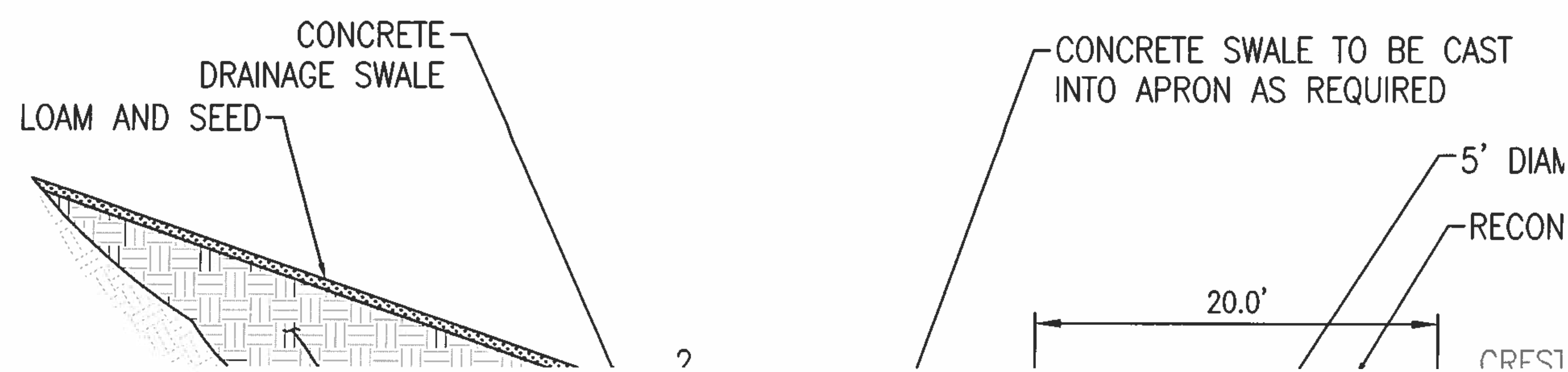
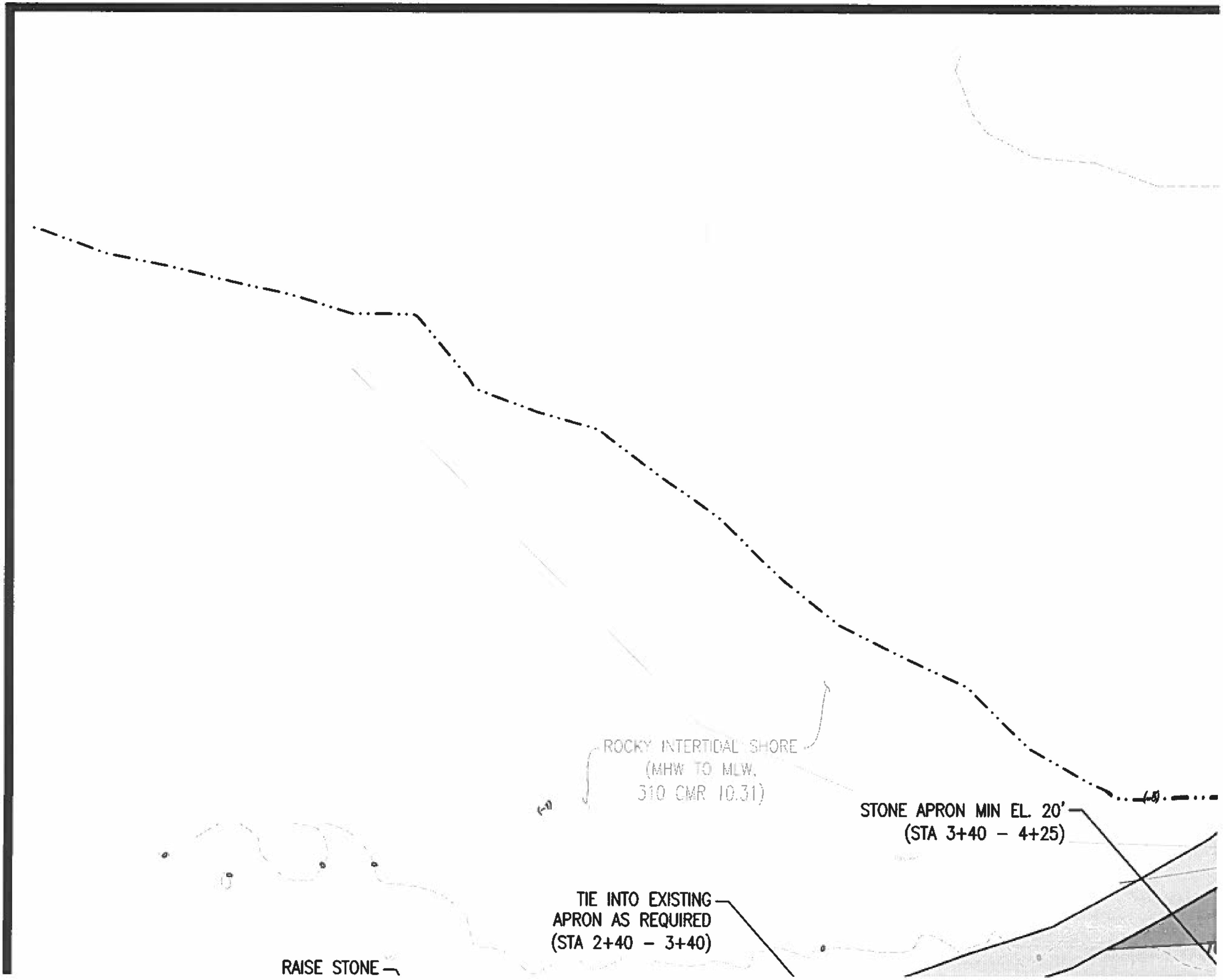
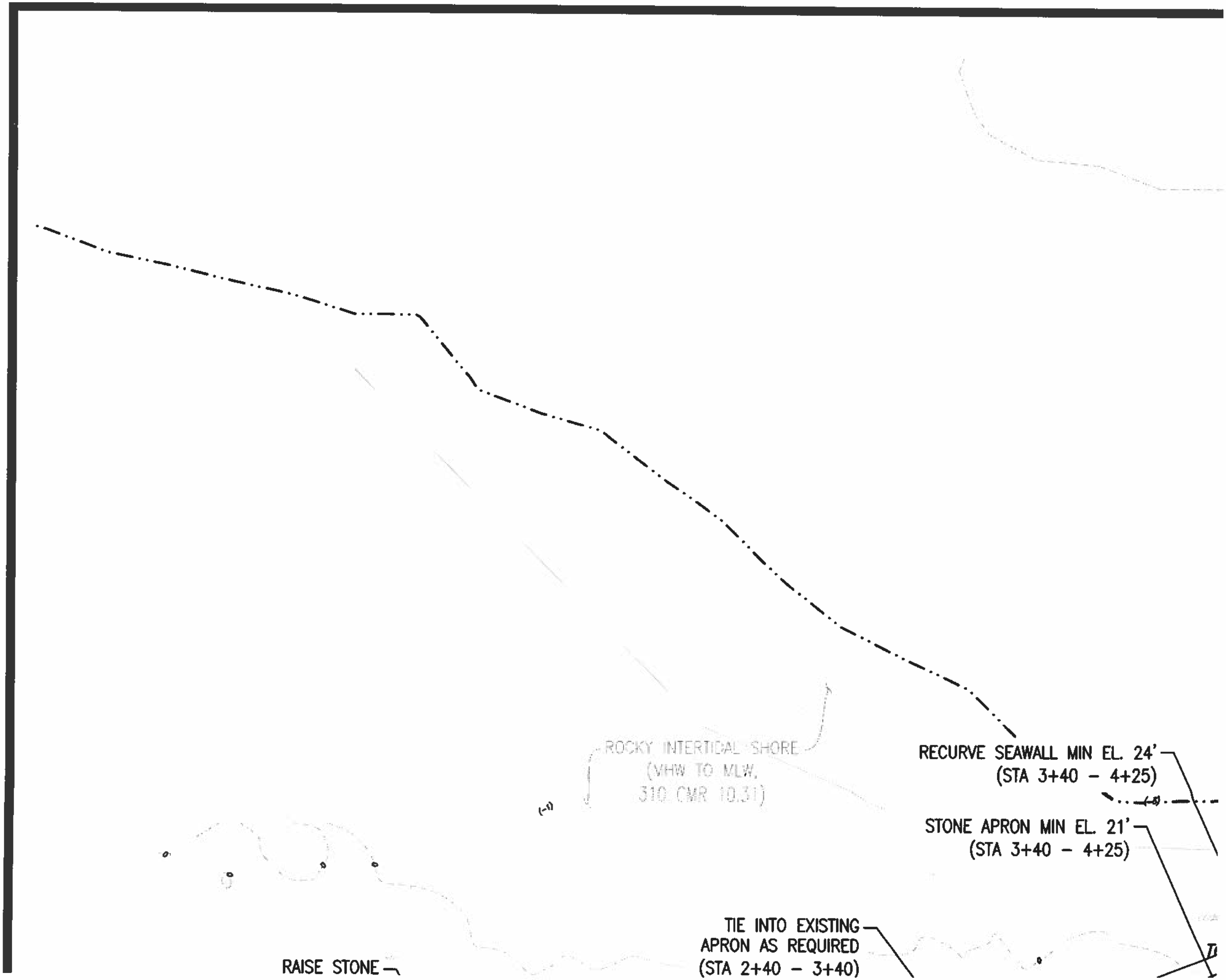

