RevWind Exhibit 1(A)(i)

Project Site Plans

Appendix A:
Project Site Plans

Onshore Substation Plans

Revolution Wind, LLC
EFSB Docket No. ____
In Re: Application of Revolution Wind, LLC for
License to Construct and Alter Major Energy Facilities
(Revolution Wind Project)

CONFIDENTIAL INFORMATION

Appendix A Proposed Revolution Wind Onshore Substation Plan Sheet C-2.00 is Layout and Materials Plan. It contains confidential Critical Energy Infrastructure Information. Revolution Wind has requested protective treatment of this confidential document in its entirety.

Revolution Wind, LLC
EFSB Docket No. ____
In Re: Application of Revolution Wind, LLC for
License to Construct and Alter Major Energy Facilities
(Revolution Wind Project)

<u>CONFIDENTIAL INFORMATION</u>

Appendix A Proposed Revolution Wind Onshore Substation Plan Sheet C-3.00 is Grading, Drainage and Utility Plan 1. It contains confidential Critical Energy Infrastructure Information. Revolution Wind has requested protective treatment of this confidential document in its entirety.

Interconnection Facility Plans

CONFIDENTIAL INFORMATION

Appendix A Proposed Revolution Wind Interconnection Facility Plan Sheet C-2.00 is Layout, Materials and Utilities Plan. It contains confidential Critical Energy Infrastructure Information. Revolution Wind has requested protective treatment of this confidential document in its entirety.

CONFIDENTIAL INFORMATION

Appendix A Proposed Revolution Wind Interconnection Facility Plan Sheet C-3.00 is Grading and Drainage Plan. It contains confidential Critical Energy Infrastructure Information. Revolution Wind has requested protective treatment of this confidential document in its entirety.

Onshore Transmission Cable Plans

EVERSOURCE
ENERGY

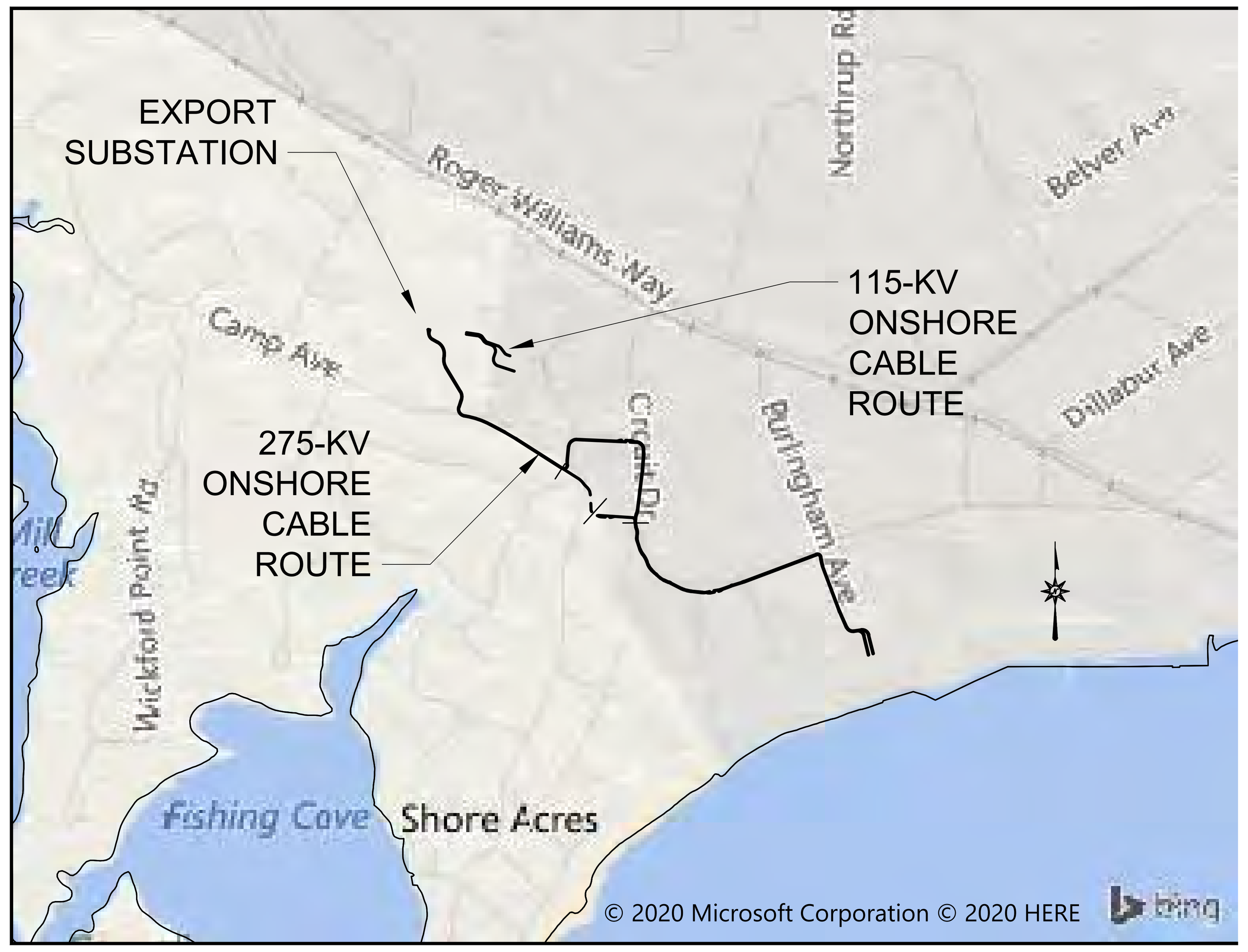
Revolution Wind | Powered by Ørsted & Eversource

275-KV AND 115-KV TRANSMISSION LINE ONSHORE CABLE ROUTE

Underground Transmission Line Construction Contract Drawings

DECEMBER 02, 2020

126851



VICINITY MAP
N.T.S.

NO.	DATE	BY	CKD	APP	DESCRIPTION
A	12/02/20	JCB	MD	NS	ISSUED FOR REVIEW–70%

BURNS McDONNELL
9400 WARD PARKWAY
KANSAS CITY, MO 64114
816-333-9400
LICENSEE NO. 000165

PRELIMINARY - NOT FOR CONSTRUCTION

ISSUED FOR REVIEW-70%

ES VER: 05/2015

DRAWING LIST TABLE	
DRAWING NUMBER	DRAWING TITLE
PG-01	COVER SHEET
PG-02	GENERAL NOTES
PG-03	KEY MAP
PG-04	275-kV ONSHORE CABLE DOUBLE CIRCUIT PLAN AND PROFILE
PG-05	275-kV ONSHORE CABLE DOUBLE CIRCUIT PLAN AND PROFILE
PG-06	275-kV ONSHORE CABLE DOUBLE CIRCUIT PLAN AND PROFILE
PG-07	275-kV ONSHORE CABLE DOUBLE CIRCUIT PLAN AND PROFILE
PG-08	275-kV ONSHORE CABLE DOUBLE CIRCUIT PLAN AND PROFILE
PG-09	275-kV ONSHORE CABLE DOUBLE CIRCUIT PLAN AND PROFILE
PG-10	275-kV ONSHORE CABLE DOUBLE CIRCUIT PLAN AND PROFILE
PG-11	275-kV ONSHORE CABLE DOUBLE CIRCUIT PLAN AND PROFILE
PG-12	275-kV ONSHORE CABLE DOUBLE CIRCUIT PLAN AND PROFILE
PG-13	275-kV ONSHORE CABLE DOUBLE CIRCUIT PLAN AND PROFILE
PG-14	275-kV ONSHORE CABLE DOUBLE CIRCUIT PLAN AND PROFILE
PG-15	275-kV ONSHORE CABLE DOUBLE CIRCUIT PLAN AND PROFILE
PG-16	275-kV ONSHORE CABLE DOUBLE CIRCUIT PLAN AND PROFILE
PG-17	275-kV ONSHORE CABLE DOUBLE CIRCUIT PLAN AND PROFILE
PG-18	115-kV ONSHORE CABLE DOUBLE CIRCUIT PLAN AND PROFILE
PG-19	115-kV ONSHORE CABLE DOUBLE CIRCUIT PLAN AND PROFILE
PG-20	ONSHORE CABLE DUCT BANK CROSS SECTION DETAILS
PG-21	INTERCONNECT DUCT BANK CROSS SECTION DETAILS
PG-22	DUCT BANK SECTIONS
PG-23	SPLICE VAULT DETAILS
PG-24	SPLICE VAULT DETAILS
PG-25	TRANSITION JOINT BAY DETAILS
PG-26	HANDHOLE DETAILS
PG-27	EXPORT RISER STRUCTURE DETAILS
PG-28	INTERCONNECT RISER STRUCTURE DETAILS
PG-29	EXPORT CABLE BONDING DIAGRAMS
PG-30	INTERCONNECT CABLE BONDING DIAGRAMS
PG-31	TYPICAL EROSION CONTROL DRAWINGS
PG-32	EROSION CONTROL NOTES

Legend

- DRAIN MANHOLE
- CATCH BASIN
- SEWER MANHOLE
- ELECTRIC MANHOLE
- TELEPHONE MANHOLE
- MANHOLE
- HH HAND HOLE
- WATER GATE
- FIRE HYDRANT
- GAS GATE
- BOLLARD w/LIGHT
- STREET SIGN
- LIGHT POLE
- UTILITY POLE
- GUY POLE
- GUY WIRE
- MONITORING WELL
- FLOOD LIGHT
- WELL
- MARSH
- F.F.E.=45.27' FINISHED FLOOR ELEVATION
- CNO COULD NOT OPEN
- NPV NO PIPES VISIBLE
- DYL DOUBLE YELLOW LINE
- DWL DASHED WHITE LINE
- SYL SINGLE YELLOW LINE
- LSA LANDSCAPED AREA
- EOP EDGE OF PAVEMENT
- CC CONCRETE CURB
- VGC VERTICAL GRANITE CURB
- SGE SLOPED GRANITE EDGE
- BB BITUMINOUS BERM
- BC BITUMINOUS CURB
- GUARD RAIL
- CHAIN LINK FENCE
- DRAINAGE LINE
- SEWER LINE
- OHW OVERHEAD WIRE
- E UNDERGROUND ELECTRIC
- T TELEPHONE LINE
- G GAS LINE
- W WATER LINE
- STONE WALL
- TREE LINE

CURVE TABLE							
CURVE NO.	RADIUS	CURVE LENGTH	TANGENT LENGTH	DEFLECTION ANGLE	POINT OF INTERSECTION	POINT OF CURVATURE	POINT OF TANGENCY
C1	50'	47.12'	25.48'	S34° 09' 03.39"E	N 185,526.47, E 344,924.49	N 185,551.75, E 344,921.32	N 185,514.18, E 344,946.81
C2	100'	120.85'	69.04'	S26° 31' 47.92"E	N 185,459.80, E 345,045.52	N 185,493.11, E 344,985.05	N 185,391.45, E 345,035.81
C3	100'	68.50'	35.65'	S11° 31' 58.44"E	N 185,336.70, E 345,028.03	N 185,372.00, E 345,033.04	N 185,306.19, E 345,046.47
C4	75'	64.92'	34.65'	S06° 21' 34.04"E	N 185,093.88, E 345,174.83	N 185,123.53, E 345,156.90	N 185,061.01, E 345,163.87
C5	50'	86.00'	58.07'	S30° 50' 03.02"E	N 184,951.91, E 345,127.50	N 185,007.01, E 345,145.87	N 184,941.94, E 345,184.71
C6	600'	190.23'	95.92'	S71° 01' 23.28"E	N 184,922.95, E 345,293.57	N 184,939.43, E 345,199.08	N 184,877.83, E 345,378.21
C7	200'	7.81'	3.91'	S60° 49' 16.75"E	N 184,819.16, E 345,488.27	N 184,821.00, E 345,484.82	N 184,817.19, E 345,491.64
C8	200'	7.92'	3.96'	S58° 34' 01.95"E	N 184,770.26, E 345,571.96	N 184,772.26, E 345,568.54	N 184,768.13, E 345,575.30
C9	25'	54.16'	47.15'	N60° 30' 01.73"E	N 184,524.23, E 345,957.16	N 184,549.61, E 345,917.42	N 184,571.36, E 345,955.87
C10	100'	12.34'	6.18'	N01° 58' 09.53"E	N 184,602.93, E 345,955.00	N 184,596.75, E 345,955.17	N 184,609.08, E 345,955.60
C11	50'	39.44'	20.81'	N28° 06' 20.05"E	N 184,734.65, E 345,967.70	N 184,713.94, E 345,965.70	N 184,747.83, E 345,983.81
C12	50'	36.50'	19.11'	N71° 37' 11.69"E	N 184,765.38, E 346,005.25	N 184,753.28, E 345,990.46	N 184,764.54, E 346,024.34
C13	50'	20.26'	10.27'	N80° 55' 43.22"E	N 184,750.94, E 346,331.44	N 184,751.40, E 346,321.19	N 184,754.57, E 346,341.05
C14	50'	20.26'	10.27'	N80° 55' 43.22"E	N 184,759.01, E 346,352.81	N 184,755.38, E 346,343.20	N 184,758.55, E 346,363.07
C15	50'	20.46'	10.37'	S75° 44' 37.20"E	N 184,755.27, E 346,437.20	N 184,755.73, E 346,426.83	N 184,750.73, E 346,446.53
C16	50'	20.46'	10.37'	S75° 44' 37.20"E	N 184,745.36, E 346,457.53	N 184,749.91, E 346,448.21	N 184,744.90, E 346,467.90
C17	50'	34.96'	18.23'	S67° 26' 08.94"E	N 184,743.81, E 346,492.74	N 184,744.61, E 346,474.53	N 184,731.47, E 346,506.16
C18	50'	39.27'	20.71'	S24° 54' 20.67"E	N 184,713.41, E 346,525.79	N 184,727.43, E 346,510.55	N 184,692.72, E 346,526.66
C19	200'	24.55'	12.29'	S01° 06' 40.54"W	N 184,652.02, E 346,528.37	N 184,664.30, E 346,527.86	N 184,639.76, E 346,527.38
C20	100'	4.18'	2.09'	S05° 49' 30.04"W	N 184,525.43, E 346,518.12	N 184,527.52, E 346,518.29	N 184,523.36, E 346,517.87
C21	100'	28.61'	14.40'	S15° 13' 06.27"W	N 184,222.15, E 346,480.77	N 184,236.45, E 346,482.53	N 184,208.94, E 346,475.05
C22	100'	40.87'	20.72'	S11° 42' 27.11"W	N 184,186.61, E 346,465.38	N 184,205.62, E 346,473.61	N 184,165.88, E 346,465.38
C23	100'	30.90'	15.57'	S08° 51' 03.12"E	N 184,123.62, E 346,465.38	N 184,139.19, E 346,465.38	N 184,108.79, E 346,470.11
C24	100'	39.33'	19.92'	S06° 26' 01.94"E	N 184,075.18, E 346,480.84	N 184,094.16, E 346,474.78	N 184,055.33, E 346,479.16
C25	50'	20.07'	10.17'	S06° 39' 57.05"E	N 184,016.37, E 346,475.86	N 184,026.50, E 346,476.72	N 184,006.70, E 346,479.03
C26	100'	36.32'	18.36'	S28° 34' 18.62"E	N 183,921.92, E 346,506.85	N 183,939.37, E 346,501.13	N 183,907.64, E 346,518.40
C27	200'	64.67'	32.62'	S29° 42' 50.50"E	N 183,879.62, E 346,541.08	N 183,904.98, E 346,520.56	N 183,849.05, E 346,552.48
C28	100'	45.54'	23.17'	S33° 29' 46.07"E	N 183,804.09, E 346,569.24	N 183,825.80, E 346,561.15	N 183,788.15, E 346,586.06
C29	100'	11.54'	5.78'	S43° 14' 09.93"E	N 183,753.12, E 346,623.03	N 183,757.09, E 346,618.84	N 183,748.69, E 346,626.74

