MEMORANDUM

TO: Kara Buzanoski, Director of Public Works, Town of Nantucket

FROM: Nicolle Burnham, Milone & MacBroom, Inc.

DATE: October 1, 2013

RE: Alternatives Analysis Summary
Baxter Road Temporary Stabilization
Nantucket, Massachusetts
MMI #2967-11

Per request of the town of Nantucket, Milone & MacBroom, Inc. has evaluated potential methods of stabilizing Baxter Road to protect access to private residences and existing sewer and water utilities located beneath the roadway. As noted on our memorandum of September 24, 2013 the goal of this current effort is to maintain vehicular access and utility service to the residential properties on Baxter Road from Bayberry Lane north to the Sankaty Head Lighthouse. The project limits evaluated by MMI are limited to those areas where Baxter Road appears in imminent danger of failure from bank failure. Specifically, our project area extends from 85 to 91 Baxter Road and from 99 to 107.

Design Criteria

For the purposes of MMI's work, measures installed will be considered temporary and intended to provide some level of protection for the short term, while long term solutions are considered by the SBPF and the town. The town has requested that the measures implemented under MMI's work consider a three year life. Given the varied erosion rates from year to year it is not possible to guarantee a specific design life of any stabilization measure here.

After considering the project site and having discussions with Haley & Aldrich, who has performed geotechnical evaluations on behalf of SBPF, we evaluated four potential stabilization methods:

1. Steel sheet piling along the toe of the bluff
2. Steel sheet piling along the top of the bluff (adjacent to Baxter Road)
3. Geotubes along the toe of the bluff
4. Grout injections for soil stabilization beneath the glacial till layer

Attached please find a matrix that compares each alternative, a plan view that depicts the installation location of each, and cross sections views that detail each alternative. Each alternative is described below.

Alternate 1

This alternate would entail driving steel sheet piling along the toe of the bluff for a distance of approximately 1720 feet, essentially through the project sections defined above, and to a depth of approximately 20 feet. The sheet piling would serve to protect the toe of slope from erosion due to wave action. To maintain this system, sand may have to be replaced along the waterward face of sheeting periodically as erosion occurs. Construction would result in steel sheeting being visible from the existing ground surface to elevation 22.0, with an average exposed height of five feet. Not only would this create less than desirable aesthetics, the sheeting would create an unnatural physical barrier paralleling the shoreline. The bulkhead would likely be capped with poured-in-place concrete. This option, focusing on

addressing the toe of slope, is considered technically feasible but costly and unlikely to be permitted by the Town's Conservation Commission.

Alternate 2

The second alternative would involve driving steel sheet piling along the edge of Baxter Road, or the edge of the town-owned roadway right-of-way, generally to the limits described above. The intent is to protect the town-owned infrastructure, rather than address toe failure. The premise behind this alternative is that the sheet piling would support the roadway in the event of a total or partial but significant slope failure. Theoretically this alternative is viable, however considering the practicality of construction and geotechnical limitations of the area, several issues suggest that driving sheeting along the roadway is not feasible. First, the sheets would be very long and difficult to drive through the thick glacial till layer. Additionally, a substantial tieback system would be required, extending under the street and likely conflicting with utilities. The depth of the sheets would be determined, in part, by the assumed retained height based on some failure scenario. Accommodating a complete slope failure would be largely infeasible, and planning for a partial failure would be difficult given the nature of the sandy soil layer along the toe of slope and difficulty in establishing slope stability in conjunction with the sheet piling. Finally, while this alternative attempts to protect the roadway and related infrastructure, it affords no protection for the privately owned properties. For these reasons, this alternative has been deemed infeasible.

Alternative 3

This alternative entails placement of sand-filled geotextile tubes along the toe of slope to provide temporary protection from wave and tidal action. This alternative is largely constructible, the sand fill is readily available, and the option presents a costs effective, short term solution for protecting the toe of slope within the town's study area. In protecting the slope, this treatment may result in short-term slope stabilization. It is critical to understand, however, that these structures could be overtopped and/or undermined even with detailed design consideration. Failure of the geotubes could result in failure of Baxter Road and we cannot predict when this may occur. While these measures are considered temporary, the installation of geotextile tubes can be expected to retard slope failure and can be designed to prevent slope failure from normal tidal events. While there would be some impact to aesthetics, we would anticipate this alternative can be permitted locally, given its temporary nature. For these reasons this alternative is deemed a viable option for the short-term.

Alternative 4

Alternative 4 was presented by Haley & Aldrich (H&A) in our discussions with them. The grout would be injected into the cohesionless sand layer at the toe of the slope and would serve to strengthen or enhance the properties of the otherwise weak soil. From our discussions with H&A and based on their previous findings in the field, the grouted sand layer would be approximately 35 feet thick. The weak sand layer is overlain by a thick glacial till. This material in itself can be stabilized under normal conditions, however given it is founded on the cohesionless underlying sand makes the glacial till susceptible to failure as has been the case. This alternative has the advantage of being low impact when compared to other options, particularly given the fact the grout will be 'invisible' from the surface following construction and restoration of the impacted areas. While this alternative may be cost prohibitive as a temporary solution, we are not dismissing this option and recommend it be studied further.

Discussion on Alternatives

After discussing this project with Haley and Aldrich we find that the selected alternative for short-term improvements should be one which, at a minimum, protects the cohesionless sand layer along the toe of

the slope. Ideally the best long term solution should be one which stabilizes the cohesionless sand layer more permanently. Based on these principles, Alternative 2 has been deemed infeasible. Haley & Aldrich prepared a memorandum detailing this further in a memorandum to SBPF dated September 27, 2013. Based on where our investigations have led us thus far, we recommend the town pursue Alternative 3, sand filled geotextile tubes at the toe of slope, to provide short-term protection while long term solutions are further explored.