CONCRETE
DRAINAGE SWALE
LOAM AND SEED
CONCRETE SWALE TO BE CAST
INTO APRON AS REQUIRED
5' DIAM
RECON
20.0'
CREST

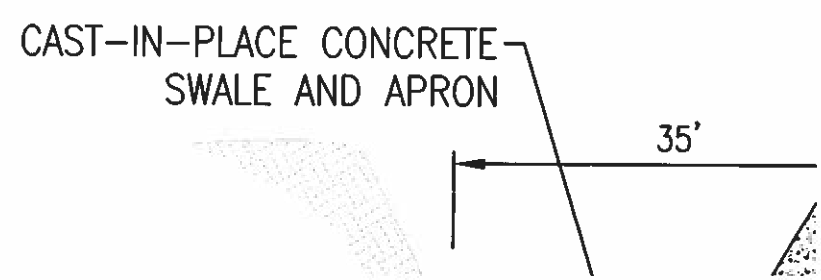

ROCKY INTERTIDAL SHORE
(MHW TO MLW,
310 CMR 10.31)
STONE APRON MIN EL. 20'
(STA 3+40 – 4+25)
TIE INTO EXISTING
APRON AS REQUIRED
(STA 2+40 – 3+40)
RAISE STONE

LOAM AND

CONCRETE
DRAINAGE
SWALE

RECONSTRUCT
BERM CREST AS


ROCKY INTERTIDAL SHORE
(VHW TO MLW,
310 CMR 10.31)
RECURVE SEAWALL MIN EL. 24'
(STA 3+40 – 4+25)
STONE APRON MIN EL. 21'
(STA 3+40 – 4+25)
TIE INTO EXISTING
APRON AS REQUIRED
(STA 2+40 – 3+40)
RAISE STONE


CAST-IN-PLACE CONCRETE
SWALE AND APRON
35'

COLLINS
ENGINEERS INC.

# ATTACHMENT B

## Estimated Project Timeline

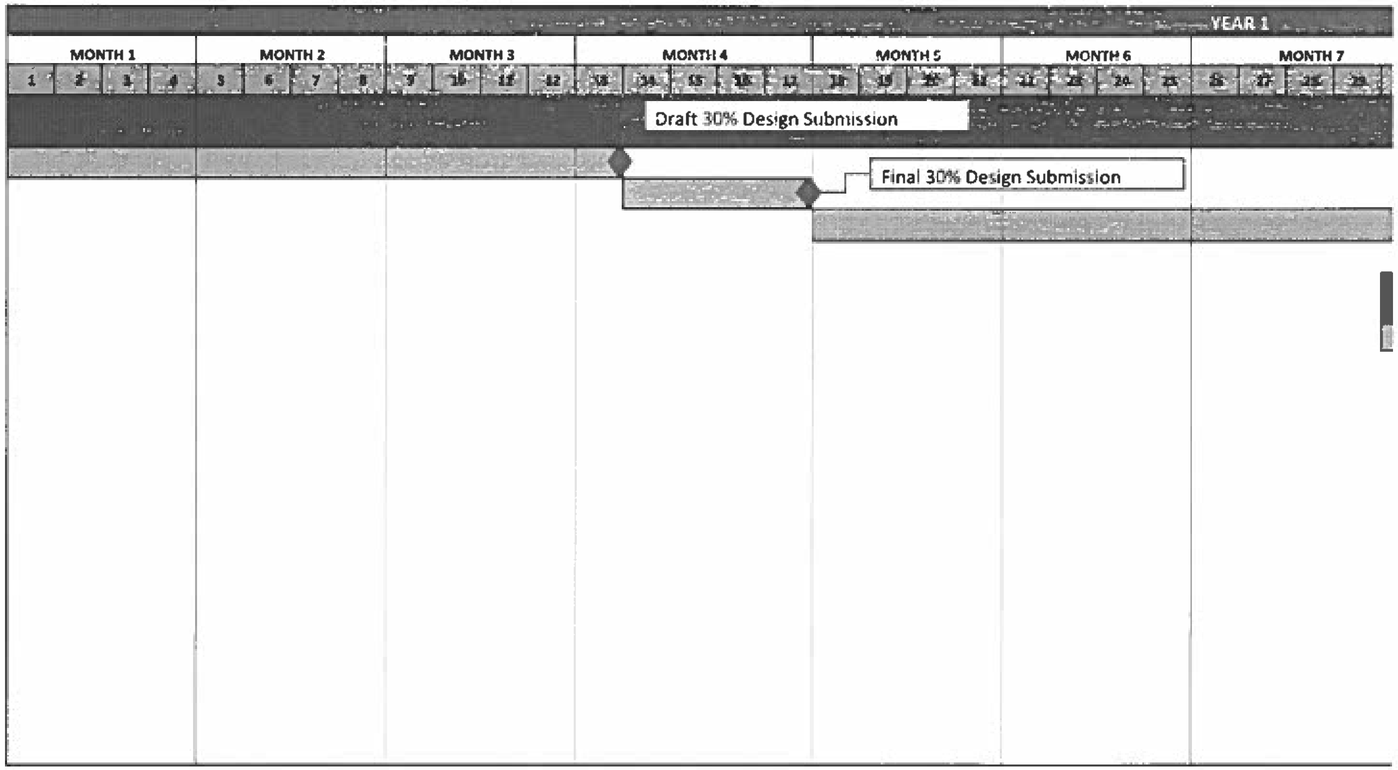
COLLINS ENGINEERS INC.

