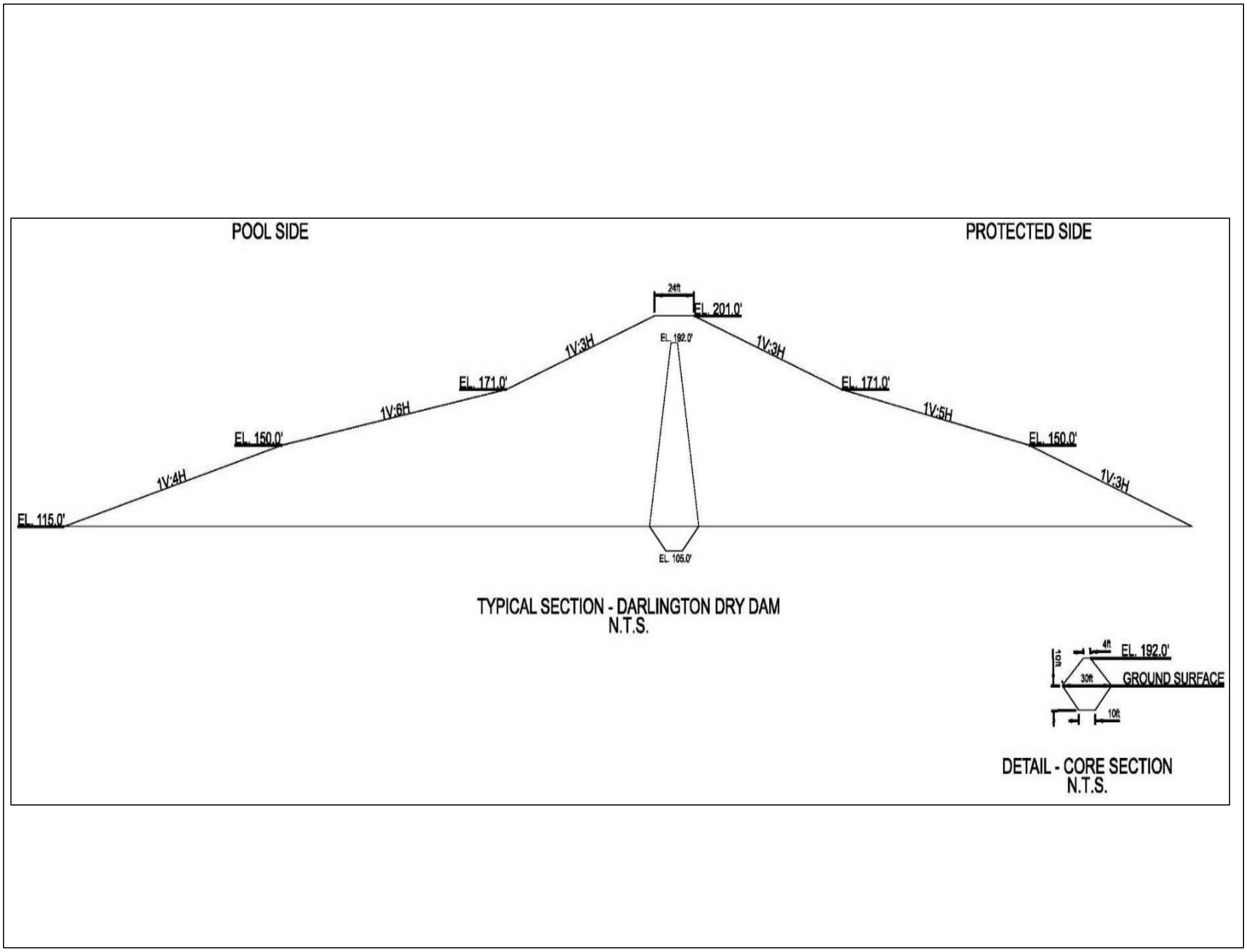


Figure B:5-1. Typical Section-Darlington Dry Dam

5.1.2 Borrow Assumptions

The top 5 feet of surface material would not be used for clay or random fill. For clay fill, assume a depth of 12 feet below the surface material, for a total depth of 17 feet. For random fill, assume a depth of 15 feet below the surface material, for a total depth of 20 feet. For every 1.0 cubic yard (CY) of material needed, 2.0 CY of material would be obtained from the borrow source (2 to 1 ratio for losses).

5.2 DRY DAM ON SANDY CREEK

5.2.1 Data & Analysis

All embankment dimensions were used from the 1992 study for the dry dam alternative. The dam consists of a clay core with a random fill outer layer. Similarly, no hydraulic analysis was performed on the outlet structure for this study. For cost, the outlet structure for Darlington Dam would be used for the outlet structures for Sandy Creek dry dams, implementing a scale factor developed by the MVN HH&C Branch. During a rain event, sluice gates would be closed to prevent flow and create a pool of water upstream of the dam. An emergency spillway would be placed at the flood control pool max elevation.

5.2.2 Borrow Assumptions

Borrow assumptions for this alternative are the same as those described in section 5.1.2. Dam Dimensions:

- Crown Width: 24 feet
- Embankment Slope 1:5

5.2.3 Quantities

Table B:5-1 provides pertinent dam dimensions for the Sandy Creek Dam that was used to generate quantities for the development of cost estimates.

Table B:5-1. Sandy Creek Dam Dimensions

Maximum Elevation (ft) (NAVD 88)	160		
Estimated Average Ground Elevation (ft) (NAVD 88)	130		
0.01 (100 yr) Annual Exceedance Probability (AEP) Pool Elevation (ft) (NAVD 88)	150.4		
0.002 (500 yr) AEP Pool Elevation (ft) (NAVD 88)	155.3		
Length (ft)	7,719		
Contour 160-foot Acreage (AC)	3,552.37		
Dam Footprint (AC)	58		
Borrow Acres (AC) (clay + random = total)	20 + 132 = 152		
Outlet Cost Scale Factor	0.15		
Quantities	**Clay**	195,405.06	CY
	Random Fill	1,602,172.79	CY
	Foundation Excavation	463,140.00	CY
	Slurry Trench	540,330.00	SF
	Outlet Cost Factor	0.15	

5.3 DRY DAM ON DARLINGTON, LILLEY, AND BLUFF CREEK

5.3.1 Data & Analysis

Data and analysis for this alternative are the same as described in Section 5.2.1.

5.3.2 Borrow Assumptions

Borrow assumptions for this alternative are the same as those described in section 5.1.2. Dam Dimensions:

- Crown Width: 24 feet
- Embankment Slope: 1:5

Tables B:5-2 through B:5-4 provide pertinent dam dimensions that were used to generate quantities for the development of cost estimates.

Table B:5-2. Darlington Creek Dam Dimensions

Maximum Elevation (ft) (NAVD 88)	185		
Estimated Average Ground Elevation (ft) (NAVD 88)	165		
0.01 (100 yr) AEP Pool Elevation (ft) (NAVD 88)	179.4		
0.002 (500 yr) AEP Pool Elevation (ft) (NAVD 88)	182.6		
Length (ft)	3,975		
Contour 185-foot Acreage (AC)	1,399.03		
Dam Footprint (AC)	21		
Borrow Acres (AC) (clay + random = total)	8 + 31 = 39		
Outlet Cost Scale Factor	0.059		
Quantities	**Clay**	81,773.19	CY
	Random Fill	378,050.97	CY
	Foundation Excavation	164,722.96	CY
	Slurry Trench	277,970.00	SF
	Outlet Cost Factor	0.059	

Table B:5-3. Lilley Creek Dam Dimensions

Maximum Elevation (ft) (NAVD 88)	170		
Estimated Average Ground Elevation (ft) (NAVD 88)	135		
0.01 (100 yr) AEP Pool Elevation (ft) (NAVD 88)	161.9		
0.002 (500 yr) AEP Pool Elevation (ft) (NAVD 88)	166.8		
Length (ft)	2,781		
Contour 170-foot Acreage (AC)	1,034.54		
Dam Footprint (AC)	24		
Borrow Acres (AC) (clay + random = total)	9 + 64 = 73		
Outlet Cost Scale Factor	0.057		
Quantities	**Clay**	84,627.38	CY
	Random Fill	770,837.07	CY
	Foundation Excavation	192,610.00	CY
	Slurry Trench	194,670.00	SF
	Outlet Cost Factor	0.057	

Table B:5-4. Bluff Creek Dam Dimensions

<table>
<tr><td>Maximum Elevation (ft) (NAVD 88)</td><td colspan="3">150</td></tr>
<tr><td>Estimated Average Ground Elevation (ft) (NAVD 88)</td><td colspan="3">130</td></tr>
<tr><td>0.01 (100 yr) AEP Pool Elevation (ft) (NAVD 88)</td><td colspan="3">143.5</td></tr>
<tr><td>0.002 (500 yr) AEP Pool Elevation (ft) (NAVD 88)</td><td colspan="3">145.8</td></tr>
<tr><td>Length (ft)</td><td colspan="3">4,978</td></tr>
<tr><td>Contour 150-foot Acreage (AC)</td><td colspan="3">1,218.04</td></tr>
<tr><td>Dam Footprint (AC)</td><td colspan="3">26</td></tr>
<tr><td>Borrow Acres (AC) (clay + random = total)</td><td colspan="3">10 + 39 = 49</td></tr>
<tr><td>Outlet Cost Scale Factor</td><td colspan="3">0.033</td></tr>
<tr><td rowspan="5">Quantities</td><td>Clay</td><td>98,868.61</td><td>CY</td></tr>
<tr><td>Random Fill</td><td>477,164.35</td><td>CY</td></tr>
<tr><td>Foundation Excavation</td><td>206,494.81</td><td>CY</td></tr>
<tr><td>Slurry Trench</td><td>348,460.00</td><td>SF</td></tr>
<tr><td>Outlet Cost Factor</td><td colspan="2">0.033</td></tr>
</table>

SECTION 6
Structural Design

MVN’s Structures Branch evaluated all data from various reports and/or previous studies to confirm that their assumptions and findings remain valid. Only the Darlington Dam alternative was designed at feasibility level. The Darlington Dam included a reinforced concrete spillway and a reinforced concrete outlet structure. No design criteria or calculations were provided within the 1992 study or the 1997 study reports. Consequently, those structures were not able to be thoroughly analyzed, except for quantities.

Quantities for the 1997 study re-evaluation for the 0.04 (25 yr) AEP Reduced Wet Darlington Dam were completed and compared to the original 1992 study report. For quantities that were not easily calculated (due to little or no information), best estimates with contingencies were made.

Structures Branch also coordinated with other branches within Engineering Division to provide an assessment on the other proposed nonstructural alternatives.

6.1 QUANTITIES

Table B:6-1 provides estimated quantities from the 1992 study for the Darlington Dam 0.04 (25 yr) AEP Reduced Wet alternative that were projected to the 1997 study.

Table B:6-1. Darlington Dam Quantities

0.04 (25 yr) AEP Reduced Wet Amite River and Tributaries Probable Construction Cost Alternative 12 - Darlington Dam 0.04 (25 yr) AEP Reduced Wet Reservoir			
Item Description	**New Quantity (1997)**	**Old Quantity (1992)**	**Unit**
Dam Structure	Height of Dam: 202.8 LF	Levee Length: 19,100 LF	
Mobilization & Demobilization	1	1	JOB
Access Roads			
Low Level Outlet			
Site Access Roads	1	1	JOB
Spillway			
Site Access Roads	1	1	JOB
Care and Diversion of Water Dam			
Cofferdam	1	1	JOB
Low Level Outlet			
Dewatering Systems - Sumps & Pumps	1	1	JOB
Spillway			
Dewatering Systems - Sumps & Pumps	1	1	JOB
Earthwork for Structure			
Dam			
Site Work - General			
Item Description	**New Quantity (1997)**	**Old Quantity (1992)**	**Unit**
Clearing and Grubbing (no stumps)	450	270	AC
Foundation Excavation (with stumps) - Adjacent Disposal	3,069,000	255,000	CY
Slurry Trench Excavation - 70 ft Depth Ave	1,260,000	1,260,000	SF
Gravel Filter Material	0	1,165,000	CY
Filter Fabric	0	635,000	SY

Semi-compacted Fill - Random (Neat + 15%) (includes foundation fill)	11,800,000	9,010,000	CY
Compacted Fill - Select Clay (Neat + 25%)	856,000	1,040,000	CY
Fertilizing & seeding	450	275	AC
Pond Elevation Riprap 400 lb Stone 24 inch Thick	21,000		TN
Low Level Outlet			
Site Work - General			
Clearing and grubbing	0	0	AC
Structural Excavation - Adjacent Disposal	90,000	120,000	CY
Site Work - Inlet and Outlet Channels			
Clearing and grubbing	8	10	AC
Common Excavation - Adjacent Disposal	90,000	120,000	CY
24-inch Rip Rap	4,700	4,700	TN
36-inch Rip Rap	15,000	15,000	TN
6-inch Bedding	2,500	2,500	CY
Filter Fabric	0	22,000	SY
Spillway			
Site Work - General			
Clearing and grubbing	20	20	AC
Structural Excavation - Adjacent Disposal	600,000	600,000	CY
Semi-compacted Fill - Random	15,000	15,000	CY
Compacted Fill - Select Clay	115,000	115,000	CY
Compacted Fill - Select Sand	26,000	26,000	CY
42-inch Rip Rap	0	123,000	TN
36-inch Rip Rap	105,464	0	TN
6-inch Bedding Material	12,000	12,000	CY
Site Work - Drainage			
Slurry Trench Excavation - 75 ft Depth	76,000	76,000	SF
Gravel Filter Material	34,000	34,000	CY
6-inch Perforated PVC Pipe	46,000	46,000	LF
12-inch PVC Pipe	1,800	1,800	LF
Site Work - Spillway Channel			
Clearing and grubbing	100	100	AC
Common Excavation - Adjacent Disposal	6,200,000	6,200,000	CY
Foundation Piling			
Low Level Outlet			
Item Description	**New Quantity (1997)**	**Old Quantity (1992)**	**Unit**

Sheet pile, PZ-22	5,000	5,000	SF
Spillway			
Sheet pile, PZ-27	33,000	33,000	SF
Concrete			
Low Level Outlet			
Culvert Structure - Reinforced Concrete			
Item Description	**New Quantity (1997)**	**Old Quantity (1992)**	**Unit**
Stabilization Slab	5,500	7,300	CY
Wall & Roof	10,400	10,400	CY
Gate Tower	380	380	CY
Alignment Collars	750	750	CY
Stoplogs	60	60	CY
Culvert Structure - Unreinforced Concrete			
Stabilization Slab	500	650	CY
Spillway			
Sand Cement Foundation Treatment	9,000	9,000	CY
Overflow Section - Reinforced Concrete			
Overlay	50,000	50,000	CY
Dowels	290,000	290,000	LB
Overflow Section - Unreinforced Concrete			
Roller Compacted Concrete	135,000	180,000	CY
Metals			
Low Level Outlet			
Trash Racks	30,000	30,000	LB
Miscellaneous Metals			
24-inch Vent Pipe	1,600	1,600	LF
3-Bulb Waterstop	3,500	3,500	LF
Expansion Joint Filler	11,500	11,000	SF
Gate and Equipment			
Low Level Outlet			
Sluice Gates (Weight: 7,500 lb each)	3	3	EA
Mechanical			
Low Level Outlet			
Gate Operation Machinery	3	3	EA

SECTION 7
Relocations

7.1 GENERAL

The Fifth Amendment to the Constitution of the United States provides that just compensation will be paid for the taking of private property for public use. This “taking” of an interest in real estate is necessary for Federal Government to subordinate such interest in real estate. In publicly owned roads and utility systems, the Federal Courts have held that the liability of the United States for such acquisition is the cost of providing substitute facilities where substitute facilities are, in fact, necessary. This is the basis of the facility and utility relocation process. Therefore, it is incumbent that the MVN, Engineering Division, Design Services Branch, Relocations Team perform an investigation of the existing public utilities, facilities, and cemeteries located within the proposed project areas that may be impacted, while considering the current design requirements for the recommended plan. If such a facility, utility, cemetery, or town would affect the construction, operation, maintenance, repair, replacement, or rehabilitation of a USACE project, then the MVN Relocations Team must determine the appropriate disposition of the impacted facility. Some facilities may require either a permanent or temporary physical adjustment or displacement to support project activities, engineering requirements, and operation and maintenance needs.

The MVN Relocations Team was tasked with investigating, identifying, and verifying public facilities and utilities located within four dry creek retention dams: Darlington Creek, Lilley Creek, Bluff Creek, and Sandy Creek. Database research included the National Pipeline Database, State Online Natural Resources Information System (SONRIS), Louisiana Department of Natural Resources (LADNR), HTST-IHS, Penwell, Google Earth Pro, and the National Pipeline Mapping System (NPMS) data. **For the nonstructural RP, no relocations were identified.**

Based on the research and investigations conducted by the MVN Relocations Team, multiple facilities or utilities have been marked, labeled, and identified within the project areas of the alternatives. Figures B:7-1 shows the overall reservoirs and Figures B:7-2 through B:7-5 show the various roads, powerlines, pipelines, and cemeteries located within each alternative.