Further Discussion

In reviewing the slope stability analysis completed by Haley & Aldrich in 2007 and their memorandum of September 27, 2013 we note that their conclusions indicate that the slope would be stable at and approximately 40 degree angle. The current slope in our project area ranges from 31 to 40 degrees with some sections near the top of slope as steep as 56 to 68 degrees. The implication is that the top of the slope in our project area is inherently unstable, even with toe protection. In 2007 Haley & Aldrich recommended toe stabilization combined with flattening the slope as the appropriate means of stabilizing this area. None of the options we evaluated suggest grading the slope. In our opinion we need to make the town aware of this issue, but we would not use a lack of proposed grading as a means to delay short term toe revetment installation. Without doing anything the bank will likely fail. By installing the toe revetment the failure may be delayed long enough to develop a long term solution.

In addition to the toe stabilization we recommend that “run-on” to this slope from roadway and lawn drainage and irrigation water be avoided. As the soils at the top of slope become saturated, weight is added to the bank, increasing the instability.

Emergency Preparedness

In a letter to the town dated September 24, 2013 we recommended that emergency planning measures be developed to address emergency access and water and sewer service the Baxter Road in the event that failure occurs. To that end, we suggest the town develop a written action plan to provide physical access, water and sewer facilities to the dwellings on Baxter Road in the event of a failure of one or more of those town-owned facilities. In addition to having a written plan, with buy-in from appropriate emergency and other staff, securing the necessary permissions and/or materials which may be necessary to respond in an emergency situation would obviously improve response time. We understand the town has initiated this process.