CURVE TABLE							
CURVE NO.	RADIUS	CURVE LENGTH	TANGENT LENGTH	DEFLECTION ANGLE	POINT OF INTERSECTION	POINT OF CURVATURE	POINT OF TANGENCY
C30	100'	33.15'	16.73'	S49° 25' 40.48"E	N 183,735.35, E 346,637.91	N 183,748.18, E 346,627.17	N 183,726.71, E 346,652.24
C31	100'	21.06'	10.57'	S64° 57' 31.76"E	N 183,704.33, E 346,689.38	N 183,709.79, E 346,680.33	N 183,700.89, E 346,699.37
C32	100'	14.68'	7.35'	S66° 47' 07.31"E	N 183,692.87, E 346,722.64	N 183,695.27, E 346,715.68	N 183,689.49, E 346,729.17
C33	100'	22.18'	11.14'	S68° 56' 01.55"E	N 183,642.14, E 346,820.42	N 183,647.27, E 346,810.54	N 183,639.31, E 346,831.19
C34	200'	30.02'	15.04'	S79° 35' 16.83"E	N 183,629.64, E 346,868.03	N 183,633.46, E 346,853.49	N 183,628.04, E 346,882.98
C35	100'	29.43'	14.82'	N87° 40' 51.57"E	N 183,617.48, E 346,981.54	N 183,619.06, E 346,966.80	N 183,620.25, E 346,996.11
C36	200'	32.42'	16.25'	N74° 36' 20.60"E	N 183,642.12, E 347,111.29	N 183,639.09, E 347,095.33	N 183,647.69, E 347,126.55
C37	200'	9.87'	4.94'	N71° 22' 32.72"E	N 183,670.02, E 347,187.78	N 183,668.33, E 347,183.15	N 183,671.48, E 347,192.50
C38	200'	11.97'	5.99'	N71° 04' 28.35"E	N 183,696.45, E 347,273.11	N 183,694.68, E 347,267.39	N 183,698.56, E 347,278.72
C39	25'	45.64'	32.34'	S58° 20' 46.48"E	N 183,913.70, E 347,849.88	N 183,902.30, E 347,819.61	N 183,881.55, E 347,853.29
C40	200'	50.41'	25.34'	S13° 16' 21.11"E	N 183,840.05, E 347,857.69	N 183,865.25, E 347,855.01	N 183,816.32, E 347,866.56
C41	200'	13.23'	6.62'	S22° 23' 14.47"E	N 183,477.52, E 347,993.18	N 183,483.71, E 347,990.87	N 183,471.49, E 347,995.90
C42	50'	64.51'	37.62'	S61° 14' 34.98"E	N 183,323.49, E 348,062.67	N 183,357.79, E 348,047.20	N 183,328.86, E 348,099.91
C43	50'	73.35'	45.07'	S56° 10' 32.16"E	N 183,343.35, E 348,200.42	N 183,336.92, E 348,155.82	N 183,299.65, E 348,211.44
C45	100'	43.30'	21.99'	S45° 01' 42.99"E	N 184,455.32, E 346,065.04	N 184,467.16, E 346,046.50	N 184,436.80, E 346,076.89
C46	50'	13.68'	6.88'	S40° 27' 44.57"E	N 184,427.92, E 346,082.57	N 184,433.72, E 346,078.86	N 184,423.34, E 346,087.71
C47	100'	80.62'	42.65'	S25° 12' 13.90"E	N 184,386.90, E 346,128.62	N 184,415.26, E 346,096.78	N 184,344.28, E 346,130.19
C48	50'	73.53'	45.23'	S44° 14' 21.26"E	N 184,199.39, E 346,135.52	N 184,244.59, E 346,133.86	N 184,196.53, E 346,180.66
C49	25'	37.69'	23.46'	S43° 11' 06.99"E	N 184,178.47, E 346,465.38	N 184,179.95, E 346,441.96	N 184,155.00, E 346,465.38
C50	50'	39.95'	21.11'	S59° 00' 52.40"E	N 185,548.36, E 345,309.97	N 185,551.34, E 345,289.06	N 185,531.31, E 345,322.41
C51	50'	30.86'	15.94'	S53° 48' 14.90"E	N 185,495.58, E 345,348.49	N 185,508.46, E 345,339.09	N 185,490.52, E 345,363.60
C52	50'	30.19'	15.57'	S54° 11' 10.07"E	N 185,461.76, E 345,449.49	N 185,466.70, E 345,434.73	N 185,449.30, E 345,458.84
C53	50'	30.22'	15.59'	S54° 12' 02.82"E	N 185,402.85, E 345,493.70	N 185,415.31, E 345,484.35	N 185,397.91, E 345,508.48
C54	50'	39.88'	21.07'	S58° 58' 23.84"E	N 185,537.55, E 345,305.48	N 185,540.54, E 345,284.63	N 185,520.53, E 345,317.90
C55	50'	30.86'	15.94'	S53° 48' 14.90"E	N 185,487.11, E 345,342.29	N 185,499.99, E 345,332.89	N 185,482.05, E 345,357.40
C56	50'	79.01'	50.47'	S26° 12' 59.22"E	N 185,456.64, E 345,433.28	N 185,472.67, E 345,385.42	N 185,408.94, E 345,416.80
C57	50'	79.03'	50.50'	S26° 13' 51.98"E	N 185,332.47, E 345,390.40	N 185,380.20, E 345,406.88	N 185,316.46, E 345,438.29
C58	50'	73.62'	45.30'	S56° 01' 33.01"E	N 183,338.26, E 348,165.09	N 183,331.79, E 348,120.25	N 183,294.27, E 348,175.93

GENERAL NOTES:

1. ALL DUCT BANK VERTICAL RADII SHALL BE 200' UNLESS OTHERWISE NOTED. CONTRACTOR SHALL NOT DEVIATE FROM STATED HORIZONTAL OR VERTICAL RADII WITHOUT OWNER APPROVAL
2. DUCT BANK SHALL MAINTAIN A TYPICAL COVER DEPTH OF 3'-0" UNLESS OTHERWISE SHOWN ON DRAWINGS. MAINTAIN 2'-0" TYPICAL VERTICAL CLEARANCE OVER OR UNDER EXISTING UTILITIES AND MAINTAIN 2'-0" TYPICAL HORIZONTAL CLEARANCE FOR ADJACENT EXISTING UTILITIES SHOWN ON DRAWINGS UNLESS OTHERWISE NOTED.
3. STATIONING INDICATED IS AT CENTERLINE OF DUCT BANK SECTIONS.
4. CONTRACTOR SHALL PLUG CONDUIT SYSTEM WHEN WORK IS CEASED IN ACCORDANCE WITH SPECIFICATIONS.
5. CONTRACTOR SHALL PERFORM ALL RESTORATION WORK AS REQUIRED IN ACCORDANCE WITH SPECIFICATIONS.
6. ANY DEVIATIONS FROM THE PROPOSED DUCT BANK ALIGNMENT AS SHOWN ON THE DRAWINGS SHALL REQUIRE APPROVAL FROM ENGINEER.
7. ALL CONSTRUCTION SHALL BE IN ACCORDANCE WITH THE PROJECT SPECIFICATIONS AND CONSTRUCTION DRAWINGS. ALL WORK SHALL BE DONE IN ACCORDANCE WITH ALL APPLICABLE CODES, REGULATIONS AND REQUIREMENTS.
8. THE UTILITIES AND NATURAL FEATURES SHOWN HEREON ARE BASED ON FIELD SURVEYS AND RECORD DOCUMENTS. OTHER FACILITIES MAY EXIST NOT DISCOVERED THROUGH THE RECORD CHECK. SUBCONTRACTOR SHALL VERIFY THE EXACT LOCATION, BOTH HORIZONTAL AND VERTICAL, OF ALL UTILITIES THROUGH THE APPROPRIATE UTILITY COMPANIES. CALL BEFORE YOU DIG.
9. SPLICE VAULT MINIMUM DEPTH OF COVER, AS MEASURED AT ANY POINT OF BURIED SPLICE VAULTS, SHALL BE 3'-0" UNLESS OTHERWISE SHOWN ON DRAWINGS.
10. VAULT LOCATIONS ARE SUBJECT TO ADJUSTMENT DUE TO UNFORESEEN CONDITIONS, AND WILL REQUIRE APPROVAL FROM ENGINEER.
11. NORTHING AND EASTING DESIGNATIONS FOR SPLICE VAULT LOCATIONS ARE REFERENCED TO OUTSIDE CORNERS OF SPLICE VAULT.
12. NORTHING AND EASTING DESIGNATIONS FOR HANDHOLE LOCATIONS ARE REFERENCED TO CENTER OF HANDHOLE.
13. ASSUMED DEPTH OF GRAVITY FACILITIES WHERE INVERT INFORMATION WAS NOT AVAILABLE IS 3'-6".
14. ASSUMED DEPTH OF NON-GRAVITY UTILITIES ARE:
    - WATER: 4'-6"
    - GAS: 3'-0"
    - ELECTRIC: 3'-0"
    - TELECOMMUNICATIONS: 3'-0"

811 Know what's below. Call before you dig.

SURVEY NOTES:

1. THE EXISTING CONDITIONS DEPICTED ON THESE DRAWINGS ARE BASED UPON AN ACTUAL ON-THE-GROUND INSTRUMENT SURVEY PERFORMED BY VHB DURING 2019 AND 2020.
2. THE LOCATIONS OF EXISTING UNDERGROUND UTILITIES DEPICTED ON THESE DRAWINGS ARE BASED ON FIELD OBSERVATIONS AND INFORMATION OF RECORD. THEY ARE NOT WARRANTED TO BE EXACTLY LOCATED NOR IS IT WARRANTED THAT ALL UNDERGROUND UTILITIES OR OTHER STRUCTURES ARE DEPICTED ON THESE DRAWINGS.
3. THE HORIZONTAL AND VERTICAL VALUES DEPICTED ON THESE DRAWINGS ARE BASED ON NAD83 CONNECTICUT STATE PLANE ZONE AND NAVD 1988 DATUMS AND WERE DETERMINED USING RTN GPS SURVEY METHODS.

ISSUED FOR REVIEW-70%

PRELIMINARY - NOT FOR CONSTRUCTION

REVISIONS DURING CONSTRUCTION					

NO.	DATE	AS BUILT REVISIONS	BY	CHK	APP	APP
A	12/02/20	ISSUED FOR REVIEW–70%	JCB	MD	NS	–

Revolution Wind | Powered by Ørsted & Eversource

TITLE REVOLUTION WIND

GENERAL NOTES

NORTH KINGSTOWN, RHODE ISLAND

BY J. BARRINGER–BMcD	CHKD M. DAGENAIS–BMcD	APP N. SCOTT–BMcD	APP
DATE 09/30/20	DATE 09/30/20	DATE 09/30/20	DATE
H-SCALE N.T.S. / V-SCALE N.T.S.	SIZE ARCH D / V.S.	FIELD BOOK & PAGES / R.E.DWG.	
R.E. PROJ. NUMBER		DWG NO. PG-02	

12/1/2020 5:47 PM – jbarringer – \\bmcd\dfs\Clients\TND\NUSC\126851_RevWindEng\Design\Underground\CADD\Working\UG-02 REV_WIND NOTES.dwg – Layout1

ISSUED FOR REVIEW-70%

PRELIMINARY - NOT FOR CONSTRUCTION

REVISIONS DURING CONSTRUCTION

NO.	DATE	AS BUILT REVISIONS	BY	CHK	APP	APP
A	12/02/20	ISSUED FOR REVIEW–70%	JCB	MD	NS	–

Revolution Wind | Powered by Ørsted & Eversource

TITLE
REVOLUTION WIND
ONSHORE CABLE ROUTE
KEY MAP
NORTH KINGSTOWN, RHODE ISLAND

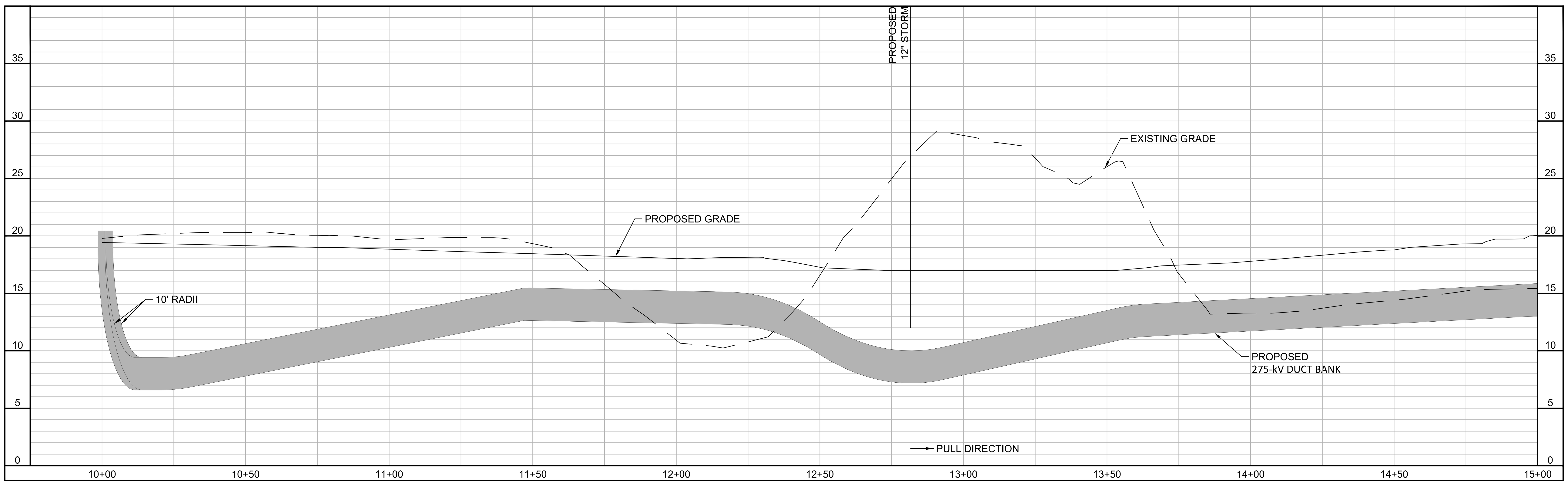
BY J. BARRINGER–BMcD	CHKD M. DAGENAIS–BMcD	APP N. SCOTT–BMcD	APP
DATE 10/5/20	DATE 10/5/20	DATE 10/5/20	DATE
H-SCALE N.T.S.	SIZE ARCH D	FIELD BOOK & PAGES	
V-SCALE N.T.S.	V.S.	R.E.DWG.	
R.E. PROJ. NUMBER		DWG NO. PG-03	

ES VER: 05/2015

12/2/2020 4:59 PM – lnroberts – \\bmcd\dfs\Clients\TND\NUSC\126851_RevWindEng\Design\Underground\CADD\Working\03 KEY MAP.dwg – PG-(03)

\\BMCD\DFS\CLIENTS\TND\NUSC\126851_REVWINDENG\DESIGN\UNDERGROUND\CADD\WORKING\03 KEY MAP.DWG 12/2/2020 4:59 PM LNROBERTS

LANDFALL LOCATION ⟶



ISSUED FOR REVIEW-70%

PRELIMINARY - NOT FOR CONSTRUCTION

NORTH

0 5' 10' VERTICAL SCALE IN FEET

0 10' 20' 40' SCALE IN FEET HORIZONTAL SCALE IN FEET

NOTES:

1. PROPOSED GRADE PER VHB GRADING PLAN DATED 11/02/2020

NO.	DATE	AS BUILT REVISIONS	BY	CHK	APP	APP
A	12/02/20	ISSUED FOR REVIEW-70%	JCB	MD	NS	–

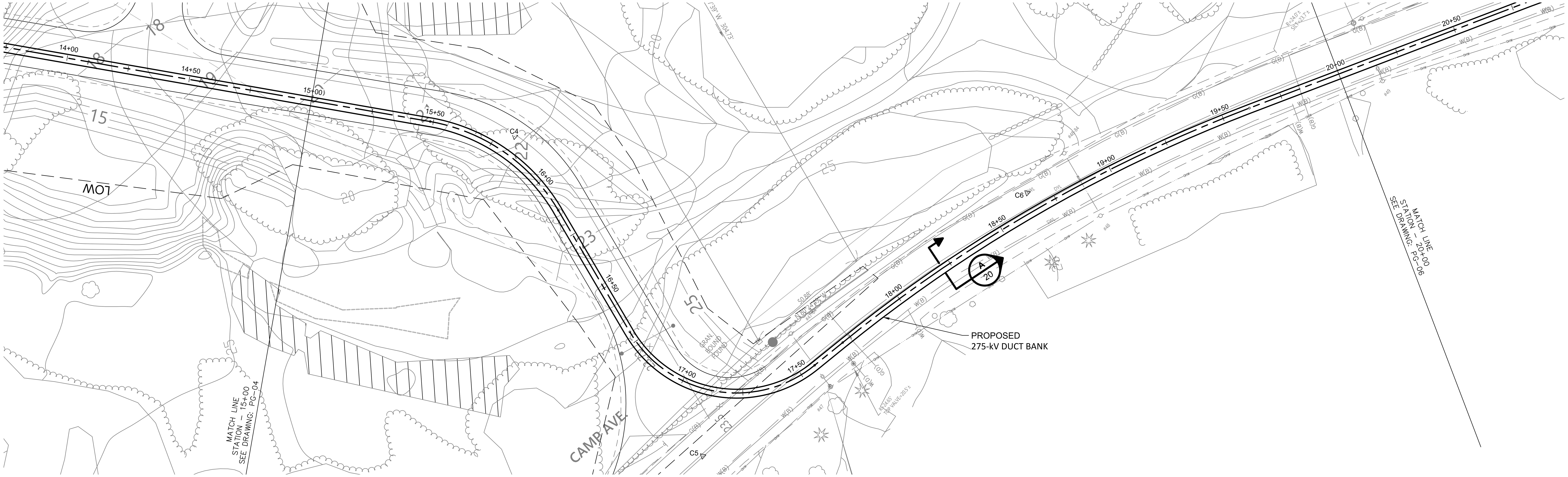
REVISIONS DURING CONSTRUCTION

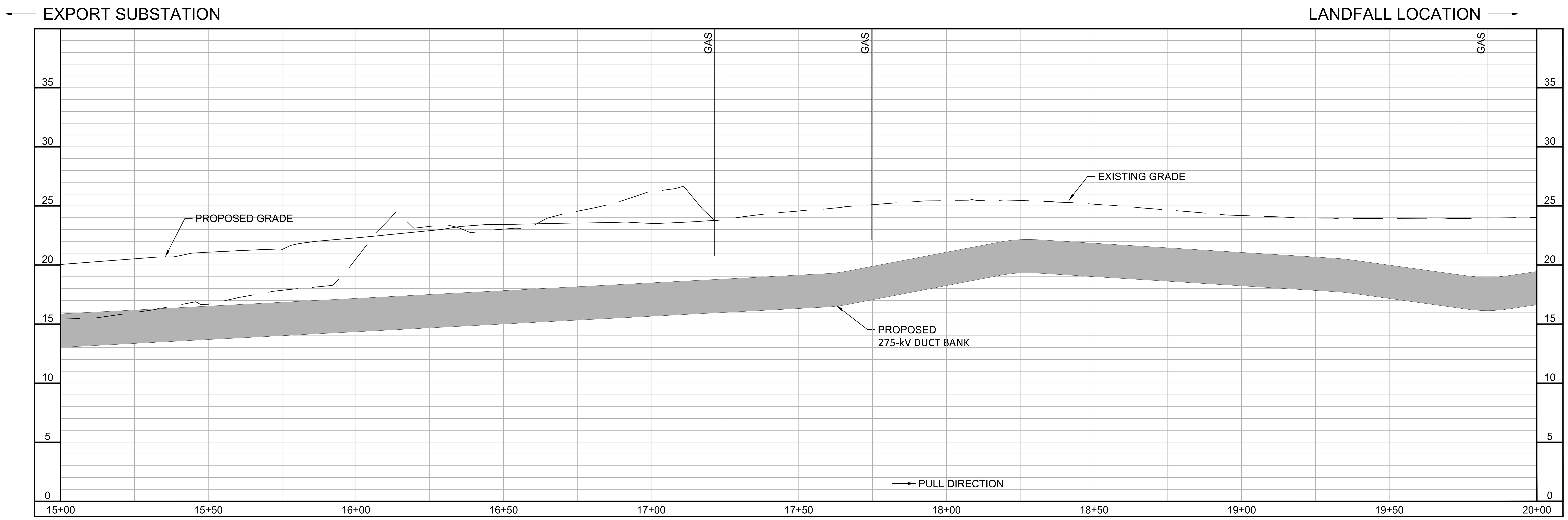
Revolution Wind | Powered by Ørsted & Eversource