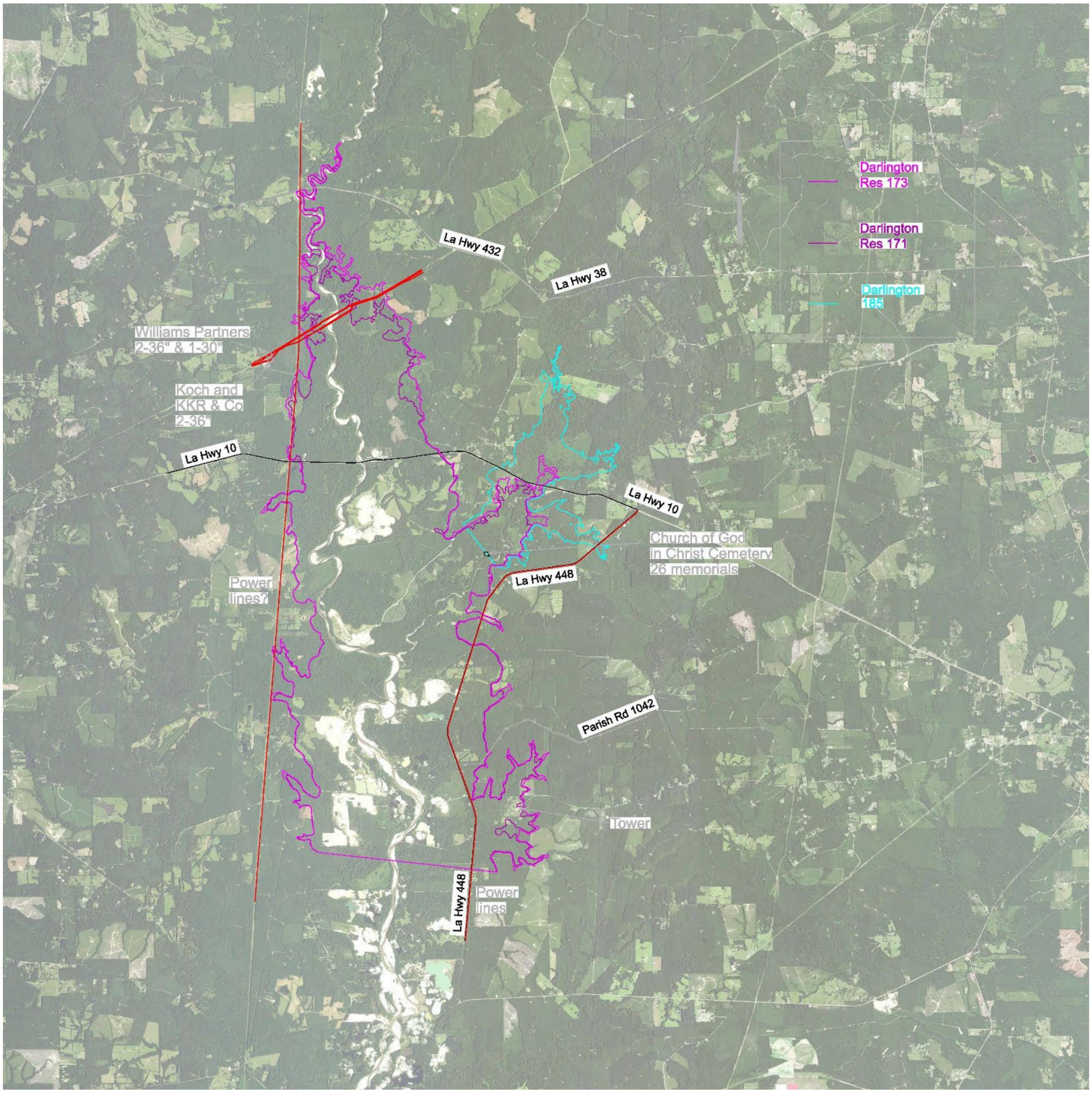


Figure B:7-1. Overall – Reduce Wet/Dry Reservoir Alternative

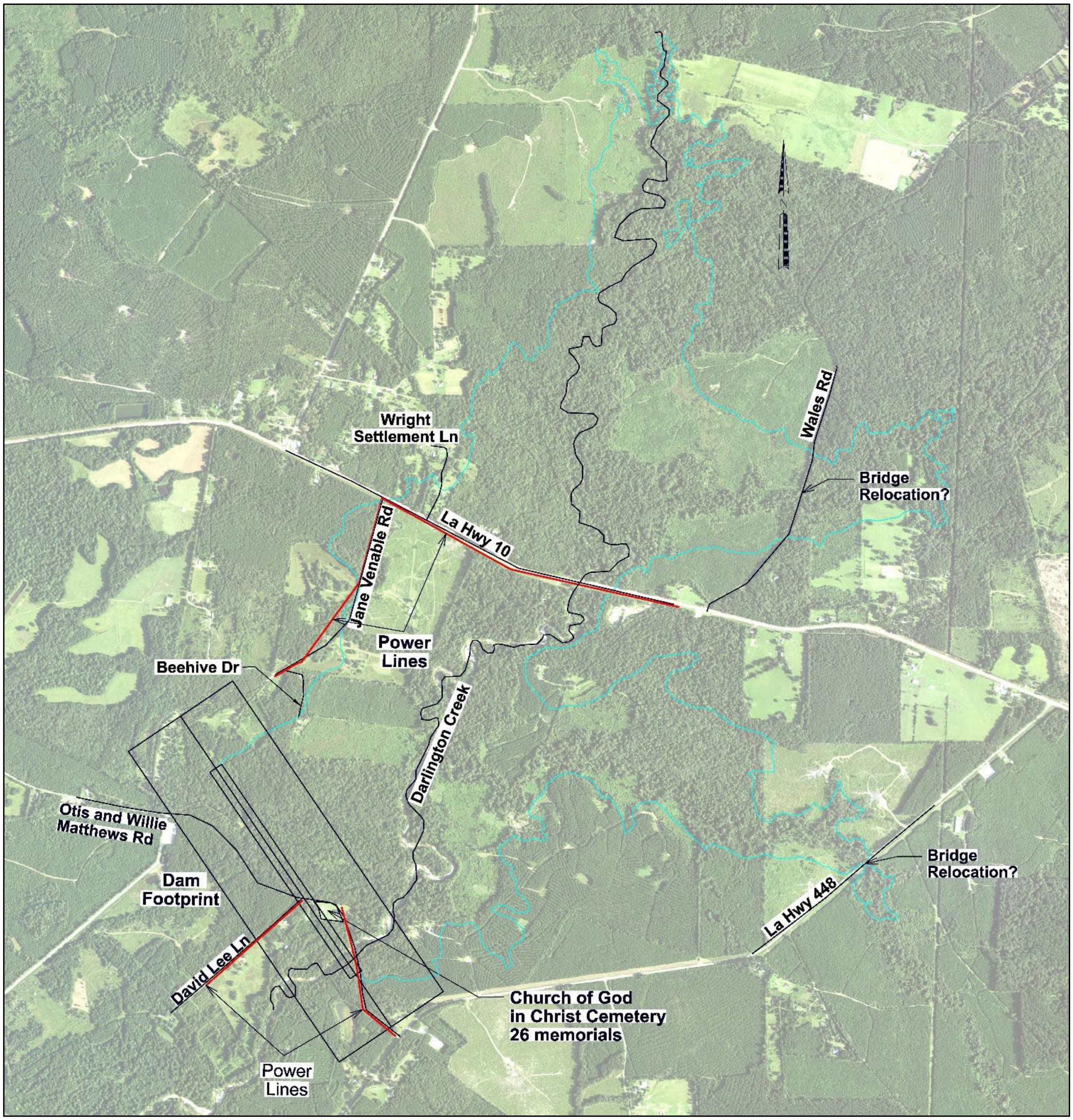


Figure B:7-2. Darlington Dam – Reduce Wet/Dry Reservoir Alternative

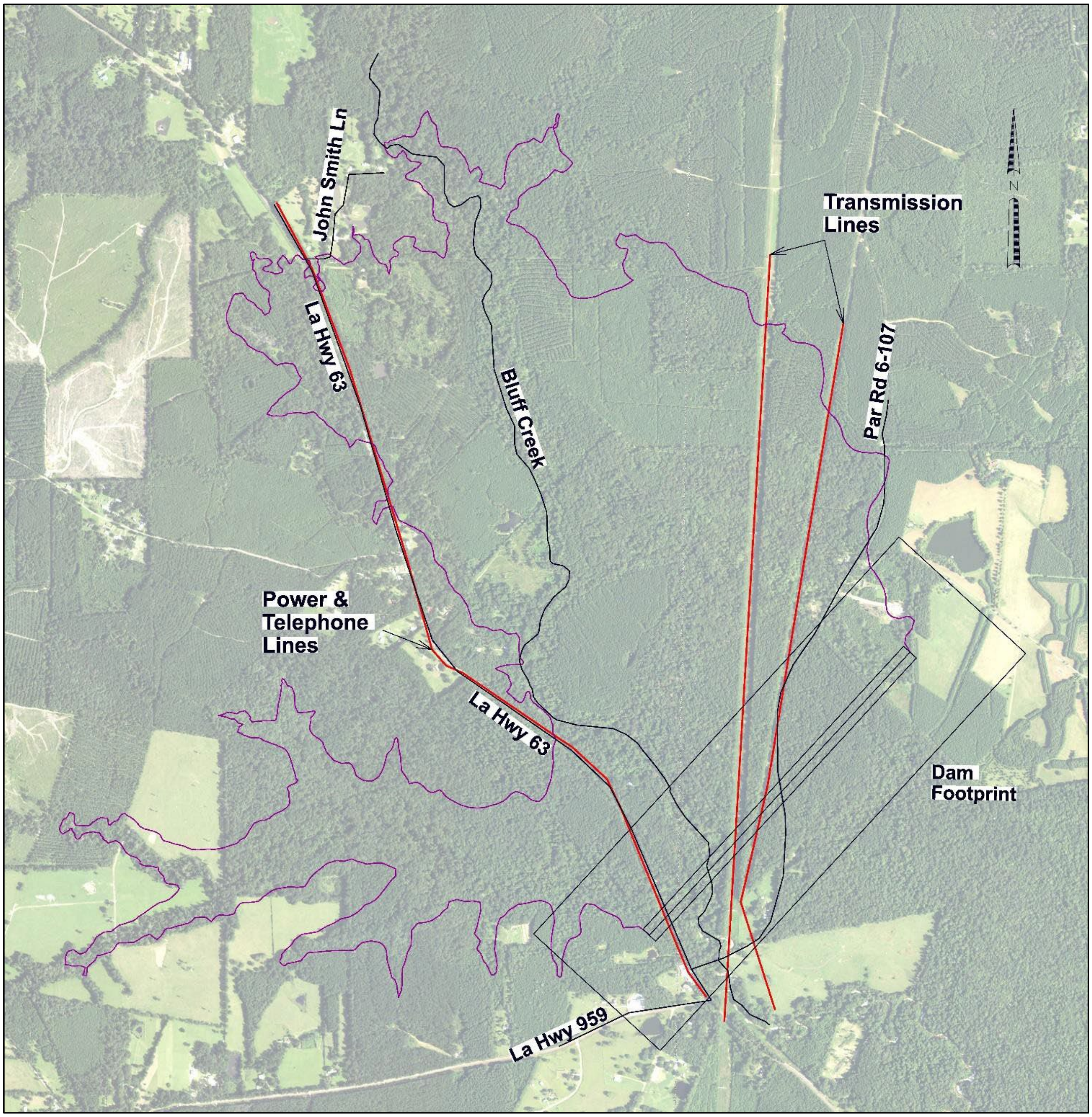


Figure B:7-3. Bluff Creek – Dry Dam Reservoir Alternative

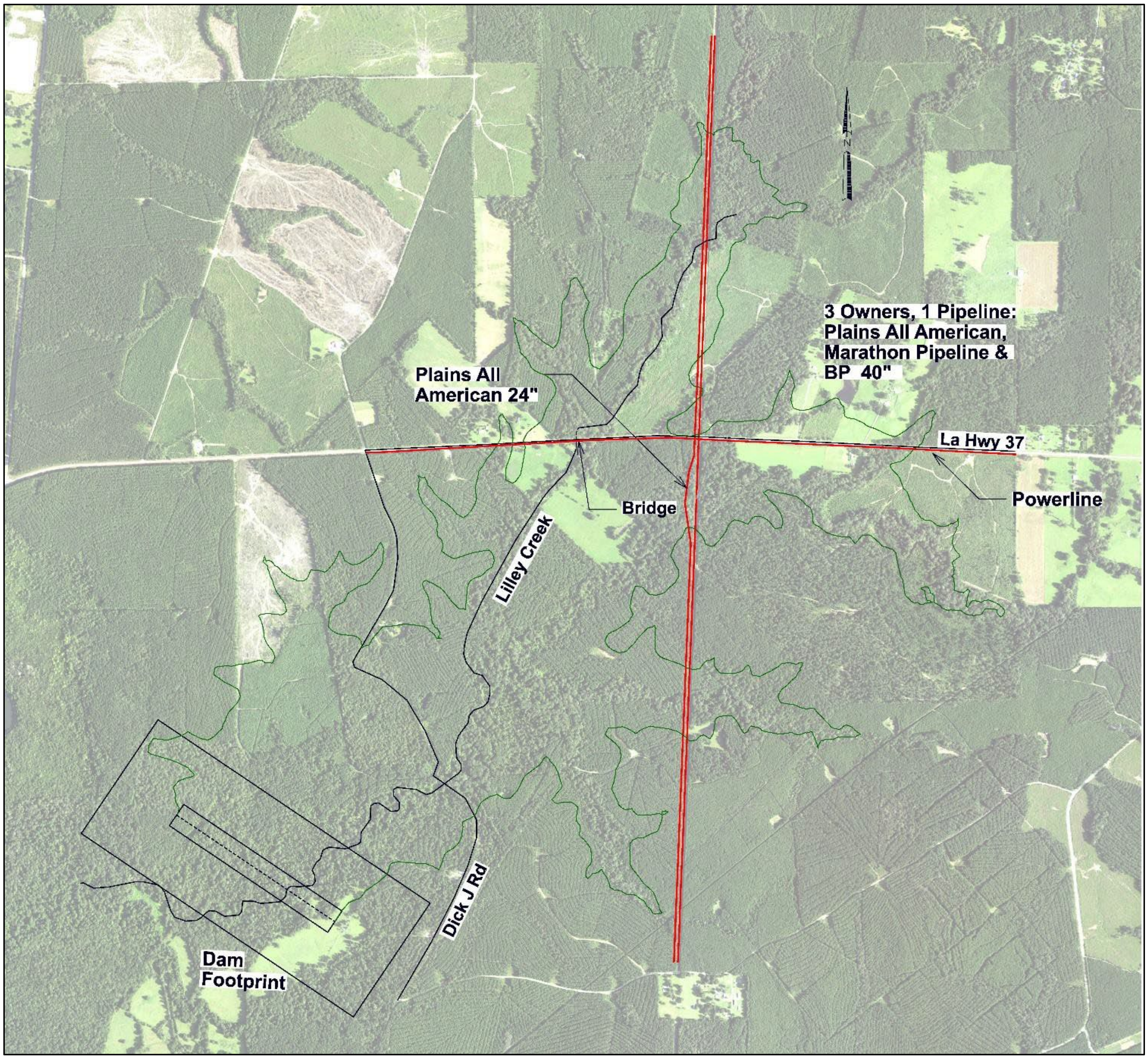


Figure B:7-4. Lilley Creek – Dry Dam Reservoir Alternative

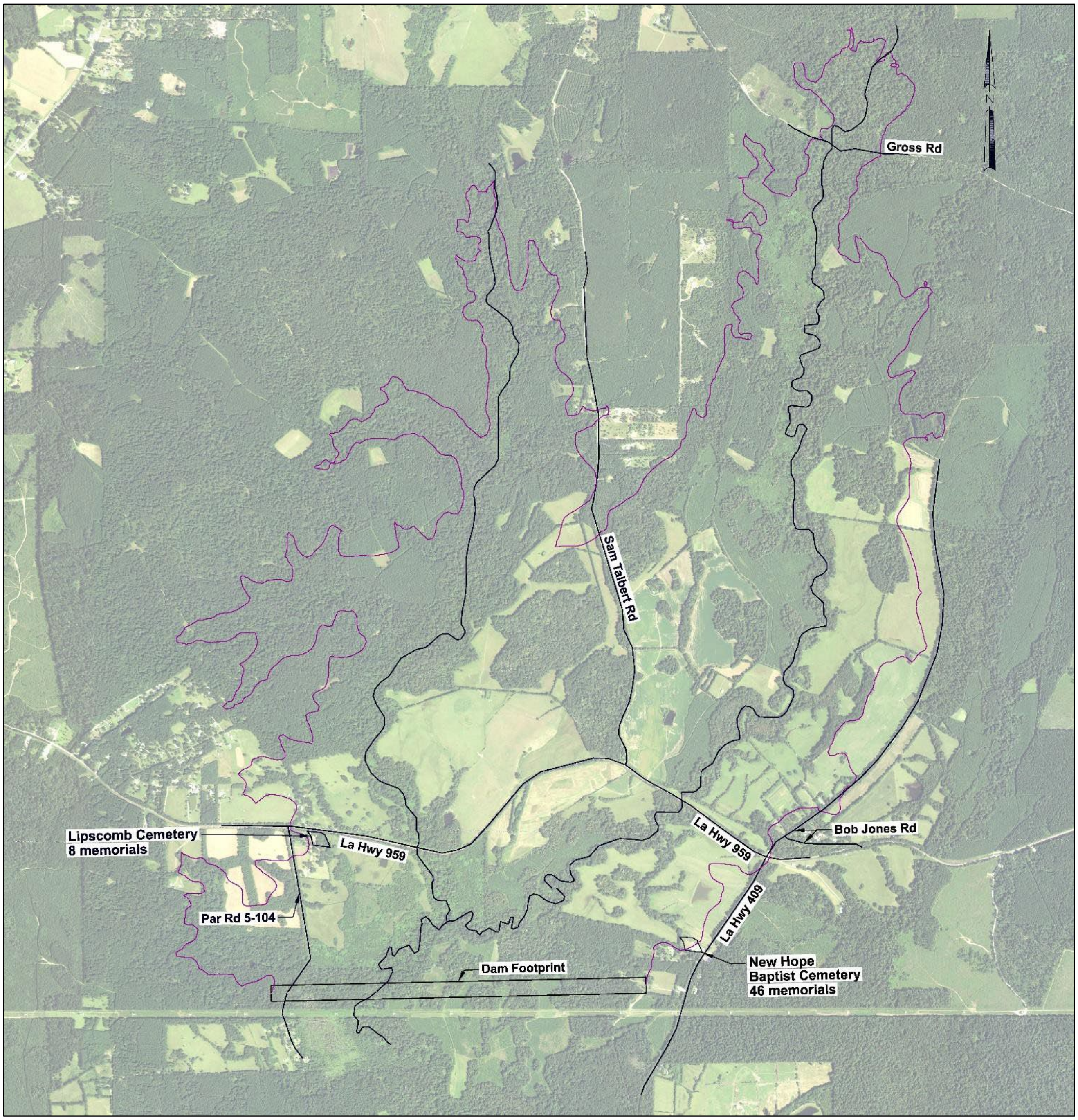


Figure B:7-5. Sandy Creek – Dry Dam Reservoir Alternative

7.2 ROADWAY RELOCATIONS

Roadways were generally agreed upon to be raised above 0.01 (100 yr) AEP flood elevation full reservoir. Selected roadways were chosen for evacuation routes, only in the case of emergencies. All other existing highways and roads that traverse the proposed reservoir would not be relocated, rerouted, or raised to accommodate a 0.01 (100 yr) AEP flood event, in accordance with LADOTD standards. Roads that only provide access to areas inside the reservoir limits would be considered abandoned and therefore were excluded from this study. However, one highway (LA Highway 448) located within the Darlington Creek dry reservoir and two Economic roads (Otis and Willie Matthews Road and David Lee Lane) located within the Darlington Creek wet reduced reservoir were impacted by the proposed earthen dams' alignments at these two reservoirs; thus, requiring them to be relocated up and over the proposed risk reduction required for continuing local traffic access.

As potential evacuation routes, the following roadways were evaluated to ascertain whether they were above the 0.01 (100 yr) AEP flood elevation:

- Darlington Creek – LA Highway 10 (Figure B:7-1)
- Bluff Creek – Highway 63 (Figure B:7-2)
- Lilley Creek – Highway 37 (Figure B:7-3)
- Sandy Creek – LA Highway 409/Parish Road 104 (Figure B:7-4)

Portions of Highway 37 and Highway 63 fell below the 0.01 (100 yr) AEP flood elevation; therefore, requiring minimum relocations to raise them. LA Highway 10 required no relocation. Highway 959 crossing Sandy Creek was considered an evacuation route.

However, due to an initial high-cost estimate to raise over 2 miles of roadway over the 0.01 (100 yr) AEP flood elevation, it was determined not to be a feasible alternative. The selective route chosen at Sandy Creek was to re-route traffic south, either onto LA Highway 409 or onto Parish Road 104 to Pride, Louisiana as a by-pass alternative route.

The proposed design elevation of the top surface of the replacement of the selected road relocations and the stringer beams of replacement bridges are the 0.01 (100 yr) AEP design flood elevation plus an additional 3 feet of freeboard. Roadway design calls for 24 feet surface roadway with 8-foot shoulders. Highways 37 and 63 would require one bridge replacement at each segment of road relocation.

