Section IV: Cost Effectiveness

Attachment 16. RPS BCA Methodology Technical Memorandum

Town of Hillsborough, River Pump Station Relocation from Floodway – FY2021 BRIC

TECHNICAL MEMORANDUM

FEMA Building Resilient Infrastructure and Communities Grant Program

Town of Hillsborough, River Pump Station Relocation from Floodway

Benefit-Cost Analysis Memorandum

November 19, 2021

Table of Contents

1 Introduction

FEMA requires that all projects funded through the Building Resilient Infrastructure and Communities (BRIC) program are cost-effective and designed to increase resilience and reduce risk of injuries, loss of life, and damage and destruction of property, including critical services and facilities. This technical report documents that the River Pump Station Relocation from Floodway Project submitted by the Town of Hillsborough under the BRIC Fiscal Year 2021 application cycle satisfies applicable cost-effectiveness requirements in compliance with OMB Circular A-94 using FEMA benefit-cost analysis (BCA) methods and tools. The technical memorandum covers the proposed mitigation activity, BCA approach including pre-mitigation and post-mitigation losses, benefits to disadvantaged populations, and analysis results. Analysis documentation also includes a completed FEMA BCA Toolkit Version 6.0, and a BCA Report.

2 Proposed Mitigation Activity

As detailed in the application, the Town of Hillsborough proposes to relocate the River Pump Station out of the floodway and Special Flood Hazard Area (SFHA). The proposed location will be outside of the floodway and Special Flood Hazard Area and will allow for the current 1.5-acre site to be returned to riparian space. The relocated pump station will also include a submersible pump design, a cost effective alternative that Town staff have experience maintaining. The consequences of flooding at the facility would result in damage to critical utility assets, loss of wastewater service, potential sewage backup in structures, and discharge of untreated effluent into the environment. A 250-kW permanent generator will be sited and installed along with an automatic transfer switch to ensure a consistent power supply to the station and uninterrupted wastewater pumping in the event of grid power loss.

Table 1 River Pump Station Location

Facility Name	Location Description	Latitude, Longitude
River Pump Station	Hillsborough, North Carolina 27278	36.072414, -79.08922

2.1 Project and Maintenance Costs

Table 2 provides total project and annual maintenance costs for implementing the proposed mitigation activity. Project costs were estimated in accordance with FEMA Hazard Mitigation Assistance (HMA) Guidance. Annual maintenance costs include those associated with the following activities:

- Inspection and testing; and
- Minor repairs.

Table 2. River Pump Station Relocation, Project and Maintenance Costs

Mitigation Activity	Project Cost	Annual Maintenance Cost
Pump Station Relocation	$8,981,187.98	$5,000.00

3 Benefit-Cost Analysis Approach

3.1 Modeled Events

In accordance with the FEMA BCA Reference Guide and Supplement, expected loss data may be used to calculate benefits to be used in a BCA. This approach involves calculating losses based on expected flood frequencies. Flood depths and recurrence intervals used in this BCA are taken from an analysis conducted by floodplain managers and engineers to determine the flood elevation for the site. Flood recurrence intervals and stillwater elevations were based on the Orange County, North Carolina Flood Insurance Study (FIS) data for the pump station site. For the purpose of this analysis, four recurrence intervals were determined using modeling methods considered as industry standard and FEMA approved. This is consistent with FEMA's "expected" damages approach as detailed in the FEMA BCA Reference Guide and Supplement.

3.2 Project Useful Life

According to the FEMA 2009 BCA Reference Guide – Project Useful Life Table (Appendix B), a project useful life of 50 years should be applied to major infrastructure, (minor localized flood reduction projects). *As such a useful life of 50 years was used for the River Pump Station Relocation Project in the BCA Toolkit*.

3.3 Software and References

The FEMA BCA Toolkit Version 6.0 was used to obtain the Benefit-Cost Ratio (BCR) for the proposed mitigation activities included in the scope of work for the project. The following narrative provides the methodology used to obtain the BCR. Following the FEMA BCA Reference Guide and Supplement, this analysis uses engineering assessment and statistical determinations of likely occurrence and associated damages during expected events. The Damage Frequency Assessment Module (DFA) was used within the FEMA BCA Toolkit to prepare this BCA. The DFA Module is the most appropriate module in the BCA Toolkit for utilities and other critical services, such as wastewater utilities. For the purposes of this analysis, the DFA Module was used to assess the benefits of wastewater service at River Pump Station.

3.4 Pump Station Vulnerability

The River Pump Station is located adjacent to the Eno River, within the floodway and SFHA, Figure 1 shows imagery of the pump station in relation to the river, floodway, and SFHA. The finished floor elevation (FFE) of the pump station is located at an elevation of 495.21 feet NAVD88. During major rainfall events, the Eno River swells and flood elevations have been identified within the pump station reaching well above the first floor elevation. The River Pump Station is currently constructed subgrade and contains the majority of the station's critical electrical equipment including control panels and pump motors which are both located below the 10-year flood recurrence interval as detailed in Figure 2 and Appendix C. Though much of the equipment is located off the floor, severe precipitation events and swelling of the Eno River can cause significant flood elevations within the station impacting the station's ability to function. During flood events, water enters the pump station through conduits and other openings located primarily at (or only slightly above) grade. Once water enters the station, pump motors and supporting equipment can become inundated and fail completely as experience in 1993, 1996, 1998, 2003. Despite recent drought conditions, the pump station was at near failure again in 2008, 2017, and 2019 (Appendix F).