TITLE
REVOLUTION WIND
275-kV ONSHORE CABLE DOUBLE CIRCUIT
PLAN AND PROFILE
NORTH KINGSTOWN, RHODE ISLAND

BY J. BARRINGER-BMcD	CHKD M. DAGENAIS-BMcD	APP N. SCOTT-BMcD	APP
DATE 10/5/20	DATE 10/5/20	DATE 10/5/20	DATE
H-SCALE N.T.S.	SIZE ARCH D	FIELD BOOK & PAGES	
V-SCALE N.T.S.	W.S.	R.E.DWG.	
R.E. PROJ. NUMBER		DWG NO. PG-04	

ES VER: 05/2015





NOTES:

1. PROPOSED GRADE PER VHB GRADING PLAN DATED 11/02/2020

ISSUED FOR REVIEW-70%

PRELIMINARY - NOT FOR CONSTRUCTION

NORTH

VERTICAL SCALE IN FEET: 0, 5', 10'

HORIZONTAL SCALE IN FEET: 0, 10', 20', 40'

REVISIONS DURING CONSTRUCTION

NO.	DATE	AS BUILT REVISIONS	BY	CHK	APP	APP
A	12/02/20	ISSUED FOR REVIEW–70%	JCB	MD	NS	–

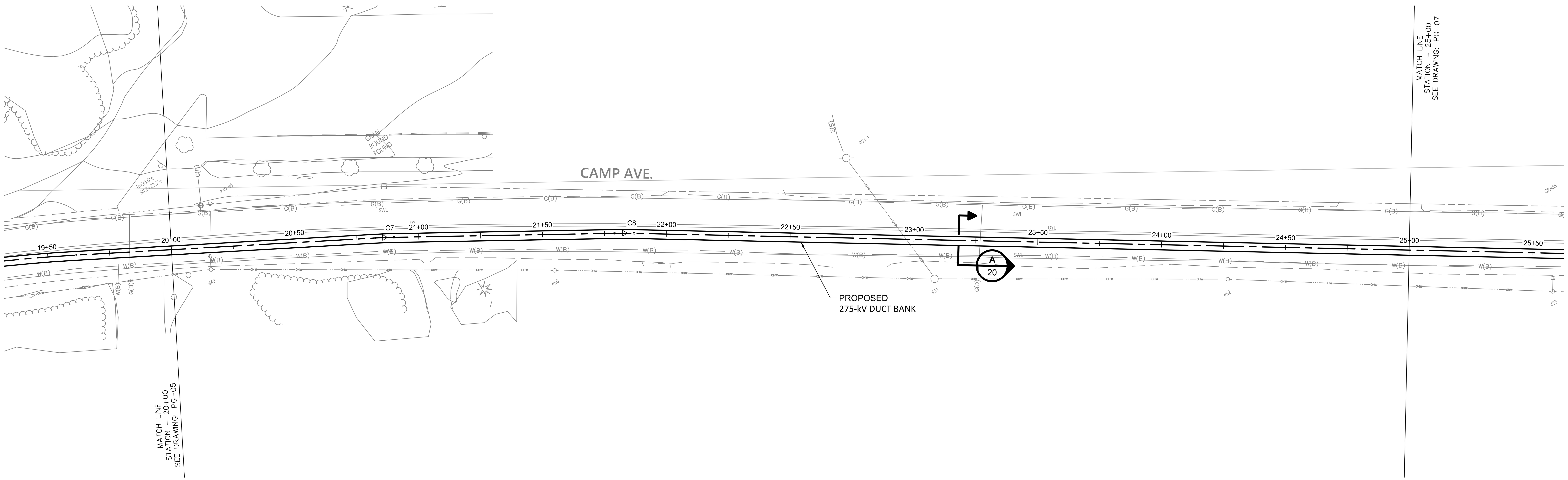
Revolution Wind | Powered by Ørsted & Eversource

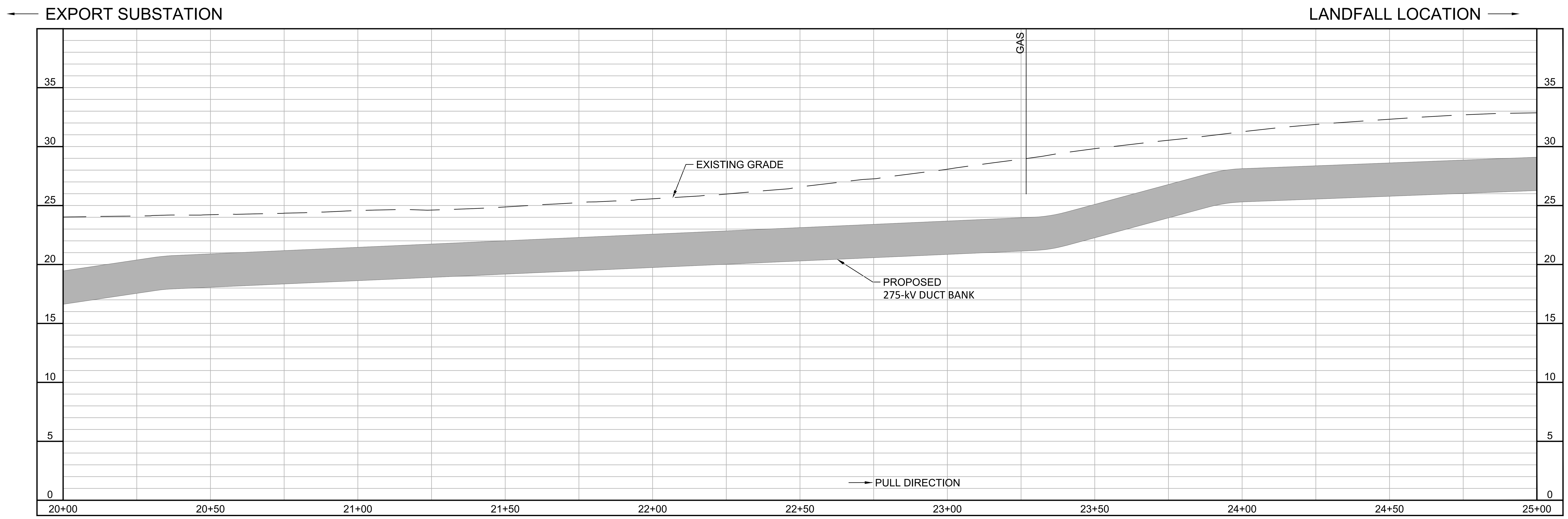
TITLE: REVOLUTION WIND
275-kV ONSHORE CABLE DOUBLE CIRCUIT
PLAN AND PROFILE
NORTH KINGSTOWN, RHODE ISLAND

BY	CHKD	APP	APP
J. BARRINGER-BMcD	M. DAGENAIS-BMcD	N. SCOTT-BMcD	
DATE 10/5/20	DATE 10/5/20	DATE 10/5/20	DATE
H-SCALE N.T.S.	SIZE ARCH D	FIELD BOOK & PAGES	
V-SCALE N.T.S.	V.S.	R.E.DWG.	
R.E. PROJ. NUMBER		DWG NO. PG-05	

12/2/2020 10:03 AM – jbarringer – \\bmcd\dfs\Clients\TND\NUSC\126851_RevWindEng\Design\Underground\CADD\Working\03 REV_WIND_PLAN AND PROFILE.dwg – PG-(05)

\\BMCD\DFS\CLIENTS\TND\NUSC\126851_REVWINDENG\DESIGN\UNDERGROUND\CADD\WORKING\03 REV_WIND_PLAN AND PROFILE.DWG 12/2/2020 10:03 AM JBARRINGER





ISSUED FOR REVIEW-70%

PRELIMINARY - NOT FOR CONSTRUCTION

NORTH

0 5' 10'
VERTICAL SCALE IN FEET

0 10' 20' 40'
SCALE IN FEET
HORIZONTAL SCALE IN FEET

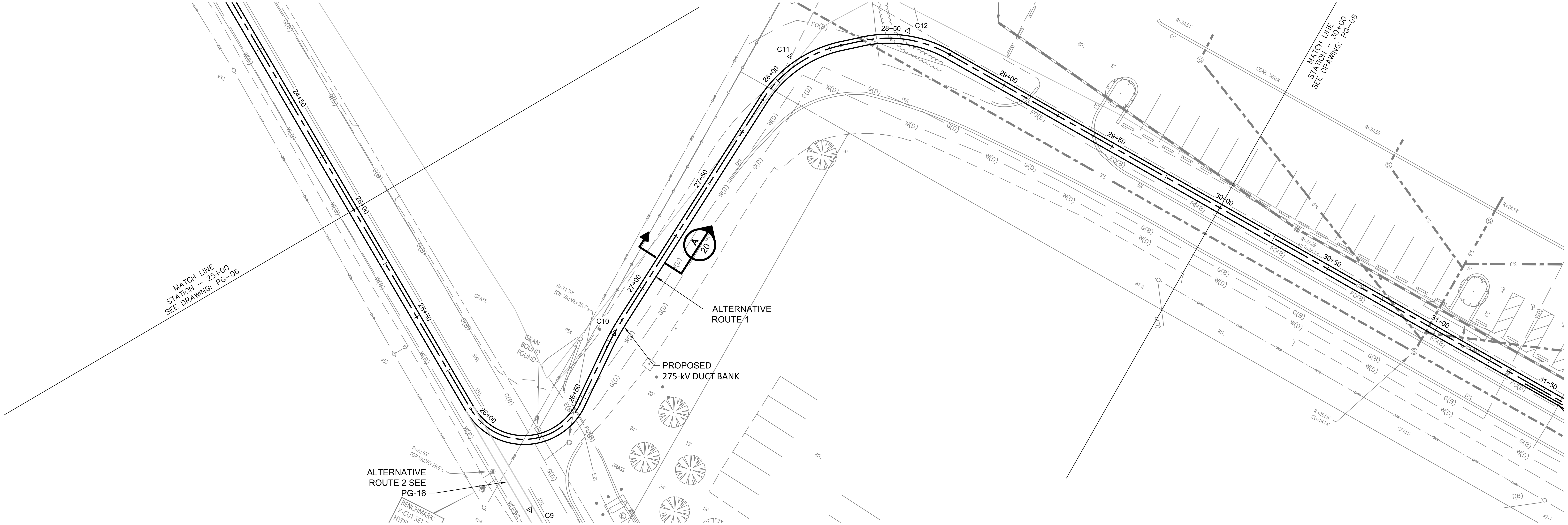
REVISIONS DURING CONSTRUCTION

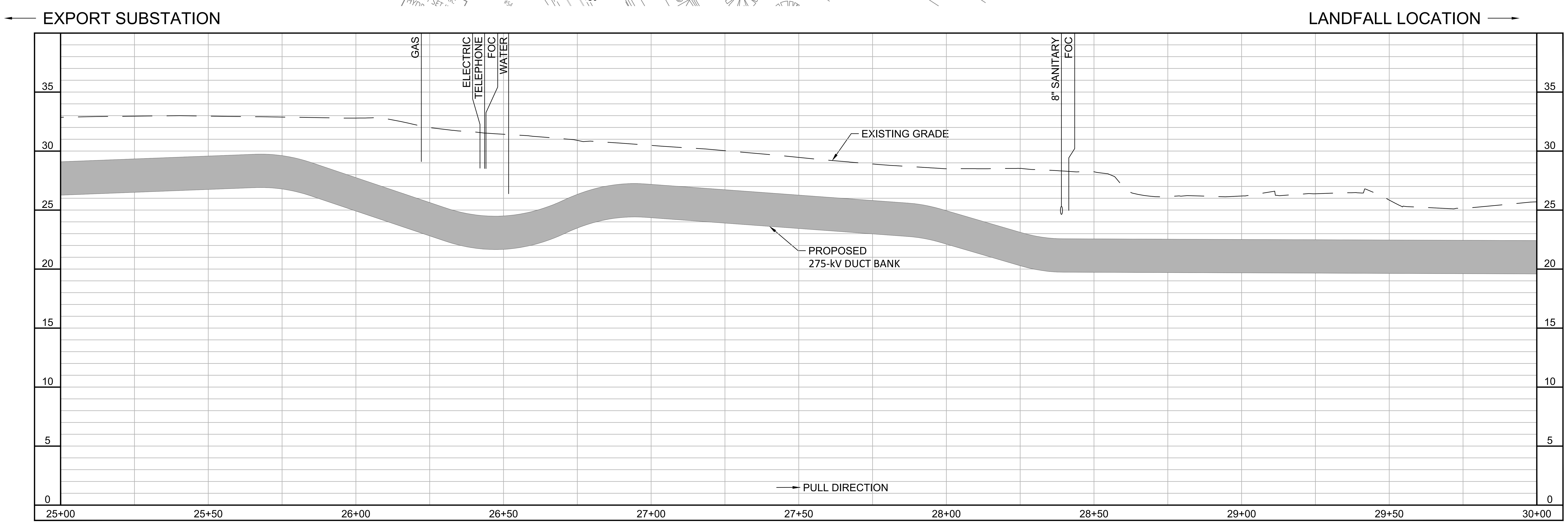
NO.	DATE	AS BUILT REVISIONS	BY	CHK	APP	APP
A	12/02/20	ISSUED FOR REVIEW-70%	JCB	MD	NS	–

Revolution Wind | Powered by Ørsted & Eversource

TITLE
REVOLUTION WIND
275-kV ONSHORE CABLE DOUBLE CIRCUIT
PLAN AND PROFILE
NORTH KINGSTOWN, RHODE ISLAND

BY J. BARRINGER-BMcD	CHK M. DAGENAIS-BMcD	APP N. SCOTT-BMcD	APP
DATE 10/5/20	DATE 10/5/20	DATE 10/5/20	DATE
H-SCALE N.T.S.	SIZE ARCH D	FIELD BOOK & PAGES	
V-SCALE N.T.S.	V.S.	R.E.DWG.	
R.E. PROJ. NUMBER		DWG NO. PG-06	





ISSUED FOR REVIEW-70%

PRELIMINARY - NOT FOR CONSTRUCTION

NORTH

VERTICAL SCALE IN FEET (0, 5', 10')

SCALE IN FEET HORIZONTAL SCALE IN FEET (0, 10', 20', 40')

NO.	DATE	AS BUILT REVISIONS	BY	CHK	APP	APP
A	12/02/20	ISSUED FOR REVIEW-70%	JCB	MD	NS	–

REVISIONS DURING CONSTRUCTION

Revolution Wind — Powered by Ørsted & Eversource

REVOLUTION WIND
275-kV ONSHORE CABLE DOUBLE CIRCUIT
PLAN AND PROFILE
NORTH KINGSTOWN, RHODE ISLAND

BY	CHK	APP	APP
J. BARRINGER-BMcD	M. DAGENAIS-BMcD	N. SCOTT-BMcD	
DATE 10/5/20	DATE 10/5/20	DATE 10/5/20	DATE
H-SCALE N.T.S.	SIZE ARCH D	FIELD BOOK & PAGES	
V-SCALE N.T.S.	V.S.	R.E.DWG.	
R.E. PROJ. NUMBER		DWG NO. PG-07	

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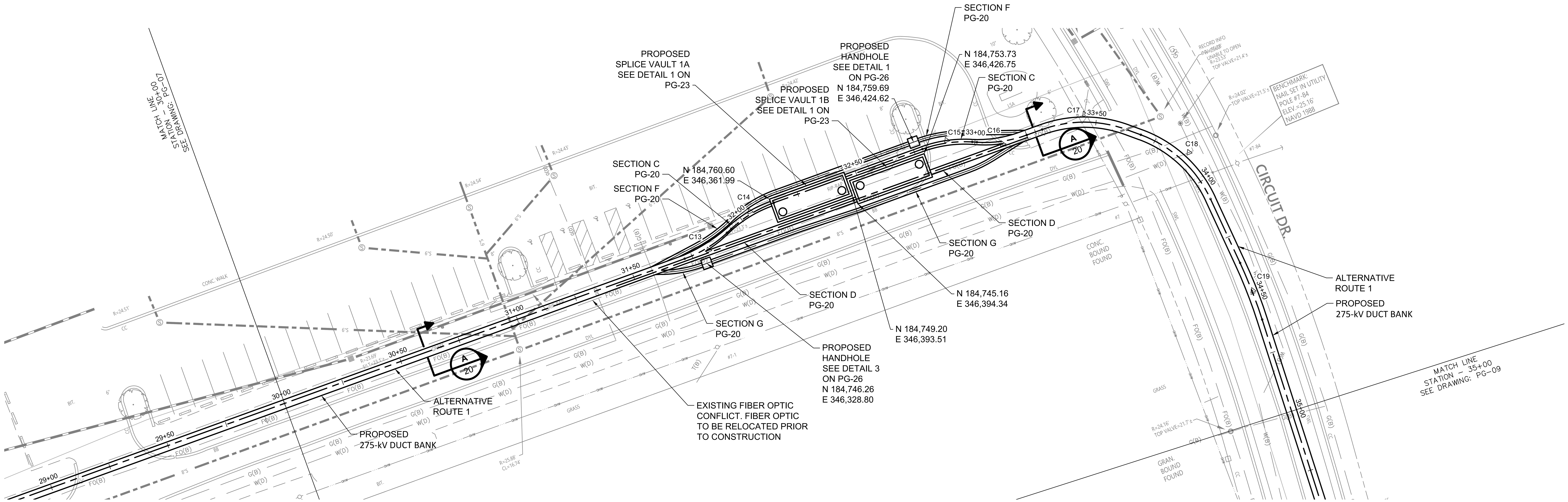
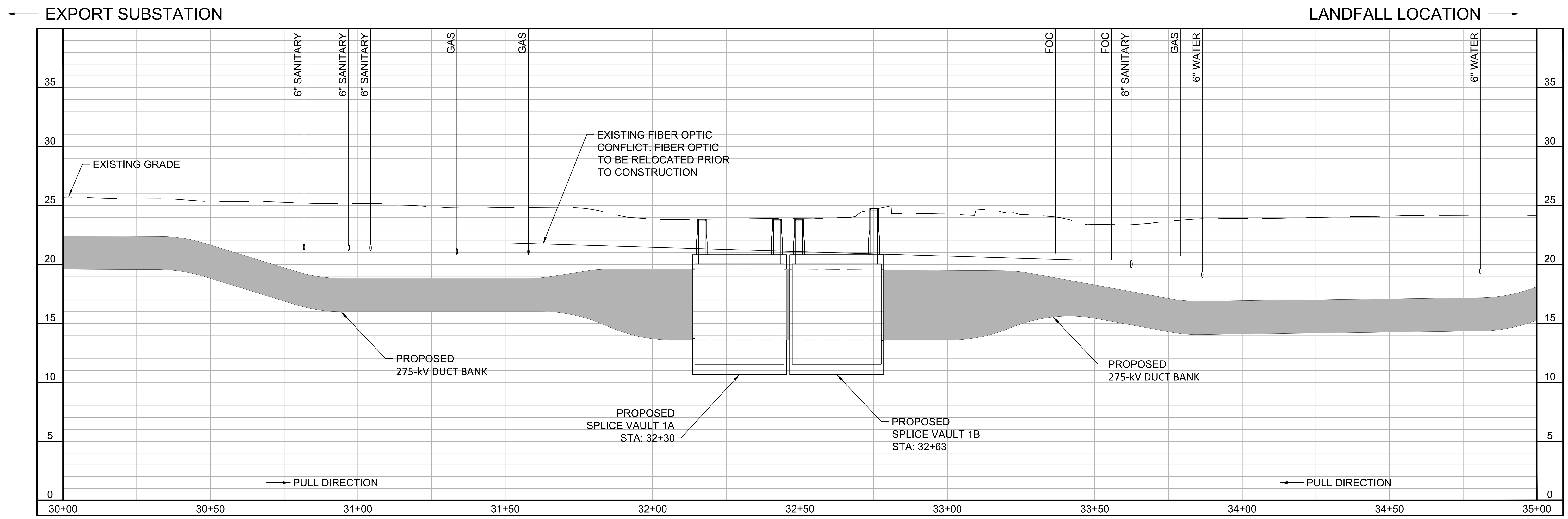