7.3 POWERLINE AND TELEPHONE RELOCATIONS

There would be minimal impacts of power distribution lines and telephone lines. The only telephone and distribution power lines requiring relocation are along Otis and Willie Matthews Road, David Lee Lane, Highway 37, and LA Highway 448. No transmission lines would require relocation through Bluff Creek, and no distribution power lines or telephone lines along Highway 63 would require relocation. Confirmation is required to determine what type of lines (distribution power or transmission lines) are located east of the Darlington Dam–Reduce Wet/Dry Reservoir Alternative. However, it does not appear that they would be impacted.

7.4 PIPELINE RELOCATIONS

Pipelines located under proposed permanent water would not be required to be relocated or weighted down to offset negative buoyancy. All pipeline crossings were buried below ground at a minimum of 3 to 5 feet in depth. Minimum requirement for crossing permanent water is 8 to 10 feet in depth.

A. Darlington Dam – Reduce Wet/Dry Reservoir Alternative (Figure B:7-1)
   1. Williams Partners (2 – 36 inch and 1 – 30-inch pipelines)
   2. Koch and KKR & Co. (2 – 36-inch pipelines)

B. Lilley Creek – Dry Dam Reservoir Alternative (Figure B:7-3)
   1. Plains All American (24 – inch pipeline)
   2. Plains All American/Marathon/BP (40–inch pipeline)

7.5 CEMETERIES AND CHURCH RELOCATIONS

Three cemeteries have been identified and would be required to be relocated:

- Darlington Creek: Church of God in Christ Cemetery (Figure B:7-1)
- Sandy Creek: Lipscomb Cemetery and New Hope Baptist Cemetery (Figure B:7- 4)

Preliminary investigations were conducted to identify the number of memorials at each cemetery. Eight memorials were identified at Lipscomb Cemetery, 46 memorials were identified at New Hope Cemetery, and 26 memorials were identified at Church of God in Christ Cemetery. There is easy access to relocate each cemetery to a nearby proposed site location that is within a 1-mile distance outside of each creek reservoir. Historical investigations, including contact of descendants, excavations, and re-interments including grave markers and burial vaults must meet state and local guidelines and regulations.

The Church of God in Christ Church, located adjacent to its cemetery, would have to be relocated outside the limits of Darlington Creek. This church's structure is estimated to have a living space of 5,000 SF, which services the local community. It is recommended that the church, along with its cemetery, be relocated to one location.

7.6 RELOCATIONS COST

This section details the relocation costs developed for each alternative.

The relocations cost estimates and contingencies shown for these alternatives were developed in 2019 and do not reflect the revised cost estimates and contingencies that were developed in 2023.

7.6.1 Darlington Dam – Reduced Wet Alternative

The relocation costs for this alternative are for one church, one cemetery, Matthew Road, Lee Lane, and LA 448. The cemetery base cost is $195,000. Including a 226 percent contingency, the cost is $637,000. The reason the cost contingency is very high is due to the likelihood for significant impacts related to scope growth. Using internet-based research, only one known cemetery was physically located within the boundaries of the flood pool of the dam, but it is believed that further in-depth research would reveal many smaller, unknown cemeteries throughout the project site that would need to be relocated. The base cost for the remaining relocations is $2,839,000. Including a 36 percent contingency, the cost is $3,863,000. The total relocations cost for this alternative is $4,500,000.

7.6.2 Darlington Dam – Dry Alternative

The relocation costs for this alternative are the same as those described in section 7.6.1 for the Darlington Dam – Reduced Wet Alternative.

7.6.3 Sandy Creek Dry Dam Alternative

The only relocation costs required for this alternative are for two cemeteries. The base cost is $415,600. Including a 222 percent contingency, the cost is $1,337,000. The cost contingency is very high due to the likelihood for significant impacts related to scope growth. Using internet-based research, two known cemeteries were physically located within the boundaries of the flood pool of the dam, but it is believed that further in-depth research would reveal several smaller, unknown cemeteries throughout the project site that would need to be relocated.

7.6.4 Three Tributary Dry Dams Alternative

The relocation costs required for this alternative are for one cemetery, three roads (O&W Rd/David Lee Rd, LA37 & LA63), and two bridges (LA37 & LA63). The base cost for the Cemetery Relocation is $195,000. Including a 222 percent contingency, the cost is $627,000. The cost contingency is very high for cemeteries due to the likelihood for significant impacts related to scope growth. Using internet-based research, one known cemetery was physically located within the boundaries of the flood pool of the dam, but it is believed that further in-depth research would reveal several smaller, unknown cemeteries throughout the project site that would need to be relocated. The base cost for the remainder relocations is $7,525,000. Including a 51 percent contingency, the cost is $11,350,000. The total relocations cost for this alternative is $11,977,000.

SECTION 8
Nonstructural Design

MVN's Structures Branch (EDS), in coordination with MVN Cost Engineering Branch (EDD-Cost), was tasked with providing nonstructural (NS) design for residential, commercial, and industrial buildings within the project area. **The nonstructural alternative is the RP.** Nonstructural options included either lifting structures or dry-proofing structures to reduce flood risk. Lifting was assumed to require segmented subsurface friction piles for the foundation and CMU piers and cribbing above ground. Dry proofing was assumed to require a masonry perimeter wall retrofitted to the lower three feet of exterior building walls. The masonry wall would be supported by a concrete slab that is scabbed (with steel dowel rods) onto the existing slab. Helical piles would be placed around the perimeter to mitigate building uplift potential. Degree and nature of lifting and dry proofing depend on building and topographical information provided by the structural inventory furnished by MVN Economics.

Geospatial Engineering was engaged to perform an analysis of the Economic Structural Inventory. Nonstructural designs are based on flood water surface elevations produced by hydrologic and hydraulic analysis conducted by the New Orleans District HH&C branch. The validity of the model approach and flooding scenarios considered are described in the H&H appendix (Appendix H). Results of the geospatial analysis are included herein.

Overall, the structural inventory contained limited structural information for each building typology for approximately 2,000 structures. The information from the inventory was used to categorize the structures according to which nonstructural design solution was most appropriate, considering constructability, cost, size, and local private sector trends. Representative designs for each category and size were developed to support the cost estimate.

The representative designs utilized assumptions for key building components that impacted the nonstructural design solution cost estimate. Assumptions in which data was not available from the structure inventory included numbers of doors, windows, and other relevant penetrations, cladding type, foundation thickness, typical utilities, etc.

8.1 GEOSPATIAL ANALYSIS

To provide greater insight into the uncertainty that may exist with the square footages provided in the structure inventory and to ascertain potential bias, a geospatial analysis was performed. The analysis compared aggregated Amite Structure Inventory datasets, provided by Economic (Planning Division), to the Louisiana Building Footprints acquired from Microsoft Bing Maps. Results are provided herein.

<u>Summary of Statistical Results:</u>

1. The spatial relationship between the data sets correlated to an acceptable percentage of 89%.

2. A root-mean-square error (RMSE) and Bias comparison analysis of the difference resulted 5,450.36 square feet (SF) (RMSE) and 624.39 SF (Bias) in which the Economic data skewed higher than Microsoft building footprint data. There was also a Mean Absolute Error (MAE) of 2,020.52 sq ft. Which is the average absolute difference between the Economics data and the Microsoft data. **These results required adjustments to how the Economic data set was used for cost estimate purposes. Adjustments implemented are discussed herein.**

Datasets Compared:

- The Amite Structure Inventory point shapefile: grand total of 2,051 points within the Amite Study area. The 2,051 points identified makeup the RP for nonstructural solutions. Please refer to the main report "Plan Formulation" section for further detailed explanation of the RP and derivation of 2,051 points.
- Microsoft's Louisiana Building Footprint shapefile. Grand total of 2,173,567 vector polygons for the entire state of Louisiana. It's available to the public and more information can be found at the link provided: https://github.com/microsoft/USBuildingFootprints.

Limitations:

Please note the Microsoft Maps Building Footprints dataset limitations used for quality assurance includes building footprints of 129,591,852 vector polygons. This total dataset was reduced to Louisiana's footprints and tailored to the Amite study area. This data was derived using Microsoft's computer vision algorithms on satellite imagery. If the algorithm identified a building was in fact a "building", then the building was included for comparison analysis. Otherwise, structures were excluded. The Figure below illustrates this limitation.

Figure B:8-1a.

Figure B:8-1a – Polygon Footprint Analysis: Represents "point 705", a 15 story building based on attribute information. However, the footprint polygon is not recognized by Microsoft's computer vision algorithm on satellite imagery. Trees covering the building is assumed to be reason for lack of recognition.

Point 705 represents a 15-story building, but no footprint appears in the Microsoft Maps dataset, whereas a footprint appears and is correlated to the Economic dataset. Conversely, the Microsoft algorithm may also recognize buildings that are not buildings (i.e. barns or other structures not targeted for raising within the context of the study). These limitations of the Microsoft dataset represent outliers which may be eliminated via one-by-one cross check with field verifications during PED. The Microsoft dataset might also consider patios, garages, and multiple buildings into a single footprint. The Microsoft dataset was determined not 100% accurate. However, Microsoft data appeared more accurate, overall, than the Econ data set based on Google Earth visual comparisons.

Additional limitations of Microsoft data include the inability to recognize foundation type (pad vs. pier) and number of stories. The basis of comparison is outlined in the following 'Methodology' section.

Methodology:

The Economic structural inventory Excel file contained 2,051 rows of coordinates. It contained occupancy types including 1-story, 2-story, and mobile homes. The comparison analysis took a sample of 1,017 Economics points that were 1-story properties. Microsoft's dataset did not differentiate building square footage based on number of stories. The Microsoft dataset SF calculation is based on an algorithm that calculates footprint SF from aerial imagery. The search by location tool was used to map the Economic dataset with the Microsoft dataset. A spatial join was implemented to have the correlated footprints join the Economics point shapefile. Calculations were performed to check difference between SF. A comparison table was then exported into an excel sheet. Larger differences between the datasets were spot checked in Google Earth to determine accuracy between the datasets.

Results:

1. Spatial Correlation - Number of points within building footprints was 909 of 1,017 Economics points, resulting in an acceptable spatial correlation of 89%.
2. Square Footage Correlation - As shown in the Figure below, square footage areas from both datasets were used to calculate the RMSE resulting in a total error of 5,450.36 square feet. RMSE is determined by taking the total difference between the two data sets, squaring that difference, dividing by the total count of compared data rows, and taking the square root. RMSE is an indicator of correlation between datasets. Within the context of this effort in a study phase, the RMSE calculation developed is considered acceptable for project cost estimation. A higher RMSE indicates a weaker correlation between the dataset SFs, however the Economic dataset SFs are much higher, therefore resulting calculation of project cost is conservative. This is demonstrated by the positive bias calculation. The Bias equaled 624.39 SF which is the sum of the difference divided by the 909 point count. The total sum difference between the correlated data points compared

equaled 567,576 SF. The Mean Absolute Error (MAE) was calculated to total of 2,020.52 SF, which is the average absolute difference between the two datasets. Therefore, the square footage correlation is poor. Consequently, adjustments were needed to decrease the overall amount of SF error used to determine cost. Essentially all residential categorized structures over 7,500 SF are estimated to be floodproofed rather than raised for cost estimating purposes. This adjustment resulted in SF statistical error reduction between the two datasets.

SUM DIFF	567576
BIAS	624.3960396
RMSE ERR	5450.36946

Figure B:8-1b.

Figure B:8-1b: Statistical analysis summary: Represents the square footage findings that were acquired from the 909 points compared between the aggregated Economics Structural inventory dataset and the Microsoft dataset.

<u>Significance of RMSE, MAE, and Bias Analysis</u>

RMSE "Root Mean Square Error" is important to include within this analysis. The measured average difference between model predicted values (in the Economics structural inventory points) and the actual values (Microsoft's building footprints) provides insight into how well predicted values correlate with actual. Values obtained from an RMSE analysis can range from zero to positive infinity. A model is better when the value derived from the RMSE is low. The results of this analysis indicate an order of magnitude difference in the 1,000's. The "5,450.36 SF" value that was obtained from this analysis signifies that Economics aggregated structural inventory SF does not correlate well with the Microsoft Building footprint SF. The Mean Absolute Error shows the average difference between these two datasets. A value of over 2,000 indicates the datasets are not in agreement.

Bias is a quantitative value that tells the user if there is significant deviation between the datasets when performing a data comparison analysis task. Bias analysis is required because bias may result in false conclusions and be misleading. We should "be aware of all potential sources of bias and undertake all possible actions to reduce or minimize the deviation from the truth", (Šimundić, Ana-Maria, 2013). The lower the value, the better the data. Higher values result in more assumptions, which causes uncertainty. The "624.39 SF" bias value signifies that the datasets are not satisfactorily correlated, and high amounts of uncertainty exist that should be addressed through further data cross checks and verification. RMSE and BIAS calculations are usually a comparison between a predicted value (Economics) against a true (Microsoft) value. Although the Microsoft dataset is taken as the true value in this analysis, Microsoft Data errors were observed although to a much lower degree than Economics data. Microsoft data was the best available dataset for this statistical analysis and appeared to provide results more correlated to Google Earth imagery comparisons of roofline SF.

<u>Quality Assurance:</u>

Spatial Join - Figure B:8-1c illustrates the spatial join was successful. The spatial join tool picked up points that were "within" a footprint with "0" U.S. feet of difference. As stated earlier, the spatial data correlated at an acceptable rate of 89% across the two data sets.

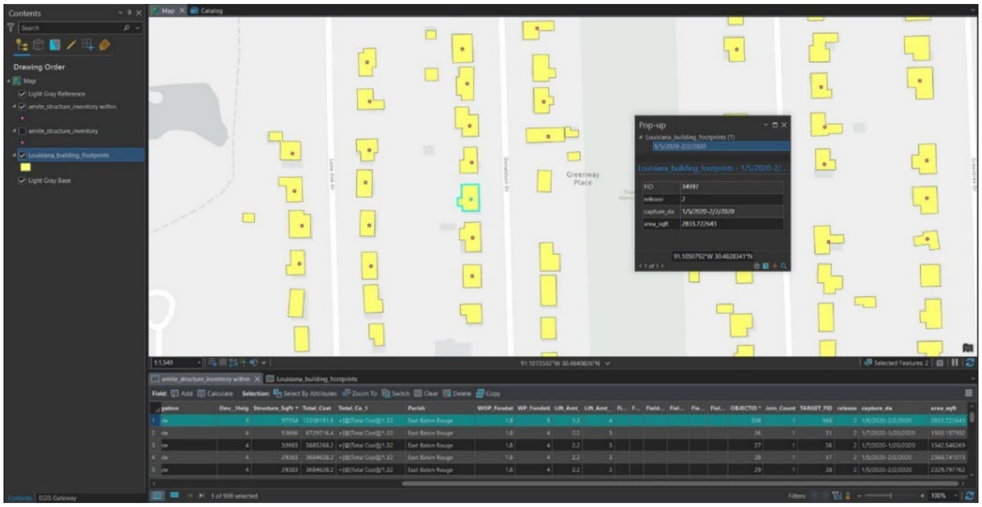


Figure B:8-1c. Spatial Join Between Point and Building Footprint.

Figure B:8-1c above highlights point FID 366. The square footage data was arranged from largest to smallest to identify outliers. Point FID 366 lists a square footage is 97,354 in the Economics set whereas the Microsoft data set lists a square footage of 2,833 for the same structure. This notable difference led to an imagery and street view (Google Maps) analysis. Figure B:8-1d illustrates the structure in question and confirms 97,354 SF is incorrect.

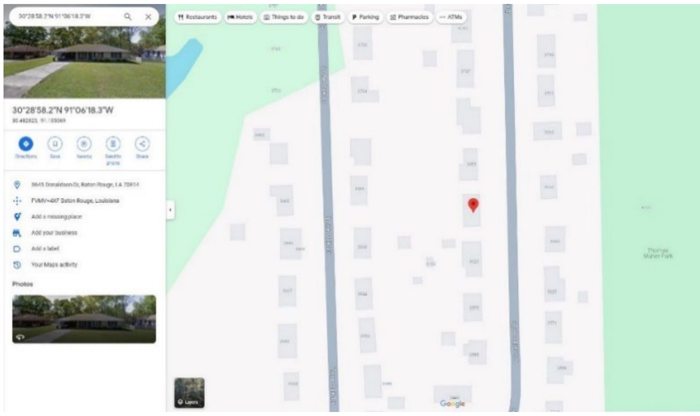


Figure B:8-1d.

Figure B:8-1d – Spatial Join Cross Check: Point FID 366 (shown in figure 3), confirming that the home is not 97,354 square feet, but around 1,500 square feet based on the front of the image provided by Google Maps.

In total, there are 31 structures within the point structure inventory attribute table between 10,000 and 98,000 SF. These points can be visualized in a google earth file that has been developed by the analysis team.

The analysis team performed a cursory review to evaluate the accuracy of the 1-story vs. 2-story structures reported in the Economics Structural Inventory. Figure B:8-1e below showcases point 119 reported as a "1-story building" in the Economics dataset. However, viewing the building in Google Maps, as shown in Figure B:8-1f, the property is a 2-story apartment building. This raises uncertainty in the Economics dataset reported number of stories which impacts weight calculations and negatively impacts cost estimation accuracy. Therefore, apartment buildings and all properties sized 7,500 SF or more were removed from the home raising cost calculation and included in the floodproofing cost calculation instead.

Point 119 specifically reported a structural inventory square footage (2,874 SF) and Microsoft's building footprint area square footage of 13,918.71 SF. This large difference (-11,045) indicates poor square footage correlation. However, this issue was far less prevalent than the issue of Economics SF data much higher than verified through Microsoft and Google Earth comparison. Therefore, this error is considered acceptable to include for cost estimating purposes as the overall RMS error reduction to 5,450.36 is maintained.

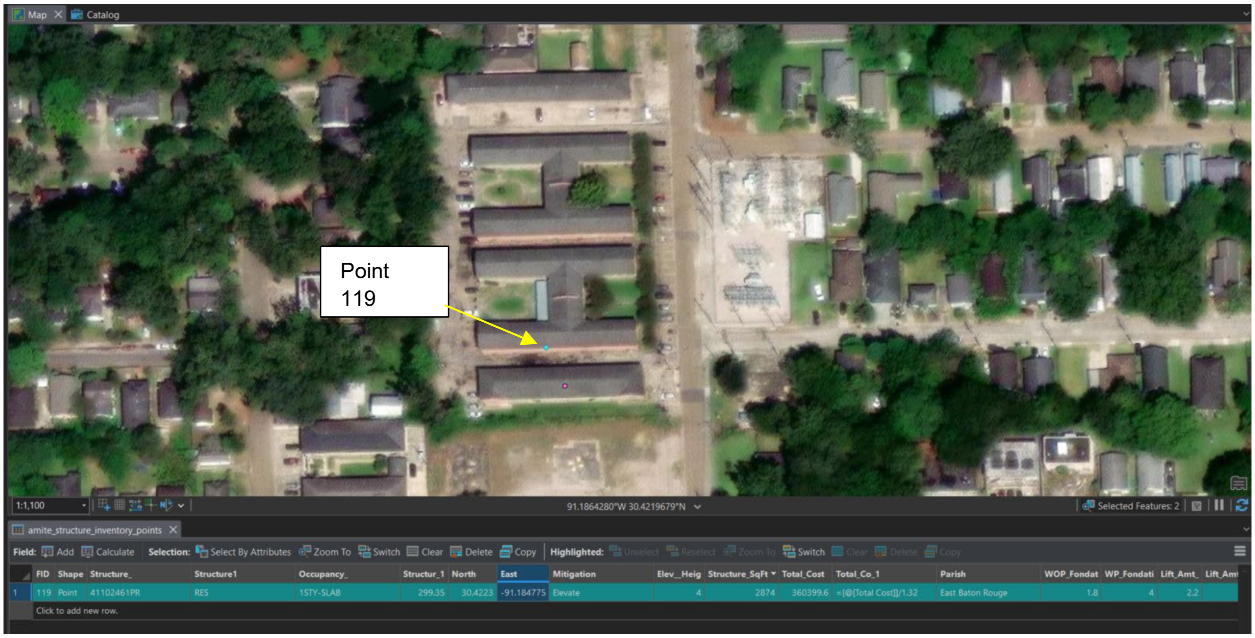


Figure B:8-1e.