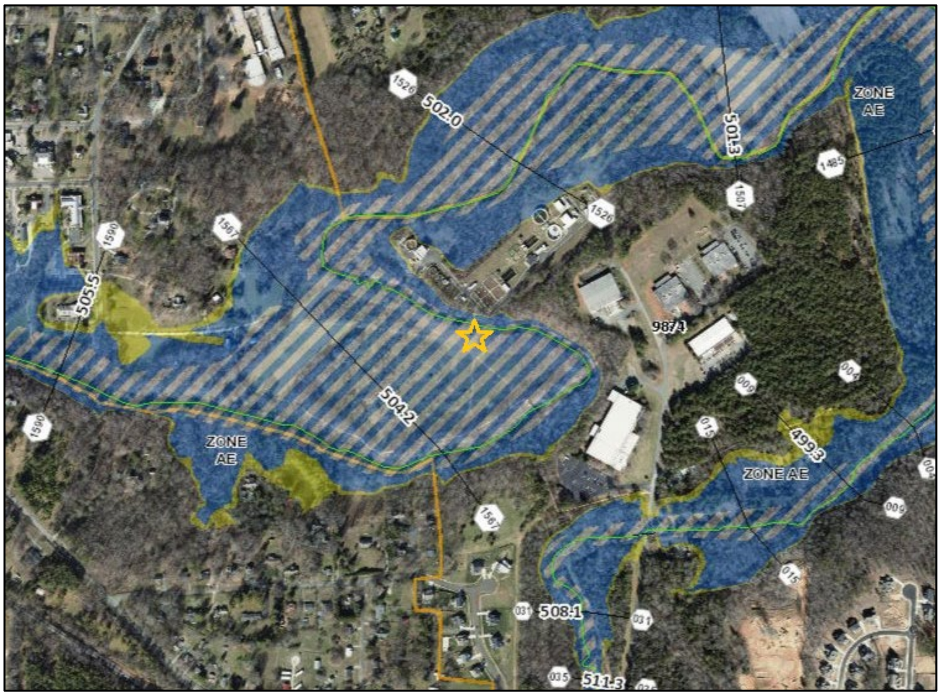


Figure 1. Location of River Pump Station in the Floodway and SFHA

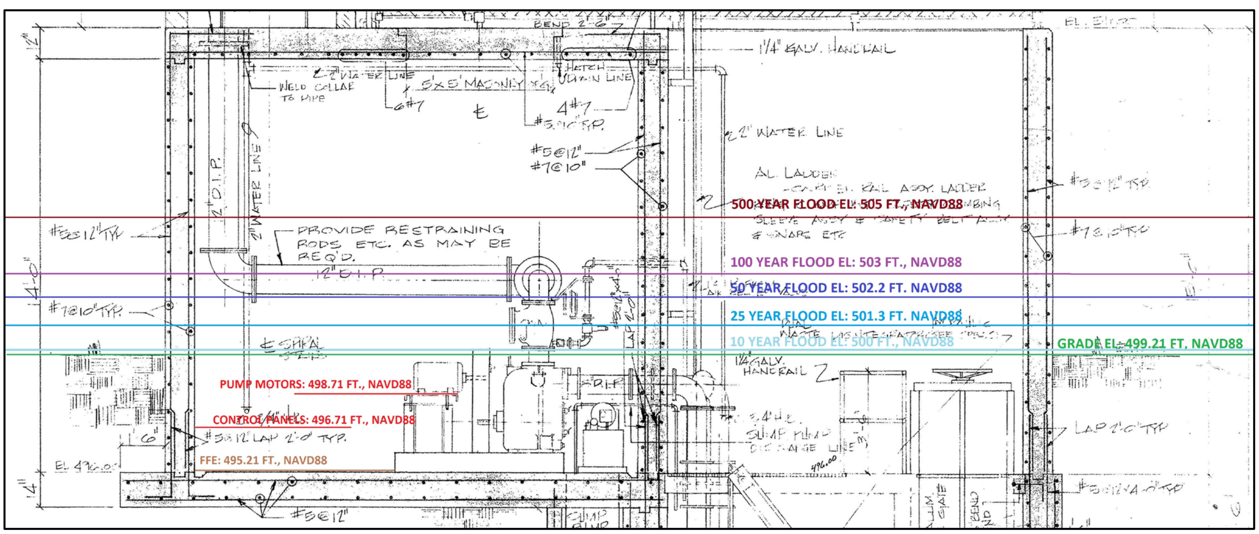


Figure 2. River Pump Station Asset and Flood Frequency Elevations

3.5 Economic Value of Wastewater Service

3.5.1 Population Served

The River Pump Station services a portion of the population of the Town of Hillsborough on a retail basis, providing treatment for customers and annual visitors to the Town. The service population for the River Pump Station (Table 3) is based on the total number of connections and average household size for the Town.

Table 3: River Pump Station, Population Served

Facility	Number of Connections	Average Household Size	Total Service Population
River Pump Station	6,500	2.46	15,990

Source: Town of Hillsborough, U.S. Census Bureau

3.5.2 Value of Critical Service

FEMA provides standard values for wastewater service in the FEMA BCA Toolkit. The economic value of wastewater service is defined in the Benefit-Cost Analysis Sustainment and Enhancements Standard Economic Value Methodology Report, dated June 2020. The report provides a $58 value for the economic impact per capita per day for loss of wastewater services in 2020 dollars. It is important to note the following limitations to the value for standard economic impact of loss of wastewater services:

- The service value only considers the treatment of wastewater without affecting the disposal of sewage or wastewater. According to the re-engineering methodology record, "FEMA *assumes that a temporary loss of wastewater service generally entails a total or partial loss of capacity to treat wastewater without affecting the residential disposal of sewage or other wastewater"* (FEMA, August 2011). This means that any impacts on conveyance and the resulting consequences – such as direct impacts on the service population and environment – are not captured by this figure.
- Direct impact to residents is not included in the plant's per capita per day value of wastewater service. Examples of direct impacts might include the following, depending on facility type, "temporary lodging for some people, increased transportation costs to sanitation facilities and so on" (FEMA, 2001).
- This value does not include the value of wastewater to residential customers - merely to the regional economy. During the re-engineering of FEMA's Benefit-Cost Analysis Toolkit it notes, "no *research value could be found which placed an economic value on wastewater service to customers. Therefore, even though no value was assigned for the loss of wastewater to residential customers, it is unlikely that a real economic value of $0 would be placed on wastewater service*. (FEMA, August 2011)"

3.5.2.1 Calculating Critical Service

The value of service provide by the River Pump Station is provided as a per capita per day figure as noted in this section. The per day service of each pump station can be calculated as follows:

Service Population x Service Value Per Capita Per Day=Per Day Service Value

Table 4 indicates the per day value of treatment service provided by each pump station using the FEMA standard value of $58.00 per capita for wastewater service. This calculation is completed automatically by the BCA Toolkit 6.0.

Table 4 River Pump Station, FEMA Standard Value Per Day

Facility	Estimated Service Population	Per Day Service Value
River Pump Station	15,990	$927,420

Source: Town of Hillsborough, FEMA Benefit-Cost Analysis Sustainment and Enhancements Standard Economic Value Methodology Report

3.6 Flood Recurrence Intervals and Stillwater Elevations

For the purpose of the analysis, it is necessary to identify the appropriate recurrence intervals associated with the level of inundation resulting in impact at the River Pump Station. The recurrence interval identifies the probability of the flood depth being met or exceeded in any given year and helps to quantify and prioritize risk and vulnerability. Stillwater flood elevations near the facility are from the FEMA Flood Insurance Study for Orange County, North Carolina and are provided in Table 5.

Table 5. Flood Recurrence Intervals with Stillwater Elevations, River Pump Station

Stillwater Elevations	Predicted X-Percent Annual Chance Elevation (Recurrence Intervals), NAVD88				
	10-Year	25-Year	50-Year	100-Year (BFE)	500-Year
River Pump Station	500 Ft.	501.3 Ft.	502.2 Ft.	504 Ft.	505 Ft.

Source: Orange County Flood Insurance Study

3.7 Determining Losses (Pre-Mitigation)

3.7.1 Direct Physical Damages

Depth damage functions (DDFs) and tables to estimate expected impacts at various flood depths are frequently used in a BCA. A depth damage function is a mathematical relationship between the depth of water and the amount of damage that can be expected from that water. These functions are developed for such structures due to their relative uniformity and design standards.