ISSUED FOR REVIEW-70%

PRELIMINARY - NOT FOR CONSTRUCTION

NORTH

VERTICAL SCALE IN FEET (0, 5', 10')

SCALE IN FEET
HORIZONTAL SCALE IN FEET (0, 10', 20', 40')

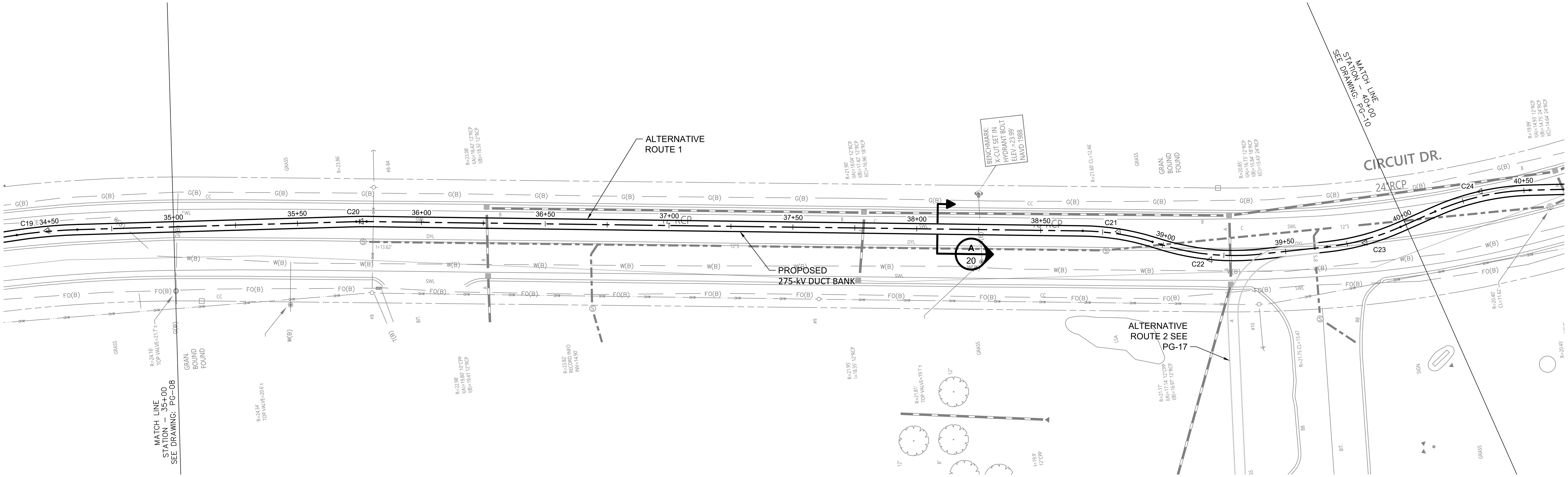
REVISIONS DURING CONSTRUCTION

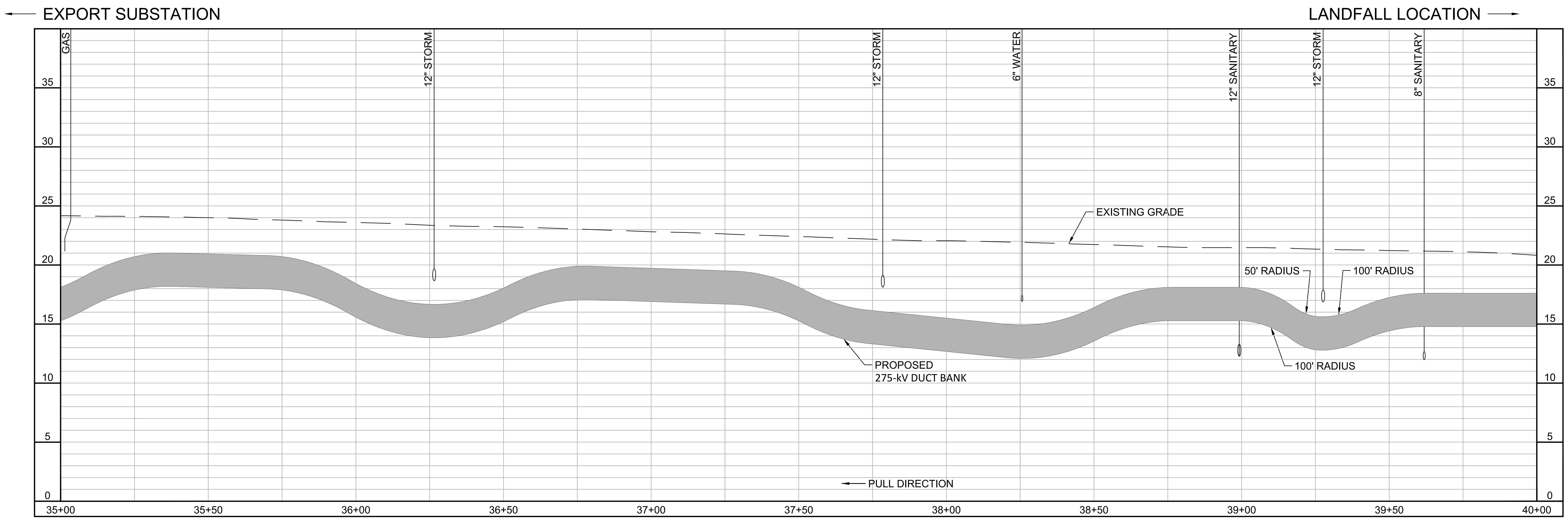
NO.	DATE	AS BUILT REVISIONS	BY	CHK	APP	APP
A	12/02/20	ISSUED FOR REVIEW-70%	JCB	MD	NS	–

Revolution Wind | Powered by Ørsted & Eversource

TITLE
REVOLUTION WIND
275-kV ONSHORE CABLE DOUBLE CIRCUIT
PLAN AND PROFILE
NORTH KINGSTOWN, RHODE ISLAND

BY J. BARRINGER-BMcD	CHKD M. DAGENAIS-BMcD	APP N. SCOTT-BMcD	APP
DATE 10/5/20	DATE 10/5/20	DATE 10/5/20	DATE
H-SCALE N.T.S.	SIZE ARCH D	FIELD BOOK & PAGES	
V-SCALE N.T.S.	V.S.	R.E.DWG.	
R.E. PROJ. NUMBER		DWG NO. PG-08	





ISSUED FOR REVIEW-70%

PRELIMINARY - NOT FOR CONSTRUCTION

NORTH

0 5' 10'
VERTICAL SCALE IN FEET

0 10' 20' 40'
SCALE IN FEET
HORIZONTAL SCALE IN FEET

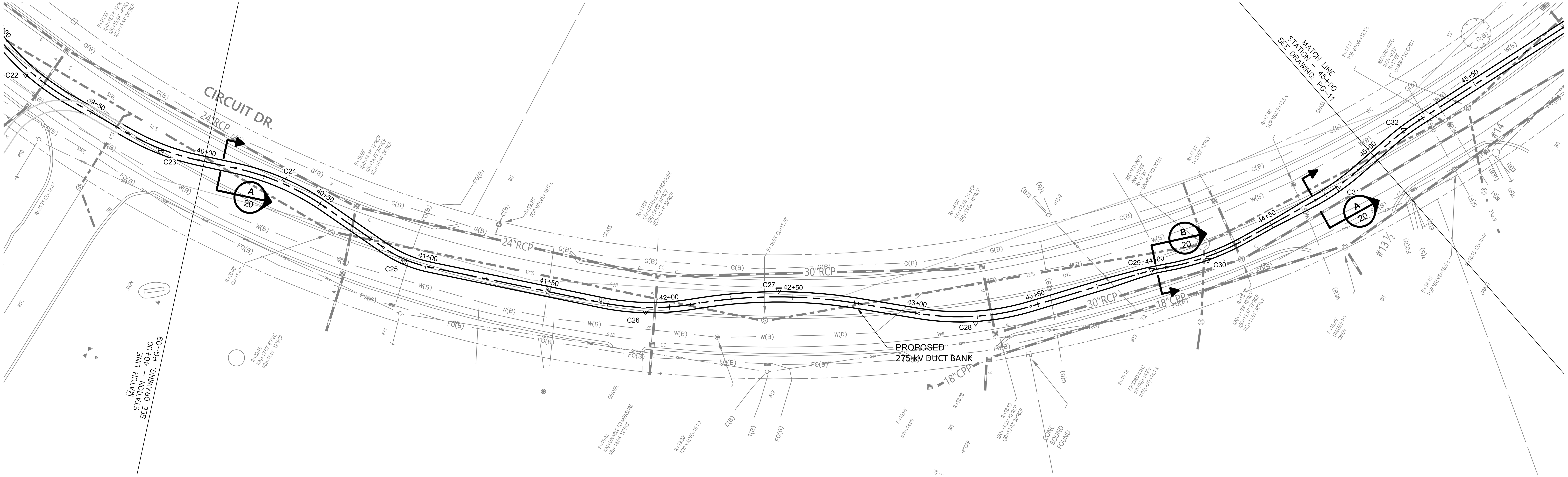
REVISIONS DURING CONSTRUCTION

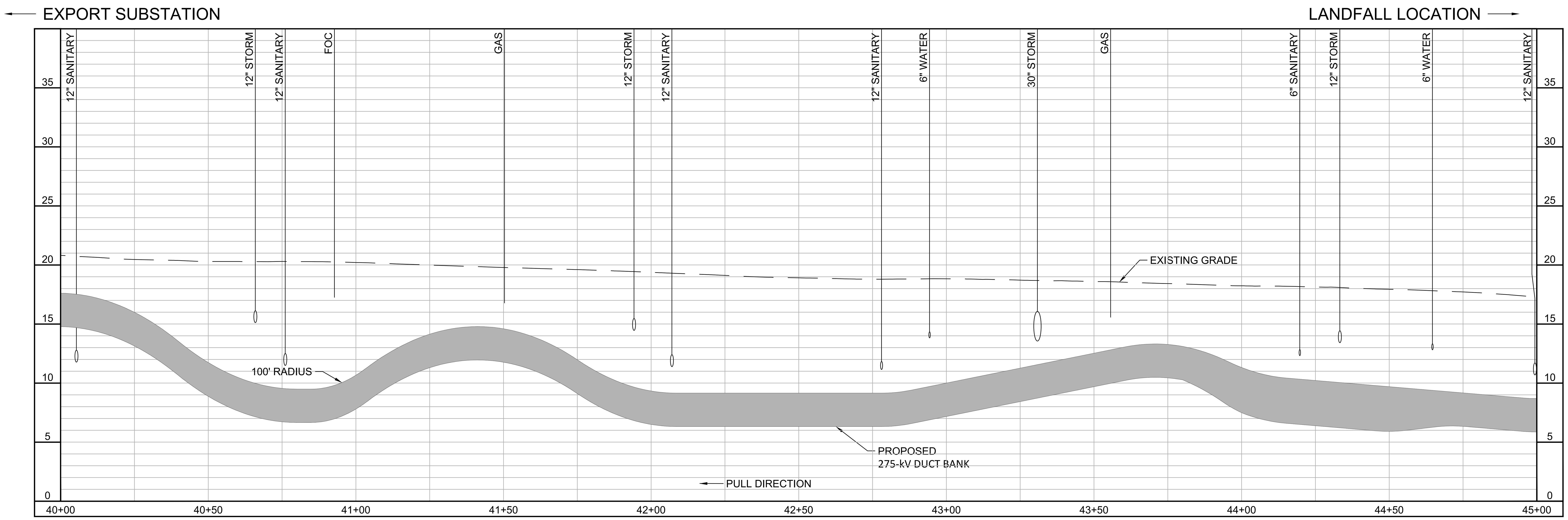
NO.	DATE	AS BUILT REVISIONS	BY	CHK	APP	APP
A	12/02/20	ISSUED FOR REVIEW-70%	JCB	MD	NS	–

Revolution Wind | Powered by Ørsted & Eversource

TITLE
REVOLUTION WIND
275-kV ONSHORE CABLE DOUBLE CIRCUIT
PLAN AND PROFILE
NORTH KINGSTOWN, RHODE ISLAND

BY J. BARRINGER-BMcD	CHKD M. DAGENAIS-BMcD	APP N. SCOTT-BMcD	APP
DATE 10/5/20	DATE 10/5/20	DATE 10/5/20	DATE
H-SCALE N.T.S.	SIZE ARCH D	FIELD BOOK & PAGES	
V-SCALE N.T.S.	V.S.	R.E.DWG.	
R.E. PROJ. NUMBER		DWG NO. PG-09	





ISSUED FOR REVIEW-70%

PRELIMINARY - NOT FOR CONSTRUCTION

NORTH

0 5' 10'
VERTICAL SCALE IN FEET

0 10' 20' 40'
SCALE IN FEET
HORIZONTAL SCALE IN FEET

REVISIONS DURING CONSTRUCTION

NO.	DATE	AS BUILT REVISIONS	BY	CHK	APP	APP
A	12/02/20	ISSUED FOR REVIEW-70%	JCB	MD	NS	–

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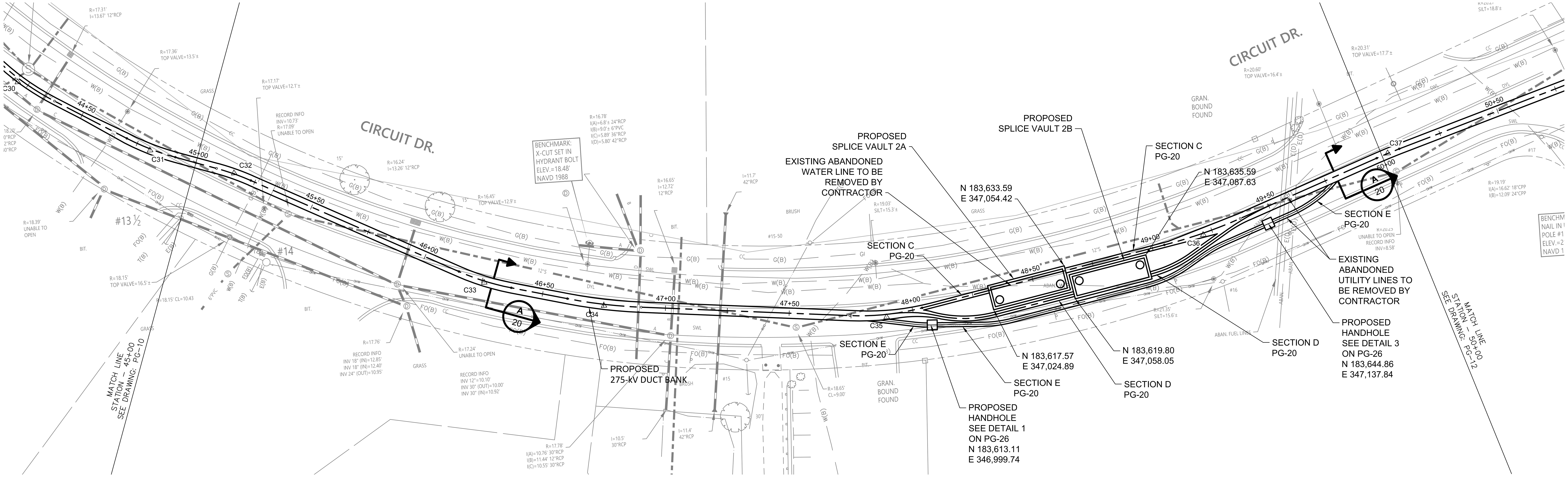
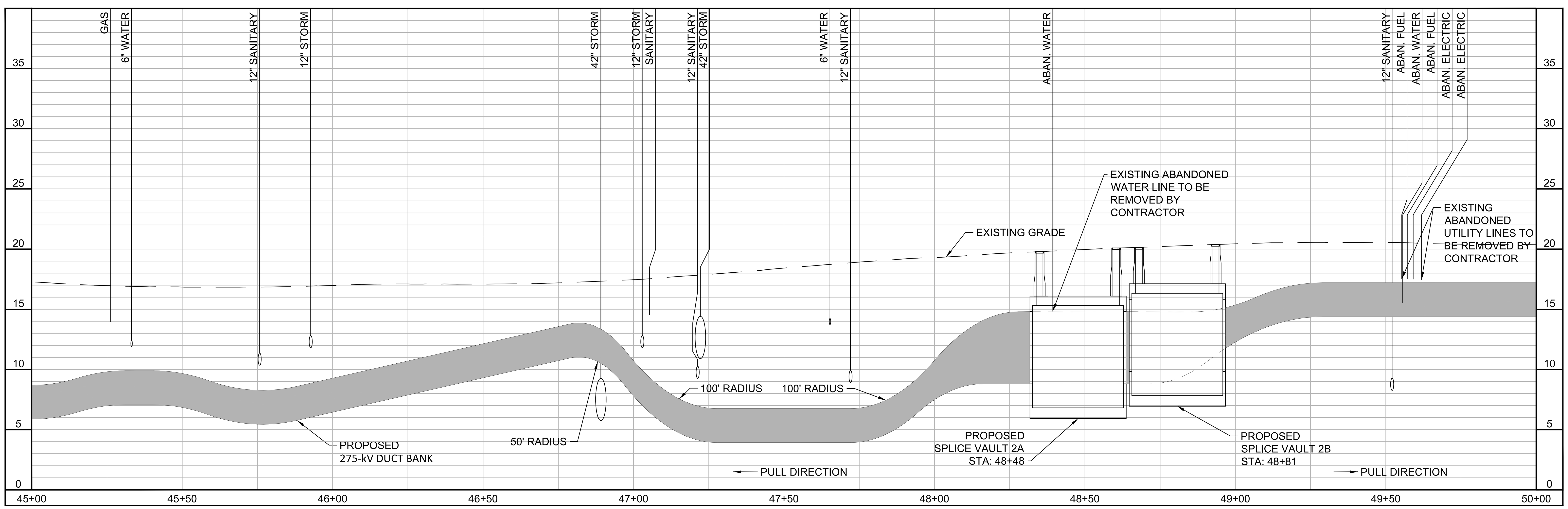
TITLE
REVOLUTION WIND
275-kV ONSHORE CABLE DOUBLE CIRCUIT
PLAN AND PROFILE
NORTH KINGSTOWN, RHODE ISLAND