Figure B:8-1e Apartment Building Statistical Analysis Image: Represents point 119 reported as a 1-story 2,874 SF building (Economics) but verified as a 2-story, >13K SF apartment building (Microsoft).

Figure B:8-1f.

Figure B:8-1f Street view of Apartment Building: Represents point 119 from a street view perspective. This is the front of the apartment complex.

An additional factor affecting the Economics structural inventory dataset is that there is a grand total of 468 from the 909 selected 1-story dataset rows in which the reported SF is valued at “2,178 SF”. Comparing the 2,178 SF value in the Economics dataset to the Microsoft’s data set as shown in the Figure below, each row contains varying values of more than 1,000 SF in difference.

F	G	H	I	J	K	L
structure_inven	structure_inve	amite_structure_inventory.Mitigation	ıcture_inventor	amite inventory sq ft 1story structure	amite microsoft footprint value	Difference
30.224103	-90.795896	Elevate	8	2178	3627.283734	-1449
30.247465	-90.849104	Elevate	8	2178	3618.642093	-1441
30.202831	-90.816901	Elevate	7	2178	3604.089447	-1426
30.216711	-90.800692	Elevate	9	2178	3577.006974	-1399
30.223255	-90.833703	Elevate	8	2178	3560.122505	-1382
30.180309	-90.856107	Elevate	10	2178	3557.029099	-1379
30.208172	-90.843975	Elevate	7	2178	3553.183048	-1375
30.205169	-90.843982	Elevate	8	2178	3551.450372	-1373
30.201012	-90.816877	Elevate	8	2178	3541.255227	-1363
30.224262	-90.831563	Elevate	8	2178	3519.08343	-1341
30.219183	-90.818995	Elevate	7	2178	3517.765921	-1340
30.22036	-90.8104	Elevate	8	2178	3508.651239	-1331
30.199417	-90.843261	Elevate	7	2178	3507.822322	-1330
30.212119	-90.803687	Elevate	7	2178	3503.536462	-1326
30.228416	-90.835387	Elevate	8	2178	3488.618934	-1311
30.196543	-90.857601	Elevate	7	2178	3465.29866	-1287
30.174922	-90.865889	Elevate	8	2178	3453.566614	-1276
30.445784	-91.143262	Elevate	7	2178	3447.094217	-1269
30.225148	-90.848031	Elevate	8	2178	3446.86538	-1269
30.23203	-90.800215	Elevate	9	2178	3445.656552	-1268
30.193913	-90.860211	Elevate	8	2178	3444.363759	-1266
30.194644	-90.841728	Elevate	9	2178	3433.136737	-1255
30.226742	-90.833842	Elevate	8	2178	3430.502869	-1253
30.186515	-90.861705	Elevate	8	2178	3428.125927	-1250
30.21793	-90.824307	Elevate	8	2178	3417.59126	-1240
30.248363	-90.860365	Elevate	7	2178	3415.937355	-1238
30.192475	-90.855996	Elevate	9	2178	3415.918467	-1238
30.240334	-90.831192	Elevate	8	2178	3402.426188	-1224
30.210556	-90.821911	Elevate	7	2178	3395.151443	-1217
30.236928	-90.793617	Elevate	8	2178	3390.768642	-1213
30.246989	-90.858234	Elevate	7	2178	3387.045558	-1209
30.198224	-90.845862	Elevate	9	2178	3380.168462	-1202
30.222675	-90.86838	Elevate	7	2178	3376.139942	-1198
30.236486	-90.867021	Elevate	7	2178	3372.810683	-1195
30.171175	-90.866727	Elevate	8	2178	3365.784066	-1188
30.219701	-90.868724	Elevate	8	2178	3364.35049	-1186
30.22367	-90.84142	Elevate	8	2178	3362.094667	-1184
30.212808	-90.812073	Elevate	8	2178	3350.736709	-1173
30.243748	-90.841442	Elevate	8	2178	3347.938061	-1170
30.262611	-90.872662	Elevate	4	2178	3333.712301	-1156
30.209133	-90.821103	Elevate	8	2178	3329.606193	-1152
30.230518	-90.836457	Elevate	8	2178	3322.477708	-1144
30.255758	-90.845725	Elevate	4	2178	3304.830302	-1127
30.198762	-90.834641	Elevate	8	2178	3293.986698	-1116

Figure B:8-1g

Figure B:8-1g: Tabular Comparison of Datasets: the Economics Structural Inventory that contains 468 rows of the same “2,178 square feet” value compared to Microsoft dataset with varying values >1K in difference.

Conclusions:

1. There is satisfactory spatial correlation between the two datasets.
2. There is unsatisfactory SF correlation as demonstrated by a root mean square analysis, mean absolute error analysis, bias analysis, and total SF difference of ~500,000 SF, which is limited to comparison 909 points of the 2,051 points provided in the Economics dataset.
3. There is unsatisfactory building story correlation between the two datasets.
4. Performing visual (Google Earth) inspections on larger variable points to compare Microsoft with Economics data using footprint areas overlain on imagery and street view in Google maps demonstrates greater confidence in the Microsoft dataset. Structure measurements using Google Earth tools to compare building SF demonstrated a statistically significant higher confidence in the Microsoft dataset.
5. The Economics dataset appeared to exclude houses in the same neighborhood and in many cases directly adjacent to structures included in the Economics Data set. Why many structures in the same vicinity are excluded from the aggregated Economics data set is not understood and represents a significant negative impact to accuracy of the cost estimate (conservatively) should these structures be eligible for elevation during project implementation. This issue shall require reconciliation in the PED phase via ground truthing to confirm and verify the Economic Structural Inventory.

Statistical Conclusions:

- Of 909 points compared, the difference in 478 points was <1,000 SF+/- (53%)
- Of 909 points compared, the difference in 47 points was <100 SF+/- (5.17%)
- Approximately 5% of points were within 100 SF of difference
- Approximately 50% of points were within 1,000 SF of difference
- The difference in SF ranged from -11,045 to 94,520 SF
- Note: Total Economic structure dataset was over 2,000 points with 900 compared in the statistical analysis discussed herein

Refinements:

1. The Geospatial analysis discovered approximately 69 structures that were categorized as residential and over 7,500 SF in the Economics dataset. A detailed analysis of these "anomalies" was then performed by Structures Branch in which Google Earth rooftop measurements were taken of the anomalies to develop SF for direct comparison to Economic data. Ultimately the SF could not be aligned as the Google Earth rooftop SF measurements were much lower. However, to maintain congruence with the Economics structural inventory upon which the study benefits are calculated, all structures categorized as "residential" and over 7,500 SF (anomalies) in size shall be floodproofed rather than raised utilizing the SF that is in the Economics Structural inventory dataset. Therefore, the cost estimate will be utilizing the same SF that the benefits calculation is based on, and ED is not estimating the raising of very large structure, which is impractical.
2. Flood proofing residential categorized structures over 7,500 SF resulted in lowering the residential home raising structure inventory total SF thus reducing the overall RMSE and MAE for home raising between the two data sets. Comparing the new differences of the remaining data reduced the RSME to 1,851.17 and a MAE to 1,247.17 and bias of 215 SF. Therefore, the average difference in datasets is now 1,247.17 SF+/- resulting in less average difference creating more confidence in average SF used to develop costs.

Conclusions

1. Due to a large structure inventory covering a very large study area, SF accuracy on an individual structure level is impractical to achieve in the study phase. Aerial Imagery in Google Earth was used to investigate anomalies, refine how the data was used for cost estimating purposes, and thereby ensure congruence with the Economics data benefits calculation and construction cost calculation. Accuracy of the size data is expected to be accurate on average across the data sets utilized and compared. Engineering concludes that "accurate on average" SF produces an "accurate on average" Class 3 level cost estimate. Geospatial Engineering's check of analyzing a large sampling of Economics (NSI) inventory SF's with Microsoft Footprint tool indicated that Economics SF looks to be overstated thereby introducing conservatism

into the cost estimate. Final verification of SF will occur during PED. The overstatement of economics SFs minimally impacts (conservatively speaking) cost.

8.2 GEOTECHNICAL EVALUATION FOR NON-STRUCTURAL

Geologic Areas of Interest (AOI) Figure B:8-2a were identified for existing structures that may need elevations (non-structural solutions). With limited existing data, recommendations for deep foundation features during the study phase of this project will be based on anticipated Pleistocene depths.

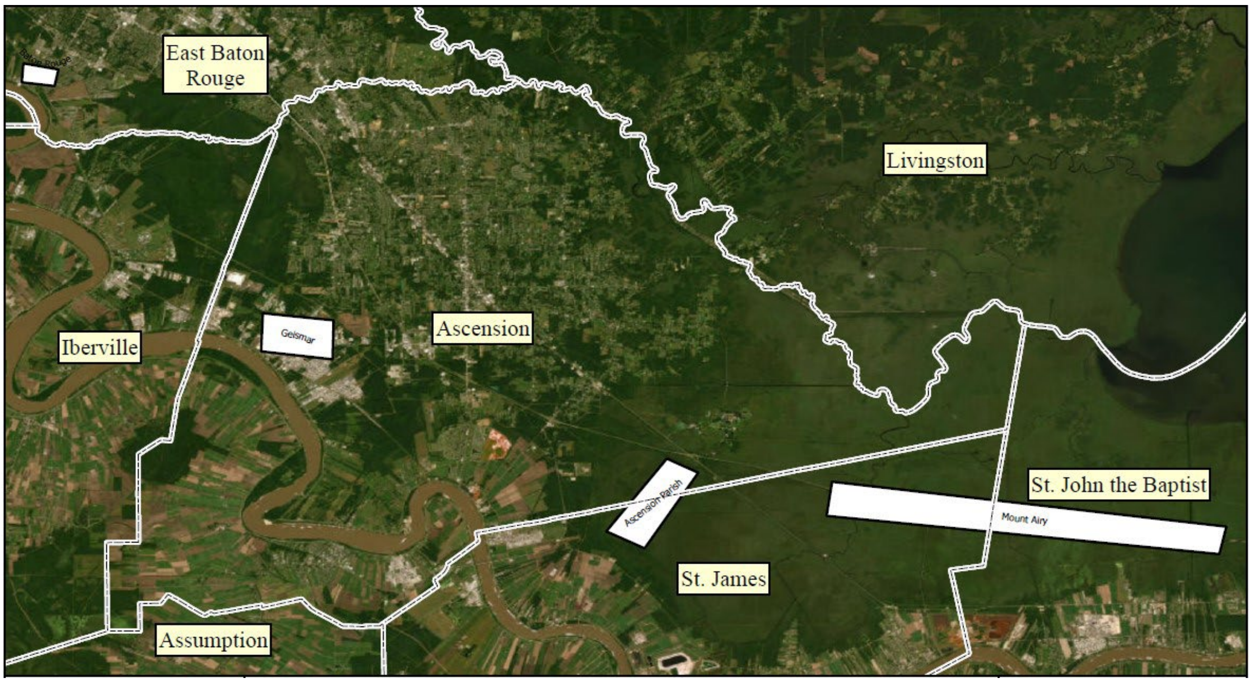


Figure B:8-2a. Pleistocene Areas of Interest

To ensure that Pleistocene is reached for the AOI defined in Figure B:8-2a above, piles are recommended to extend to a depth of 60 to 70 feet below ground surface. Foundations will likely consist of either piles or extensions of existing piles for structural elevation changes or retaining wall foundation support around larger structures (such as warehouses) in which elevation is not feasible. Final subsurface investigation requirements will be defined during Planning, Engineering, and Design (PED).

Due to the lack of boring information outside the vicinity of the Mississippi River, the depths of the Pleistocene were determined using Fisk's geologic classifications. These classifications were based on historic borings. Generally, the depth to Pleistocene becomes shallower as the distance increases from the existing course of the Mississippi River. In general, the Pleistocene strata in the four AOI defined in Figure B:8-2a above began at or near the surface, extending to an unknown depth.

In the Baton Rouge area, the top of the Pleistocene strata in the study project area is estimated to occur near surface, extending to an unknown depth. This can be concluded because the study area is outside the mapped course of the Mississippi River in the Holocene era. Reference Figures B:8-2b through B:8-2h below.

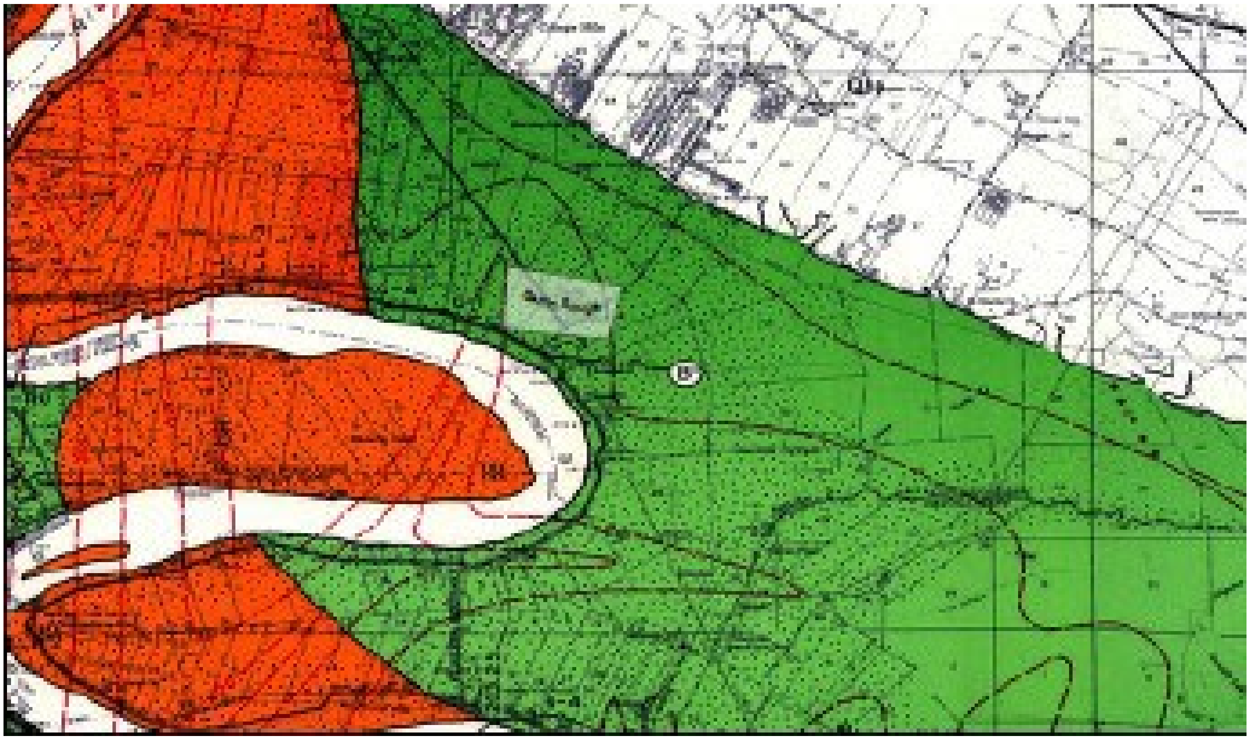


Figure B:8-2b. Pleistocene Areas of Interest near Baton Rouge

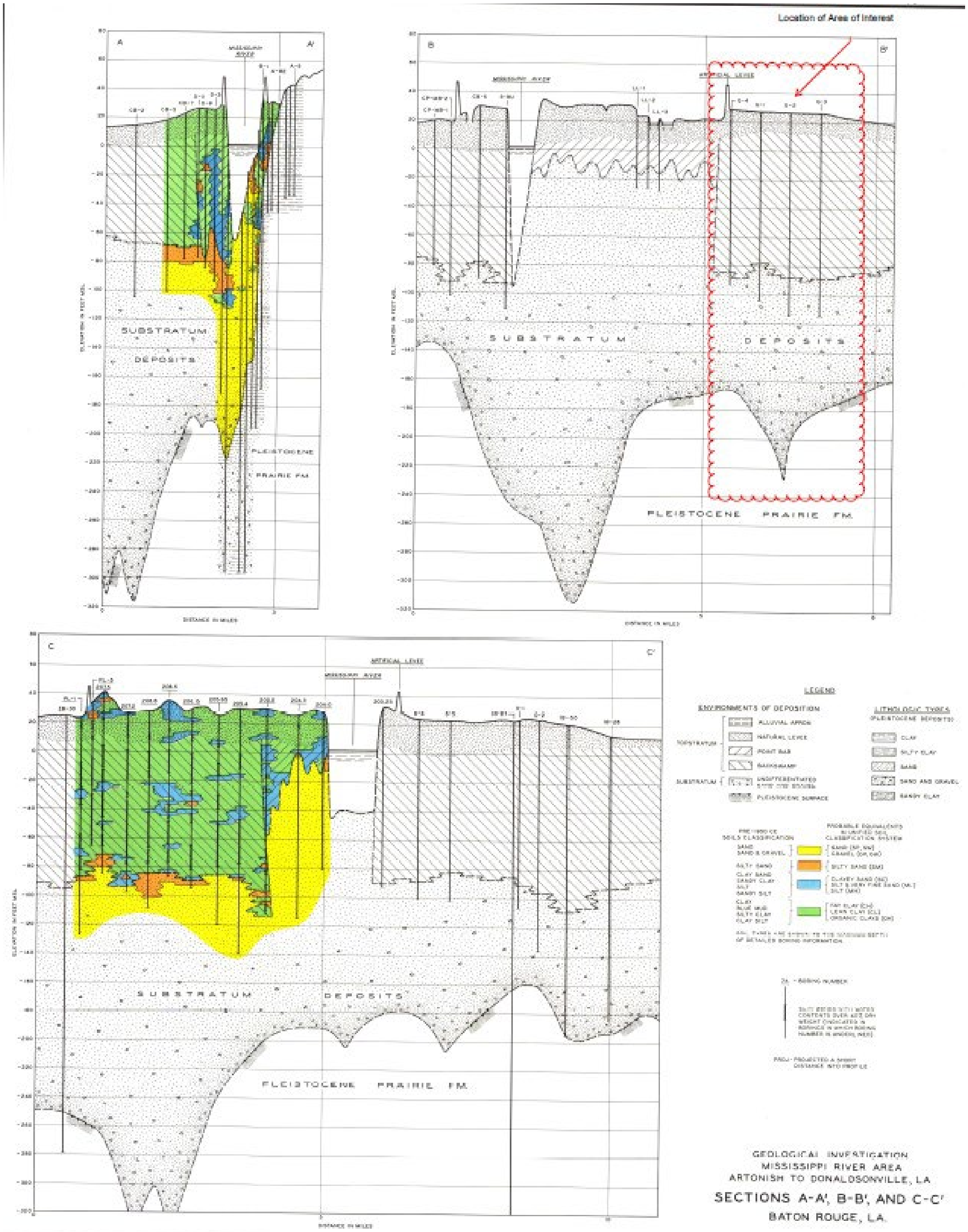


Figure B:8-2c. Geologic Investigation Section, Near Baton Rouge, LA

Moving southeast into Fisk's White Castle Quadrangle, specifically within the Geismar area, the Pleistocene is similar to the Baton Rouge Area, with its lower boundary also extending to an unspecified depth. See Figure B:8-2d below:

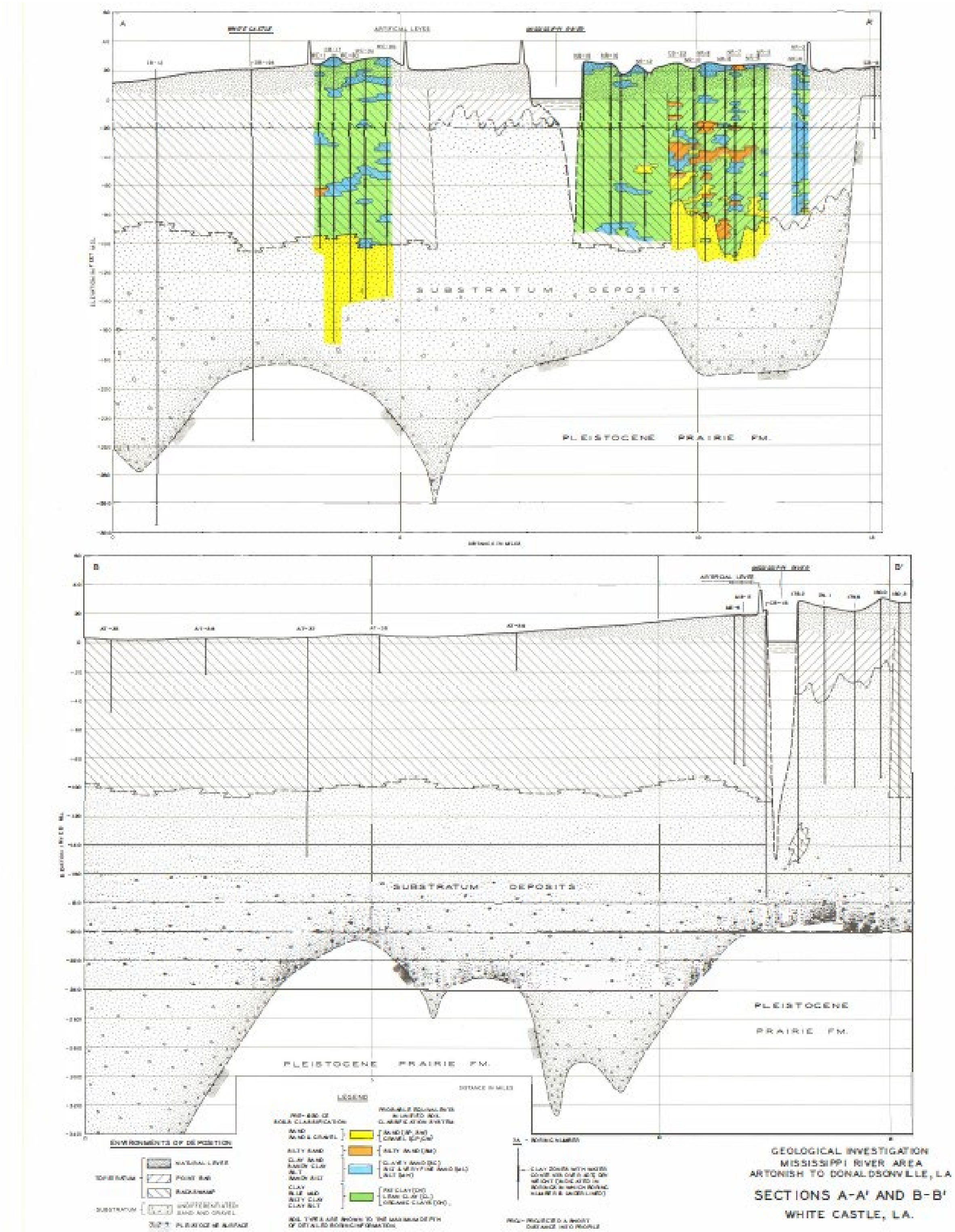


Figure B:8-2d. Geological Investigation Section Near White Castle, LA

Moving east, within the Ascension Parish Fisk's Donaldsonville area, the Pleistocene layer is closer to sea level and is approximately 5 to 10 feet below the surface continuing to an undetermined depth. See Figures B:8-2e below:

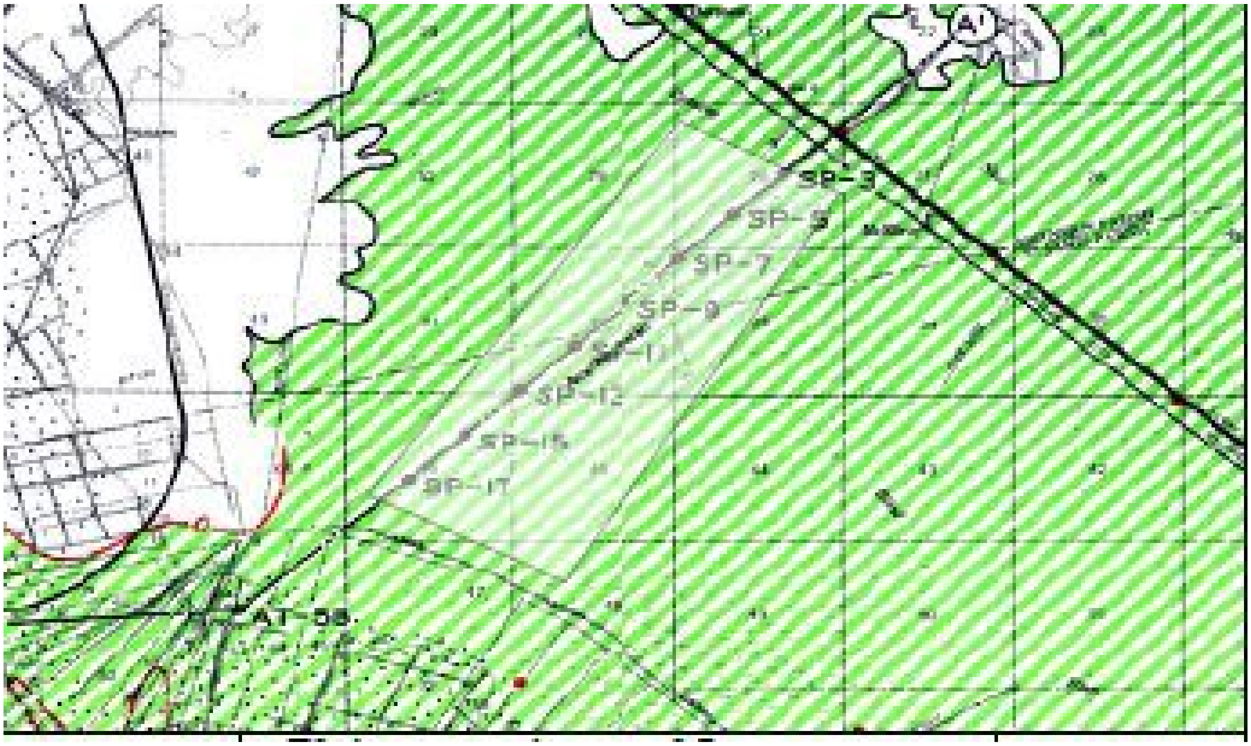


Figure B:8-2e. Pleistocene Areas of Interest, Ascension Parish

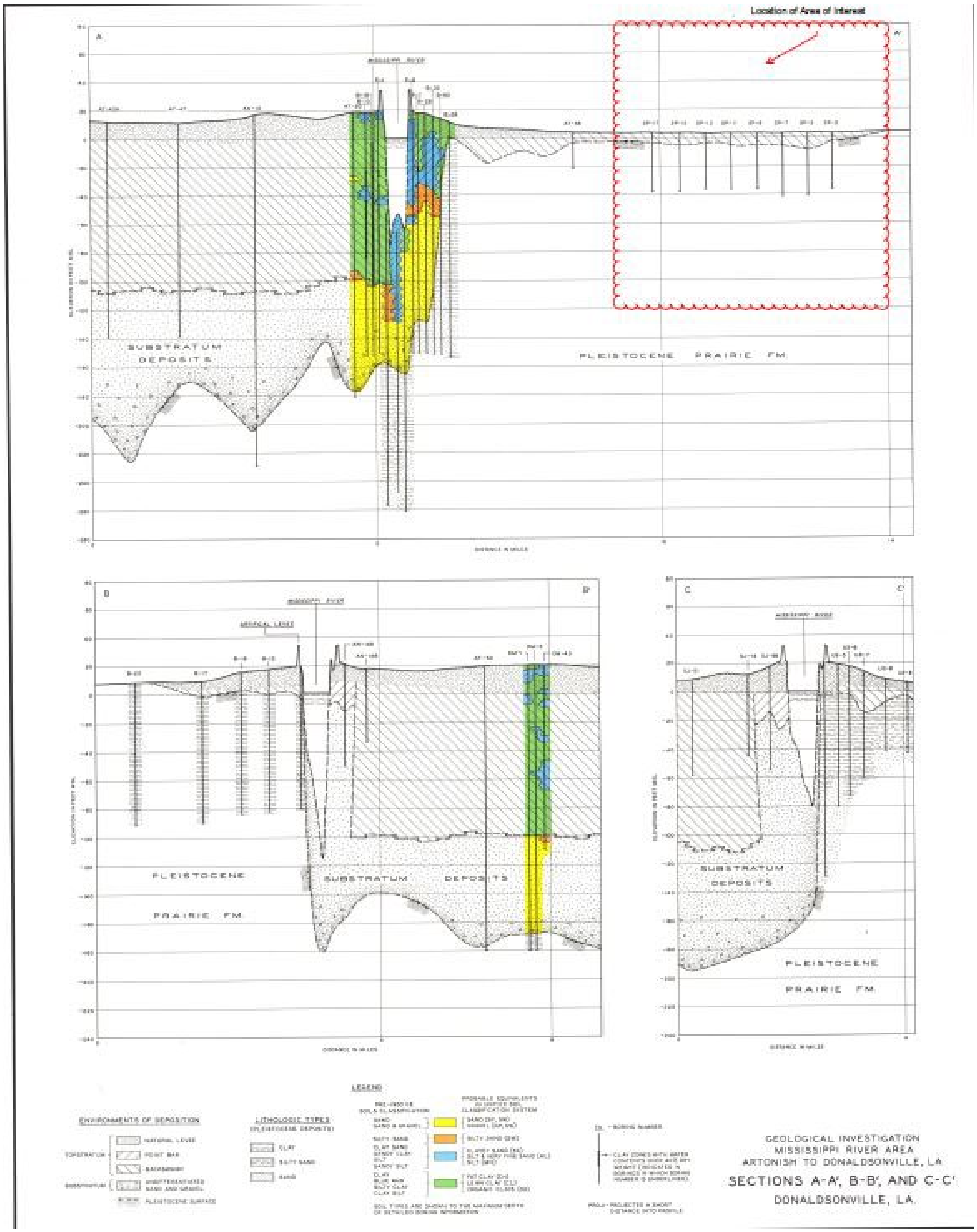


Figure B:8-2f. Geological Investigation Section Near White Castle, LA

Finally, to the southeast of Donaldsonville, in the Fisk's Mount Airy quadrangle, the Pleistocene starts at about -35 feet below sea level and similarly extends to an unknown depth. Reference Figure B:8-2g below.

Figure B:8-2g. Pleistocene Area of Interest – Mount Airy

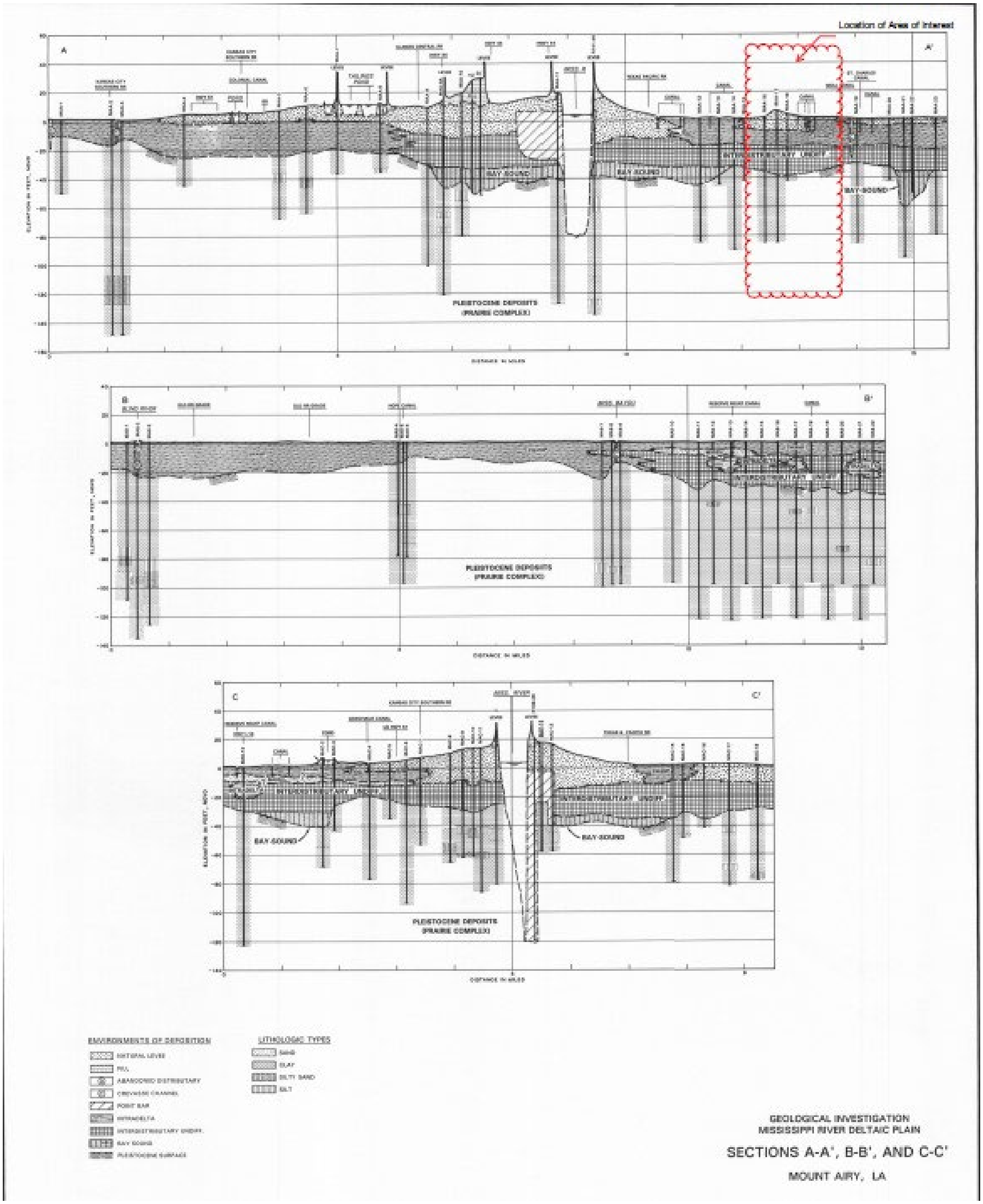


Figure B:8-2h. Geological Investigation Section Near Mount Airy, LA

These Figures illustrate the variation in Pleistocene stratigraphy across the mapped regions, highlighting differences in depth and geological characteristics.

In conclusion, considering all the available data, general knowledge of geologic conditions within the study area, and general knowledge of home raising requirements, a depth of 60-70 feet was assumed for pier and segmented block length requirements for representative design and cost estimating purposes.

8.3 RESIDENTIAL RAISINGS (STRUCTURAL)

Several representative designs were developed for lifting residential buildings to provide a design basis to support the cost estimate reflecting the variation in the residential sample inventory. The sample inventory was sorted into 1-story buildings, 2-story buildings, slab foundations, pier foundations, and mobile homes (also pier foundations). Reviewing numerous residential structures included in the sample inventory through satellite imagery presented many unique configurations. However in-depth structural details were not available for this feasibility study. Assumptions were made based on average room sizes for rectangular shaped homes. These structure types were evaluated as representations of different anticipated conditions. Different variations in equipment and materials required to perform a lift are expected based on varying weight and foundation type.

Table B:8-3a. Estimated Weight per SF

					With Brick			No Brick				
			Width	Length	no slab	4" Slab	6" Slab	no slab	4" Slab	6" Slab		
		SF	ft	ft	tons	tons	tons	tons	tons	tons		
1 Story		1,200	15	80	89.1	118.7	133.7	54.1	83.7	98.7		Typical Mobile Home
		1,507	15	100	111.4	148.0	166.8	67.5	104.0	122.8	Mobile	SF used for Mobile Home in data set
		2,000	24	83	115.4	157.0	182.0	72.3	113.9	138.9		Average 1-Story double 12ft RMs 4 Br
		2,291	30	76	122.8	167.9	196.6	77.2	122.4	151.0	1 Stry Pier	Average 1-Story Pier from Cost Analysis
		2,340	30	78	124.8	170.9	200.1	78.6	124.6	153.9	1 Stry Slab	Average 1-Story slab from Cost Analysis
		2,040	34	60	109.3	149.5	175.0	66.0	106.1	131.6		Average 1-Story Center Hall 15ft Rms, 3 BR
		3,000	50	60	154.4	209.2	246.7	88.7	143.4	180.9		large 1 story
		4,000	50	80	190.6	261.1	311.1	116.8	187.3	237.3		large 1-Story 4 to 5 BR
2 Story	full top	1,400	15	47	94.3	130.6	148.1	49.4	85.7	103.2		Example 2 story, single width, full top
	full top	2,000	25	40	111.9	156.9	181.9	59.0	104.0	129.0		Average 2 story, full top
	full top	4,000	30	67	191.7	271.7	321.7	108.3	188.3	238.3		large 2 story
	2/3 top	2,855	30	63	178.9	231.7	267.4	98.1	150.9	186.6	2Stry Pier	2 story Pier from Cost Analisys 1903 SF
	2/3 top	2,898	30	64	180.9	234.4	270.6	99.4	152.8	189.0	2Stry Slab	2 story slab foundation from Cost Analisys 1932 SF
	2/3 top	3,125	30	69	191.5	233.6	272.6	105.9	147.9	187.0		2 story repetitively used in data set
	2/3 top	5,500	50	73	310.8	395.5	464.3	168.7	253.4	322.2		Large 2 story

Given these judgment-based dimensions and estimated weights, structural engineering generated designs to provide data needed for cost estimation. The highlighted SF shown in Table B:8-3b represent average square footages for the respective structure type developed from the sample inventory.