3.7.1.1 Building and Contents Replacement Values

The FEMA standard Building Replacement Value (BRV) (Appendix D) of $75.95/sf for light Industrial structures was applied to the total square footage of the River Pump Station pulled from pump station as-built drawings (Appendix E). The FEMA standard contents replacement value of 150% of the building value for light industrial was applied to the building replacement value (Table 6). This value is pulled directly from the FEMA BCA Module and should be considered conservative, as it does not represent the value of the critical assets within the pump station.

Table 6: River Pump Station, Building and Contents Replacement Values

Building	First Floor Elevation (NAVD88)	Square Footage	Building Replacement Value	Contents Replacement Value
River Pump Station	495.21 Ft.	510	$38,734.50	$58,101.75

Source: As-Built Drawings, FEMA BCA Guidance Supplement

3.7.1.2 Depth-Damage Functions

For the purposes of this analysis, physical damages to the structure and contents were determined using the USACE Industrial Light DDF from the Flood Module of the BCA Toolkit. The tables below provide the calculated damages used in the BCA (Table 7).

Table 7: Building and Content Damages Calculated at Identified Flood Depths, River Pump Station

Recurrence Interval (yr.)	Flood Depth (ft.) in Pump Station	Structure Damage (%)	Total Structure Damage ($)	Contents Damage (%)	Total Content Damage ($)
10	<1	0.0%	$-	0.00%	$-
25	1	10.4%	$4,028.39	19.0%	$11,039.33
50	2	16.8%	$6,507.40	31.00%	$18,011.54
100	4	25.9%	$10,032.24	52.00%	$30,212.91
500	4	25.9%	$10,032.24	52.00%	$30,212.91

Source: Orange County FIS, BCA Toolkit 6.0, USACE Light Industrial Depth Damage Functions

These damages should be considered a conservative estimate as the analysis performed focused solely on enclosed structure square footage at the site and did not consider other site improvements. Furthermore, the percentage of critical assets that may exist below the flood frequency elevation are often considered to be highly vulnerable and could not be assessed based on the developed methodology.

3.7.2 Loss of Function

3.7.2.1 Assumptions In Calculating Loss of Function

Loss of function calculations do not take into consideration the amount of time it will take for the water to recede because this is unknown. As such, estimates are conservative and are based on the duration engineers identified as necessary and reasonable to pump out any remaining water and assess damage, order parts, and repair the pump station to existing conditions, under optimal restoration conditions (no parts shortages, full resource availability) (Table 8). The majority of impacts to level of service can be expected as a result of damage to electrical equipment. Lead times for repairs to this equipment based on industry standards for what can reasonably be expected,

Table 8. Expect Flood Impacts to River Pump Station

River Pump Station – Flood Impact Description	Time Required for Recovery for Minor Flood Events (1-5 Day Range)		Time Required for Recovery from Significant Flood Events (61 Days Total)			
	Pumps Out	Emergency Restoration	Pumps Out	Order Parts	Repairs	Total
Controls damage and pump motor damage	1 Day	5 Days	1 Day	56 Days	14 Days	61 Days

3.7.2.2 River Pump Station Anticipated Outage

According to an engineering estimate, the River Pump Station would begin to experience loss of function impacts during 25-year storm event at the elevation identified. With approximately 1.3 feet of flooding at the site at this recurrence interval, it is anticipated that repair time would take 1 day before the facility is brought back to a fully functioning condition. This estimate is increased as storm intensity and flood depth escalate.

It is important to note that the identified anticipated outage time is drastically less than the standard values provided within the BCA Toolkit 6.0. The New Orleans, Utility, Structure, Long Duration recurrence interval provided in the toolkit identifies loss of function values beginning at 45 days for 1 foot of water (Table 9).

Table 9: Associated Recurrence Interval, Flood Depth and Anticipated Days of Outage, River Pump Station and the New Orleans, Utility, Structure, Long Duration Loss of Function Days

Recurrence Interval (yr.)	Flood Depth (ft.) in Pump Station	River Pump Station Anticipated Outage Time (days)	New Orleans, Utility, Structure, Long Duration Loss of Function (days)
10	<1	0	0
25	1	1	45
50	2	5	90
100	4	60	180
500	4	60	180

Source: Orange County FIS, BCA Toolkit 6.0, USACE New Orleans Depth Damage Functions

3.7.2.3 Loss of Function – Wastewater Service

Based on the information discussed in this technical memorandum, the per day service of wastewater service for River Pump Station can be calculated as approximately $927,420 .00. The calculation indicates the per day value of wastewater treatment service provided by the pump station. This calculation is completed automatically by the BCA Toolkit 6.0. With a total value of service per day, using the anticipated outage durations identified above, wastewater service would result in the following loss of function values (Table 10).

Table 10: Wastewater Service Loss of Function Values per Recurrence Interval and Anticipated Outage Time, River Pump Station

Recurrence Interval (yr.)	Flood Depth (ft.)	River Pump Station Anticipated Outage Time (days)	Wastewater Total Loss of Function Value ($)
10	<1	0	-
25	1	1	927,420
50	2	5	4,637,100
100	4	61	56,572,620
500	4	61	56,572,620

Source: Orange County FIS, BCA Toolkit 6.0, USACE New Orleans Depth Damage Functions

3.7.3 Ecosystem Services

Ecosystem service benefits accrue when land use is changed or enhanced by a mitigation activity to provide a higher level of natural benefits. The economic values for the ecosystem services are valued per-acre. The former River Pump Station site, which is approximately 1.5 acres, will be left to return to its pre-developed riparian natural state. For riparian land uses, the economic valuation is $39,545/acre/year. To determine the total economic service benefits, the BCA Toolkit multiplies the area (acres) by the economic value of the land use type selected as calculated in Table _.

Table 11. River Pump Station Relocation, Project and Maintenance Costs

Acres Returned to Natural State	Riparian Economic Value (acre/year)	Total Ecosystem Service Benefits
1.5 acres	$39,545.00	$59,317.50

Source: FEMA BCA Toolkit 6.0

3.8 Level of Protection (Post-Mitigation)

The proposed mitigation project will provide a level of protection above the 500-year flood event. Therefore, it can be anticipated that impacts at the relocated River Pump Station will be similar to the 25-year event if a flood event exceeds the 500-year flood event (Table 12). This identified level of protection is reflected in the BCA at the 500.1-year flood event damages after mitigation.

Table 12: Post-Mitigation Level of Protection, River Pump Station

Recurrence Interval (yr.)	Total Structure Damage ($)	Total Contents Damage ($)	Wastewater Total Loss of Function Value ($)
25	$4,028.39	$11,039.33	927,420

Source: Orange County FIS, BCA Toolkit 6.0, USACE New Orleans Depth Damage Functions

4 Analysis Results

The benefit-cost ratio (BCR) for the project is listed in Table 13. Costs included in the determination of the BCR include maintenance costs over the project useful life of the mitigation project. This BCR is considered a conservative estimate as additional benefits such as physical damages to exterior equipment not contained in a structure, equipment below the expected flood frequency elevations; cost of emergency protective measures; wastewater back-up in the collection system; and environmental damages were not used in the analysis. **The total project BCR is 1.26 which demonstrates that the mitigation project is a cost-effective solution**. The BCA Report is provided in Appendix A.