# POINT ALLERTON COASTAL ENGINEERING SHORE PROTECTION ASSESSMEN

MASSACHUSETTS DEPARTMENT OF CONSERVATION & RECREATION

**ESTIMATED PROJECT TIMELINE**

| TASK | START - END |
|---|---|
| 1 - DESIGN DEVELOPMENT | MONTH 1 - MONTH 10 |
| *Draft 30% Design* | *14 weeks* |
| *Review Period & Final 30% Design* | *4 weeks* |
| *Draft 75% Design* | *20 weeks* |
| *Review Period & Final 75% Design* | *4 weeks* |
| 2 - PERMITTING | MONTH 7 - MONTH 54 |
| *MEPA ENF* | *21 Weeks* |
| *ConCom Notice of Intent* | *10 weeks* |
| *USACE Individual Permit ** | *65 weeks* |
| *401 WQC *** | *60 weeks* |
| *Chapter 91 License *** | *68 weeks* |
| *MESA Review Filing* | *4 weeks* |
| *Closeout Requirements* | *4 weeks* |
| 3 - CONTRACT DOCUMENTS | MONTH 31 -MONTH 35 |
| *100% Design* | *16 weeks* |
| *Bid Documents* | *5 weeks* |
| 4 - CONSTRUCTION PHASE SERVICES | MONTH 36 - MONTH 54 |
| *Construction Phase* | *78 weeks (assumed)* |




Notes:

1. The schedule has been developed to depict the anticipated progression of work throughout the duration of the Project, assuming permit applications are Submitted as shown on the schedule.
2. The milestones and timelines reflect our best reasonable judgement including submissions, review periods, and minimal float time to meet the overall project deadlines. The actual schedule may be acceleratec
3. Construction Phase Services task does not consider time of year (TOY) restrictions that permitting agencies may require for in-water construction work. The construction schedule may be extended depending c

*** USACE regulations indicate that Individual Permit decisions are typically made within two to three months. However, based on recent experience obtaining USACE permits, it is possible that the review tim**

**** MassDEP Waterways regulations do not indicate anticipated permit review timelines, but the schedules shown are based on recent experience obtaining Chapter 91 Licenses and Section 401 Water Quali**

◆ = Milestone
|| = Schedule Breakline

COLLINS ENGINEERS INC.

# POINT ALLERTON COASTAL ENGINEERING SHORE PROTECTION ASSESSME

MASSACHUSETTS DEPARTMENT OF CONSERVATION & RECREATION

**ESTIMATED PROJECT TIMELINE**

| TASK | START - END |
|---|---|
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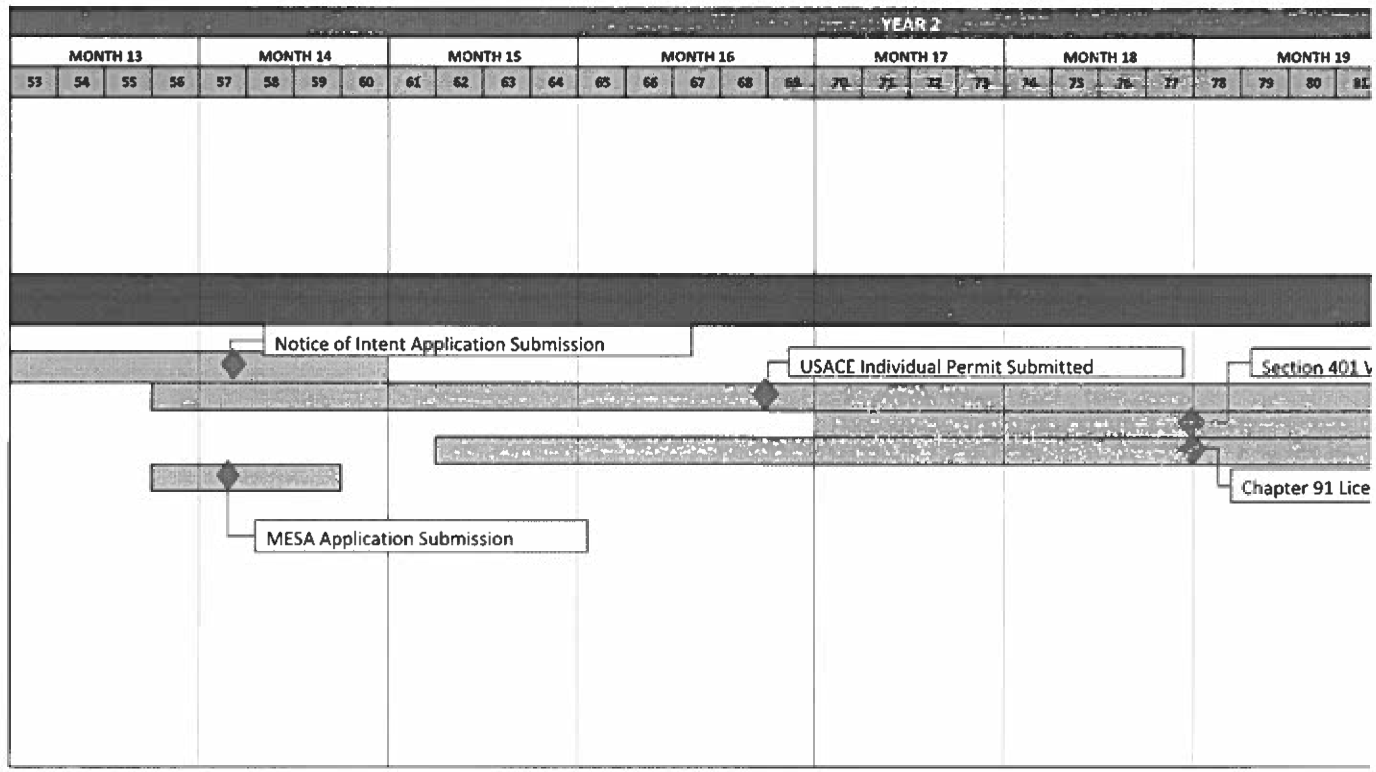
| *Review Period & Final 30% Design* | *4 weeks* |
| *Draft 75% Design* | *20 weeks* |
| *Review Period & Final 75% Design* | *4 weeks* |
| 2 - PERMITTING | MONTH 7 - MONTH 54 |
| *MEPA ENF* | *21 Weeks* |
| *ConCom Notice of Intent* | *10 weeks* |
| *USACE Individual Permit ** | *65 weeks* |
| *401 WQC *** | *60 weeks* |
| *Chapter 91 License *** | *68 weeks* |
| *MESA Review Filing* | *4 weeks* |
| *Closeout Requirements* | *4 weeks* |
| 3 - CONTRACT DOCUMENTS | MONTH 31 - MONTH 35 |
| *100% Design* | *16 weeks* |
| *Bid Documents* | *5 weeks* |
| 4 - CONSTRUCTION PHASE SERVICES | MONTH 36 - MONTH 54 |
| *Construction Phase* | *78 weeks (assumed)* |