BY J. BARRINGER-BMcD	CHKD M. DAGENAIS-BMcD	APP N. SCOTT-BMcD	APP
DATE 10/5/20	DATE 10/5/20	DATE 10/5/20	DATE
H-SCALE N.T.S.	SIZE ARCH D	FIELD BOOK & PAGES	
V-SCALE N.T.S.	V.S.	R.E.DWG.	
R.E. PROJ. NUMBER		DWG NO.	PG-10



← EXPORT SUBSTATION LANDFALL LOCATION →



ISSUED FOR REVIEW-70%

PRELIMINARY - NOT FOR CONSTRUCTION

NORTH

VERTICAL SCALE IN FEET (0, 5', 10')

SCALE IN FEET HORIZONTAL SCALE IN FEET (0, 10', 20', 40')

REVISIONS DURING CONSTRUCTION

NO.	DATE	AS BUILT REVISIONS	BY	CHK	APP	APP
A	12/02/20	ISSUED FOR REVIEW-70%	JCB	MD	NS	–

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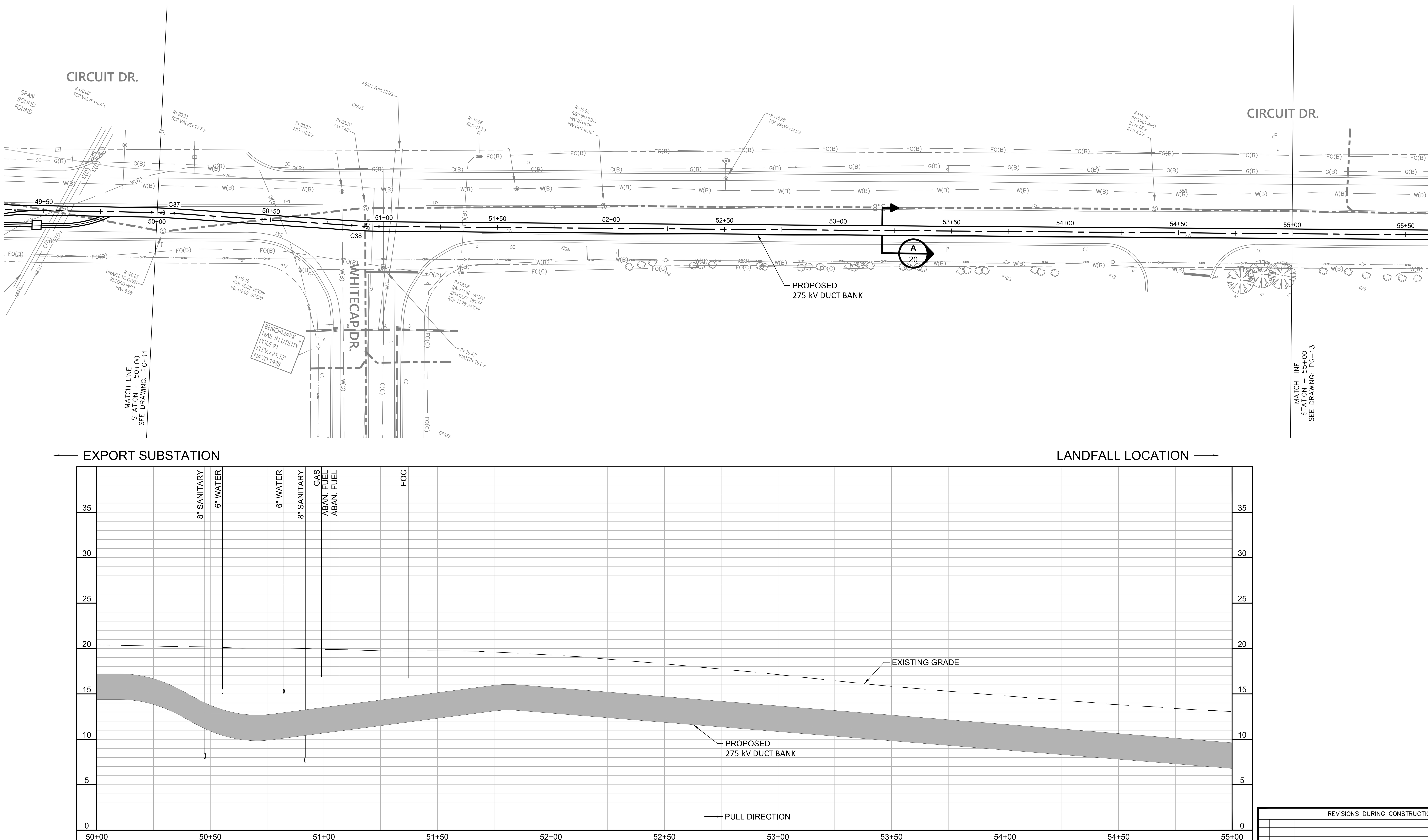
TITLE: REVOLUTION WIND
275-kV ONSHORE CABLE DOUBLE CIRCUIT
PLAN AND PROFILE
NORTH KINGSTOWN, RHODE ISLAND

BY	CHK	APP	APP
J. BARRINGER-BMcD	M. DAGENAIS-BMcD	N. SCOTT-BMcD	
DATE 10/5/20	DATE 10/5/20	DATE 10/5/20	DATE
H-SCALE N.T.S.	SIZE ARCH D	FIELD BOOK & PAGES	
V-SCALE N.T.S.	W.S.	R.E.DWG.	
R.E. PROJ. NUMBER		DWG NO. PG-11	

ES VER: 05/2015



ISSUED FOR REVIEW-70%

PRELIMINARY - NOT FOR CONSTRUCTION

NORTH

0 5' 10'
VERTICAL SCALE IN FEET

0 10' 20' 40'
SCALE IN FEET
HORIZONTAL SCALE IN FEET

REVISIONS DURING CONSTRUCTION

NO.	DATE	AS BUILT REVISIONS	BY	CHK	APP	APP
A	12/02/20	ISSUED FOR REVIEW-70%	JCB	MD	NS	–

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TITLE
REVOLUTION WIND
275-kV ONSHORE CABLE DOUBLE CIRCUIT
PLAN AND PROFILE
NORTH KINGSTOWN, RHODE ISLAND

BY J. BARRINGER-BMcD	CHK'D M. DAGENAIS-BMcD	APP N. SCOTT-BMcD	APP
DATE 10/5/20	DATE 10/5/20	DATE 10/5/20	DATE
H-SCALE N.T.S.	SIZE ARCH D	FIELD BOOK & PAGES	
V-SCALE N.T.S.	V.S.	R.E.DWG.	
R.E. PROJ. NUMBER		DWG NO.	PG-12

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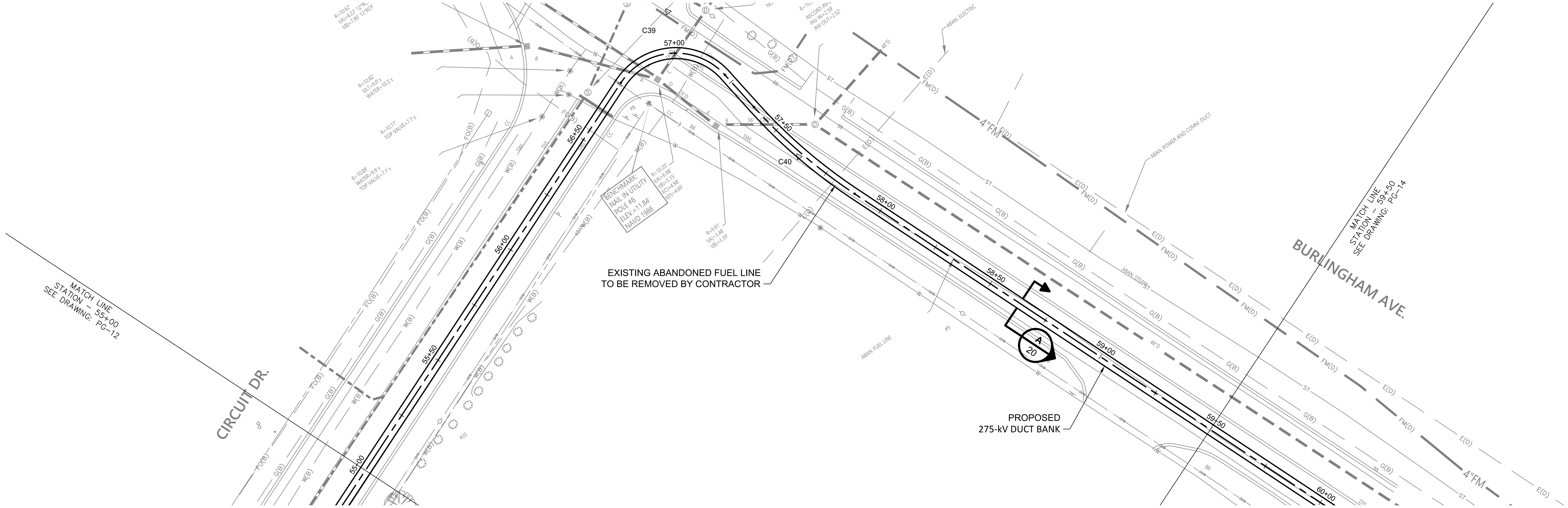
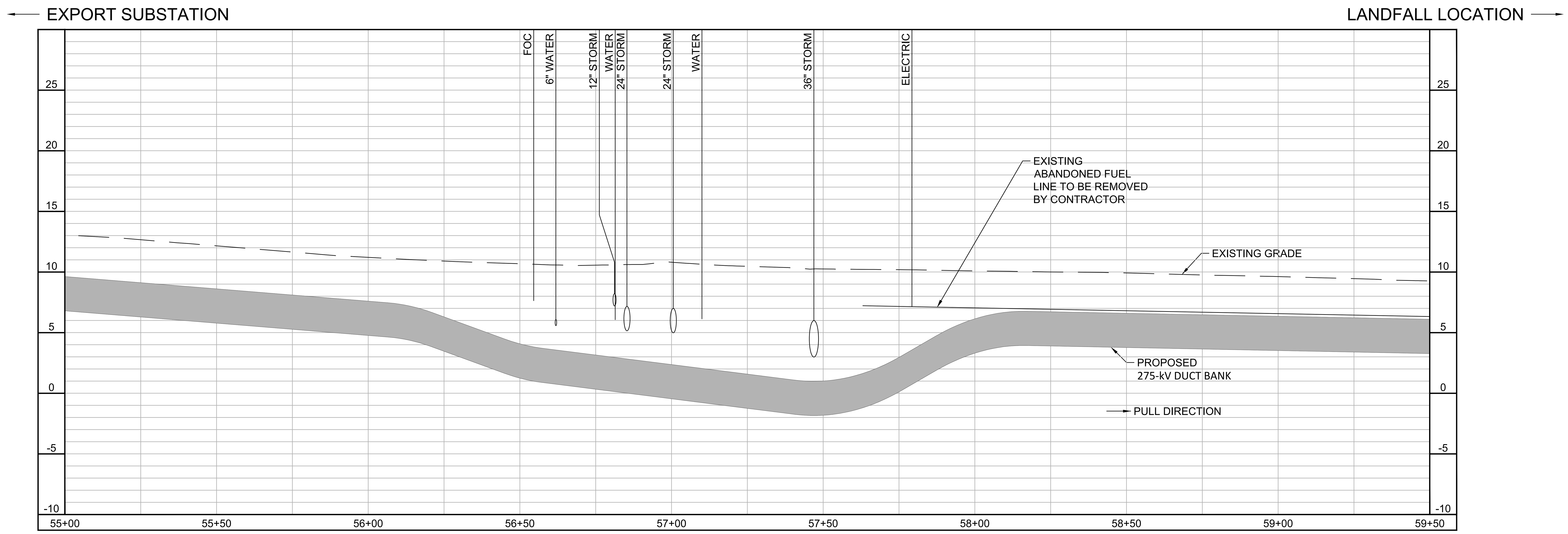
ES VER: 05/2015





ISSUED FOR REVIEW-70%

PRELIMINARY - NOT FOR CONSTRUCTION

NORTH

0 5' 10'
VERTICAL SCALE IN FEET

0 10' 20' 40'
SCALE IN FEET
HORIZONTAL SCALE IN FEET

REVISIONS DURING CONSTRUCTION

NO.	DATE	AS BUILT REVISIONS	BY	CHK	APP	APP
A	12/02/20	ISSUED FOR REVIEW-70%	JCB	MD	NS	–

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TITLE
REVOLUTION WIND
275-kV ONSHORE CABLE DOUBLE CIRCUIT
PLAN AND PROFILE
NORTH KINGSTOWN, RHODE ISLAND

BY J. BARRINGER-BMcD	CHKD M. DAGENAIS-BMcD	APP N. SCOTT-BMcD	APP
DATE 10/5/20	DATE 10/5/20	DATE 10/5/20	DATE
H-SCALE N.T.S.	SIZE ARCH D	FIELD BOOK & PAGES	
V-SCALE N.T.S.	V.S.	R.E.DWG.	
R.E. PROJ. NUMBER		DWG NO. PG-13	

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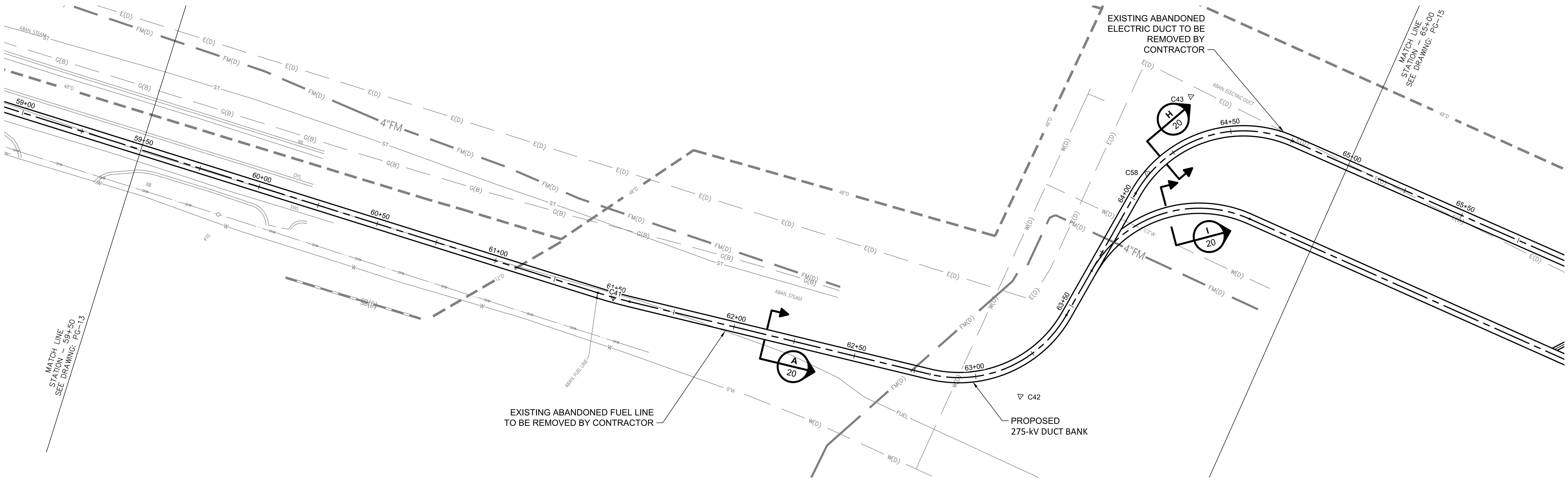

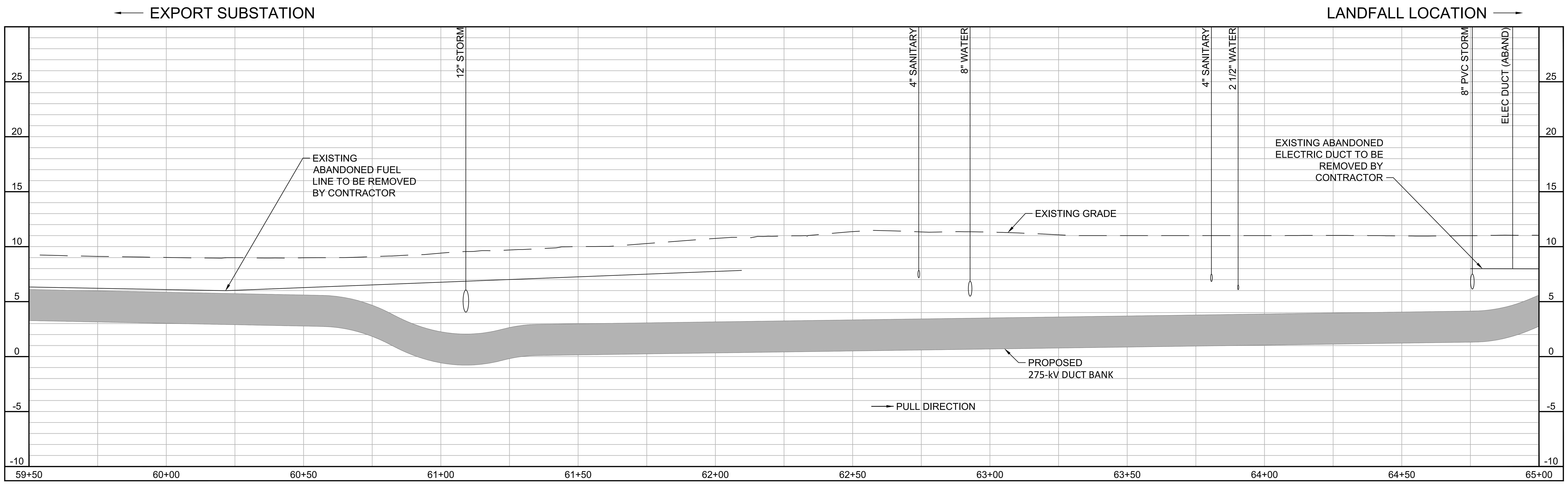

NOTES:

1. AS OF 12/02/2020, SURVEY HAS NOT BEEN RECEIVED AT STATION 60+25 AND AHEAD STATIONING.

ISSUED FOR REVIEW-70%

PRELIMINARY - NOT FOR CONSTRUCTION

NORTH

VERTICAL SCALE IN FEET: 0 5' 10'

SCALE IN FEET / HORIZONTAL SCALE IN FEET: 0 10' 20' 40'

REVISIONS DURING CONSTRUCTION

NO.	DATE	AS BUILT REVISIONS	BY	CHK	APP	APP
A	12/02/20	ISSUED FOR REVIEW–70%	JCB	MD	NS	–

Revolution Wind | Powered by Ørsted & Eversource

TITLE: REVOLUTION WIND
275-kV ONSHORE CABLE DOUBLE CIRCUIT
PLAN AND PROFILE
NORTH KINGSTOWN, RHODE ISLAND

BY J. BARRINGER–BMcD	CHKD M. DAGENAIS–BMcD	APP N. SCOTT–BMcD	APP
DATE 10/5/20	DATE 10/5/20	DATE 10/5/20	DATE
H-SCALE N.T.S.	SIZE ARCH D	FIELD BOOK & PAGES	
V-SCALE N.T.S.	V.S.	R.E.DWG.	
R.E. PROJ. NUMBER		DWG NO. PG-14	

ES VER: 05/2015

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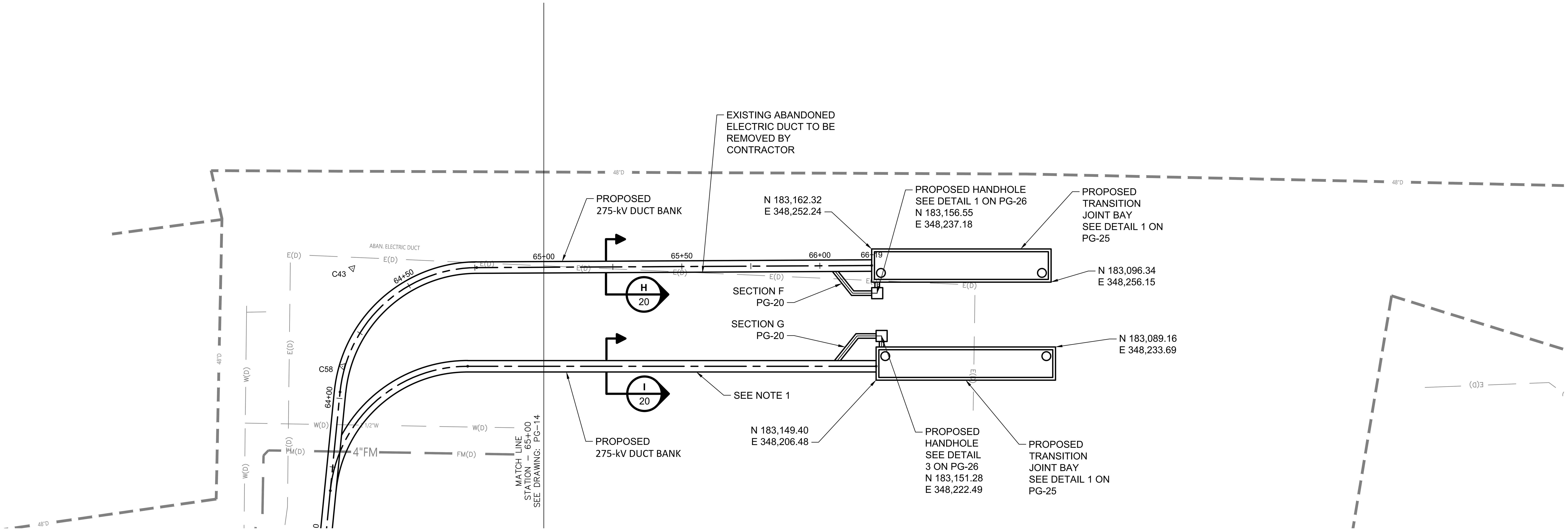
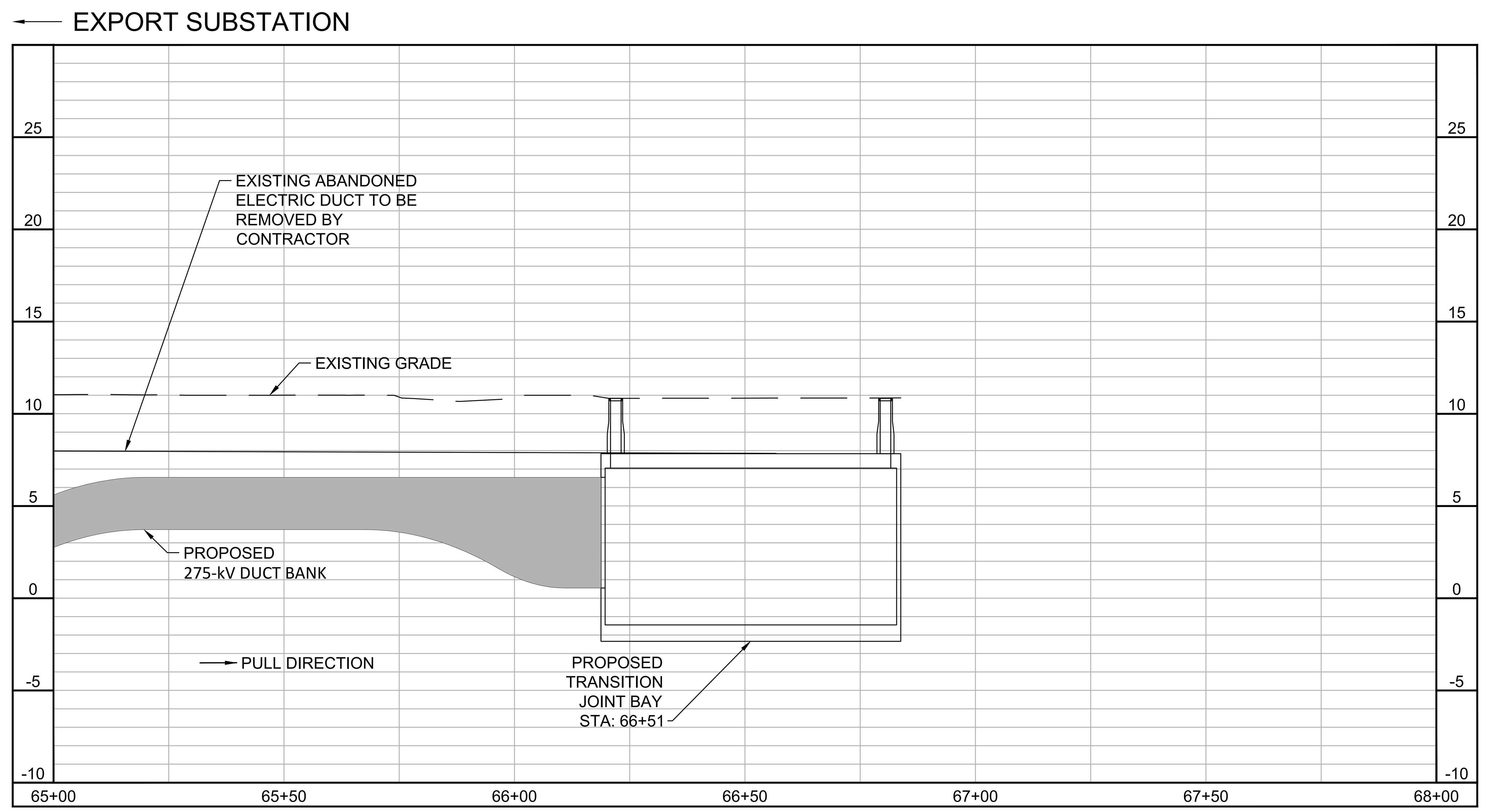




ISSUED FOR REVIEW-70%

PRELIMINARY - NOT FOR CONSTRUCTION

NORTH

VERTICAL SCALE IN FEET: 0, 5', 10'

HORIZONTAL SCALE IN FEET: 0, 10', 20', 40'

NOTES:

1. IT IS ASSUMED GRADE WILL BE THE SAME FOR THE BOTH ALIGNMENTS INTO TRANSITION JOINT BAYS
2. AS OF 12/02/2020, SURVEY HAS NOT BEEN RECEIVED AT STATION 60+25 AND AHEAD STATIONING.

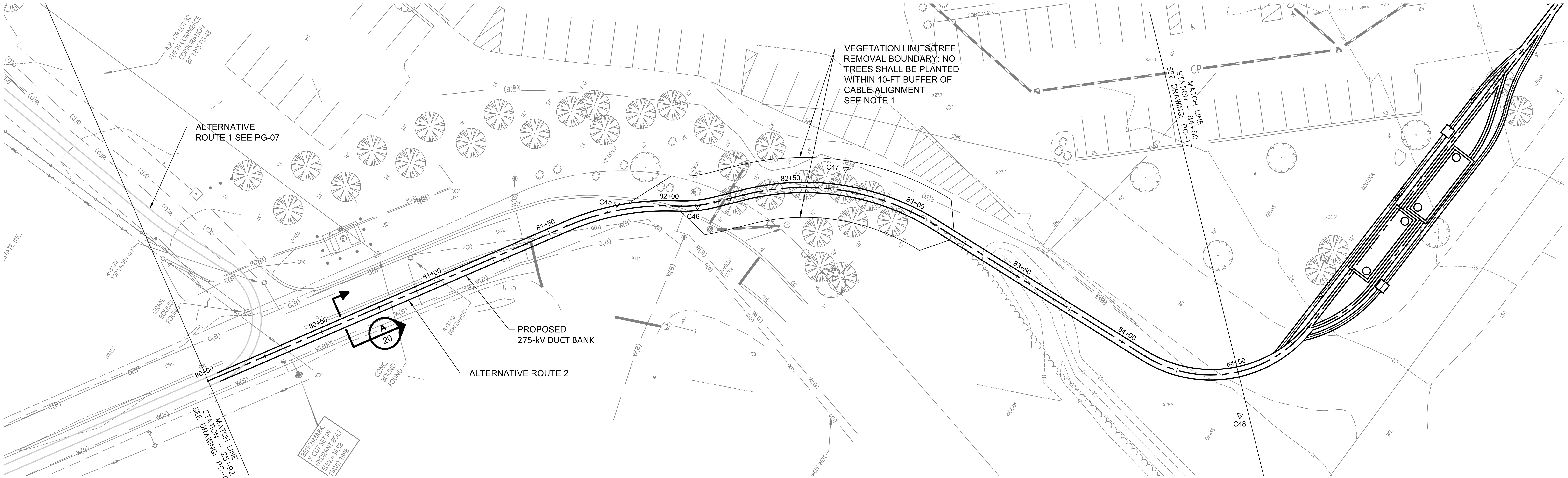
REVISIONS DURING CONSTRUCTION

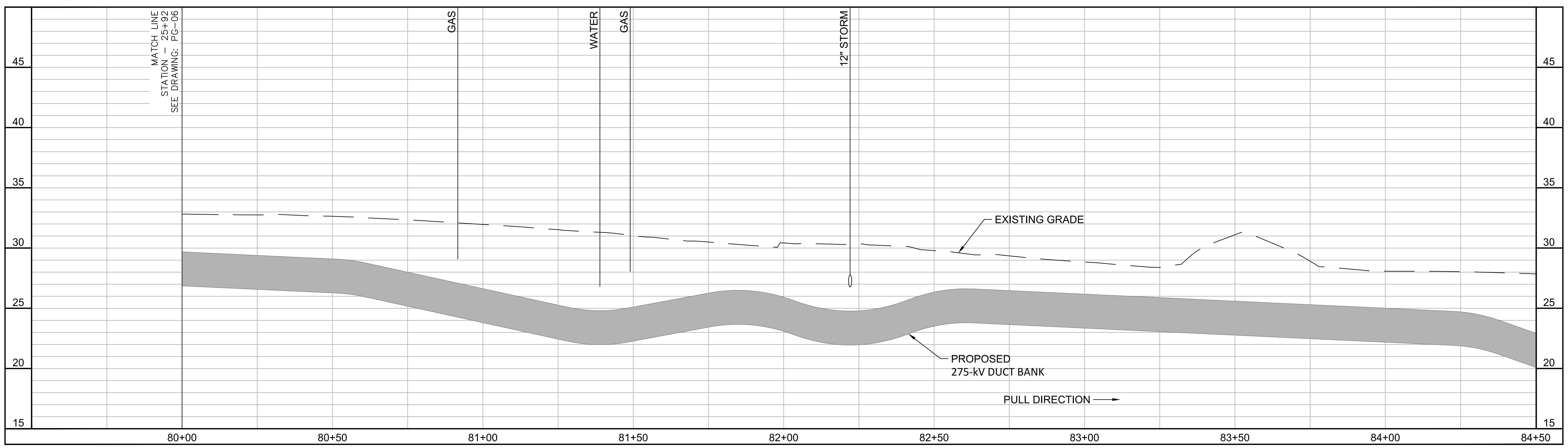
NO.	DATE	AS BUILT REVISIONS	BY	CHK	APP	APP
A	12/02/20	ISSUED FOR REVIEW-70%	JCB	MD	NS	–

Revolution Wind | Powered by Ørsted & Eversource

TITLE: REVOLUTION WIND
275-kV ONSHORE CABLE DOUBLE CIRCUIT
PLAN AND PROFILE
NORTH KINGSTOWN, RHODE ISLAND

BY J. BARRINGER-BMcD	CHKD M. DAGENAIS-BMcD	APP N. SCOTT-BMcD	APP
DATE 10/5/20	DATE 10/5/20	DATE 10/5/20	DATE
H-SCALE N.T.S.	SIZE ARCH D	FIELD BOOK & PAGES	
V-SCALE N.T.S.	V.S.	R.E.DWG.	
R.E. PROJ. NUMBER		DWG NO.	PG-15





NOTES:

1. CONTRACTOR TO CONFIRM TREE CLEARING EXTENTS WITH EVERSOURCE PRIOR TO CONSTRUCTION

ISSUED FOR REVIEW-70%

PRELIMINARY - NOT FOR CONSTRUCTION

NORTH

VERTICAL SCALE IN FEET: 0, 5', 10'

SCALE IN FEET HORIZONTAL SCALE IN FEET: 0, 10', 20', 40'

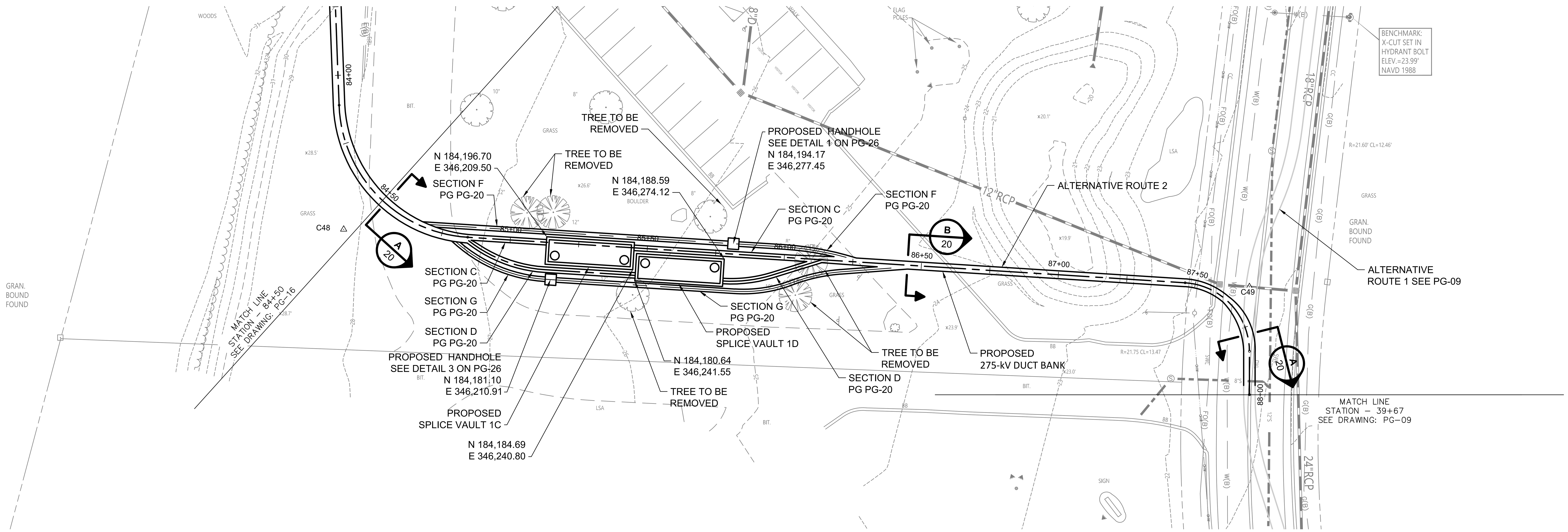
REVISIONS DURING CONSTRUCTION

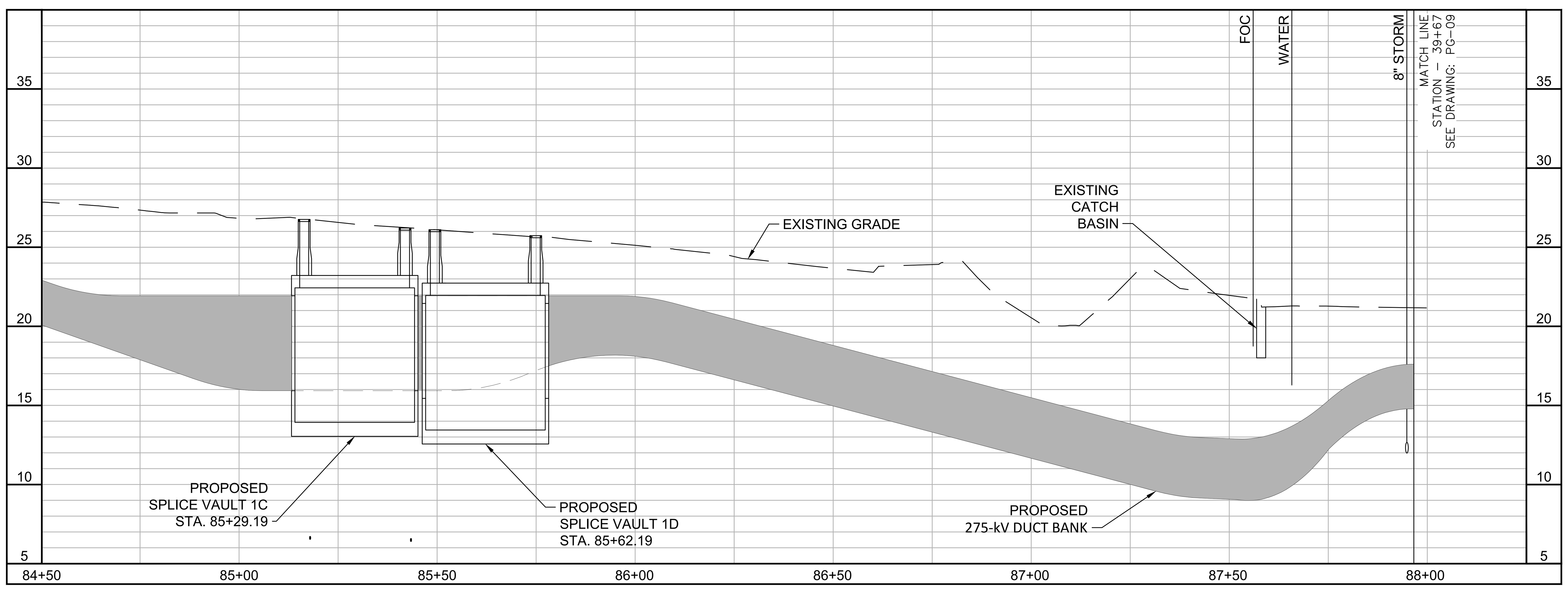
NO.	DATE	AS BUILT REVISIONS	BY	CHK	APP	APP
A	12/02/20	ISSUED FOR REVIEW-70%	JCB	MD	NS	–