Table 13: River Pump Station Relocation Project, BCA Results

Description	Benefits	Costs	BCR
River Pump Station Relocation Project	$11,426,031	$9,050,192	1.26

Source: BCA Toolkit 6.0

Appendix A
Benefit Cost Analysis Report

Benefit-Cost Calculator

V.6.0 (Build 20211021.0641)

Benefit-Cost Analysis

Project Name: Town of Hillsborough, River Pump Station Relocation

Map Marker ▲	Mitigation Title	Property Type	Hazard	Benefits (B)	Costs (C)	BCR (B/C)
1	Other @ Orange County, North Carolina		DFA - Riverine Flood	$ 11,426,031	$ 9,050,192	1.26
TOTAL (SELECTED)				**$ 11,426,031**	**$ 9,050,192**	**1.26**
TOTAL				**$ 11,426,031**	**$ 9,050,192**	**1.26**

Property Configuration

Property Title:	Other @ Orange County, North Carolina
Property Location:	27278, Orange, North Carolina
Property Coordinates:	36.0613973, -79.1205954
Hazard Type:	Riverine Flood
Mitigation Action Type:	Other
Property Type:	Utilities
Analysis Method Type:	Professional Expected Damages

Cost Estimation

Other @ Orange County, North Carolina

Project Useful Life (years):	50
Project Cost:	$8,981,187.98
Number of Maintenance Years:	50 Use Default:Yes
Annual Maintenance Cost:	$5,000

Damage Analysis Parameters - Damage Frequency Assessment

Other @ Orange County, North Carolina

Year of Analysis Conducted:	2021
Year Property was Built:	1978
Analysis Duration:	44 Use Default:Yes

Utilities Properties

Other @ Orange County, North Carolina

Type of Service:	Wastewater
Number of Customers Served:	15,990
Value of Unit of Service ($/person/day):	$58 Use Default:Yes
Total Value of Service Per Day ($/day):	$927,420

Professional Expected Damages Before Mitigation

Other @ Orange County, North Carolina

	WASTEWATER	OPTIONAL DAMAGES			VOLUNTEER COSTS		TOTAL
Recurrence Interval (years)	Impact (days)	Building Damages ($)	Contents Damages ($)	Category 3 ($)	Number of Volunteers	Number of Days	Damages ($)
25	1	4,028.39	11,039.33	0	0	0	942,488
50	5	6,507.4	18,011.54	0	0	0	4,661,619
100	61	10,032.24	30,212.91	0	0	0	56,612,865
500	61	10,032.24	30,212.91	0	0	0	56,612,865

Annualized Damages Before Mitigation
Other @ Orange County, North Carolina

Annualized Recurrence Interval (years)	Damages and Losses ($)	Annualized Damages and Losses ($)
25	942,488	41,921
50	4,661,619	162,452
100	56,612,865	452,903
500	56,612,865	113,220
	Sum Damages and Losses ($)	Sum Annualized Damages and Losses ($)
	118,829,837	770,496

Professional Expected Damages After Mitigation
Other @ Orange County, North Carolina

	WASTEWATER	OPTIONAL DAMAGES			VOLUNTEER COSTS		TOTAL
Recurrence Interval (years)	Impact (days)	Building Damages ($)	Contents Damages ($)	Category 3 ($)	Number of Volunteers	Number of Days	Damages ($)
500.1	1	4,028.39	11,039.33	0	0	0	942,488

Annualized Damages After Mitigation
Other @ Orange County, North Carolina

Annualized Recurrence Interval (years)	Damages and Losses ($)	Annualized Damages and Losses ($)
500.1	942,488	1,885
	Sum Damages and Losses ($)	Sum Annualized Damages and Losses ($)
	942,488	1,885

Standard Benefits - Ecosystem Services
Other @ Orange County, North Carolina

Total Project Area (acres):	1.5
Percentage of Green Open Space:	0.00%
Percentage of Riparian:	100.00%
Percentage of Wetlands:	0.00%
Percentage of Forests:	0.00%
Percentage of Marine Estuary:	0.00%
Expected Annual Ecosystem Services Benefits:	$59,317.5

Benefits-Costs Summary

Other @ Orange County, North Carolina

Total Standard Mitigation Benefits:	$11,426,031
Total Social Benefits:	$0
Total Mitigation Project Benefits:	$11,426,031
Total Mitigation Project Cost:	$9,050,192
Benefit Cost Ratio - Standard:	1.26
Benefit Cost Ratio - Standard + Social:	1.26