STABILIZATION ALTERNATIVE	DESCRIPTION	ALTERNATIVE ADVANTAGES	ALTERNATIVE DISADVANTAGES	APPROXIMATE CONSTRUCTION ESTIMATE	APPROXIMATE CONSTRUCTION DURATION
ALTERNATIVE #1 STEEL SHEET PILES AT BEACH	SHEET PILES DRIVEN AT TOE OF SLOPE, AT APPROXIMATE ELEVATION 22.0. PILES TO BE 25.0' LONG WITH 5.0' LEFT EXPOSED	SHEETING PROVIDES SOLID PROTECTION FROM UNDERMINING AND EROSION OF TOE THROUGH WAVE ACTION DURING STORMS. PILES INSTALLED IN SAND LENS AT TOE OF SLOPE MORE EASILY INSTALLED. SOIL COMPOSITION REQUIRES LESS IMPACT OR VIBRATION TO REACH DESIRED INSTALLATION DEPTH. INSTALLATION FROM BEACH PROVIDES RESULTS IN FEWER DISRUPTIONS TO BAXTER ROAD VEHICLE TRAFFIC AND LOCAL RESIDENTS.	STEEL SHEETING IS A FORM OF HARD ARMORING EROSION PROTECTION. WAVE REFLECTION MAY BECOME A CONCERN IF THE SAND IN FRONT OF THE SHEETING ERODES. ANY SAND WHICH ERODES FROM IN FRONT OF THE SHEETING WILL NEED TO BE REPLENISHED PRIOR TO REMOVAL OF SHEETING. SAND MAY NEED TO BE REPLENISHED EACH SPRING. CRANE AND OTHER EQUIPMENT WILL REQUIRE ADDITIONAL MOBILIZATION TO REMOVE PILES. MATERIAL/EQUIPMENT WILL NEED TO BE BARGED TO SHORE. DANGER OF FLANKING AT ENDS.	SHEET PILE ESTIMATE APPROXIMATE TOTAL SHEET PILE WALL LENGTH = 1,270 FT TYPICAL DRIVEN DEPTH = 25.0 FT UNIT PRICE = $50/SF INSTALLED SHEETING COST = $1,587,500 SAND REPLENISHMENT ESTIMATE TOTAL REPLENISHMENT VOLUME = 6,600 CY UNIT PRICE = $50/CY SAND REPLENISHMENT COST = $330,000 (PER APPLICATION) TOTAL ESTIMATED COST = $1,917,500	ESTIMATED DAILY OUTPUT = 1000 SF PER 8 HOUR DAY TOTAL BURIED SHEETING SQUARE FOOTAGE = 28,575 SF ESTIMATED CONSTRUCTION DURATION = 29 WORK DAYS
ALTERNATIVE #2 STEEL SHEET PILES AT ROAD	SHEET PILES DRIVEN AT THE TOP OF SCONSET BLUFF, APPROXIMATELY 10' EAST OF THE EASTERN EDGE OF BAXTER ROAD.	SHEETING CAN BE INSTALLED FROM THE TOP OF THE BLUFF, ELIMINATING THE NEED TO BARGE EQUIPMENT ONTO THE BEACH. SHEETING SHOULD PREVENT SUDDEN CATASTROPHIC COLLAPSE OF BAXTER ROAD AND EXISTING UTILITIES SHOULD THE BLUFF ERODE AND RETREAT TOWARDS THE ROADWAY.	TO PREVENT GLOBAL FAILURE OF THE SLOPE PILES WILL NEED TO HAVE A LENGTH OF 80 FT OR MORE. INSTALLATION IS IN CLOSE PROXIMITY TO RESIDENCES. DUE TO THE DENSE SOIL COMPOSITION AT THE TOP OF THE BLUFF THE SHEET PILES WILL NEED TO BE HAMMERED INTO THE GROUND. THIS INSTALLATION TECHNIQUE WILL BE DISRUPTIVE TO RESIDENTS. DRIVING OF PILES IN CLOSE PROXIMITY TO EXISTING WATER MAIN ALONG BAXTER ROAD COULD CREATE UNSEEN DAMAGE AND/OR LEAKS. SHEET PILE INSTALLATION AT TOP OF BLUFF DOES NOT PREVENT/RETARD EROSION AT THE TOE OF THE SLOPE. IF THE SLOPE FAILS UP TO THE SHEET PILES FUTURE REMOVAL MAY BECOME DIFFICULT/IMPOSSIBLE. CRANE WILL NEED TO BE INSTALLED WITHIN BAXTER ROAD, BLOCKING ACCESS TO AREAS TO THE NORTH.	SHEET PILE ESTIMATE APPROXIMATE TOTAL SHEET PILE WALL LENGTH = 1,160 FT TYPICAL DRIVEN DEPTH = 80 FT UNIT PRICE = $50/SF INSTALLED SHEETING COST = $4,640,000 TOTAL ESTIMATED COST = $4,640,000	ESTIMATED DAILY OUTPUT = 750 SF PER 8 HOUR DAY TOTAL BURIED SHEETING SQUARE FOOTAGE = 92,800 SF ESTIMATED CONSTRUCTION DURATION = 124 WORK DAYS
ALTERNATIVE #3 SAND-FILLED GEOTUBES	LARGE GEOTEXTILE TUBE FILLED WITH SAND. INSTALLED AT TOE OF SLOPE TO PROTECT AGAINST UNDERMINING OF SAND TOE.	INSTALLATION MATERIAL (OTHER THAN GEOTUBE) IS AVAILABLE ON ISLAND. INSTALLATION CAN BE COMPLETED WITH A RELATIVELY SMALL WORK CREW IN A VERY SHORT TIMEFRAME IN A COST-EFFECTIVE MANNER. TOE SCOUR IS PREVENTED BY THE ADDITION OF A GEOTEXTILE FABRIC WING WHICH IS PART OF THE GEOTUBE SYSTEM. REMOVAL OF GEOTUBE AT COMPLETION OF TEMPORARY STABILIZATION REQUIRES ONLY THE REMOVAL OF GEOTEXTILE FABRIC. SAND FILLING COULD REMAIN ON BEACH, IF DESIRED, WHICH COULD BE USED FOR FUTURE REPLENISHMENT.	GEOTEXTILE FABRIC COULD BE TORN BY LARGE DEBRIS CONTAINED WITHIN STORM WAVES. SAND BACKFILL MAY NEED TO BE REPLENISHED AFTER EACH STORM SEASON. SAND DELIVERY SYSTEM AT TOP OF BLUFF (CRANE W/HOPPER, CONVEYOR BELT, ETC.) COULD BE DISRUPTIVE TO RESIDENTS. DANGER OF FLANKING AT ENDS OF GEOTUBE.	GEOTUBE ESTIMATE APPROXIMATE TOTAL GEOTUBE LENGTH = 1,220 FT UNIT PRICE = $560/LF INSTALLED GEOTUBE COST = $683,200 SAND BACKFILL ESTIMATE TOTAL BACKFILL VOLUME = 4,300 CY UNIT PRICE = $50/CY SAND BACKFILL COST = $215,000 TOTAL ESTIMATED COST = $898,200	ESTIMATED DAILY OUTPUT = 150 FT PER 8 HOUR DAY APPROXIMATE TOTAL GEOTUBE LENGTH = 1,220 SF ESTIMATED CONSTRUCTION DURATION = 9 WORK DAYS
ALTERNATIVE #4 GROUT INJECTION	SHAFTS ARE DRILLED INTO THE SLOPE FROM THE TOE UPWARD, FOLLOWED BY PRESSURE INJECTION OF GROUT WHICH HARDENS/STRENGHTENS THE WEAK SAND AT THE BASE OF THE SLOPE.	WEAK SAND LAYER AT BASE OF BLUFF IS HARDENED, INCREASING ITS RESISTANCE TO EROSION DUE TO STORM WAVE ACTION. GROUTING CAN BE COMPLETED FROM THE BEACH, ELIMINATING POTENTIAL IMPACTS TO RESIDENTS. GROUT COMPOSITION DOES NOT CHANGE THE APPEARANCE OF SAND. GROUTED SECTION SHOULD NOT REQUIRE ANY MAINTENANCE.	TO ADEQUATELY STRENGTHEN THE SLOPE, GROUTING WOULD BE REQUIRED OVER A RELATIVELY LARGE AREA (35 FT HEIGHT X 35 FT DEPTH). SOIL GROUTING NEEDS TO BE USED IN TANDEM WITH ADDITIONAL SLOPE STABILIZATION TO PROTECT AGAINST WAVE SCOUR (E.G. GEOTUBE). MATERIAL/EQUIPMENT WILL NEED TO BE BARGED ONTO THE BEACH FOR INSTALLATION. GROUT COMPOSITION NEEDS TO BE CUSTOMIZED BASED ON EXISTING SOIL CONDITIONS, INCREASING LEAD TIME. ESTIMATED CONSTRUCTION DURATION IS EXCESSIVE BASED ON PROJECT NEEDS.	GROUT INJECTION ESTIMATE APPROXIMATE GROUT CROSS SECTIONAL VOLUME = 80 CY/FT TOTAL GROUTED SLOPE LENGTH = 1,220 FT UNIT PRICE = $375/CY INSTALLED GROUTING COST = $36,600,000 GEOTUBE ESTIMATE INSTALLED GEOTUBE COST (FROM ABOVE) = $845,950 TOTAL ESTIMATED COST = $37,445,950	ESTIMATED DAILY OUTPUT = 500 CY PER 8 HOUR DAY TOTAL GROUTED VOLUME = 97,600 CY ESTIMATED CONSTRUCTION DURATION = 196 WORK DAYS

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REVISIONS

TYPICAL CROSS SECTION - SLOPE STABILIZATION

BAXTER ROAD
SLOPE STABILIZATION

NANTUCKET, MASSACHUSETTS

RSD	SMW	--
DESIGNED	DRAWN	CHECKED

SCALE: N.T.S.