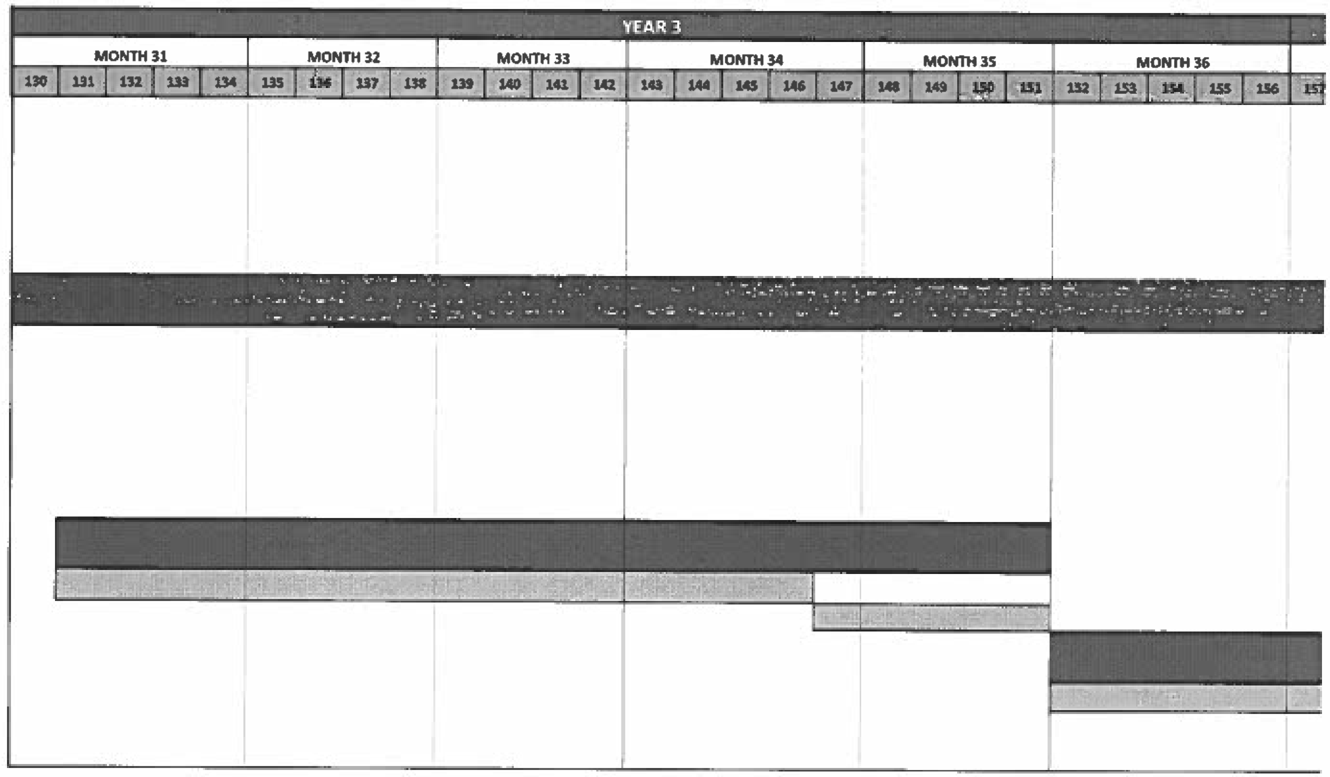


COLLINS ENGINEERS INC

# POINT ALLERTON COASTAL ENGINEERING SHORE PROTECTION ASSESSM

MASSACHUSETTS DEPARTMENT OF CONSERVATION & RECREATION

| TASK | START - END |
|---|---|
| 1 - DESIGN DEVELOPMENT | MONTH 1 - MONTH 10 |
| *Draft 30% Design* | *14 weeks* |
| *Review Period & Final 30% Design* | *4 weeks* |
| *Draft 75% Design* | *20 weeks* |
| *Review Period & Final 75% Design* | *4 weeks* |
| 2 - PERMITTING | MONTH 7 - MONTH 54 |
| *MEPA ENF* | *21 Weeks* |
| *ConCom Notice of Intent* | *10 weeks* |
| *USACE Individual Permit ** | *65 weeks* |
| *401 WQC *** | *60 weeks* |
| *Chapter 91 License *** | *68 weeks* |
| *MESA Review Filing* | *4 weeks* |
| *Closeout Requirements* | *4 weeks* |
| 3 - CONTRACT DOCUMENTS | MONTH 31 -MONTH 35 |
| *100% Design* | *16 weeks* |
| *Bid Documents* | *5 weeks* |
| 4 - CONSTRUCTION PHASE SERVICES | MONTH 36 - MONTH 54 |
| *Construction Phase* | *78 weeks (assumed)* |



COLLINS ENGINEERS INC.

# ATTACHMENT C
## Conceptual Cost Estimate

# COLLINS ENGINEERS

Client: Mass. Department of Conservation & Recreation
Project: Point Allerton Coastal Engineering Shore Protection Assessment
Description: Conceptual Cost Estimate
Job No: 15 14907.00
Prep. By: AVR Date: 7/2/2024
Checked By: DIG Date: 9/27/2024

**Point Allerton Coastal Engineering Shore Protection - Design Alternatives**
**Conceptual Cost Estimate**

**Alternative 1 - Revetment Reconstruction**

| Item | Quantity | Unit | Unit Price | | | Total Cost* | | | Notes | Source |
|---|---|---|---|---|---|---|---|---|---|---|
| Site Prep/Erosion Control | 1 | LS | $60,000 | - | $80,000 | $60,000 | - | $80,000 | Fencing, barriers, haybales/silt socks, turbidity curtain | Recent project costs |
| Demolition and Removal | 700 | CY | $375 | - | $500 | $262,500 | - | $350,000 | Demolish existing revetment, apron, and seawall as required | Recent project costs |
| Remove and Reset Stone Revetment | 7000 | CY | $100 | - | $150 | $700,000 | - | $1,050,000 | Removal of existing stones to accommodate improvements, reinstallation | Recent project costs |
| Geotextile Fabric | 6000 | SY | $12 | - | $12 | $72,000 | - | $72,000 | Furnish and install geotextile fabric, primarily above MHW | MassDOT Weighted Bid Prices Item No. 698.1 and recent project costs (obtained 7/1/2024) |
| Furnish and Install Bedding and Crushed Stone | 6900 | TON | $100 | - | $125 | $690,000 | - | $862,500 | 6" stone beneath revetment and swale | MassDOT Weighted Bid Prices Item No. 156.8 and recent project costs (obtained 7/1/2024) |
| Furnish and Install Core Stone | 103500 | TON | $120 | - | $150 | $12,420,000 | - | $15,525,000 | 50 lb interior revetment stones with delivery | RSMeans Line No. 313713100300 and recent project costs (obtained 7/1/2024) |
| Furnish and Install Filter Stones | 23000 | TON | $150 | - | $180 | $3,450,000 | - | $4,140,000 | 0.5 - 1 Ton Revetment Stones with delivery | Quote, Plymouth Quarries LLC (obtained 7/2/2024) |
| Furnish and Install Armor Stones | 56000 | TON | $300 | - | $450 | $16,800,000 | - | $25,200,000 | 8 - 12 ton armor stone with delivery (includes scour protection / toe stone) | Quotes: JH Lynch & Sons Inc, Plymouth Quarries LLC (obtained 7/2/2024) |
| Site Restoration | 1 | LS | $15,000 | - | $25,000 | $15,000 | - | $25,000 | Site cleanup | Recent project costs |
| Granite Block | 240 | LF | $400 | - | $550 | $96,000 | - | $132,000 | Raising elevation of existing seawall | RSMeans Line No. 323253100500 and recent project costs (obtained 7/2/2024) |
| CIP Concrete | 400 | CY | $600 | - | $1,000 | $240,000 | - | $400,000 | Concrete drainage swale | RSMeans Line No. 033113350300 and recent project costs (obtained 7/2/2024) |
| Structural Fill | 1400 | CY | $45 | - | $65 | $63,000 | - | $91,000 | Restoring earthen slope | RSMeans Line No. 312323130300 and recent project costs (obtained 7/1/2024) |
| Loam and Seed | 50 | SY | $9 | - | $12 | $450 | - | $600 | Loam and seed earthen slope | MassDOT Weighted Bid Prices Item No. 765 and recent project costs (obtained 7/1/2024) |
| | | | | | Contractor Mobilization/Demobilization (10%) | $3,487,000 | - | $4,793,000 | | |
| | | | | | Contingency (20%) | $6,974,000 | - | $9,586,000 | | |
| | | | | | Sub-Total: | $45,330,000 | to | $62,308,000 | | |
| | | | | | Engineering and Permitting (5%)** | $2,267,000 | - | $3,116,000 | | |
| | | | | | **Total:** | **$47,597,000** | **to** | **$65,424,000** | | |