Table B:8-3b. Inputs for Cost Analysis

		Foot Print	W	D	Jack Area	Jk Pt	Columns	Est. Weight	Wt/Jk	Wt/Column
	SF	SF	Ft	Ft	SF	#	#	tons	tons	tons
Pier										
Typical Mobile Home	1200	1200.0	80	15	100	12	18	54.1	4.5	3.0
Mobile Home used in data set	1507	1507.0	100	15	100	16	22	67.5	4.2	3.1
Avg 2-Story Pier home from Cost Analysis 1903 SF	2854.35	1902.9	63.43	30	90	22	32	98.1	4.5	3.1
Avg 1-Story Pier home from Cost Analysis	2290.95	2291.0	76.365	30	120	20	32	77.2	3.9	2.4
Slab										
Average 1-Story double 12ft RMs 4 Br	2000	2000	83.33	24	95	22	30	181.9	8.3	6.1
Average 1-Story slab from Cost Analysis	2337.9	2337.9	77.93	30	90	26	32	200.1	7.7	6.3
large 1 story - Slab	3000	3000	60	50	100	30	42	264.7	8.8	6.3
2 story slab foundation from Cost Analisys 1932 SF	2898	1932	64.4	30	60	34	32	270.6	8.0	8.5
2 story repetitively used in data set	3125	2070	69	30	64	34	32	272.6	8.0	8.5

Use of hydraulic jacks and cribbing is a standard private industry practice for lifting structures in the project area. Therefore, a preliminary jacking layout design was incorporated into the structural design. A maximum anticipated weight/jacking point was assumed to be between 8-9 tons based on lifting method. A unified jacking system was the assumed lifting method with 2-inch hydraulic pistons distributed around the perimeter, support beams, and in some instances additional jacks are needed beneath the interior. Segmented piers are jacked to refusal using the industry standard maximum pressure on the jacking system, assumed to be 8,000 psi (8,000 psi on a 2-inch cylinder is roughly 12.5 tons per jack). Therefore, the estimated weight of a home was limited to (8-9 tons/JkPt) plus the added weight of a new slab and grade beam which would reach near the 12.5 tons estimated per jack. This load would maintain similar compression on piers jacked to refusal at 8,000 psi. Another limiting factor is grade beam design. Grade beams were spaced in 10-12 foot spacings depending on the configuration of columns beneath the house. Each input worksheet includes a rough graphic to show jack spacing and column spacing. Key residential assumption are as follows:

1. Mobile home, 1-story, and 2-story houses <7,500 SF will be lifted.
2. Residential buildings in item 1 are subdivided into <6ft and >6ft lifts for cost estimating due to differing lift methodologies based on lifting heights.
3. Assume 2 exterior doors for mobile homes and 3 for all other residential. Exterior doors assumed to be 3 feet wide.
4. Access stairs for 2 of the 3 exterior doors will be estimated. Connection to the 3rd exterior door will be by connected elevated walkway between the 2 access stairs. Access to electrical panels will also be via the elevated walkway.
5. Rollup doors will not be addressed for elevated residential structures.

8.4 COMMERCIAL FLOODPROOFING MASONRY CONSTRUCTION

Commercial buildings consist of eateries, groceries, professional, public, repair shops, residential structures (>7500 SF), and other multi-use structures. Each commercial building type had assumptions made for doors and windows summarized in Table B:8-4a.

Table B:8-4a: Assumptions Inputs from EDS for Cost Estimate

BLDG. TYPE	Ext. Doors	Ext. Sliding Door	Storefront Window	Rollup Door
EATERY	3-3' Wide*		5-4' Wide	
GROCERY (small < 2000 SF)		1-6' Wide	5-4' Wide	1-12' Wide
GROCERY (large > 2000 SF)		2-6'Wide	5-4' Wide	1-12' Wide
MULTI-USE	4-3' Wide**		6-3' Wide	
PROFESSIONAL	2-3' Wide***		4-3’ Wide	
PUBLIC	4-3' Wide		4' Wide / 20LF perimeter	1-12' Wide
REPAIR	4-3' Wide		2-4' Wide	2-12' Wide / 1200 SF
RES >7500SF	1-3' Wide / 1000 SF	1-6' Wide / 1000 SF	N/A	
*	doors assumption for an eatery is 1 - double front door (6ft) and 1 backdoor (3ft) for deliveries.			
**	doors assumption based on 2 - rental units			
***	# of doors per tenant - 1 tenant/1250 SF			

A flood proofing section was utilized for masonry commercial buildings for cost estimating purposes. The standard section was provided by the Cost Center of Expertise in Walla Walla. In summary, the section consists of two masonry walls that would be attached to the perimeter of each commercial structure with a three-feet high water-resistant membrane. The system is pictured in Figure B:8-4a.

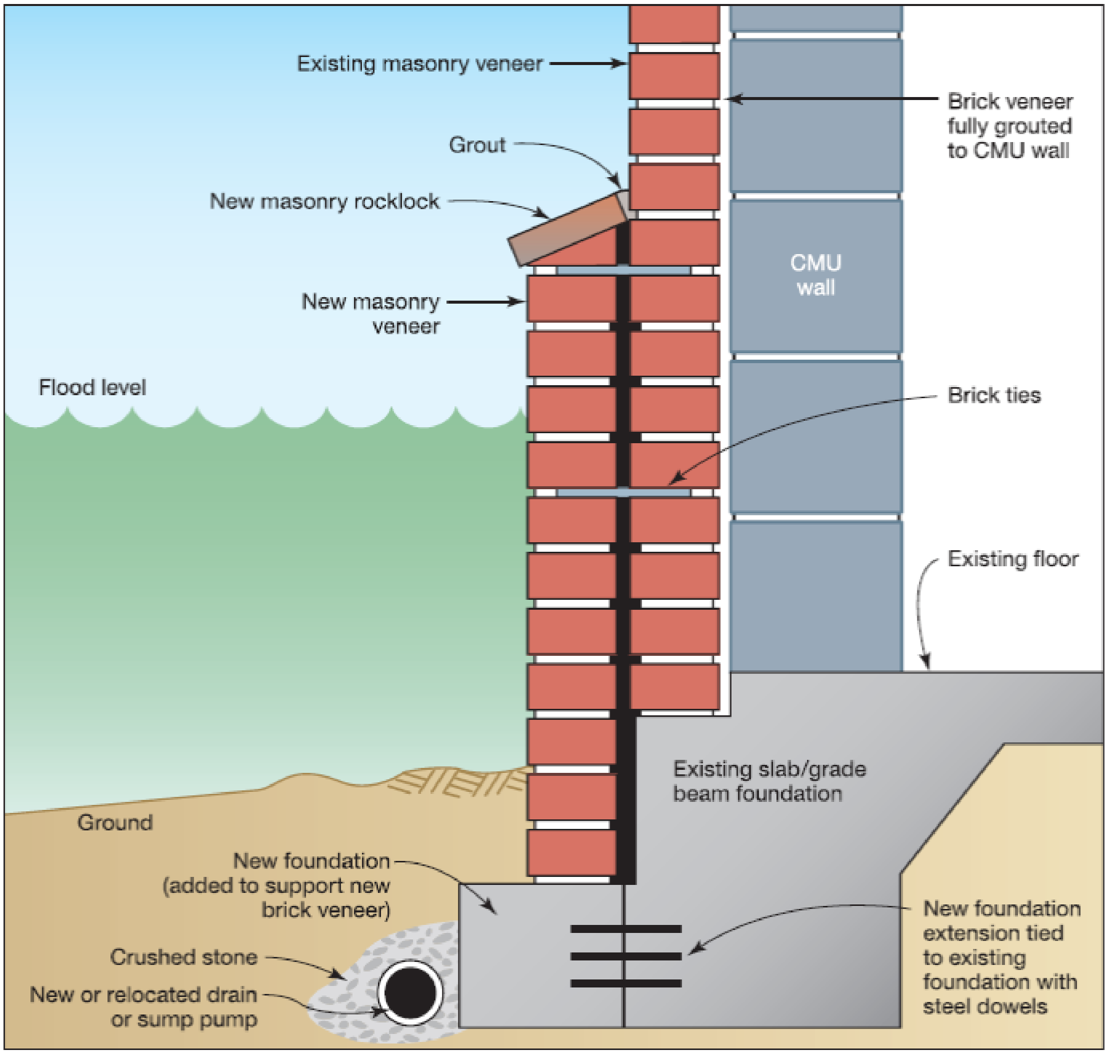


Figure 5D-2. A way to seal an existing brick-faced wall is to add an additional layer of brick with a seal in between. Please note that weep holes and wick drains work both ways to allow for moisture passage from high to low pressure. Weepholes and flashing should be located above the DFE, and the veneer below the DFE should be fully grouted.

Figure B:8-4a. Dry Floodproofing Representative Section for Commercial Properties

The section depicted in Figure B:8-4a is invasive. Adding the brick wythe and membrane on the exterior of the existing veneer will block the existing weep holes. To avoid moisture and mold issues, the existing weep holes and associated flashing will need to be elevated above the flood line. This means selective demolition of existing veneer (if present), adjusting flashing, and installation of the masonry/membrane system. Installation of the concrete masonry units (CMUs) wall is invasive as well. If the CMU installation replaces a stud wall, all electrical and plumbing features will be affected as well as window/door framing. Reestablishment of the building envelope will be required. Any additional structural weight may impact the existing structural foundation design, particularly over soft soils located in the region, and would require load and stability analysis on a site-by-site basis. Moreover, during this work, the business may have to close or temporarily relocate. Key assumption for commercial buildings are:

1. See Table 8-4a for assumptions made for doors per different type of commercial building.
2. See Table 8-4a for assumptions made for windows per different type of commercial building.
3. Door and window barrier costs are standard off the shelf commercial items from Walla Walla District‘s Cost Engineering Center of Expertise and do not require a separate design.
4. Rollup or warehouse style deliver are assumed to be 12 ft wide (maximum), which is small enough to deploy a commercially available prefabricated flood barrier to fit within the door jambs. Larger doors may require additional engineering that would be addressed during PED or in the Design/Build contract.
5. Membranes shall be applied as shown on Figure B:8-4a.
6. No membrane for floodproofing will be done below grade to any foundation elements.
7. Designs were provided to develop quantities for equipment platforms.
8. Uplift due to water pressure from surrounding flood water elevation was evaluated, and the weight of the building and building contents are unknowns that would need to be verified during PED. Uplift on commercial buildings can be mitigated with the use of helical anchors, which can be developed as a site-specific item.

8.5 INDUSTRIAL METAL BUILDING FLOODPROOFING

Similarly, a section was developed to show a method for flood proofing warehouse type, sheet metal buildings. Different methods to dry floodproof industrial buildings were reviewed to mitigate potential uplift pressure such as cut off walls and helical anchors. The method used to floodproof for metal buildings is similar to commercial masonry buildings with a membrane installed on an exterior of a block wall building skirt 3 feet above grade. The assumptions for doors and windows on industrial buildings are noted in the Table 8-5.

Table B:8-5. Assumptions Inputs from EDS for Cost Estimate

BLDG. TYPE	Ext. Doors	Rollup Door	Storefront Window
WAREHOUSE	2-3' doors / 3000 SF	2-12' Rollup / 1200 SF	2-3' window/ 4000SF

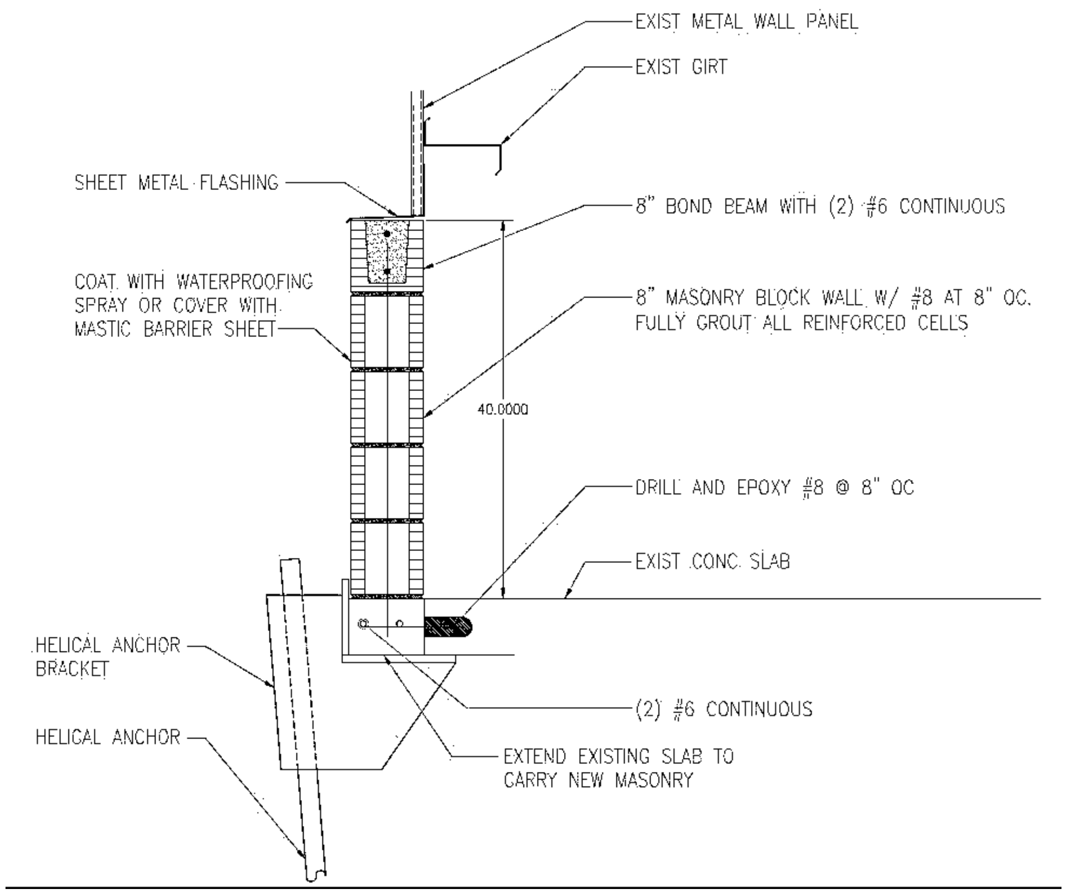


Figure B:8-5. Dry Floodproofing Representative Section for Industrial Properties

Key assumptions for Industrial Buildings are as follows:

1. See Table 8-5 for assumptions made for doors and windows.
2. Door and window barrier costs are standard off the shelf commercial items provided by Walla Walla District‘s Cost Engineering Center of Expertise and do not require a separate design.
3. Rollup or warehouse style deliver doors are assumed to be 12 ft wide (maximum), which is small enough to deploy a commercially available prefabricated flood barrier to fit within the door jambs. Larger doors may require additional engineering that would be addressed during PED or in the Design/Build contract.
4. Membranes shall be applied on the exterior of the block wall as shown in Figure B:8-5
5. No membrane will be applied to any below grade foundation elements.
6. Designs were provided to develop quantities for equipment platforms.
7. Uplift due to hydrostatic pressure was evaluated. Building weight and contents are unknowns requiring verification during PED. Uplift can be mitigated with the use of helical anchors based on site specific designs. For cost estimation, a design utilizing 65 feet helical anchors spaced at 10 feet was assumed for quantity development.

SECTION 9
References

USACE, New Orleans District, Amite River and Tributaries, Darlington Reservoir Feasibility Study, dated September 1992.

Harza Consultants (Response to original feasibility study), *Harza Engineering Report*, dated April 1995.

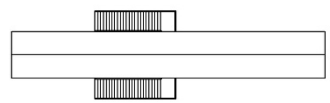
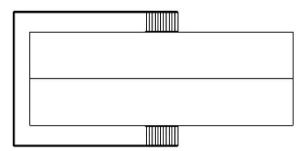
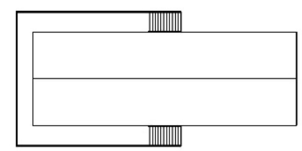
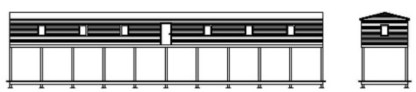
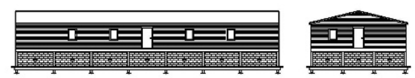
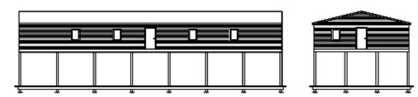
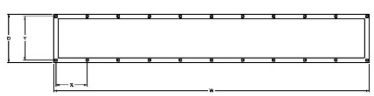
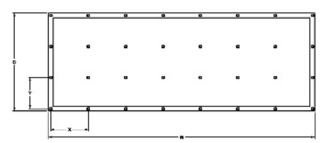
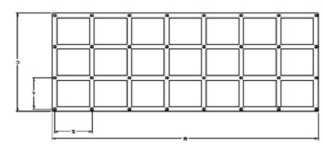
USACE, New Orleans District, (response to Harza Engineering Report), *Amite River and Tributaries, Darlington Reservoir Re-evaluation Study (Reconnaissance Scope)*, dated September 1997.