DATE: OCT. 1, 2013

PROJECT NO.: 2967-11

SHEET NO.: 1 OF 6

SHEET NAME: MATRIX

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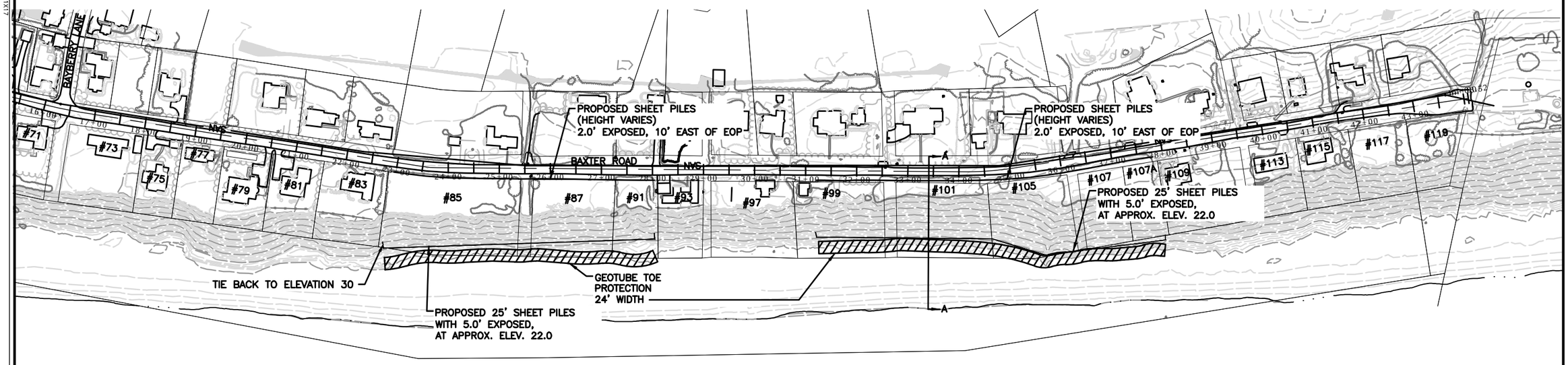

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REVISIONS

PLAN VIEW - SLOPE STABILIZATION ALTERNATIVES

BAXTER ROAD
SLOPE STABILIZATION

NANTUCKET, MASSACHUSETTS

FOR CONSTRUCTION

RSD	SMW	--
DESIGNED	DRAWN	CHECKED

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DATE: OCT. 1, 2013

PROJECT NO.: 2967-11

SHEET NO.: 2 OF 6

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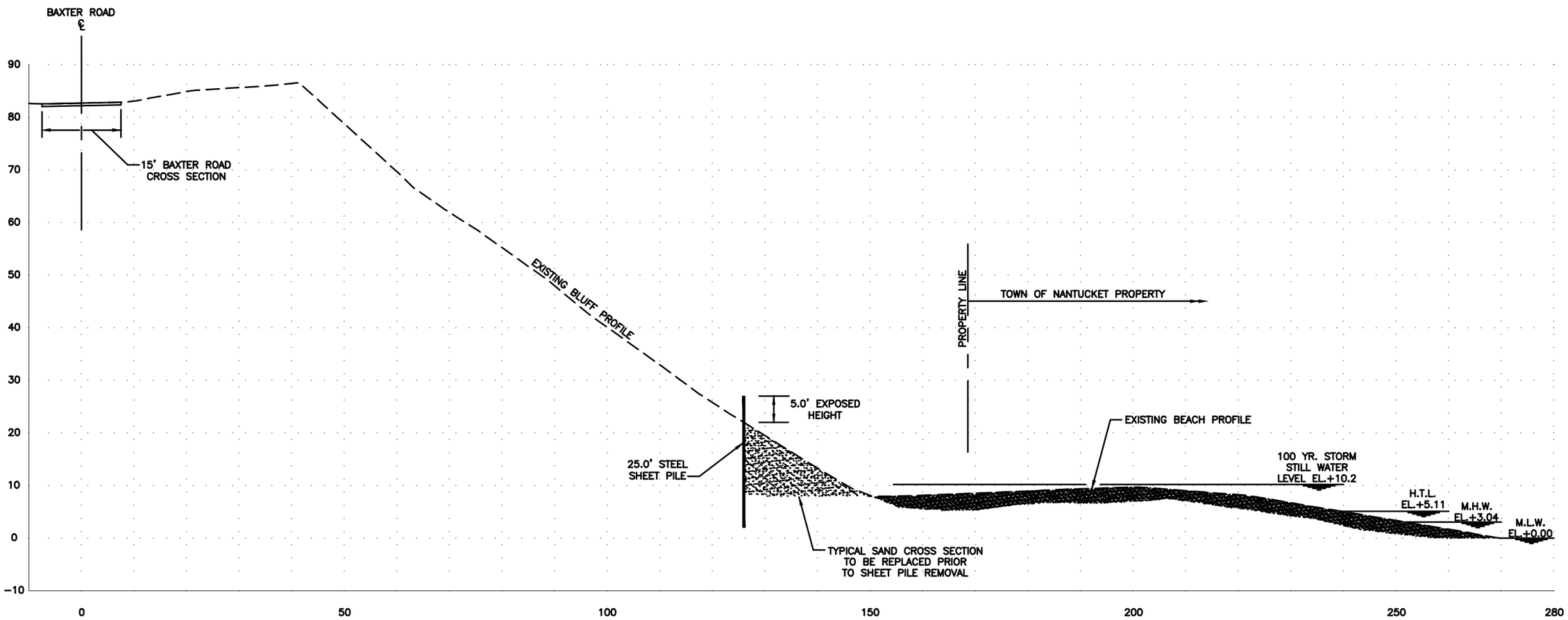