**Alternative 2 - Composite Berm**

| Item | Quantity | Unit | Unit Price | | | Total Cost* | | | Notes | Source |
|---|---|---|---|---|---|---|---|---|---|---|
| Site Prep/Erosion Control | 1 | LS | $60,000 | - | $80,000 | $60,000 | - | $80,000 | Fencing, barriers, haybales/silt socks, turbidity curtain | Recent project costs |
| Demolition and Removal | 700 | CY | $375 | - | $500 | $262,500 | - | $350,000 | Demolish existing revetment, apron, and seawall as required | Recent project costs |
| Remove and Reset Stone Revetment | 3400 | CY | $100 | - | $150 | $340,000 | - | $510,000 | Removal of existing stones to accommodate improvements, reinstallation | Recent project costs |
| Geotextile Fabric | 4700 | SY | $12 | - | $15 | $56,400 | - | $70,500 | Furnish and install geotextile fabric | MassDOT Weighted Bid Prices Item No. 698.1 and recent project costs (obtained 7/1/2024) |
| Furnish and Install Bedding and Crushed Stone | 1900 | TON | $100 | - | $125 | $190,000 | - | $237,500 | 6" stone beneath revetment and swale | MassDOT Weighted Bid Prices Item No. 156.8 and recent project costs (obtained 7/1/2024) |
| Furnish and Install Core Stone | 7000 | TON | $120 | - | $150 | $840,000 | - | $1,050,000 | 50 lb interior revetment stones with delivery | RSMeans Line No. 313713100300 and recent project costs (obtained 7/1/2024) |
| Furnish and Install Filter Stones | 48000 | TON | $150 | - | $180 | $7,200,000 | - | $8,640,000 | 0.5 - 1 Ton Revetment Stones with delivery | Quote, Plymouth Quarries LLC (obtained 7/2/2024) |
| Furnish and Install Armor Stones | 126000 | TON | $300 | - | $450 | $37,800,000 | - | $56,700,000 | 8 - 12 ton armor stone with delivery (includes scour protection / toe stone) | Quotes: JH Lynch & Sons Inc, Plymouth Quarries LLC (obtained 7/2/2024) |
| Site Restoration | 1 | LS | $15,000 | - | $25,000 | $15,000 | - | $25,000 | Site cleanup | Recent project costs |
| Granite Block | 240 | LF | $400 | - | $550 | $96,000 | - | $132,000 | Raising elevation of existing seawall | RSMeans Line No. 323253100500 and recent project costs (obtained 7/2/2024) |
| CIP Concrete | 400 | CY | $600 | - | $1,000 | $240,000 | - | $400,000 | Concrete drainage swale | RSMeans Line No. 033113350300 and recent project costs (obtained 7/2/2024) |
| Structural Fill | 1400 | CY | $45 | - | $65 | $63,000 | - | $91,000 | Restoring earthen slope | RSMeans Line No. 312323130300 and recent project costs (obtained 7/1/2024) |
| Loam and Seed | 50 | SY | $9 | - | $12 | $450 | - | $600 | Loam and seed earthen slope | MassDOT Weighted Bid Prices Item No. 765 and recent project costs (obtained 7/1/2024) |
| | | | | | Contractor Mobilization/Demobilization (10%) | $4,717,000 | - | $6,829,000 | | |
| | | | | | Contingency (20%) | $9,433,000 | - | $13,658,000 | | |
| | | | | | Sub-Total: | $61,314,000 | to | $88,774,000 | | |
| | | | | | Engineering and Permitting ([illegible])** | $3,066,000 | - | $4,439,000 | | |
| | | | | | **Total:** | **$64,380,000** | **to** | **$93,213,000** | | |

**Alternative 3 - Composite Berm and Offshore Breakwater**

| Item | Quantity | Unit | Unit Price | | | Total Cost* | | | Notes | Source |
|---|---|---|---|---|---|---|---|---|---|---|
| Site Prep/[illegible] Control | 1 | LS | $60,000 | - | $80,000 | $60,000 | - | $80,000 | Fencing, barriers, haybales/silt socks, turbidity curtain | Recent project costs |
| Demolition and Removal | 700 | CY | $375 | - | $500 | $262,500 | - | $350,000 | Demolish existing revetment, apron, and seawall as required | Recent project costs |
| Remove and Reset Stone Revetment | 3300 | CY | $100 | - | $150 | $3[illegible]0,000 | - | $495,000 | Removal of existing stones to accommodate improvements, reinstallation | Recent project costs |
| Geotextile Fabric | 6000 | SY | $12 | - | $15 | $72,000 | - | $90,000 | Furnish and install geotextile fabric | MassDOT Weighted Bid Prices Item No. 698.1 and recent project costs (obtained 7/1/2024) |
| Furnish and Install Bedding and Crushed Stone | 1900 | TON | $100 | - | $125 | $190,000 | - | $237,500 | 6" stone beneath revetment and swale | MassDOT Weighted Bid Prices Item No. 156.8 and recent project costs (obtained 7/1/2024) |
| Furnish and Install Core Stone | 4100 | TON | $120 | - | $150 | $492,000 | - | $615,000 | 50 lb interior revetment stones | RSMeans Line No. 313713100300 and recent project costs (obtained 7/1/2024) |
| Furnish and Install Filter Stones | 83000 | TON | $150 | - | $180 | $12,450,000 | - | $14,940,000 | 0.5 - 1 Ton Revetment Stones with delivery | Quote, Plymouth Quarries LLC (obtained 7/2/2024) |
| Furnish and Install Armor Stones | 130000 | TON | $300 | - | $450 | $39,000,000 | - | $58,500,000 | 8 - 12 ton armor stone with delivery (includes scour protection / toe stone) | Quotes: JH Lynch & Sons Inc, Plymouth Quarries LLC (obtained 7/2/2024) |
| Site Restoration | 1 | LS | $15,000 | - | $25,000 | $15,000 | - | $25,000 | Site cleanup | Recent project costs |
| Granite Block | 240 | LF | $400 | - | $550 | $96,000 | - | $132,000 | Raising elevation of existing seawall | RSMeans Line No. 323253100500 and recent project costs(obtained 7/2/2024) |
| CIP Concrete | 400 | CY | $600 | - | $1,000 | $240,000 | - | $400,000 | Concrete drainage swale | RSMeans Line No. 033113350300 and recent project costs(obtained 7/2/2024) |
| Structural Fill | 1400 | CY | $45 | - | $65 | $63,000 | - | $91,000 | Restoring earthen slope | RSMeans Line No. 312323130300 and recent project costs (obtained 7/1/2024) |
| Loam and Seed | 100 | SY | $9 | - | $12 | $900 | - | $1,200 | Loam and seed earthen slope | MassDOT Weighted Bid Prices Item No. 765 and recent project costs (obtained 7/1/2024) |
| | | | | | Contractor Mobilization/Demobilization (10%) | $5,328,000 | - | $7,596,000 | | |
| | | | | | Contingency (20%) | $10,655,000 | - | $15,192,000 | | |
| | | | | | Sub-Total: | $69,255,000 | to | $98,745,000 | | |
| | | | | | Engineering and Permitting (5%)** | $3,463,000 | - | $4,938,000 | | |
| | | | | | **Total:** | **$72,718,000** | **to** | **$103,683,000** | | |