Appendix B

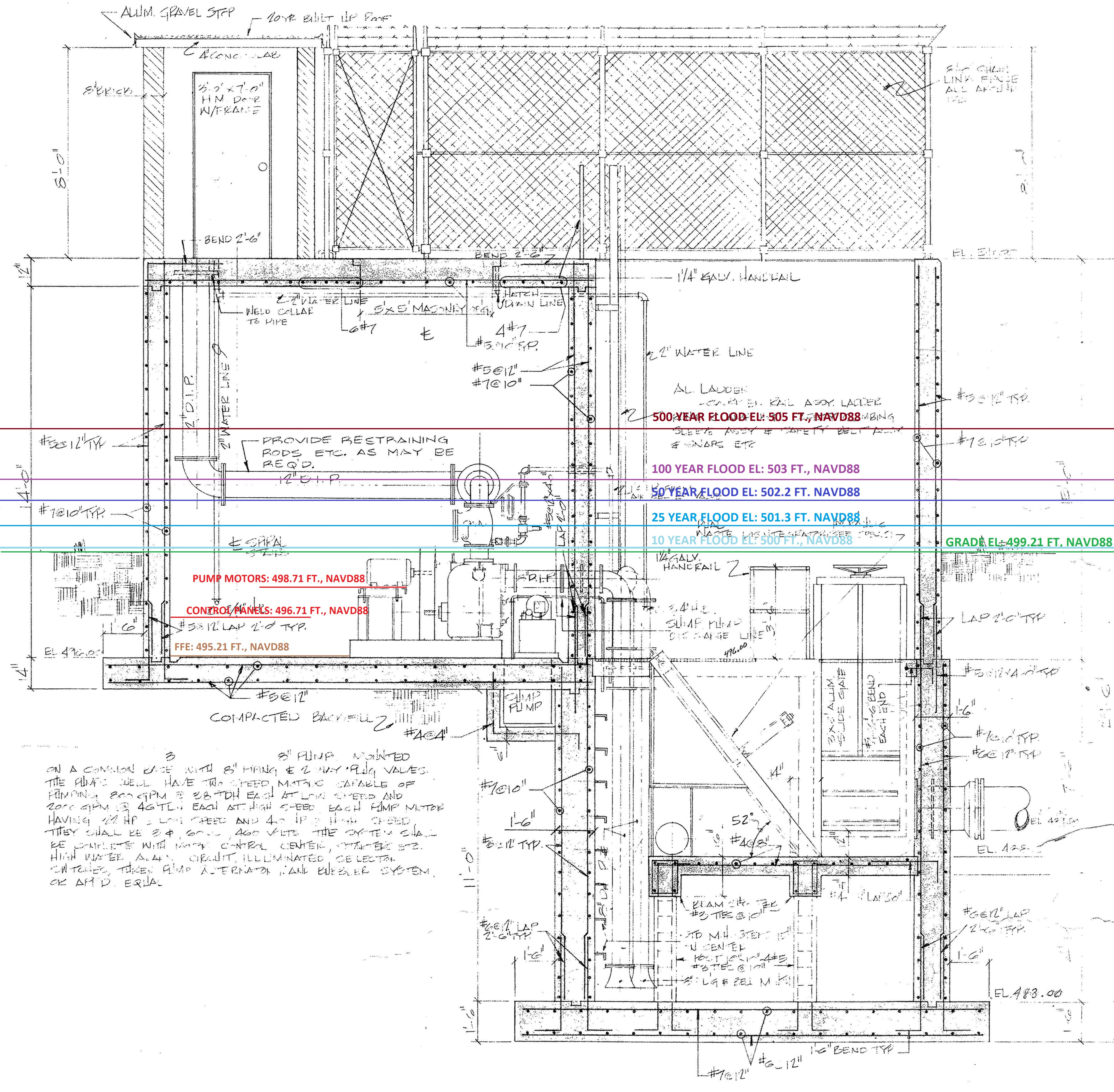
Project Useful Life Table

Project Type	Useful Life (years)		Comment
	Standard Value	Acceptable Limits (documentation required)	
Acquisition/Relocation			
All Structures	100	100	
Elevation			
Residential Building	30	30–50	
Non-Residential Building	25	25–50	
Public Building	50	50–100	
Historic Buildings	50	50–100	
Structural/Non-Structural Building Project			
Residential Building Retrofit	30	30	
Non-Residential Building Retrofit	25	25–50	
Public Building Retrofit	50	50–100	
Historic Building Retrofit	50	50–100	
Roof Diaphragm Retrofit	30	30	Roof hardening and roof clips
Tornado Safe Room – Residential	30	30	
Tornado Safe Room – Community	30	30–50	Retrofit or small community safe room ≤ 16 people (30 yr), New (50 yr)
Non-Structural Building Elements	30	30	Ceilings, electrical cabinets, generators, parapet walls, or chimneys
Non-Structural Major Equipment	15	15–30	Elevators, HVAC, sprinklers
Non-Structural Minor Equipment	5	5–20	Generic contents, racks, shelves
Infrastructure Projects			
Major Infrastructure (minor localized flood reduction projects)	50	35–100	
Concrete Infrastructure, Flood Walls, Roads, Bridges, Major Drainage System	50	35–50	
Culverts (concrete, PVC, CMP, HDPE, etc.)	30	25–50	Culvert **with** end treatment (i.e., wing walls, end sections, head walls, etc.)
	10	5–20	Culvert **without** end treatment (i.e., wing walls, end sections, head walls, etc.)
Pump Stations, Substations, Wastewater Systems, or Equipment Such as Generators	50	50	Structures
	5	5–30	Equipment
Hurricane Storm Shutters	15	15–30	Depends on type of storm shutter
Utility Mitigation Projects	50	50–100	Major (power lines, cable, hardening gas, water, sewer lines, etc.)
	5	5–30	Minor (backflow values, downspout disconnect, etc.)

Project Type	Useful Life (years)		Comment
	Standard Value	Acceptable Limits (documentation required)	
Miscellaneous Equipment Projects			
Equipment Purchases	2	2–10	Small, portable equipment (e.g., computer)
	30	5–30	Heavy equipment
Wildfire Mitigation Projects			
Defensible Space/Hazardous Fuels Reduction Vegetation Management	4	2–4	Brush – Depends on drought conditions
	1	1	Grass – Depends on geographic location and precipitation
	20	3–20	Forest canopy – Must be maintained every 3 years
Ignition-Resistant Construction	10	10–30	Depends on type of construction and materials used

Appendix C

River Pump Station Asset and Flood Frequency Elevations



SECTION "A-A"

SCALE: 3/8" = 1'-0"

Appendix D

FEMA Standard Building and Contents Replacement Value

Table 14.1 Default Full Replacement Cost Models (Means, 2006)

HAZUS Occupancy Class Description		Sub-category	Means Model Description (Means Model Number)	Means Typ Size	Means Cost/SF (2006)
OCC Code	OCC Description	OCC sub-class			
RES1	Single Family Dwelling	See Table 14-2			
RES2	Manufactured Housing	Manufactured Housing	Manufactured Housing Institute, 2004 average sales price and size data for new manufactured home (latest data available)	1,625	$35.75
RES3A	Multi Family Dwelling – small	Duplex	SFR Avg 2 St., MF adj, 3000 SF	3,000	$79.48
RES3B		Triplex/Quads	SFR Avg 2 St., MF adj, 3000 SF	3,000	$86.60
RES3C	Multi Family Dwelling – medium	5-9 units	Apt, 1-3 st, 8,000 SF (M.010)	8,000	$154.31
RES3D		10-19 units	Apt., 1-3 st., 12,000 SF (M.010)	12,000	$137.67
RES3E	Multi Family Dwelling – large	20-49 units	Apt., 4-7 st., 40,000 SF (M.020)	40,000	$135.39
RES3F		50+ units	Apt., 4-7 st., 60,000 SF (M.020)	60,000	$131.93
RES4	Temp. Lodging	Hotel, medium	Hotel, 4-7 st., 135,000 SF (M.350)	135,000	$132.52
RES5	Institutional Dormitory	Dorm, medium	College Dorm, 2-3 st, 25,000 SF (M.130)	25,000	$150.96
RES6	Nursing Home	Nursing home	Nursing Home, 2 st., 25,000 SF (M.450)	25,000	$126.95
COM1	Retail Trade	Dept Store, 1 st	Store, Dept., 1 st., 110,000 SF (M.610)	110,000	$82.63
COM2	Wholesale Trade	Warehouse, medium	Warehouse, 30,000 SF (M.690)	30,000	$75.95
COM3	Personal and Repair Services	Garage, Repair	Garage, Repair, 10,000 SF (M.290)	10,000	$102.34
COM4	Prof./ Tech./Business Services	Office, medium	Office, 5-10 st., 80,000 SF (M.470)	80,000	$133.43
COM5	Banks	Bank	Bank, 1 st., 4100 SF (M.050)	4,100	$191.53
COM6	Hospital	Hospital, medium	Hospital, 2-3 st., 55,000 SF (M.330)	55,000	$224.29

Table 14.2 Default Full Replacement Cost Models (Means, 2006) (Continued)