SECTION A–A: ALTERNATIVE 1

STABILIZATION ALTERNATIVE	DESCRIPTION	ALTERNATIVE ADVANTAGES	ALTERNATIVE DISADVANTAGES	APPROXIMATE CONSTRUCTION ESTIMATE	APPROXIMATE CONSTRUCTION DURATION
ALTERNATIVE #1 STEEL SHEET PILES	SHEET PILES DRIVEN AT TOE OF SLOPE, AT APPROXIMATE ELEVATION 22.0. PILES TO BE 25.0' LONG WITH 5.0' LEFT EXPOSED	SHEETING PROVIDES SOLID PROTECTION FROM UNDERMINING AND EROSION OF TOE THROUGH WAVE ACTION DURING STORMS. PILES INSTALLED IN SAND LENS AT TOE OF SLOPE MORE EASILY INSTALLED. SOIL COMPOSITION REQUIRES LESS IMPACT OR VIBRATION TO REACH DESIRED INSTALLATION DEPTH. INSTALLATION FROM BEACH PROVIDES RESULTS IN FEWER DISRUPTIONS TO BAXTER ROAD VEHICLE TRAFFIC AND LOCAL RESIDENTS.	STEEL SHEETING IS A FORM OF HARD ARMORING EROSION PROTECTION. WAVE REFLECTION MAY BECOME A CONCERN IF THE SAND IN FRONT OF THE SHEETING ERODES. ANY SAND WHICH ERODES FROM IN FRONT OF THE SHEETING WILL NEED TO BE REPLENISHED PRIOR TO REMOVAL OF SHEETING. SAND MAY NEED TO BE REPLENISHED EACH SPRING. CRANE AND OTHER EQUIPMENT WILL REQUIRE ADDITIONAL MOBILIZATION TO REMOVE PILES. MATERIAL/EQUIPMENT WILL NEED TO BE BARGED TO SHORE. DANGER OF FLANKING AT ENDS.	SHEET PILE ESTIMATE APPROXIMATE TOTAL SHEET PILE WALL LENGTH = 1,270 FT TYPICAL DRIVEN DEPTH = 25.0 FT UNIT PRICE = $50/SF INSTALLED SHEETING COST = $1,587,500 SAND REPLENISHMENT ESTIMATE TOTAL REPLENISHMENT VOLUME = 6,600 CY UNIT PRICE = $50/CY SAND REPLENISHMENT COST = $330,000 (PER APPLICATION) TOTAL ESTIMATED COST = $1,917,500	ESTIMATED DAILY OUTPUT = 1000 SF PER 8 HOUR DAY TOTAL BURIED SHEETING SQUARE FOOTAGE = 28,575 SF ESTIMATED CONSTRUCTION DURATION = 29 WORK DAYS

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TYPICAL CROSS SECTION - SLOPE STABILIZATION - ALT. 1

BAXTER ROAD
SLOPE STABILIZATION

NANTUCKET, MASSACHUSETTS

RSD	SMW	--
DESIGNED	DRAWN	CHECKED

SCALE: 1" = 20'

DATE: OCT. 1, 2013

PROJECT NO.: 2967-11

SHEET NO.: 3 OF 6

SHEET NAME: ALT 1

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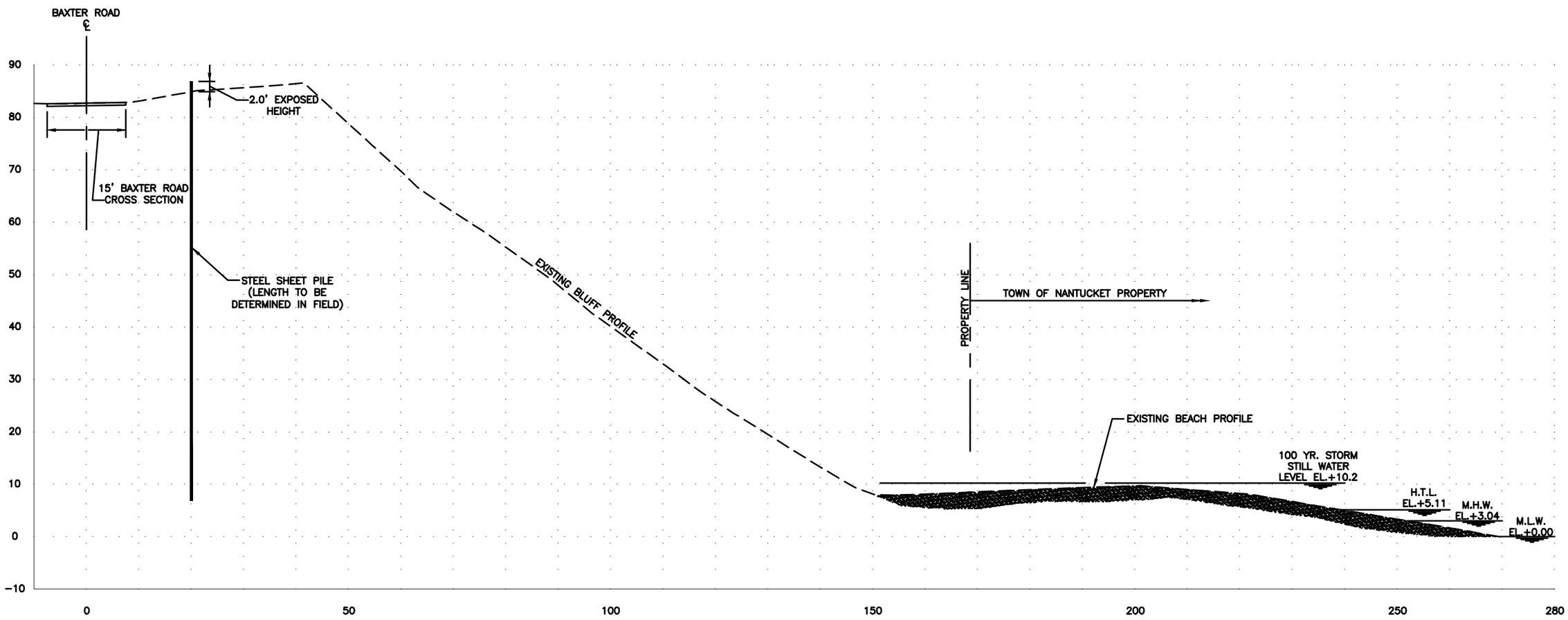