**Alternative 4 - Revetment Reconstruction and Recurve Seawall**

| Item | Quantity | Unit | Unit Price | | | Total Cost* | | | Notes | Source |
|---|---|---|---|---|---|---|---|---|---|---|
| Site Prep/Erosion Control | 1 | LS | $60,000 | - | $80,000 | $60,000 | - | $80,000 | Fencing, barriers, haybales/silt socks, turbidity curtain | Recent project costs |
| Demolition and Removal | 3700 | CY | $375 | - | $500 | $1,387,500 | - | $1,850,000 | Demolish existing revetment, apron, and seawall as required | Recent project costs |
| Remove and Reset Stone Revetment | 7000 | CY | $100 | - | $150 | $700,000 | - | $1,050,000 | Removal of existing stones to accommodate improvements, reinstallation | Recent project costs |
| Geotextile Fabric | 4500 | SY | $12 | - | $15 | $54,000 | - | $67,500 | Furnish and install geotextile fabric | MassDOT Weighted Bid Prices Item No. 698.1 and recent project costs (obtained 7/1/2024) |
| Furnish and Install Bedding and Crushed Stone | 3300 | TON | $100 | - | $125 | $330,000 | - | $412,500 | 6" stone beneath revetment and swale | MassDOT Weighted Bid Prices Item No. 156.8 and recent project costs (obtained 7/1/2024) |
| Furnish and Install Core Stone | 13000 | TON | $120 | - | $150 | $1,560,000 | - | $1,950,000 | 50 lb interior revetment stones with delivery | RSMeans Line No. 313713100300 and recent project costs (obtained 7/1/2024) |
| Furnish and Install Filter Stones | 11000 | TON | $150 | - | $180 | $1,650,000 | - | $1,980,000 | 0.5 - 1 Ton Revetment Stones with delivery | Quote, Plymouth Quarries LLC (obtained 7/2/2024) |
| Furnish and Install Armor Stones | 31000 | TON | $300 | - | $450 | $9,300,000 | - | $13,950,000 | 8 - 12 ton armor stone with delivery (includes scour protection / toe stone) | Quotes: JH Lynch & Sons Inc, Plymouth Quarries LLC (obtained 7/2/2024) |
| Site Restoration | 1 | LS | $15,000 | - | $25,000 | $15,000 | - | $25,000 | Site cleanup | Recent project costs |
| Granite Block | 240 | LF | $400 | - | $550 | $96,000 | - | $132,000 | Raising elevation of existing seawall | RSMeans Line No. 323253100500 and recent project costs (obtained 7/2/2024) |
| CIP Concrete | 1200 | CY | $750 | - | $2,000 | $900,000 | - | $2,400,000 | Concrete drainage swale, recurve wall, and retaining wall | RSMeans Line No. 033113350300 and recent project costs (obtained 7/2/2024) |
| Structural Fill | 700 | CY | $45 | - | $65 | $31,500 | - | $45,500 | Restoring earthen slope | RSMeans Line No. 312323130300 and recent project costs (obtained 7/1/2024) |
| Loam and Seed | 50 | SY | $9 | - | $12 | $450 | - | $600 | Loam and seed earthen slope | MassDOT Weighted Bid Prices Item No. 765 and recent project costs (obtained 7/1/2024) |
| Deep Foundation | 190 | EA | $20,000 | - | $30,000 | $3,800,000 | - | $5,700,000 | Steel H piles (plumb and batter at 8' o.c.) | Recent project costs |
| | | | | | Contractor Mobilization/Demobilization (10%) | $1,609,000 | - | $2,395,000 | | |
| | | | | | Contingency (20%) | $3,217,000 | - | $4,789,000 | | |
| | | | | | Sub-Total: | $24,711,000 | to | $36,828,000 | | |
| | | | | | Engineering and Permitting (5%)** | $1,236,000 | - | $1,842,000 | | |
| | | | | | **Total:** | **$25,947,000** | **to** | **$38,670,000** | | |

* This cost estimate is an opinion of probable cost for the Point Allerton Coastal Engineering Shore Protection Project. Actual cost may vary depending on when the work is completed, volatile labor and material costs, and the waterfront marine construction bid environment. Individual line item cost estimates are order of magnitude estimates with respect to the total project cost estimate.

** This cost estimate assumes that the project will be constructed as shown on the drawings, and shows the total cost for constructing each phase (top of wall elevation) of the project from existing conditions. Actual effort may vary depending on permits and the bid and construction phase services. The installation of a cofferdam was not included in cost analysis, and use of cofferdam is at the discretion of the contractor.

*** This cost estimate is an approximate calculation of the likely cost, duration, and other factors associated with the scope of work shown on the associated Drawings. Due to the specialty nature of the proposed work, published cost estimating data is not available for all of the work items. When sourcing cost data, Collins has used the latest version of available databases including RSMeans, MassDOT, and recent bid prices for similar work in the Boston metropolitan area.

COLLINS ENGINEERS INC.

# ATTACHMENT D

Edgewater Conceptual Design Analysis

# Conceptual Design Analysis (Rev 01)

## Point Allerton, Massachusetts

Edgewater resources

October 15, 2024

# TABLE OF CONTENTS

## INTRODUCTION

The original sea wall at Point Allerton was constructed by the US Army Corps of Engineers in 1874 as a stacked granite block structure. The granite block structure, fronted with large armor stone, has undergone numerous repairs since 1978. However, due to the increasing intensity of extreme storm events coupled with sea level rise, the structure is no longer adequate for protecting the shoreline from coastal storm damage.

Collins Engineers, Inc. (Collins) and Edgewater Resources (EWR), collectively The Team, were retained by the Massachusetts Department of Conservation and Recreation (DCR) to provide an assessment of shore protection at Point Allerton in Hull, MA. The first task of the assessment included the development of a Basis of Design (BOD) report, which provided background information on the site, a summary of the analyses and severity of the environmental factors inducing upland erosion, and recommendations for future designs to protect the upland structures.

In the BOD document, a series of explanations were presented that likely explain the failure of the structure, highlighting the original design inadequacies. The use of concrete fill at the crest of the structure, combined with its insufficient height, resulted in high overtopping volumes and high-water velocities upon reaching the crest. This led to significant erosion behind the structure, instability, settlement, and stone loss, ultimately compromising its structural integrity and protective function.

Large-scale breakwater failures most often occur behind the crest of the structure, typically a result of overtopping, as high-water volumes and velocities can erode the backslope or displace stones where armor interlock is weakest. For the Point Allerton revetment seawall, the majority of revetment failure appears to be a result of this crest overtopping. Additionally, the damage appears to be more severe in locations where expansion of the structure occurred, where tie-in locations likely became points of weaker interlock.

Following the BOD submission, The Team advanced the recommended structure repairs/modifications to the conceptual design level, including this Conceptual Design Report (CDR) which summarizes the preliminary calculations and assumptions that were described in detail in the BOD. The BOD is included as an appendix to this report, and provides detailed site information, project objectives, existing conditions, existing and projected environmental site characteristics, results of the wind and wave analysis, and the numerical modeling effort and conclusions made from this analysis.

BASIS OF DESIGN CONSIDERATIONS

The damage to the seawall at Point Allerton is mainly attributed to large overtopping volumes that reach the back of the crest. To understand how the waves approach the structure, a comprehensive numerical modeling effort was undertaken to determine the worst-case scenarios affecting the structure. A total of 18 cases were modeled, with directions ranging from the NNE to the SE. The results indicated that events coming from the ENE direction yield the highest significant wave height at the toe of the structure, resulting in the most overtopping over the crest.

Therefore, the design storm condition is based on the 0.8% (or 125-year Return Period) ENE event, combined with the design water level, which incorporates FEMA's 0.8% Still Water Elevation and is supplemented by the projected Relative Sea Level Rise according to the Representative Concentration Pathway (RCP) 8.5 scenario for the year 2070. This results in a design water level elevation of 3.66 m NAVD88 (12 ft NAVD88)[1].