HAZUS Occupancy Class Description		Sub-category	Means Model Description (Means Model Number)	Means Typ Size	Means Cost/SF (2006)
OCC Code	OCC Description	OCC sub-class			
COM7	Medical Office/Clinic	Med. Office, medium	Medical office, 2 st., 7,000 SF (M.410)	7,000	$164.18
COM8	Entertainment & Recreation	Restaurant	Restaurant, 1 st., 5,000 SF (M.530)	5,000	$170.51
COM9	Theaters	Movie Theatre	Movie Theatre, 12,000 SF (M.440)	12,000	$122.05
COM10	Parking	Parking garage	Garage, Pkg, 5 st., 145,000 SF (M.270)	145,000	$43.72
IND1	Heavy	Factory, small	Factory, 1 st., 30,000 SF (M.200)	30,000	$88.28
IND2	Light	Warehouse, medium	Warehouse, 30,000 SF (M.690)	30,000	$75.95
IND3	Food/Drugs/Chemicals	College Laboratory	College Lab, 1 st., 45,000 SF (M.150)	45,000	$145.07
IND4	Metals/Minerals Processing	College Laboratory	College Lab, 1 st., 45,000 SF (M.150)	45,000	$145.07
IND5	High Technology	College Laboratory	College Lab, 1 st., 45,000 SF (M.150)	45,000	$145.07
IND6	Construction	Warehouse, medium	Warehouse, 30,000 SF (M.690)	30,000	$75.95
AGR1	Agriculture	Warehouse, medium	Warehouse, 30,000 SF (M.690)	30,000	$75.95
REL1	Church	Church	Church, 1 st., 17,000 SF (M.090)	17,000	$138.57
GOV1	General Services	Town Hall, small	Town Hall, 1 st., 11,000 SF (M.670)	11,000	$107.28
GOV2	Emergency Response	Police Station	Police Station, 2 st., 11,000 SF (M.490)	11,000	$166.59
EDU1	Schools/Libraries	High School	School, High, 130,000 SF (M.570)	130,000	$115.31
EDU2	Colleges/Universities	College Classroom	College Class. 2-3 st, 50,000 SF (M.120)	50,000	$144.73

Table 10: Hazus MR2 Default Contents Value Based on Percentage of Structure Value

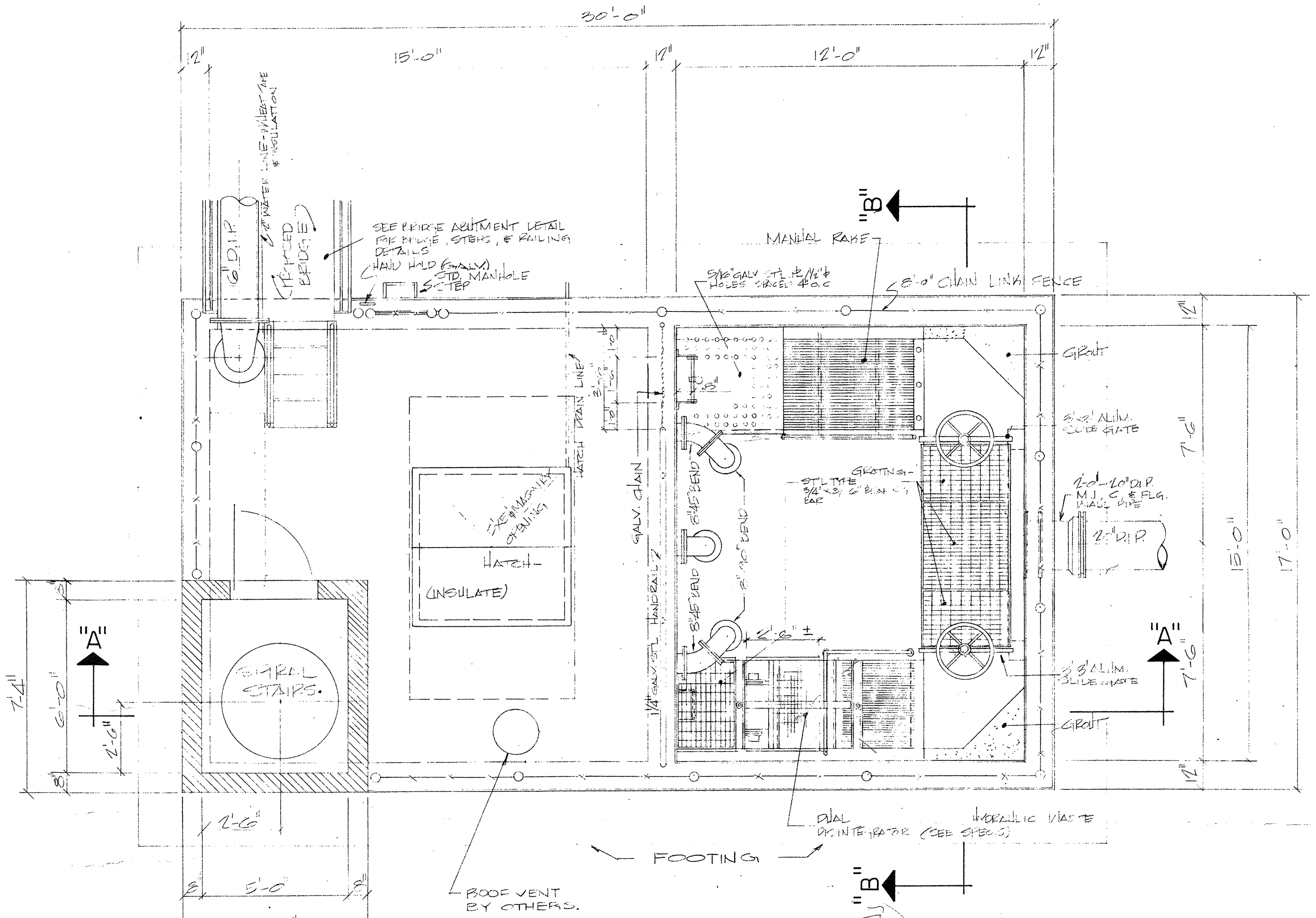
No.	Hazus Occupancy Class Code	Hazus Occupancy Class Description	Contents Value (% of BRV)
Residential			
1	RES1	Single Family Dwelling	50
2	RES2	Mobile Home	50
3	RES3	Multi Family Dwelling	50
4	RES4	Temporary Lodging	50
5	RES5	Institutional Dormitory	50
6	RES6	Nursing Home	50
Commercial			
7	COM1	Retail Trade	100
8	COM2	Wholesale Trade	100
9	COM3	Personal and Repair Services	100
10	COM4	Professional/Technical/Business Services	100
11	COM5	Banks	100
12	COM6	Hospital	150
13	COM7	Medical Office/Clinic	150
14	COM8	Entertainment & Recreation	100
15	COM9	Theaters	100
16	COM10	Parking	50
Industrial			
17	IND1	Heavy	150
18	IND2	Light	150
19	IND3	Food/Drugs/Chemicals	150
20	IND4	Metals/Minerals Processing	150
21	IND5	High Technology	150
22	IND6	Construction	100
Agriculture			
23	AGR1	Agriculture	100
Religion/Non-Profit			
24	REL1	Church/Membership Organization	100
Government			
25	GOV1	General Services	100
26	GOV2	Emergency Response	150
Education			
27	EDU1	Schools/Libraries	100
28	EDU2	Colleges/Universities	150

The exception to these defaults is when users select residential USACE Generic DDFs. The BCA software uses 100% of the BRV for the contents replacement value as the default when USACE Generic DDFs are selected because the content-to-structure value ratio is already incorporated in the contents DDF.