SECTION A–A: ALTERNATIVE 2

STABILIZATION ALTERNATIVE	DESCRIPTION	ALTERNATIVE ADVANTAGES	ALTERNATIVE DISADVANTAGES	APPROXIMATE CONSTRUCTION ESTIMATE	APPROXIMATE CONSTRUCTION DURATION
ALTERNATIVE #2 STEEL SHEET PILES	SHEET PILES DRIVEN AT THE TOP OF SCONSET BLUFF, APPROXIMATELY 10' EAST OF THE EASTERN EDGE OF BAXTER ROAD.	SHEETING CAN BE INSTALLED FROM THE TOP OF THE BLUFF, ELIMINATING THE NEED TO BARGE EQUIPMENT ONTO THE BEACH. SHEETING SHOULD PREVENT SUDDEN CATASTROPHIC COLLAPSE OF BAXTER ROAD AND EXISTING UTILITIES SHOULD THE BLUFF ERODE AND RETREAT TOWARDS THE ROADWAY.	TO PREVENT GLOBAL FAILURE OF THE SLOPE PILES WILL NEED TO HAVE A LENGTH OF 80 FT OR MORE. INSTALLATION IS IN CLOSE PROXIMITY TO RESIDENCES. DUE TO THE DENSE SOIL COMPOSITION AT THE TOP OF THE BLUFF THE SHEET PILES WILL NEED TO BE HAMMERED INTO THE GROUND. THIS INSTALLATION TECHNIQUE WILL BE DISRUPTIVE TO RESIDENTS. DRIVING OF PILES IN CLOSE PROXIMITY TO EXISTING WATER MAIN ALONG BAXTER ROAD COULD CREATE UNSEEN DAMAGE AND/OR LEAKS. SHEET PILE INSTALLATION AT TOP OF BLUFF DOES NOT PREVENT/RETARD EROSION AT THE TOE OF THE SLOPE. IF THE SLOPE FAILS UP TO THE SHEET PILES FUTURE REMOVAL MAY BECOME DIFFICULT/IMPOSSIBLE. CRANE WILL NEED TO BE INSTALLED WITHIN BAXTER ROAD, BLOCKING ACCESS TO AREAS TO THE NORTH.	SHEET PILE ESTIMATE APPROXIMATE TOTAL SHEET PILE WALL LENGTH = 1,160 FT TYPICAL DRIVEN DEPTH = 80 FT UNIT PRICE = $50/SF INSTALLED SHEETING COST = $4,640,000 TOTAL ESTIMATED COST = $4,640,000	ESTIMATED DAILY OUTPUT = 750 SF PER 8 HOUR DAY TOTAL BURIED SHEETING SQUARE FOOTAGE = 92,800 SF ESTIMATED CONSTRUCTION DURATION = 124 WORK DAYS

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TYPICAL CROSS SECTION - SLOPE STABILIZATION - ALT. 2

BAXTER ROAD
SLOPE STABILIZATION

NANTUCKET, MASSACHUSETTS

RSD	SMW	--
DESIGNED	DRAWN	CHECKED

SCALE: 1" = 20'