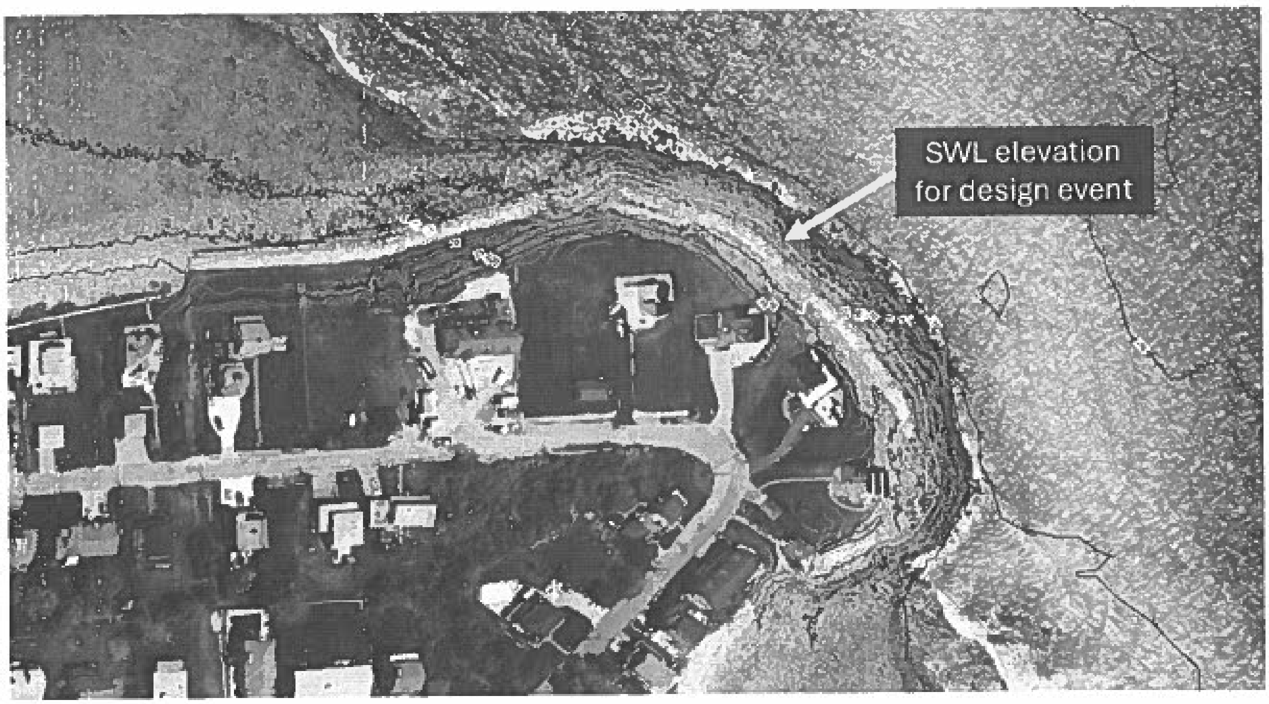



*Figure 1: Stillwater elevation for the design event corresponding to EL. 12 ft. NAVD88.*

Due to the absence of as-built drawings from both the original construction and subsequent repairs of the seawall and revetment, certain assumptions were necessary for this analysis. The existing conditions drawings provided by Collins included approximate locations of each element, as well as cross-sections of the structure. According to these drawings, the original stacked granite wall is covered by 4–8-ton armor stones along the crest in most areas of interest (Station 4+92 to 10+53). This seawall is fronted with 8-12-

[1] Refer to the BOD document for a more detailed explanation of the design conditions.

ton armor stones placed atop core stone along the front face, with slopes varying from 1.5:1 to 2:1 (Horizontal).

Ignoring areas of damage due to settling or stone displacement, the revetment is not designed to properly absorb wave energy. The concrete fill has created impermeable and smooth surfaces that are counterproductive to energy dissipation. Insufficient crest height and crest width, combined with the existing steep revetment slopes have resulted in high overtopping velocities and volumes, causing significant erosion and structural damage landward of the revetment.

The redesign alternatives discussed in this document aim to:

- Reduce overtopping to tolerable levels.
- Increase wave energy dissipation.
- Manage storm conditions under present circumstances and future storms exacerbated by climate change.

WAVE OVERTOPPING CALCULATIONS

Overtopping of coastal structures refers to the process where wave action causes water to flow over the top of these structures, such as seawalls, breakwaters, and dikes. The extent and impact of overtopping are critical factors in coastal engineering, as they influence the stability and safety of the structures and the areas they protect. Overtopping rates are influenced by various factors, including wave height, wave period, structure geometry, and crest freeboard.

All overtopping calculations follow the formulae and methods described in the EurOtop *Manual on wave overtopping of sea defenses and related structures* (Second edition, 2018). This manual is largely based on extensive European research and is considered to be the industry standard for predicting and assessing wave overtopping seawalls, flood embankments, breakwaters and other shoreline structures.

The analysis methods described in the EurOtop Manual are primarily based upon a deterministic approach in which overtopping discharges are calculated for wave and water level conditions representing an event with a given probability or return period. The design equations require data on water levels and wave conditions at the toe of the defense structure. Input wave conditions should take account of nearshore wave transformations for which the use of numerical models is recommended. In this analysis, the nearshore wave transformations were taken into account by the SW model that simulated the transition from the offshore wave conditions to the conditions at the toe of the structure.

Understanding and predicting overtopping discharges for rubble mound structures involves detailed analysis of wave conditions, structural geometry, and material properties. This ensures that these structures provide adequate protection against coastal flooding and erosion under both current and future sea-level conditions.

Key parameters in the EurOtop formulations are defined below:

<u>Wave height</u>

The wave height used in the EurOtop wave run-up and overtopping formulae is the incident significant wave height Hm0 at the toe of the structure, also called the spectral wave height.

Given that the significant wave heights at the toe vary along the Pt Allerton structure six distinct areas were identified:

1. North face area (Stations 0+00 to 2+40): Subject to relatively low wave energy.
2. Transition zone (Stations 2+40 to 3+40): Between the vertical wall and the proposed structure.
3. North face area of the proposed structure (Stations 3+40 to 4+25): Subject to moderate wave energy.
4. Northwest corner and front face of the structure (Stations 4+25 to 10+20): Subject to the highest wave energy.
5. Southeast corner of the structure (Stations 10+20 to 11+50): Transition zone between the highest wave energy and a relative low energy area.

6. South face area (Stations 11+50 to 11+81): Subject to the lowest wave energy.

These areas were identified due to the distinctly different energy losses experienced by the waves as they refract and diffract around the peninsula. The significant wave height for the design storm condition is notably higher at Station 7+00, where the waves impact directly without any change in direction (Figure 2).

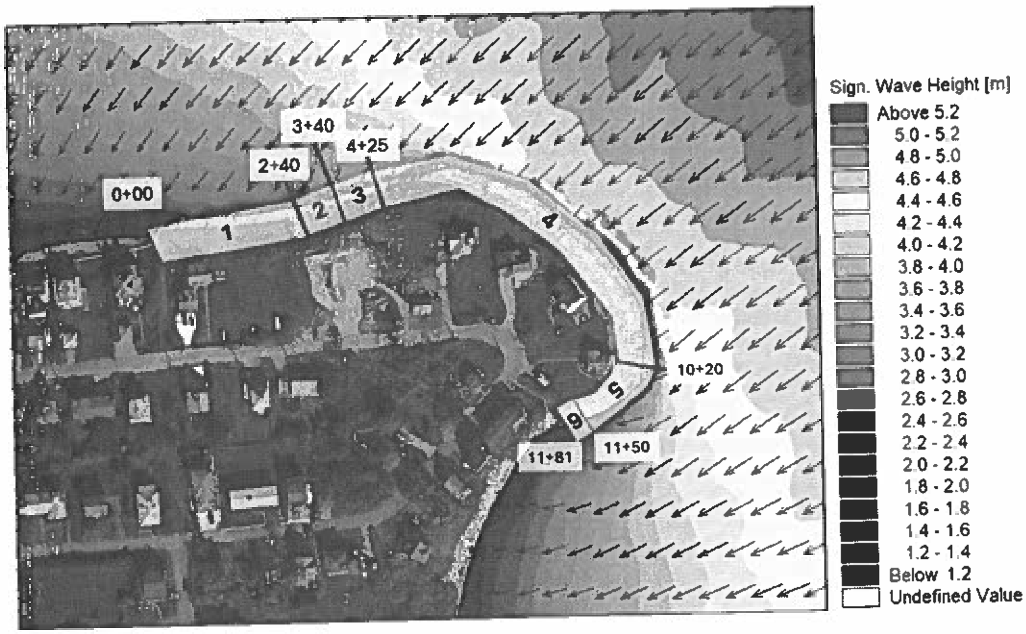



*Figure 2: Significant wave height map for the design storm condition, 0.8% ENE event with a 3.66 WL.*

For the purposes of preliminary design, three representative sections in the most critical areas were selected for calculations:

- Section 2+40 to 4+25
- Section 4+25 to 10+25
- Section 10+20 to 11+50

Wave conditions at the toe of the structure in these critical sections were derived from the SW model output for the design storm condition (0.8% ENE event). These wave heights are specified in Tables 2, 3, 4, and 6. Sections 0+00 to 2+40 and 11+50 to 11+81 were considered transition zones, where the new structure ties into the existing grade.