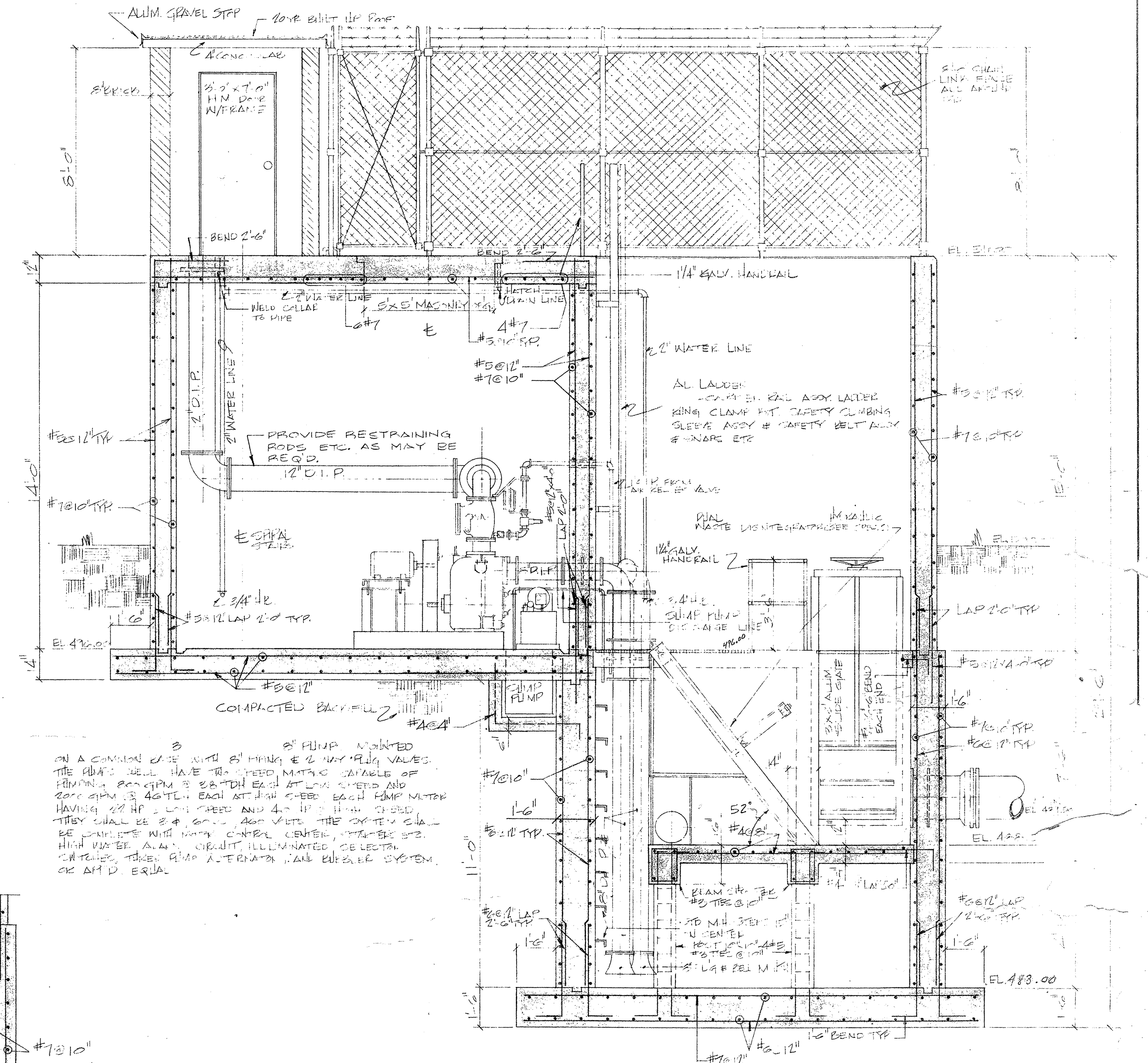
When conducting a Flood module analysis, the user normally uses the default contents values provided by the BCA software. The default contents values are based on the DDF selection (residential or non-residential/primary use, number of stories, basement type, and default or generic). However, in some situations, the primary building use for non-residential buildings