DATE: OCT. 1, 2013

PROJECT NO.: 2967-11

SHEET NO.: 4 OF 6

SHEET NAME: ALT 2

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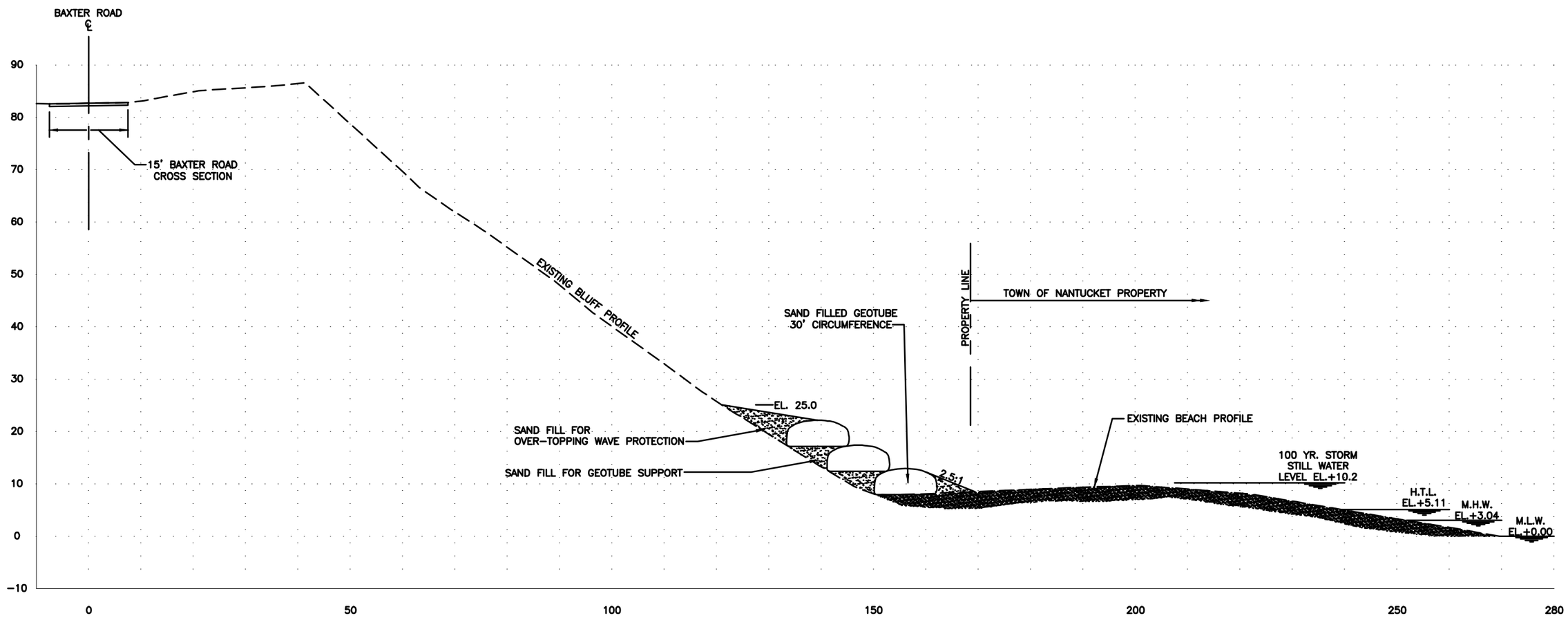

SECTION A–A: ALTERNATIVE 3

STABILIZATION ALTERNATIVE	DESCRIPTION	ALTERNATIVE ADVANTAGES	ALTERNATIVE DISADVANTAGES	APPROXIMATE CONSTRUCTION ESTIMATE	APPROXIMATE CONSTRUCTION DURATION
ALTERNATIVE #3 SAND–FILLED GEOTUBES	LARGE GEOTEXTILE TUBE FILLED WITH SAND. INSTALLED AT TOE OF SLOPE TO PROTECT AGAINST UNDERMINING OF SAND TOE.	INSTALLATION MATERIAL (OTHER THAN GEOTUBE) IS AVAILABLE ON ISLAND. INSTALLATION CAN BE COMPLETED WITH A RELATIVELY SMALL WORK CREW IN A VERY SHORT TIMEFRAME IN A COST–EFFECTIVE MANNER. TOE SCOUR IS PREVENTED BY THE ADDITION OF A GEOTEXTILE FABRIC WING WHICH IS PART OF THE GEOTUBE SYSTEM. REMOVAL OF GEOTUBE AT COMPLETION OF TEMPORARY STABILIZATION REQUIRES ONLY THE REMOVAL OF GEOTEXTILE FABRIC. SAND FILLING COULD REMAIN ON BEACH, IF DESIRED, WHICH COULD BE USED FOR FUTURE REPLENISHMENT.	GEOTEXTILE FABRIC COULD BE TORN BY LARGE DEBRIS CONTAINED WITHIN STORM WAVES. SAND BACKFILL MAY NEED TO BE REPLENISHED AFTER EACH STORM SEASON. SAND DELIVERY SYSTEM AT TOP OF BLUFF (CRANE W/HOPPER, CONVEYOR BELT, ETC.) COULD BE DISRUPTIVE TO RESIDENTS. DANGER OF FLANKING AT ENDS OF GEOTUBE.	GEOTUBE ESTIMATE APPROXIMATE TOTAL GEOTUBE LENGTH = 1,220 FT UNIT PRICE = $560/LF INSTALLED GEOTUBE COST = $683,200 SAND BACKFILL ESTIMATE TOTAL BACKFILL VOLUME = 4,300 CY UNIT PRICE = $50/CY SAND BACKFILL COST = $215,000 TOTAL ESTIMATED COST = $898,200	ESTIMATED DAILY OUTPUT = 150 FT PER 8 HOUR DAY APPROXIMATE TOTAL GEOTUBE LENGTH = 1,220 SF ESTIMATED CONSTRUCTION DURATION = 9 WORK DAYS

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TYPICAL CROSS SECTION - SLOPE STABILIZATION - ALT. 3

BAXTER ROAD
SLOPE STABILIZATION

NANTUCKET, MASSACHUSETTS

RSD	SMW	--
DESIGNED	DRAWN	CHECKED

SCALE: 1" = 20'