Revolution Wind — Powered by Ørsted & Eversource

TITLE: REVOLUTION WIND
275-kV ONSHORE CABLE DOUBLE CIRCUIT
PLAN AND PROFILE
NORTH KINGSTOWN, RHODE ISLAND

BY J. BARRINGER-BMcD	CHKD M. DAGENAIS-BMcD	APP N. SCOTT-BMcD	APP
DATE 10/5/20	DATE 10/5/20	DATE 10/5/20	DATE
H-SCALE N.T.S.	SIZE ARCH D	FIELD BOOK & PAGES	
V-SCALE N.T.S.	V.S.	R.E.DWG.	
R.E. PROJ. NUMBER		DWG NO.	PG-16





NOTES:

1. CONTRACTOR TO CONFIRM TREE CLEARING EXTENTS WITH EVERSOURCE PRIOR TO CONSTRUCTION

ISSUED FOR REVIEW-70%

PRELIMINARY - NOT FOR CONSTRUCTION

NORTH

VERTICAL SCALE IN FEET 0 5' 10'

SCALE IN FEET HORIZONTAL SCALE IN FEET 0 10' 20' 40'

REVISIONS DURING CONSTRUCTION

Revolution Wind | Powered by Ørsted & Eversource

REVOLUTION WIND
275-kV ONSHORE CABLE DOUBLE CIRCUIT
PLAN AND PROFILE
NORTH KINGSTOWN, RHODE ISLAND

BY	CHK'D	APP	APP
J. BARRINGER-BMcD	M. DAGENAIS-BMcD	N. SCOTT-BMcD	
DATE 10/5/20	DATE 10/5/20	DATE 10/5/20	DATE
H-SCALE N.T.S.	SIZE ARCH D	FIELD BOOK & PAGES	
V-SCALE N.T.S.	V.S.	R.E.DWG.	
R.E. PROJ. NUMBER		DWG NO. PG-17	

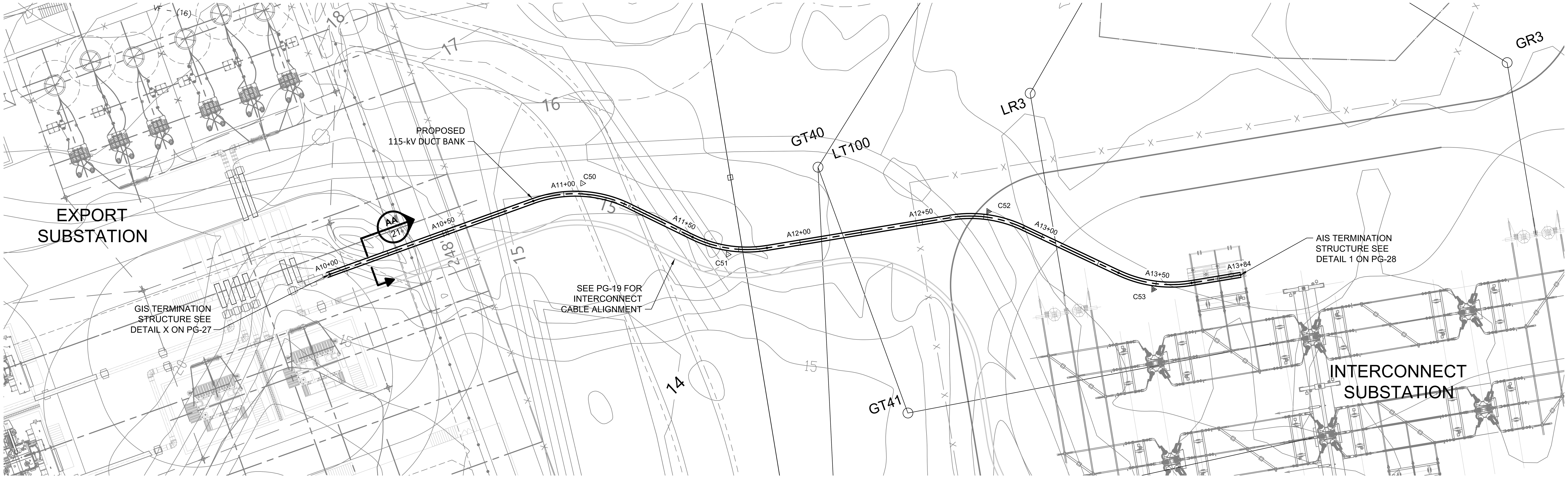
NO.	DATE	AS BUILT REVISIONS	BY	CHK	APP	APP
A	12/02/20	ISSUED FOR REVIEW-70%	JCB	MD	NS	–

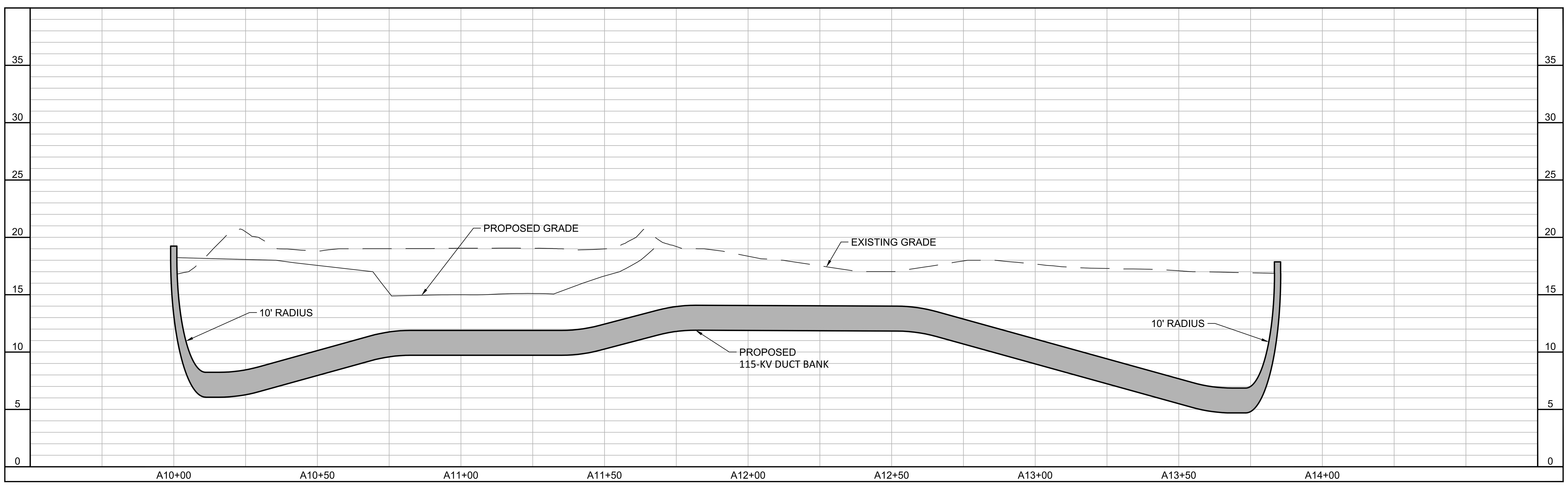
ES VER: 05/2015

11/30/2020 12:27 PM – jbarringer – \\bmcd\dfs\Clients\TND\NUSC\126851_RevWindEng\Design\Underground\CADD\Working\15 REV_WIND_PLAN AND PROFILE.dwg – PG-(17)

\\BMCD\DFS\CLIENTS\TND\NUSC\126851_REVWINDENG\DESIGN\UNDERGROUND\CADD\WORKING\15 REV_WIND_PLAN AND PROFILE.DWG 11/30/2020 12:27 PM JBARRINGER

ES VER: 05/2015





NOTES:

1. PROPOSED GRADE PER VHB GRADING PLAN DATED 11/02/2020

ISSUED FOR REVIEW-70%

PRELIMINARY - NOT FOR CONSTRUCTION

NORTH

VERTICAL SCALE IN FEET: 0, 5', 10'

SCALE IN FEET, HORIZONTAL SCALE IN FEET: 0, 10', 20', 40'

NO.	DATE	AS BUILT REVISIONS	BY	CHK	APP	APP
A	12/02/20	ISSUED FOR REVIEW-70%	JCB	MD	NS	–

REVISIONS DURING CONSTRUCTION

Revolution Wind | Powered by Ørsted & Eversource

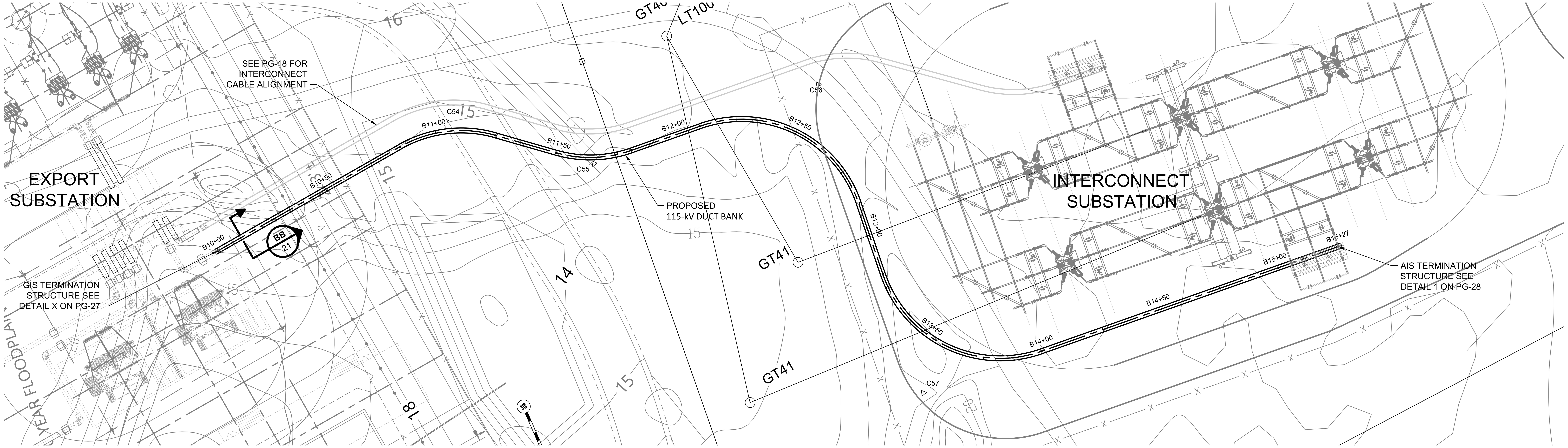
TITLE: REVOLUTION WIND
115-kV INTERCONNECT CABLE DOUBLE CIRCUIT PLAN AND PROFILE
NORTH KINGSTOWN, RHODE ISLAND

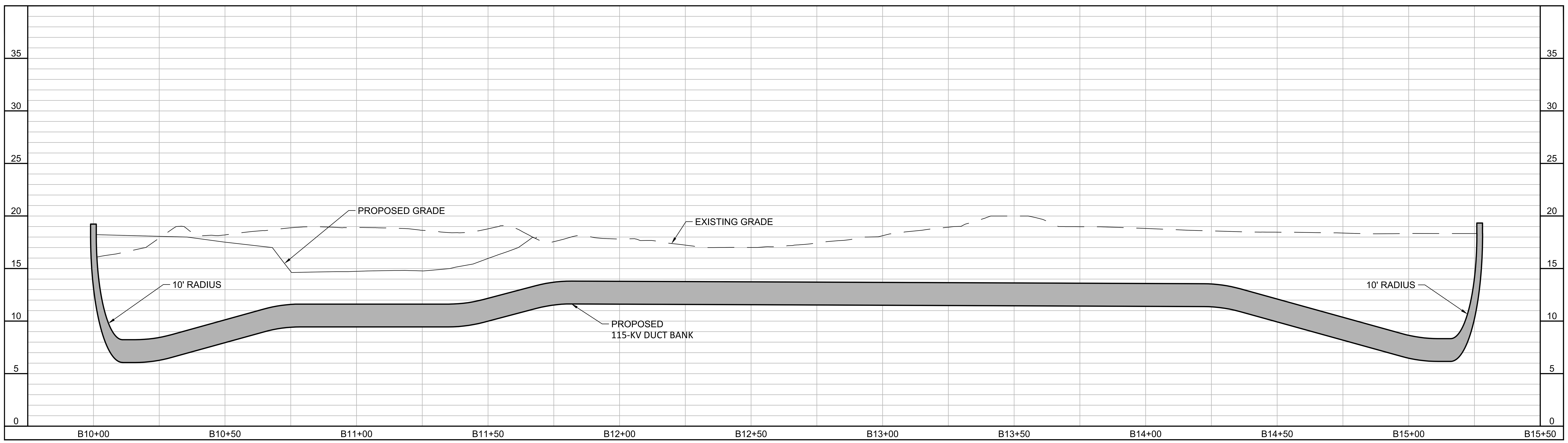
BY J. BARRINGER-BMcD	CHKD M. DAGENAIS-BMcD	APP N. SCOTT-BMcD	APP
DATE 10/5/20	DATE 10/5/20	DATE 10/5/20	DATE
H-SCALE N.T.S.	SIZE ARCH D	FIELD BOOK & PAGES	
V-SCALE N.T.S.	V.S.	R.E.DWG.	
R.E. PROJ. NUMBER		DWG NO. PG-18	

11/25/2020 2:49 PM – jbarringer – \\bmcd\dfs\Clients\TND\NUSC\126851_RevWindEng\Design\Underground\CADD\Working\18 REV_WIND_PLAN AND PROFILE.dwg – PG-(18)

\\BMCD\DFS\CLIENTS\TND\NUSC\126851_REVWINDENG\DESIGN\UNDERGROUND\CADD\WORKING\18 REV_WIND_PLAN AND PROFILE.DWG 11/25/2020 2:49 PM JBARRINGER

ES VER: 05/2015





NOTES:

1. PROPOSED GRADE PER VHB GRADING PLAN DATED 11/02/2020

ISSUED FOR REVIEW-70%

PRELIMINARY - NOT FOR CONSTRUCTION

NORTH

0 5' 10'
VERTICAL SCALE IN FEET

0 10' 20' 40'
SCALE IN FEET
HORIZONTAL SCALE IN FEET

NO.	DATE	AS BUILT REVISIONS	BY	CHK	APP	APP
A	12/02/20	ISSUED FOR REVIEW-70%	JCB	MD	NS	–

REVISIONS DURING CONSTRUCTION

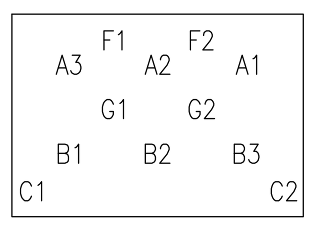
Revolution Wind — Powered by Ørsted & Eversource