Appendix E

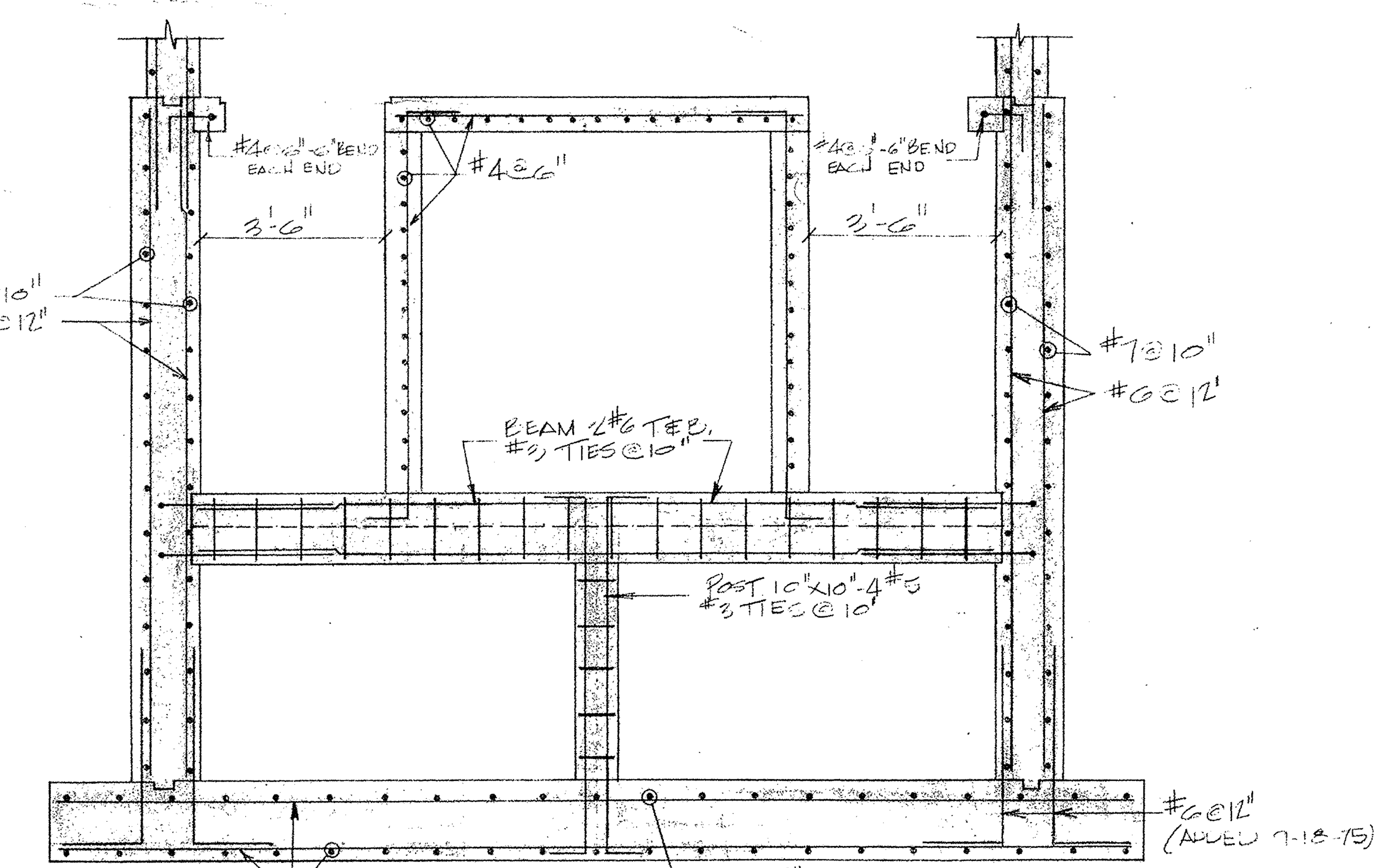
River Pump Station As-built Drawings



PLAN
SCALE: 3/8"=1'-0"



SECTION "A-A"
SCALE: 3/8"=1'-0"



SECTION "C-C"
SCALE 3/8"=1'-0"

NO.	REVISIONS	DATE							
1						RAW SEWAGE PUMP STATION	TOWN OF HILLSBOROUGH, N. C. WASTE TREATMENT FACILITY	DRAWN BY M. P. T.	ROSE, PRIDGE[illegible] [illegible]MON[illegible]
2								CHECKED BY S. I. P.	
3								DATE	CHAPEL HILL
4								SCALE 3/8"=1'-0"	

Appendix F

Peak Stream Flow Events – Eno River

Peak Streamflow for the Nation

USGS 02085000 ENO RIVER AT HILLSBOROUGH, NC

Available data for this site Surface-water: Peak streamflow GO

Orange County, North Carolina
Hydrologic Unit Code 03020201
Latitude 36°04'16", Longitude 79°05'44" NAD83
Drainage area 66 square miles
Gage datum 487.44 feet above NGVD29

Output formats

Table
Graph
Tab-separated file
peakfq (watstore) format
Reselect output format

Water Year	Date	Gage Height (feet)	Stream-flow (cfs)
1996	1996-09-06	21.13	10,800
1945	1945-09-18	20.01	8,980
1930	1929-10-02	18.00[5]	6,750
1965	1965-07-11	17.58	5,970
1993	1993-03-04	17.58	5,970
1998	1998-03-19	17.46	5,600[5]
1944	1944-07-15	17.30	5,530

Water Year	Date	Gage Height (feet)	Stream-flow (cfs)
1995	1995-06-29	17.10	5,180
1939	1939-08-18	16.90	4,910
2017	2017-06-20	17.00	4,730[5]
2019	2019-04-13	16.98[2]	4,710[5]
2003	2003-03-20	16.61	4,580[5]
2008	2008-09-06	16.57	4,530[5]
1946	1946-07-10	16.43	4,280
1999	1999-09-16	16.06	4,190[5]
1960	1960-05-28	16.24	4,070
1987	1987-03-01	16.11	4,060
1997	1997-04-29	15.83	3,980[5]
1928	1928-09-19	16.00[5]	3,880
1931	1931-05-21	16.26	3,880
1952	1952-03-04	16.04	3,880
1986	1985-11-21	15.67	3,730
1936	1936-08-28	15.95	3,670
2000	2000-03-17	15.74	3,640[5]
1989	1989-02-21	15.50	3,620
1932	1932-03-06	15.70[5]	3,610
1938	1938-07-24	15.80	3,610
1955	1955-08-17	15.60	3,530
1963	1963-03-06	15.49	3,450
1935	1934-12-01	14.90[5]	3,260
1966	1966-02-28	15.17	3,230
1992	1992-01-04	14.78	3,200
1957	1957-02-01	15.05	3,120
1949	1948-11-28	14.86	3,060
2010	2010-02-06	14.93	3,060[5]
1962	1962-01-06	14.88	3,050
2020	2020-02-06	15.10	3,030[5]
2016	2015-12-23	14.83	3,010[5]
1953	1953-03-24	14.84	3,000

Water Year	Date	Gage Height (feet)	Stream-flow (cfs)
1994	1994-03-02	14.22	2,950
2018	2018-09-17	14.86	2,890[5,9]
1991	1991-01-12	13.66	2,730
2005	2005-01-14	13.85	2,540[5]
2014	2014-03-07	13.63	2,530[5]
1937	1937-01-20	13.40[5]	2,500
1961	1961-02-08	13.56	2,440
1990	1990-04-03	12.70	2,390
1956	1956-03-16	13.07	2,270
1958	1958-04-06	13.10	2,270
1934	1934-04-09	13.00	2,240
2001	2001-03-30	12.95	2,200[5]
1941	1940-11-14	12.38	2,180
1948	1948-02-14	12.65	2,110
1970	1970-07-10	12.08	1,950
2013	2013-08-21	12.09	1,930[5]
2007	2006-11-22	11.81	1,850[5]
1940	1940-02-07	11.45	1,830
1942	1942-05-16	11.26	1,800
1964	1964-04-08	11.36	1,760
1933	1932-11-26	11.10	1,690
1969	1969-06-16	11.02	1,670
1943	1942-11-24	10.77	1,650
1954	1954-01-22	10.94	1,640
1971	1971-05-16	10.81	1,620
2012	2012-09-18	10.96	1,620[5]
1947	1947-01-14	10.84	1,610
1959	1958-12-28	10.70	1,600
1951	1951-04-08	10.61	1,570
2004	2004-08-30	10.70	1,560[5]
1950	1949-10-30	10.32	1,500
2006	2006-06-25	9.57	1,310[5]

Water Year	Date	Gage Height (feet)	Stream-flow (cfs)
2009	2009-03-01	8.88	1,180[5]
1968	1968-03-12	8.44	1,150
1988	1988-08-29	7.97	1,150
2015	2014-12-24	7.12	925[5]
1967	1967-02-21	6.70	804
2002	2002-01-20	4.67	454[5]
2011	2011-03-30	4.51	424[5]

?
Peak Gage-Height Qualification Codes.

- 2 -- Gage height not the maximum for the year
- 5 -- Gage height is an estimate

?
Peak Streamflow Qualification Codes.

- 5 -- Discharge affected to unknown degree by Regulation or Diversion
- 9 -- Discharge due to Snowmelt, Hurricane, Ice-Jam or Debris Dam breakup

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