DATE: OCT. 1, 2013

PROJECT NO.: 2967-11

SHEET NO.: 5 OF 6

SHEET NAME: ALT 3

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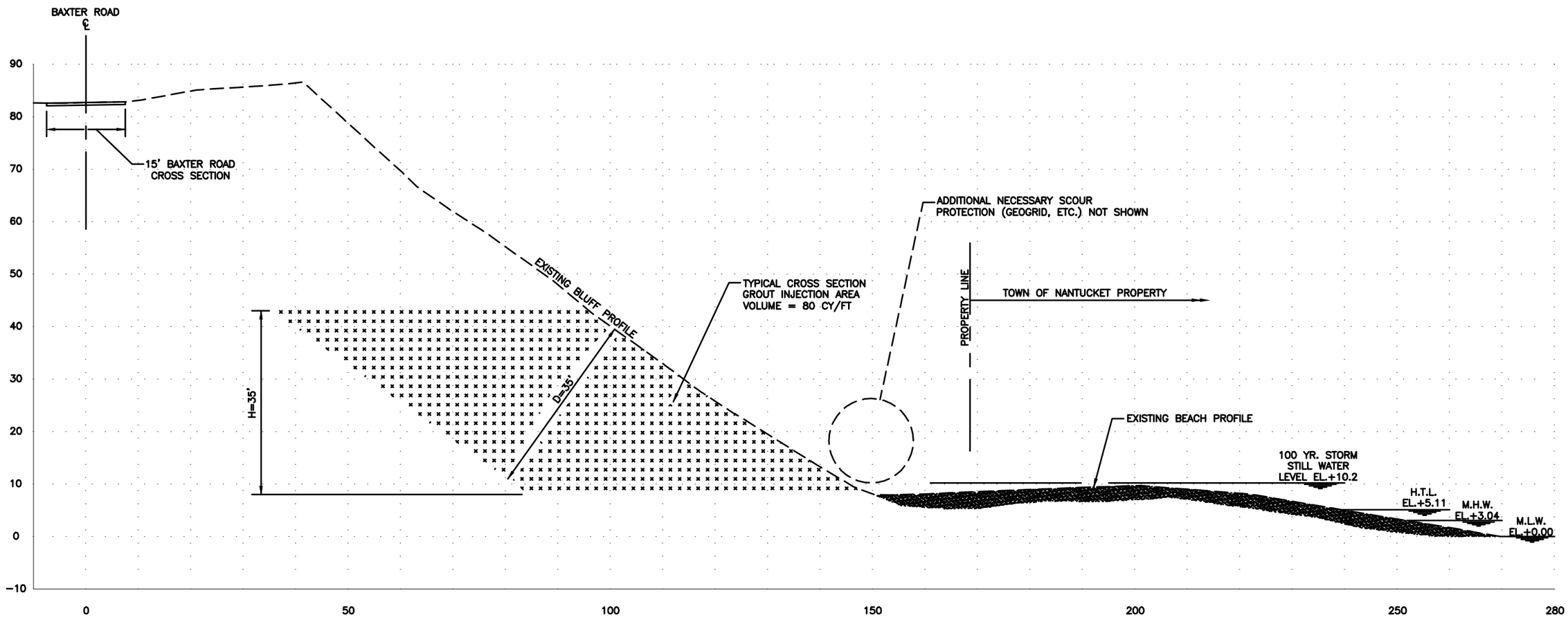

SECTION A–A: ALTERNATIVE 4

STABILIZATION ALTERNATIVE	DESCRIPTION	ALTERNATIVE ADVANTAGES	ALTERNATIVE DISADVANTAGES	APPROXIMATE CONSTRUCTION ESTIMATE	APPROXIMATE CONSTRUCTION DURATION
ALTERNATIVE #4 GROUT INJECTION	SHAFTS ARE DRILLED INTO THE SLOPE FROM THE TOE UPWARD, FOLLOWED BY PRESSURE INJECTION OF GROUT WHICH HARDENS/STRENGHTENS THE WEAK SAND AT THE BASE OF THE SLOPE.	WEAK SAND LAYER AT BASE OF BLUFF IS HARDENED, INCREASING ITS RESISTANCE TO EROSION DUE TO STORM WAVE ACTION. GROUTING CAN BE COMPLETED FROM THE BEACH, ELIMINATING POTENTIAL IMPACTS TO RESIDENTS. GROUT COMPOSITION DOES NOT CHANGE THE APPEARANCE OF SAND. GROUTED SECTION SHOULD NOT REQUIRE ANY MAINTENANCE.	TO ADEQUATELY STRENGTHEN THE SLOPE, GROUTING WOULD BE REQUIRED OVER A RELATIVELY LARGE AREA (35 FT HEIGHT X 35 FT DEPTH). SOIL GROUTING NEEDS TO BE USED IN TANDEM WITH ADDITIONAL SLOPE STABILIZATION TO PROTECT AGAINST WAVE SCOUR (E.G. GEOTUBE). MATERIAL/EQUIPMENT WILL NEED TO BE BARGED ONTO THE BEACH FOR INSTALLATION. GROUT COMPOSITION NEEDS TO BE CUSTOMIZED BASED ON EXISTING SOIL CONDITIONS, INCREASING LEAD TIME. ESTIMATED CONSTRUCTION DURATION IS EXCESSIVE BASED ON PROJECT NEEDS.	GROUT INJECTION ESTIMATE APPROXIMATE GROUT CROSS SECTIONAL VOLUME = 80 CY/FT TOTAL GROUTED SLOPE LENGTH = 1,220 FT UNIT PRICE = $375/CY INSTALLED GROUTING COST = $36,600,000 GEOTUBE ESTIMATE INSTALLED GEOTUBE COST (FROM ABOVE) = $845,950 TOTAL ESTIMATED COST = $37,445,950	ESTIMATED DAILY OUTPUT = 500 CY PER 8 HOUR DAY TOTAL GROUTED VOLUME = 97,600 CY ESTIMATED CONSTRUCTION DURATION = 196 WORK DAYS

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REVISIONS

TYPICAL CROSS SECTION - SLOPE STABILIZATION - ALT. 4

BAXTER ROAD
SLOPE STABILIZATION

NANTUCKET, MASSACHUSETTS

RSD	SMW	--
DESIGNED	DRAWN	CHECKED

SCALE: 1" = 20'

DATE: OCT. 1, 2013

PROJECT NO.: 2967-11

SHEET NO.: 6 OF 6

SHEET NAME: ALT 4

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Drawing: F:\SDSKPRO\2967-11-DE\CAD\ALTERNATIVES-TYPICAL SECTIONS-11X17.DWG Layout: TabOPTION4 (5)
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