Dewberry Engineers Inc., Louisiana Department of Transportation and Development, *Amite River Basin Numerical Model*, 2019

SECTION 10
List of Acronyms and Abbreviations

AC	Acreage
AEP	Annual Exceedance Probability
CY	Cubic Yard
CMU	Concrete Masonry Unit
DEM	Digital Elevation Model
EA	Each
EM	Engineering Manual
ER	Engineering Regulation
FOS	Factor of Safety
FT	Feet
GIS	Geographic Information System
HH&C	Hydraulic, Hydrology, and Coastal Engineering Branch
LADOTD	Louisiana Department of Transportation and Development
LB	Pound
LF	Linear Feet
LiDAR	Light Detection and Ranging
MSL	Mean Sea Level
MVN	New Orleans District
NAVD 88	North American Vertical Datum of 1988
NFS	Non-Federal Sponsor
NS	**Nonstructural**
O&M	**O**&M Manual
PED	Preconstruction Engineering and Design
SF	Square Feet
TN	Ton
USACE	US Army Corps of Engineers
YR	Year

ANNEX 1: RESIDENTIAL LIFT AND DRYPROOFING STRUCTURE DIAGRAMS

	MOBILE HOME	1&2 STORY PIER/SLAB - LOW LIFT (<6ft)	1&2 STORY PIER/SLAB - HIGH LIFT (>6ft)
ROOF PLAN			
ELEVATIONS			
FOUNDATION			
W	100ft	84ft	84ft
D	15ft	30ft	30ft
X	10ft	12ft	12ft
Y	14ft	10ft	10ft

US Army Corps of Engineers ®

MARK	DESCRIPTION	DATE

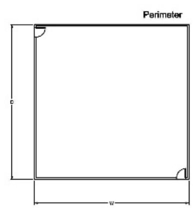
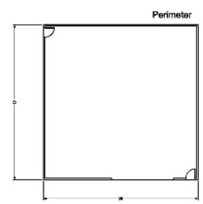
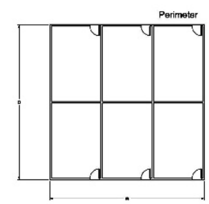
DESIGNED BY: STEPHEN J. BORENGASSER
DRAWN BY: AAW
CHECKED BY: STEPHEN J. BORENGASSER
SUBMITTED BY: STEPHEN J. BORENGASSER
SIZE: ANSI D
ISSUE DATE: AUG 2024
SOLICITATION NO.:
CONTRACT NO.:
FILE NUMBER:
FILE NAME: A001.dgn

US ARMY CORPS OF ENGINEERS
NEW ORLEANS DISTRICT
NEW ORLEANS, LOUISIANA

U.S.ARMY CORPS OF ENGINEERS
AMITE RIVER AND TRIBUTARIES
AR&T NONSTRUCTURAL
TANGIPAHOA PARISH, LOUISIANA

RESIDENTIAL LIFT AND DRYPROOFING
STRUCTURE DIAGRAMS

SHEET ID
001

	COMMERCIAL BUILDING	INDUSTRIAL BUILDING	RESIDENTIAL > 7500 S.F.
PLAN VIEW			
PERIMETER	Square Root of S.F x 4	Square Root of S.F x 4	Square Root of S.F x 4
D	Square Root of S.F	Square Root of S.F	Square Root of S.F
W	Square Root of S.F	Square Root of S.F	Square Root of S.F

US Army Corps of Engineers ®

MARK	DESCRIPTION	DATE

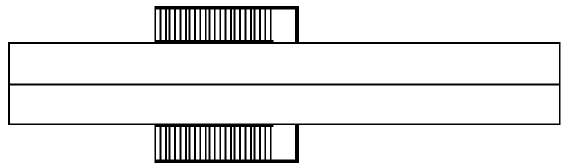
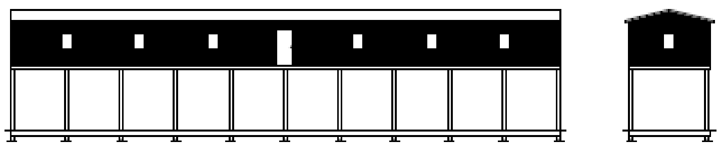
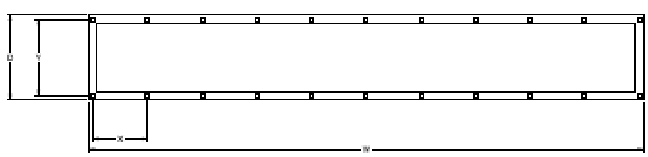
DESIGNED BY: STEPHEN J. BORENGASSER
ISSUE DATE: AUG 2024
DRAWN BY: AAW
SOLICITATION NO.:
CHECKED BY: STEPHEN J. BORENGASSER
CONTRACT NO.:
SUBMITTED BY: STEPHEN J. BORENGASSER
FILE NUMBER:
SIZE: ANSI D
FILE NAME: [redacted] A-001.dgn

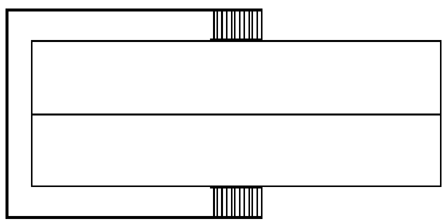
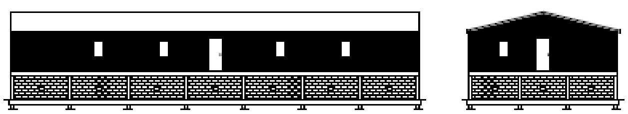
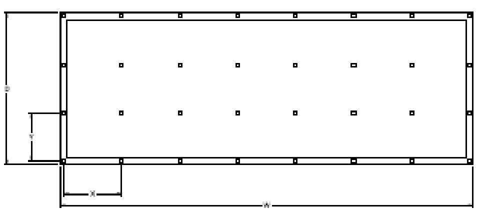
US ARMY CORPS OF ENGINEERS
NEW ORLEANS DISTRICT
NEW ORLEANS, LOUISIANA

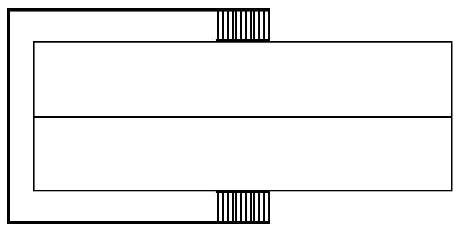
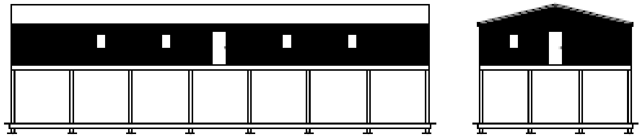
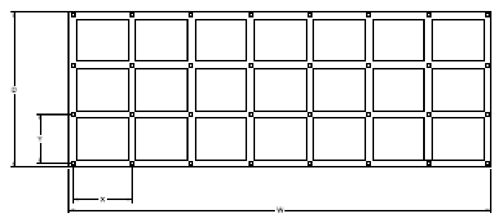
U.S ARMY CORPS OF ENGINEERS
AMITE RIVER AND TRIBUTARIES
AR&T NONSTRUCTURAL
TANGIPAHOA PARISH, LOUISIANA

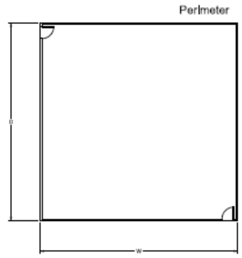
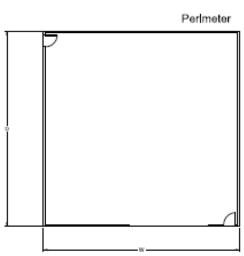
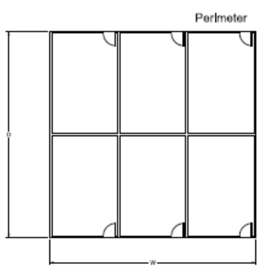
RESIDENTIAL LIFT AND DRYPROOFING
STRUCTURE DIAGRAMS

SHEET ID
002

	MOBILE HOME
ROOF PLAN	
ELEVATIONS	
FOUNDATION	
W	100ft
D	15ft
X	10ft
Y	14ft

1&2 STORY PIER/SLAB - LOW LIFT (<6ft)



84ft
30ft
12ft
10ft

1&2 STORY PIER/SLAB - HIGH LIFT (>6ft)



84ft
30ft
12ft
10ft

	COMMERCIAL BUILDING	INDUSTRIAL BUILDING	RESIDENTIAL > 7500 S.F.
PLAN VIEW			
PERIMETER	Square Root of S.F x 4	Square Root of S.F x 4	Square Root of S.F x 4
D	Square Root of S.F	Square Root of S.F	Square Root of S.F
W	Square Root of S.F	Square Root of S.F	Square Root of S.F

ANNEX 2: STRUCTURE RAISE QUANTITIES

* "Jacking Area" varies by relative spacing of the jacks required to achieve even jack distribution

* "Column Spacing" varies with respect to grade beam availability or use6.5" column spacing for pile under typical reinforced slabs.

* "Grade Beam Width" varies12" - 18" for 1-story 18" - 24" for 2-story.

Inputs:
*Were given by Orleans and Davie Shoring. Input row 10, 11, 13 -17.

*Was jacking area given by Shoring Companies?

*Pile segments are the length of the CMU used for pile segments 8"x8"8"

*What is Depth to Pile Refusal?

*Row 5 and 6 given by economics

*Row 7 - 9 are Assumed.

Calculations:
*Height of Lift (ft): (Lowest Adjacent Grade (ft, NAVD88)+Foundation Height (ft)+1' Slab (See figure 1))-First Floor Elevation (ft, NAVD88)

*Foundation Height (ft): CMU Courses * (8/12) (8" in the size of the CMU 8" x 8"x8")

*CMU Courses: (Target Elevation (ft, NAVD88)-Lowest Adjacent Grade (ft, NAVD88)-1 Slab (6" slab see Figure 1)- initial lifting phase) *12 in/ft (Coverting to inches))/8" (8" in the size of the CMU 8" x 8"x?)

*Column Grid Lines (Width): # of columns along perimeter on width side

*Column Grid Lines (Depth): # of columns along perimeter on length side

*No. of Columns: Total Columns around perimeter and interior

*Cribbing Levels below 6' per riser: # of risers

*Cribbing Levels below 6':
-If above 6' total height limit/Box Cribbing Timber Height Dimension (in)/12in/ft = xx
-If below 6' -Foundation Height (ft)/Box Cribbing Timber Height Dimension (in)/12in/ft =xx

*Cribbing Levels above 6'
-If above 6' total height limit/Box Cribbing Timber Height Dimension (in)/12in/ft
-Cribbing Levels below 6'

*Segments per pile below grade:
-Depth to Pile Refusal (ft)/Pile Segment Lengths (in)/12 in/ft

*Segments per pile above grade
- IF greater than 6' then 0 If not Foundation Height (ft)/8"(8" in the size of the CMU 8" x 8"x8")
/12 in/ft

*Perimeter Piles: # of piles around house

*Interior piles: Total Columns - Perimeter Columns

Outputs:
*House Square Footage (sf) =House Width (ft)*House Width (ft)

*Steel Beams, Crossing (CWT)= Crossing Steel Beams *60LF *40LB/LF/100

*Steel Beams, Main (CWT)= Main Steel Beams *(60 LF*50LB/LF)/100

*Crib Point Riser Pairs below 6' (Pair) = No. of Jacking Points*Cribbing Levels below 6'

Crib Point Riser Pairs above 6' (Pair) = No. of Jacking Points Cribbing Levels above 6'

*Initial Lifting Phases (ea) = 1'

*Addt'l Lifting Phases below 6' (ea) = (Height of Lift (ft)/Box Cribbing Timber Height Dimension (in)/12 in/ft)-Addt'l Lifting Phases above 6' (ea)-Initial Lifting Phases (ea)

*Addt'l Lifting Phases above 6' (ea) = Cribbing Levels above 6'

*Grade Beam (LF) =
When is the grade used and where and why difference in below and above 6'?
Below 6' use CMU Wall Grade Beam (LF) = 0
Above 6' use Grade Beam (LF) = For High Lifts, pour grade beams between piers and slab-on-grade.

*CMU Columns Blocks (EA) = CMU Courses*No. of Columns

*Anchors (ea) = # of columns What are the anchors?

* Perimeter Screening sf = Footprint Perimeter (ft)*Foundation Height (ft)

*Slab-on-Grade Area (sf) = no slab below 6'.
For above 6': SF of house - area of columns

Summary

	SF	Foot Print SF	W Ft	D Ft	Jack Area SF	Jk Pt #	Columns #	Est. Weight tons
Pier								
Typical Mobile Home	1200	1200.0	80	15	100	12	18	54.1
Mobile Home used in data set	1507	1507.0	100	15	100	16	22	67.5
Avg 2-Story Pier home from Cost Analysis 1903 SF	2854.35	1902.9	63.43	30	90	22	32	98.1
Avg 1-Story Pier home from Cost Analysis	2290.95	2291.0	76.365	30	120	20	32	77.2
Slab								
Average 1-Story double 12ft RMs 4 Br	2000	2000	83.33	24	95	22	30	181.9
Average 1-Story slab from Cost Analysis	2337.9	2337.9	77.93	30	90	26	32	200.1
large 1 story - Slab	3000	3000	60	50	100	30	42	264.7
2 story slab foundation from Cost Analisys 1932 SF	2898	1932	64.4	30	60	34	32	270.6
2 story repetitively used in data set	3125	2070	69	30	64	34	32	272.6

Pier Mobile Quantity 1507 SF

House Raise Pier Founded Quantity Worksheet

Mobile Home used in data set

Inputs

Desc	Value	Assumptions
House Width (ft)	100.5'	
House Depth(ft)	15.0'	15' width for Hwy travel
Lowest Adjacent Grade (ft, NAVD88)	7.9'	
First Floor Elevation (ft, NAVD88)	9.9'	
Target Elevation (ft, NAVD88)	13.9'	
Jacking Area (sf)	100.0 SF	based on jacking points
Box Cribbing Timber Height Dimension (in)	6"	referencing Fema Drawing
Crossing Steel Beam Spacing (ft)	10.0'	likely use the existing frame
Main Steel Beam Spacing (ft)	10.0'	likely use the existing frame
Column Spacing, Width (ft)	10.0'	10 ft max
Column Spacing, Depth (ft)	14.0'	near outter edge only
Grade Beam Width (in)	18"	1 story (Depth = 12") and 2 story (Depth = 24")
Support Column Width (in)	10"	

Outputs

Desc	Value
House Square Footage (sf)	1507.0
Steel Beams, Crossing (CWT)	316.8
Steel Beams, Main (CWT)	60.0
Crib Point Riser Pairs below 6' (Pair)	176.0
Crib Point Riser Pairs above 6' (Pair)	0.0
Initial Lifting Phases (ea)	1.0
Addt'l Lifting Phases below 6' (ea)	8.0
Addt'l Lifting Phases above 6' (ea)	0.0
Grade Beam (LF)	332.9
CMU Columns Blocks (EA)	176.0
Anchors (ea)	22.0
Perimeter Screening (sf)	1231.6
Slab-on-Grade Area (sf)	1491.7

Calculations

Desc	Value	Formula	Assumptions
Footprint Square Footage (sf)	1507.0 SF	W x D	
Footprint Perimeter (ft)	230.9'	2W + 2D	
No. of Jacking Points	16	SF/Jacking Area	Jacking pt are on the frame of mobile home
Height of Lift (ft)	4.3'	(LowestAdjGrd+FoundationHt+1)-1stFloorEL	
Foundation Height (ft)	5.3'	CMU Courses x (8/12)	
CMU Courses	8	ROUNDUP(TargetEL-LowestAdjGrd-1)*(12/8),0)	
Column Grid Lines (Width)	11	ROUNDUP(W/ColumnSpacingW,0)+1	max 10ft spacing (no+1)
Column Grid Lines (Depth)	2	Depth/Column Spacing	Columns near outter edge only (no+1)
No. of Columns	22	Grid Line W x Grid Line D	
Crossing Steel Beams	11	W / Crossing Steel Spacing (no +1)	Extra steel should not be necessary for Mobile
Main Steel Beams	2	D / Main Steel Spacing (no+1)	Extra steel should not be necessary for Mobile
Cribbing Levels below 6'	11	IF(FoundHt>6,ROUNDUP(6/(CribHt/12),0),ROUNDUP(B25/(CribHt/12),0))	
Cribbing Levels above 6'	0	IF(FoundHt>6,ROUNDUP(FoundHt/(CribHt/12),0)-Crib<6,0)	

Figure 2: Plan View
Columns and Segemented Piles

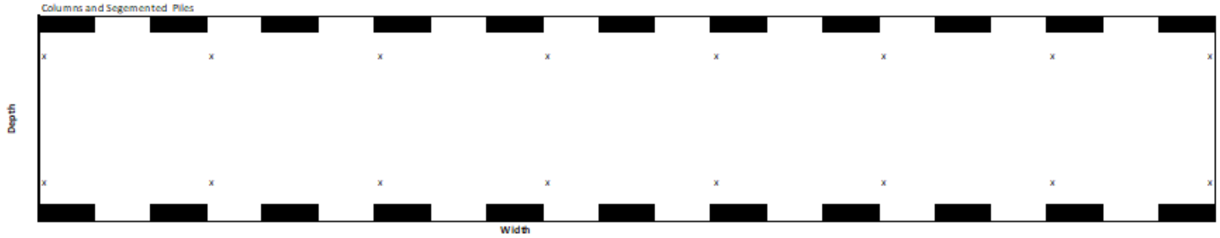


Figure 2: Plan View
Grade Beams 6' and below

Figure 2: Plan View
Grade Beams above 6'

Pier 2 Story Quantity 1903 SF

House Raise Pier Founded Quantity Worksheet

Avg 2 Story Pier home from Cost Analysis 1903 SF

Inputs

Desc	Value	
House Width (ft)	63.43'	
House Depth (ft)	30.0'	2 rooms 12 SQ, side by side
Lowest Adjacent Grade (ft, NAVD88)	7.9'	
First Floor Elevation (ft, NAVD88)	9.9'	
Target Elevation (ft, NAVD88)	13.9'	
Jacking Area (sf)	90.0 SF	varies
Box Cribbing Timber Height Dimension (in)	6"	referencing Fema Drawing
Crossing Steel Beam Spacing (ft)	8.0'	varies
Main Steel Beam Spacing (ft)	12.0'	varies
Column Spacing, Width (ft)	10.0'	varies
Column Spacing, Depth (ft)	12.0'	varies
Grade Beam Width (in)	18"	1 story (Depth = 12")and 2 sto
Support Column Width (in)	10"	

Outputs

Desc	Value	
House Square Footage (sf)	2854.4	Total usable SF of a 2 story house is roughly 1.5 x SF of the foot print
Steel Beams, Crossing (CWT)	201.6	
Steel Beams, Main (CWT)	90.0	
Crib Point Riser Pairs below 6' (Pair)	242.0	
Crib Point Riser Pairs above 6' (Pair)	0.0	
Initial Lifting Phases (ea)	1.0	
Addt'l Lifting Phases below 6' (ea)	8.0	
Addt'l Lifting Phases above 6' (ea)	0.0	
Grade Beam (LF)	445.7	
CMU Columns Blocks (EA)	256.0	
Anchors (ea)	32.0	
Perimeter Screening (sf)	996.6	
Slab on Grade Area (sf)	2832.1	

Calculations

Footprint Square Footage (sf)	1902.9 SF
Footprint Perimeter (ft)	186.9'
No. of Jacking Points	22
Height of Lift (ft)	4.3'
Foundation Height (ft)	5.3'
CMU Courses	8
Column Grid Lines (Width)	8
Column Grid Lines (Depth)	4
No. of Columns	32
Crossing Steel Beams	7
Main Steel Beams	3
Cribbing Levels below 6'	11
Cribbing Levels above 6'	0

Figure 2: Plan View
Columns and Piles

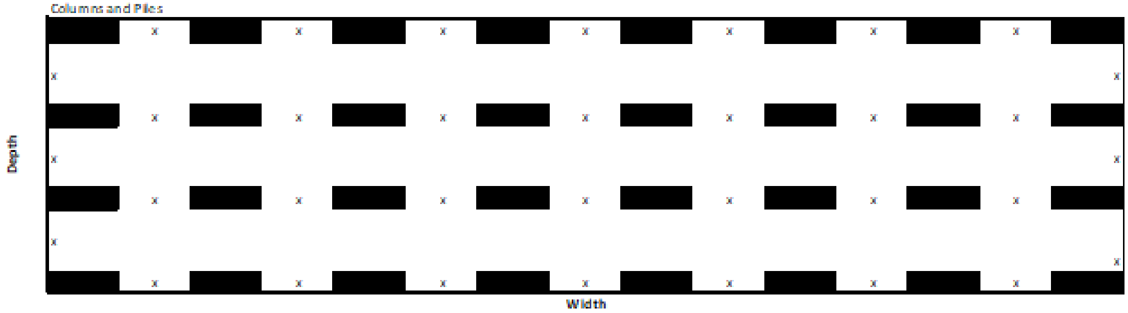


Figure 2: Plan View
Grade Beams 6' and below

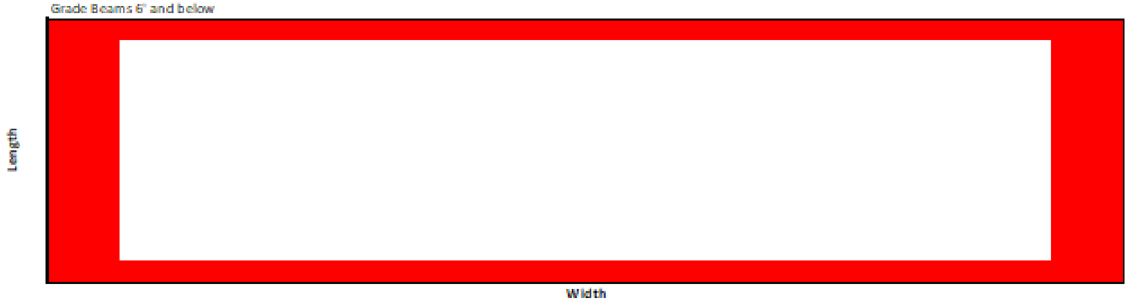


Figure 2: Plan View
Grade Beams above 6'