<u>Wave steepness</u>

Wave steepness is defined in EurOtop 2018, as the ratio of wave height to wavelength ($s_0 = H_{m0} / L_0$). This parameter indicates the wave characteristics, whether it is a typical swell sea or wind sea. Swell seas are associated with long period waves, where it is the period that becomes the main parameter that affects overtopping.

The wave steepness for the design storm condition is $s_0$=0.01 which indicates a typical swell sea.

Breaker parameter

Also called surf similarity parameter or Iribarren number is defined as $\xi_{m-1,0} = \tan\alpha/(H_{m0}/L_{m-1,0})^{½}$, where α is the slope of the front face of the structure and $L_{m-1,0}$ being the deep-water wavelength $gT^2_{m-1,0}/(2\pi)$.

This parameter indicates a certain type of wave breaking as shown in Figure 3.

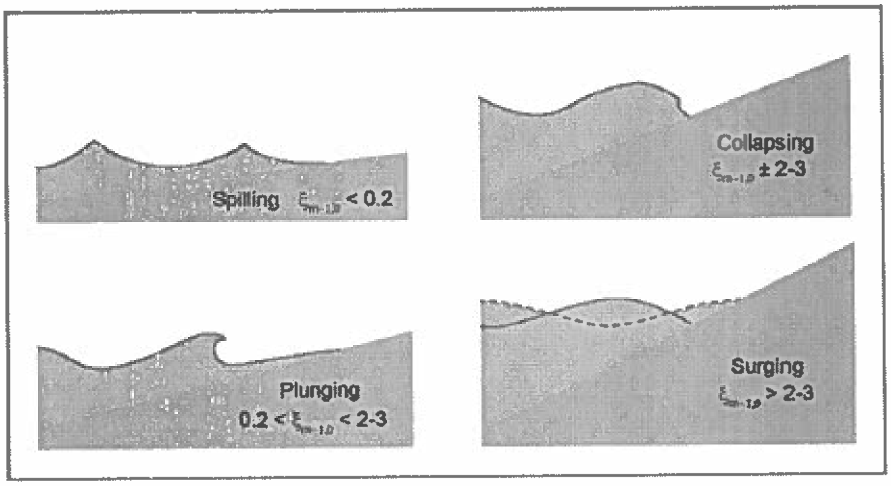



*Figure 3: Breaking type on a slope. EurOtop, 2018.*

The wave breaker parameter for the design storm condition is 3.27, which indicates that the waves are considering not to be breaking but surging on the structure. These occur on steep slopes where the wave does not break in the traditional sense. Instead, the wave crest remains unbroken and surges up the slope. This results in the energy dissipating by friction along the revetment surface.

Wave Runup

Wave runup is the maximum vertical extent of wave uprush on a beach or coastal structure above the still water level. It consists of two components: the wave setup and the swash. Historically, wave runup has been a critical parameter in coastal engineering and management as it determines the extent to which waves can reach and potentially impact coastal structures, beaches, and backshore areas. The 2% runup height ($R_{u2\%}$) is considered the design basis for crest level assessments. It is defined by EurOtop as the elevation exceeded by two percent of the incident waves.

However, over the past decade, the design for safety assessment has shifted towards allowable overtopping rather than wave runup.

Mean Overtopping discharge

The average overtopping discharge, $q$, is commonly used to assess the performance and safety of coastal structures. It represents the average volume of water overtopping per unit length of the structure per

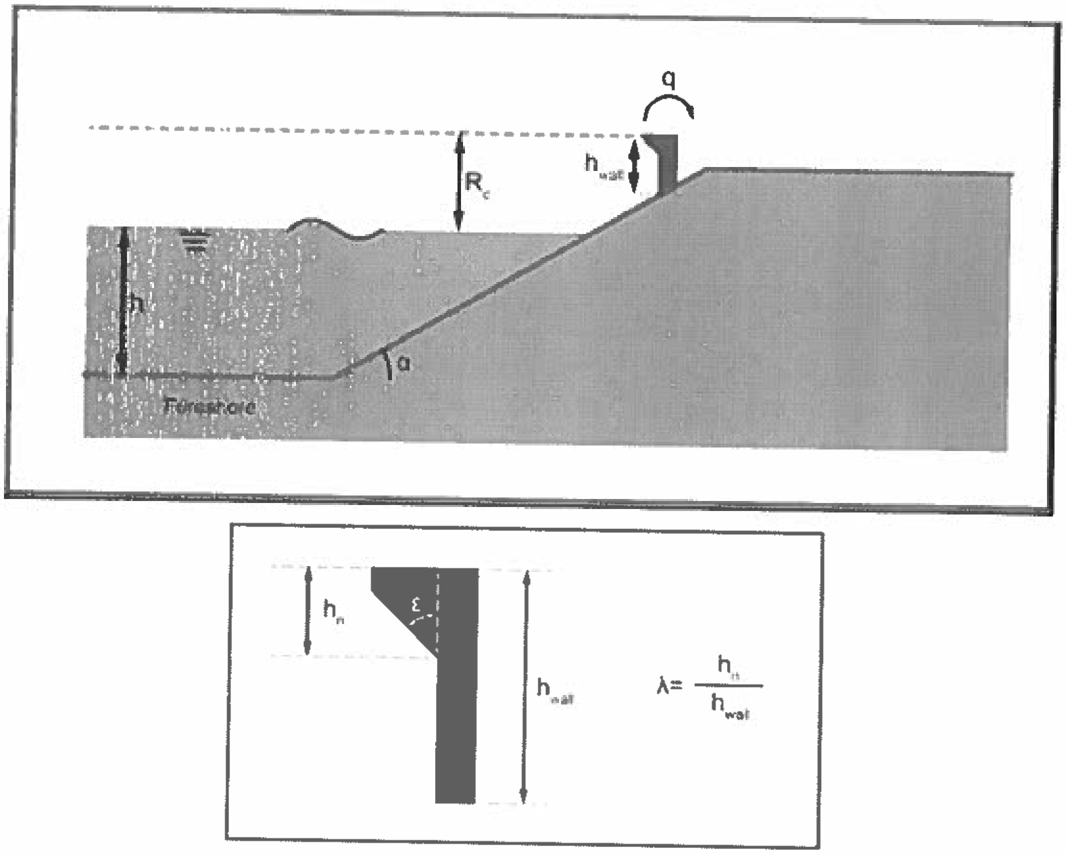



*Figure 16: Configuration of a slope with a storm wall and bullnose, EurOtop, 2018.*

*Table 6: Preliminary dimensions for the revetment repair and wall height.*

| Stations | Hm0 at toe (ft) | Proposed Crest Elevation (NAVD88) | Proposed Structure Slope | Proposed Wall Elevation (NAVD88) |
|---|---|---|---|---|
| 2+40 to 4+25 | 12.4 | 20 | 2:1 | 24 |
| 4+25 to 10+20 | 15.0 | 31 | 2:1 | 37 |
| 10+20 to 11+50 | 10.2 | 21 | 2:1 | 26 |