Pier 1 Story Quantity 2291 SF

House Raise Pier Founded Quantity Worksheet

Avg 1-Story Pier home from Cost Analysis

Inputs

Desc	Value	
House Width (ft)	76.365'	
House Depth (ft)	30.0'	
Lowest Adjacent Grade (ft, NAVD88)	7.9'	
First Floor Elevation (ft, NAVD88)	9.9'	
Target Elevation (ft, NAVD88)	13.9'	
Jacking Area (sf)	120.0 SF	varies
Box Cribbing Timber Height Dimension (in)	6"	referencing Fema Drawing
Crossing Steel Beam Spacing (ft)	12.0'	varies
Main Steel Beam Spacing (ft)	12.0'	varies
Column Spacing, Width (ft)	12.0'	varies
Column Spacing, Depth (ft)	12.0'	varies
Grade Beam Width (in)	18"	1 story (Depth = 12")and 2 sto
Support Column Width (in)	10"	

Outputs

Desc	Value
House Square Footage (sf)	2291.0
Steel Beams, Crossing (CWT)	201.6
Steel Beams, Main (CWT)	90.0
Crib Point Riser Pairs below 6' (Pair)	220.0
Crib Point Riser Pairs above 6' (Pair)	0.0
Initial Lifting Phases (ea)	1.0
Addt'l Lifting Phases below 6' (ea)	8.0
Addt'l Lifting Phases above 6' (ea)	0.0
Grade Beam (LF)	497.5
CMU Columns Blocks (EA)	256.0
Anchors (ea)	32.0
Perimeter Screening (sf)	1134.6
Slab-on-Grade Area (sf)	2268.7

Calculations

Footprint Square Footage (sf)	2291.0 SF
Footprint Perimeter (ft)	212.7'
No. of Jacking Points	20
Height of Lift (ft)	4.3'
Foundation Height (ft)	5.3'
CMU Courses	8
Column Grid Lines (Width)	8
Column Grid Lines (Depth)	4
No. of Columns	32
Crossing Steel Beams	7
Main Steel Beams	3
Cribbing Levels below 6'	11
Cribbing Levels above 6'	0

Figure 2: Plan View
Columns and Segemented Piles

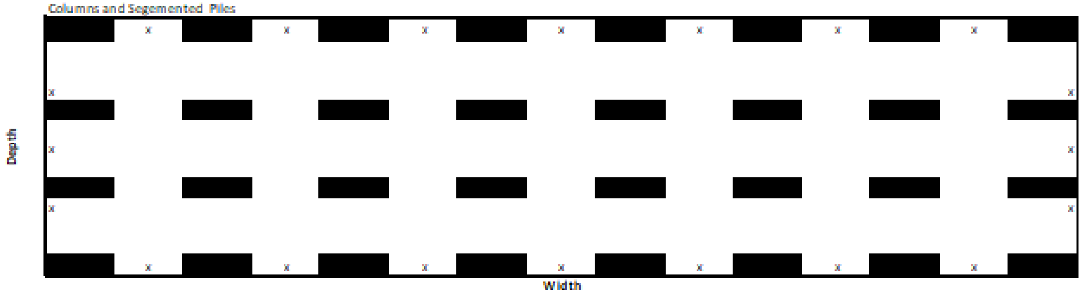


Figure 2: Plan View
Grade Beams 6' and below

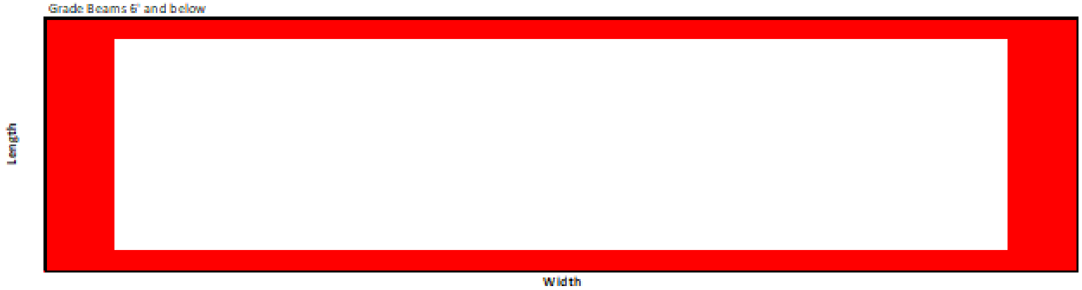


Figure 2: Plan View
Grade Beams above 6'

Slab-founded 1 Story Quantity 2338 SF

House Raise Slab Founded Quantity Worksheet

Average 1-Story slab from Cost Analysis

Inputs

Desc	Value		
House Width (ft)	77.93'		
House Depth (ft)	30.0'		
Lowest Adjacent Grade (ft, NAVD88)	2.5'		
First Floor Elevation (ft, NAVD88)	3.0'		
Target Elevation (ft, NAVD88)	8.0'		
Jacking Area (sf)	90.0 SF	x	varies
Box Cribbing Timber Height Dimension (in)	6"		referencing Fema Drawing
Pile Segment Lengths (in)	8"	x	referencing Fema Drawing
Depth to Pile Refusal (ft)	70.0'	x	verification
Column Spacing, Width (ft)	12.0'	x	varies
Column Spacing, Depth (ft)	10.0'	x	varies
Grade Beam Width (in)	18"	x	1 story (Depth = 12")and 2 st
Support Column Width (in) (16" x 16")	16"	x	

Outputs

Desc	Value	
House Square Footage (sf)	2337.9	
Trench Excavation (bcy)	298.5	
Perimeter pile segments below grade (ea)	2100.0	# segments/pile X # of piles
Interior pile segments below grade (ea)	1260.0	# segments/pile X # of piles
Crib Point Riser Pairs below 6' (Pair)	260.0	
Crib Point Riser Pairs above 6' (Pair)	0.0	
Initial Lifting Phases (ea)	1.0	
Addt'l Lifting Phases below 6' (ea)	10.0	
Addt'l Lifting Phases above 6' (ea)	0.0	
Perimeter pile segements above grade (ea)	140.0	# segments/pile X # of piles
Interior pile segements above grade (ea)	84.0	# segments/pile X # of piles
Grade Beam (LF)	503.7	
CMU Columns Blocks (EA)	224.0	
Anchors (ea)	32.0	
CMU Wall Grade Beam (LF)	215.9	
CMU Foundation Enclosure Wall (sf)	1007.3	
Slab-on-Grade Area (sf)	2281.0	
Flood Vents	24.0	every 100 SF - reference FEMA drawings

Calculations

Footprint Square Footage (sf)	2337.9 SF	WxD
Footprint Perimeter (ft)	215.9'	2W+2D
No. of Jacking Points	26	ROUNDUP(SF/JackArea SF/2,0)*2
Height of Lift (ft)	5.2'	(LowestAdjGrd/FoundationHt+1)-1stFloorEL
Foundation Height (ft)	4.7'	CMU Courses X (8/12)
CMU Courses	7	ROUNDUP(LowestAdjGrd-TargetEL-1)*(12/8),0)
Column Grid Lines (Width)	8	ROUNDUP(W/ColumnSpacingW,0)+1
Column Grid Lines (Depth)	4	ROUNDUP(D/ColumnSpacingD,0)+1
No. of Columns	32	ColumnGrid (WxD)
Cribbing Levels below 6'	10	IF(FoundHt>6,ROUNDUP(6/(CribHt/12),0),ROUNDUP(B25/(CribHt/12),0))
Cribbing Levels above 6'	0	IF(FoundHt>6,ROUNDUP(FoundHt/(CribHt/12),0)-Crib<6,0)
Segments per pile below grade	105	ROUNDUP(PileDpth/(PileSegmentLth/12),0)
Segments per pile above grade	7	IF(FoundHt>6,0,ROUNDUP(FoundHt/(8/12),0))
Perimeter Piles	20	2*(ROUNDUP(W/ColumnSpacingW,0)+1)+2*(ROUNDUP(L/ColumnSpacingL,0)-1)
Interior Piles	12	NoColumns-PerimeterPiles

Grade Beam Dimension 6 below
Grade Beam Dimension 6 above

1 vs 2 Story depth of Refusal?

Figure 1

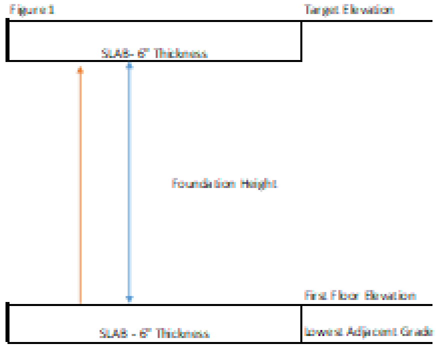


Figure 2: Plan View
Columns and Segmented Piles

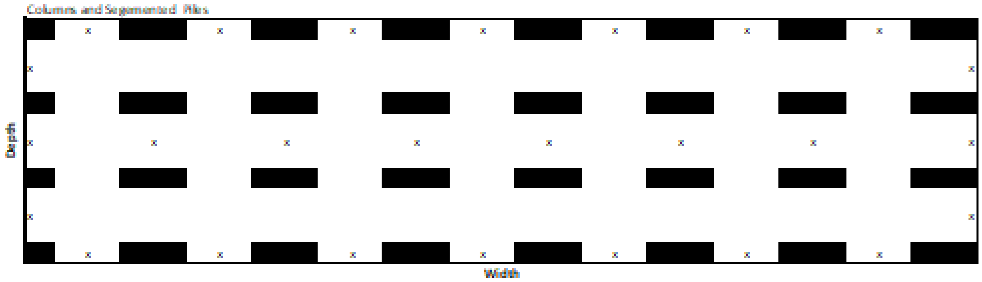


Figure 2: Plan View
Grade Beams 6' and below

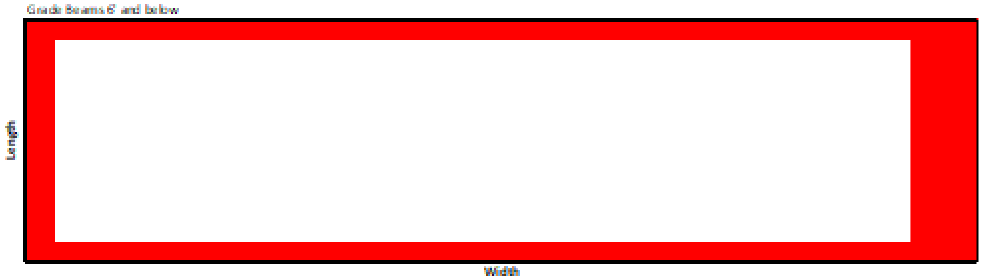
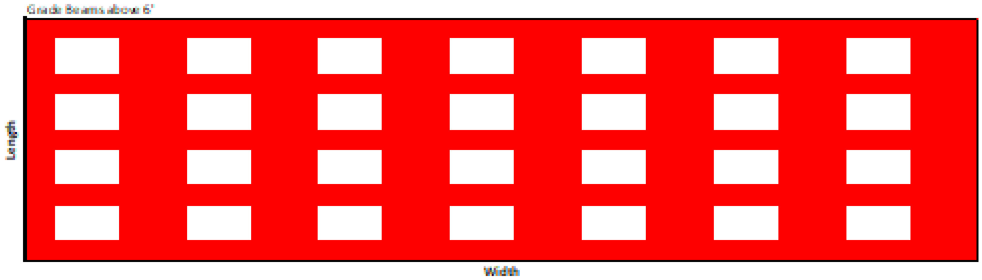


Figure 2: Plan View
Grade Beams above 6'



Slab-founded 2 Story Quantity 1932 SF

House Raise Slab Founded Quantity Worksheet

2 story slab foundation from Cost Analisys 1932 SF

Inputs

Desc	Value		
House Width (ft)	64.4'		
House Depth (ft)	30.0'		
Lowest Adjacent Grade (ft, NAVD88)	2.5'		
First Floor Elevation (ft, NAVD88)	3.0'		
Target Elevation (ft, NAVD88)	8.0'		
Jacking Area (sf)	60.0 SF	x	varies
Box Cribbing Timber Height Dimension (in)	6"		referencing Fema Drawing
Pile Segment Lengths (in)	8"	x	referencing Fema Drawing
Depth to Pile Refusal (ft)	70.0'	x	verification
Column Spacing, Width (ft)	10.0'	x	varies
Column Spacing, Depth (ft)	10.0'	x	varies
Grade Beam Width (in)	18"	x	1 story (Depth = 12")and 2 stc
Support Column Width (in) (16" x 16")	16"	x	

Calculations

Desc	Value	Formula
Footprint Square Footage (sf)	1932.0 SF	WxD
Footprint Perimeter (ft)	188.8'	2W+2D
No. of Jacking Points	34	ROUNDUP(SF/JackArea SF/2,0)*2
Height of Lift (ft)	5.2'	(LowestAdjGrd/FoundationHt+1)-1stFloorEL
Foundation Height (ft)	4.7'	CMU Courses X (8/12)
CMU Courses	7	ROUNDUP(LowestAdjGrd-TargetEL-1)*(12/8),0)
Column Grid Lines (Width)	8	ROUNDUP(W/ColumnSpacingW,0)+1
Column Grid Lines (Depth)	4	ROUNDUP(D/ColumnSpacingD,0)+1
No. of Columns	32	ColumnGrid (WxD)
Cribbing Levels below 6'	10	IF(FoundHt>6,ROUNDUP(6/(CribHt/12),0),ROUNDUP(B25/(CribHt/12),0))
Cribbing Levels above 6'	0	IF(FoundHt>6,ROUNDUP(FoundHt/(CribHt/12),0)-Crib<6,0)
Segments per pile below grade	105	ROUNDUP(PileDpth/(PileSegmentLth/12),0)
Segments per pile above grade	7	IF(FoundHt>6,0,ROUNDUP(FoundHt/(8/12),0))
Perimeter Piles	20	2*(ROUNDUP(W/ColumnSpacingW,0)+1)+2*(ROUNDUP(L/ColumnSpacingL,0)-1)
Interior Piles	12	NoColumns-Perimeter Piles

Grade Beam Dimension 6 below
Grade Beam Dimension 6 above

1 vs 2 Story depth of Refusal?

Outputs

Desc	Value	
House Square Footage (sf)	2898.0	Total usable SF of a 2 story house is roughly 1.5 x SF of the foot print
Trench Excavation (bcy)	266.4	
Perimeter pile segments below grade (ea)	2100.0	# segments/pile X # of piles
Interior pile segments below grade (ea)	1260.0	# segments/pile X # of piles
Crib Point Riser Pairs below 6' (Pair)	340.0	
Crib Point Riser Pairs above 6' (Pair)	0.0	
Initial Lifting Phases (ea)	1.0	
Addt'l Lifting Phases below 6' (ea)	10.0	
Addt'l Lifting Phases above 6' (ea)	0.0	
Perimeter pile segements above grade (ea)	140.0	# segments/pile X # of piles
Interior pile segements above grade (ea)	84.0	# segments/pile X # of piles
Grade Beam (LF)	449.6	
CMU Columns Blocks (EA)	224.0	
Anchors (ea)	32.0	
CMU Wall Grade Beam (LF)	188.8	
CMU Foundation Enclosure Wall (sf)	881.1	
Slab-on-Grade Area (sf)	2841.1	
Flood Vents	29.0	every 100 SF - reference FEMA drawings

Figure 1

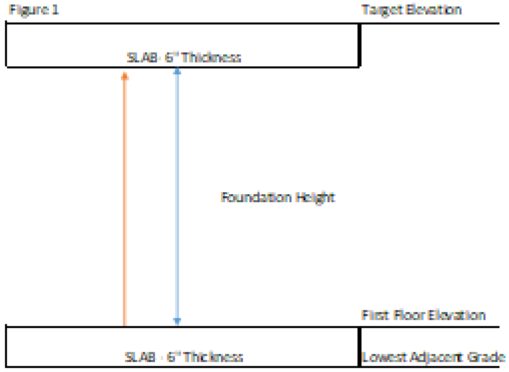


Figure 2: Plan View
Columns and Segemented Piles

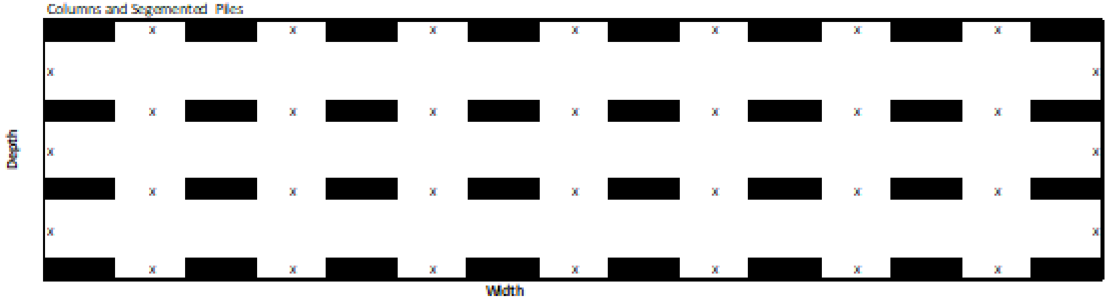


Figure 2: Plan View
Grade Beams 6' and below

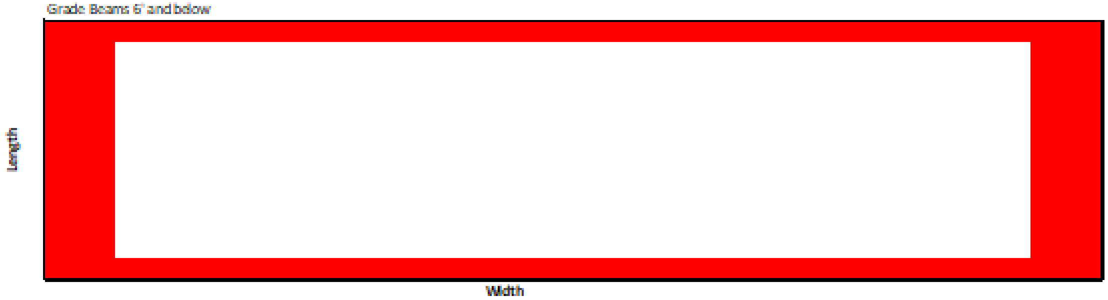


Figure 2: Plan View
Grade Beams above 6'