TITLE
REVOLUTION WIND
115-kV INTERCONNECT CABLE DOUBLE CIRCUIT
PLAN AND PROFILE
NORTH KINGSTOWN, RHODE ISLAND

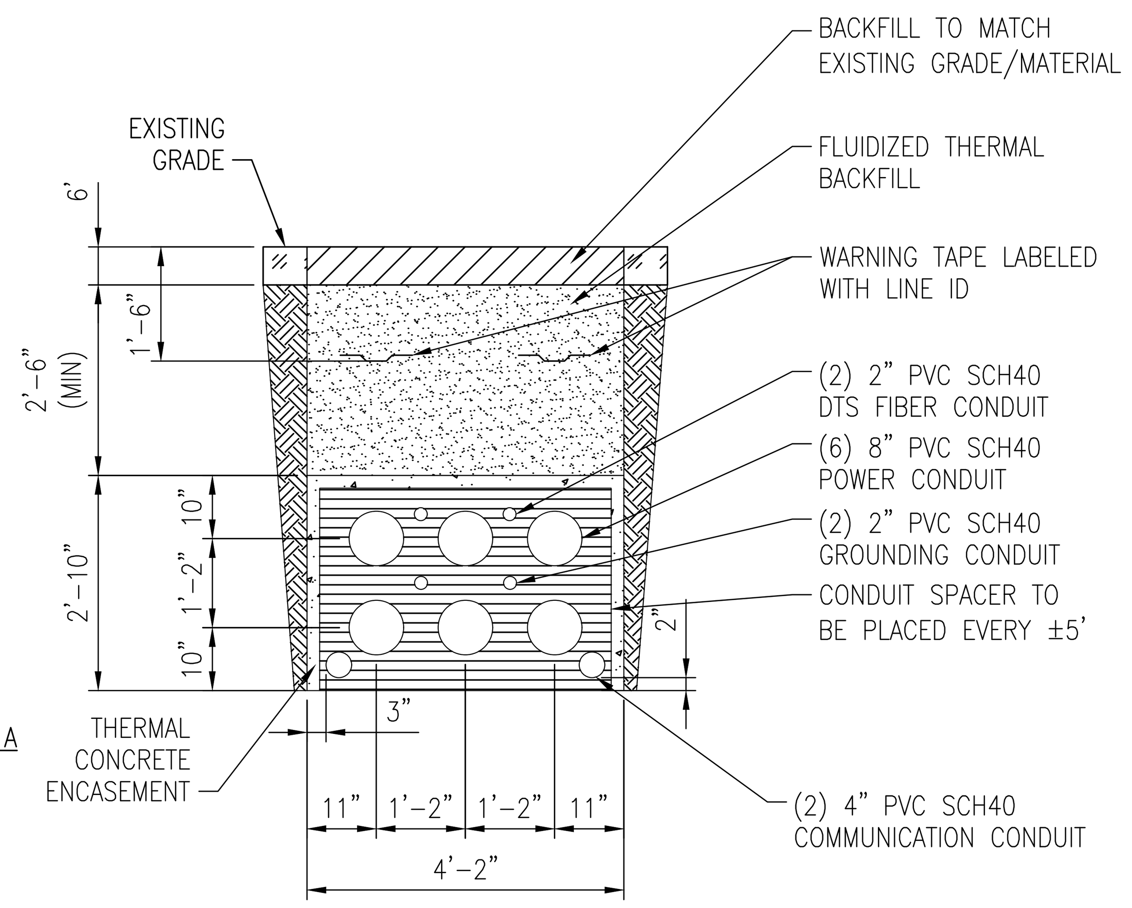
BY J. BARRINGER-BMcD	CHKD M. DAGENAIS-BMcD	APP N. SCOTT-BMcD	APP
DATE 10/5/20	DATE 10/5/20	DATE 10/5/20	DATE
H-SCALE N.T.S.	SIZE ARCH D	FIELD BOOK & PAGES	
V-SCALE N.T.S.	V.S.	R.E.DWG.	
R.E. PROJ. NUMBER		DWG NO. PG-19	

11/25/2020 2:44 PM – jbarringer – \\bmcd\dfs\Clients\TND\NUSC\126851_RevWindEng\Design\Underground\CADD\Working\19 REV_WIND_PLAN AND PROFILE.dwg – PG-(19)

\\BMCD\DFS\CLIENTS\TND\NUSC\126851_REVWINDENG\DESIGN\UNDERGROUND\CADD\WORKING\19 REV_WIND_PLAN AND PROFILE.DWG 11/25/2020 2:44 PM JBARRINGER

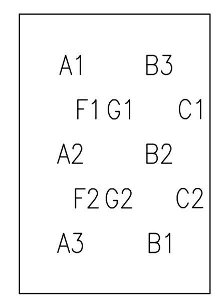


CONDUIT NAMING FOR SECTION A

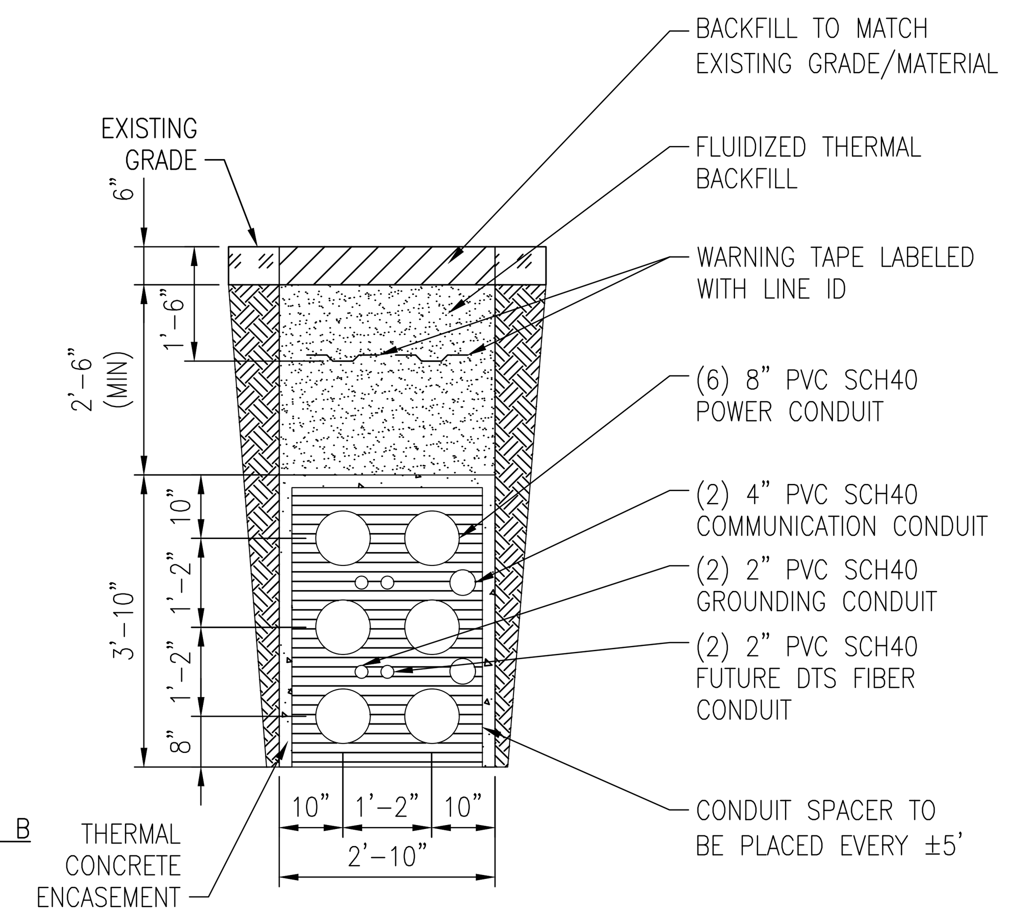


TYPICAL DOUBLE CIRCUIT 275kV
DUCT BANK CROSS SECTION

SECTION A
NTS

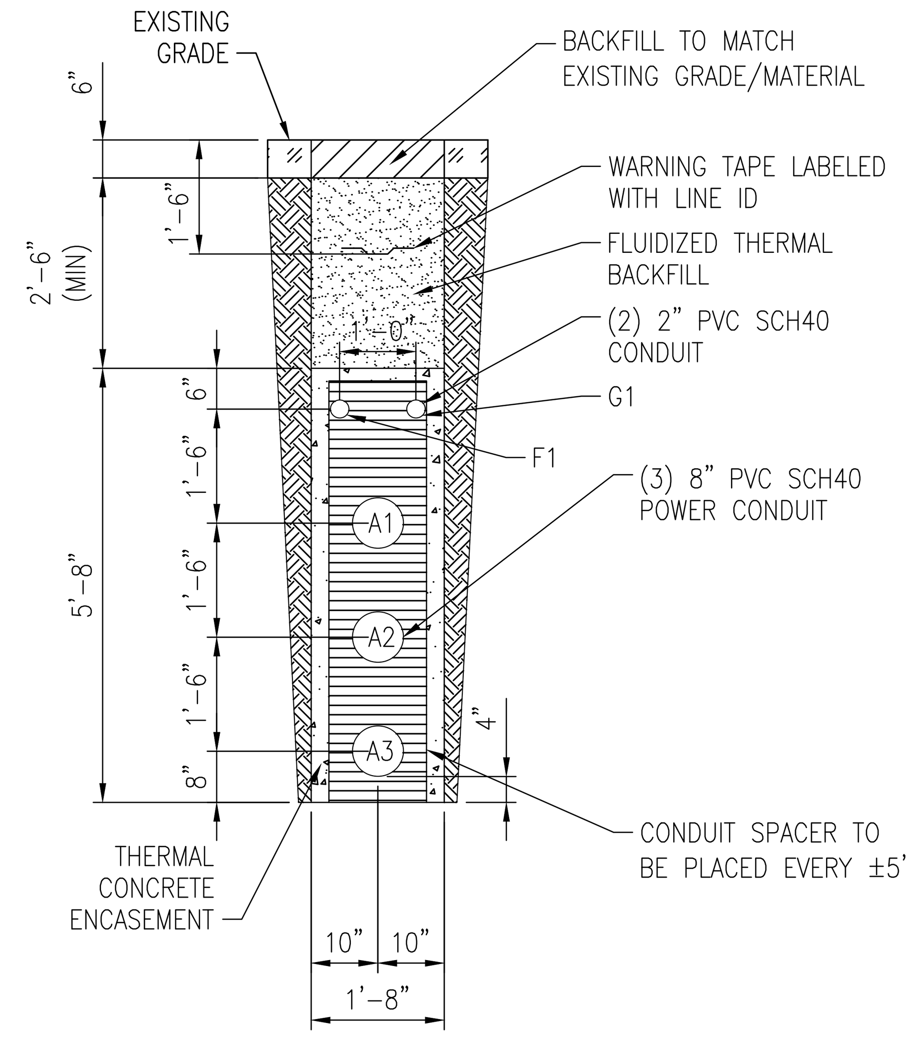


CONDUIT NAMING FOR SECTION B



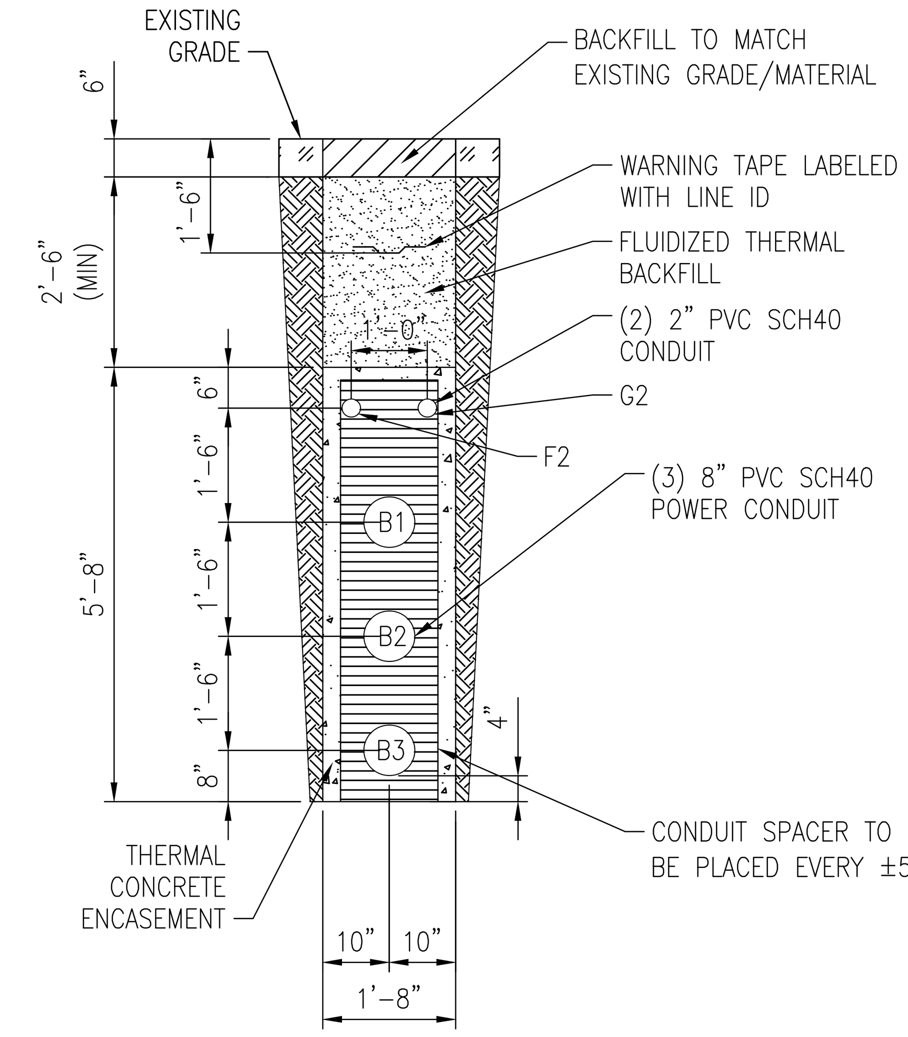
DOUBLE CIRCUIT 275kV
DUCT BANK CROSS SECTION

SECTION B
NTS



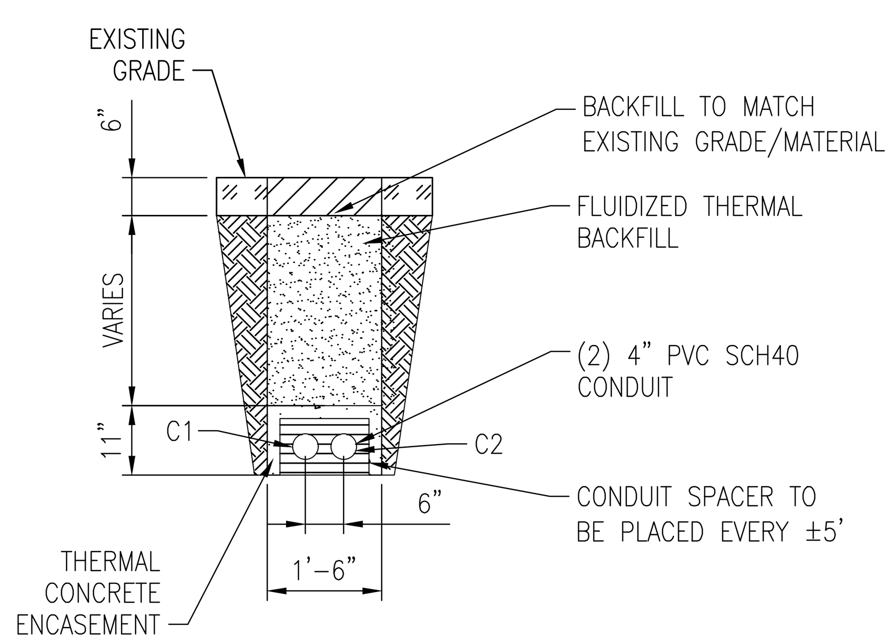
SINGLE CIRCUIT 275kV
DUCT BANK CROSS SECTION AT VAULTS

SECTION C



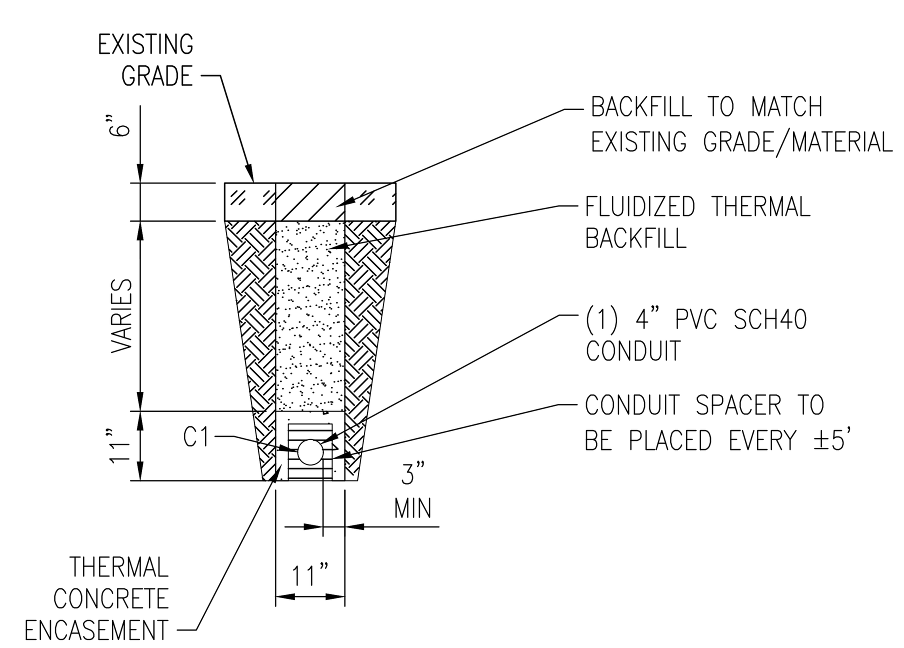
SINGLE CIRCUIT 275kV
DUCT BANK CROSS SECTION AT VAULTS

SECTION D



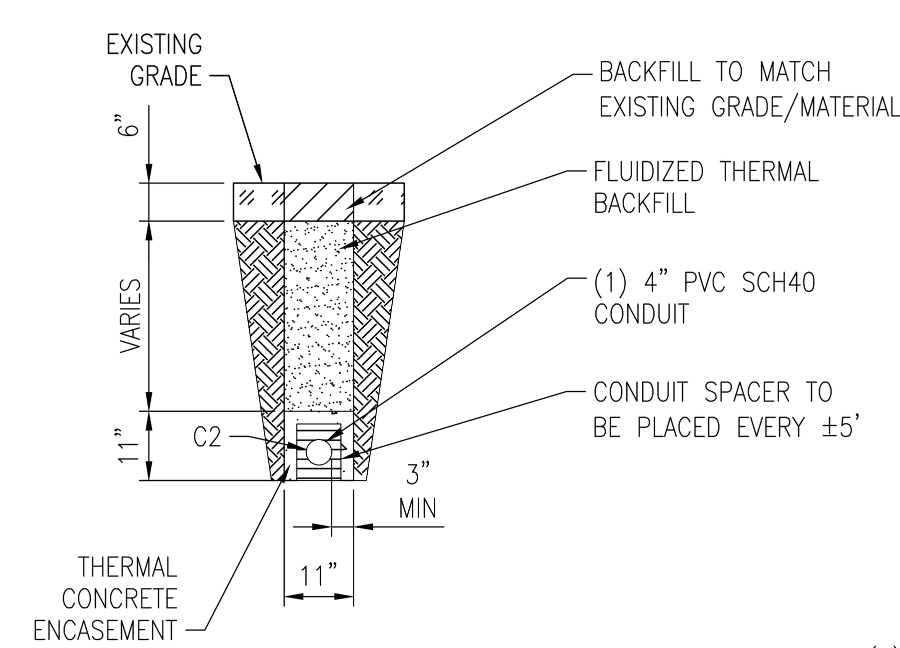
COMMUNICATION DUCT BANK

SECTION E
NTS



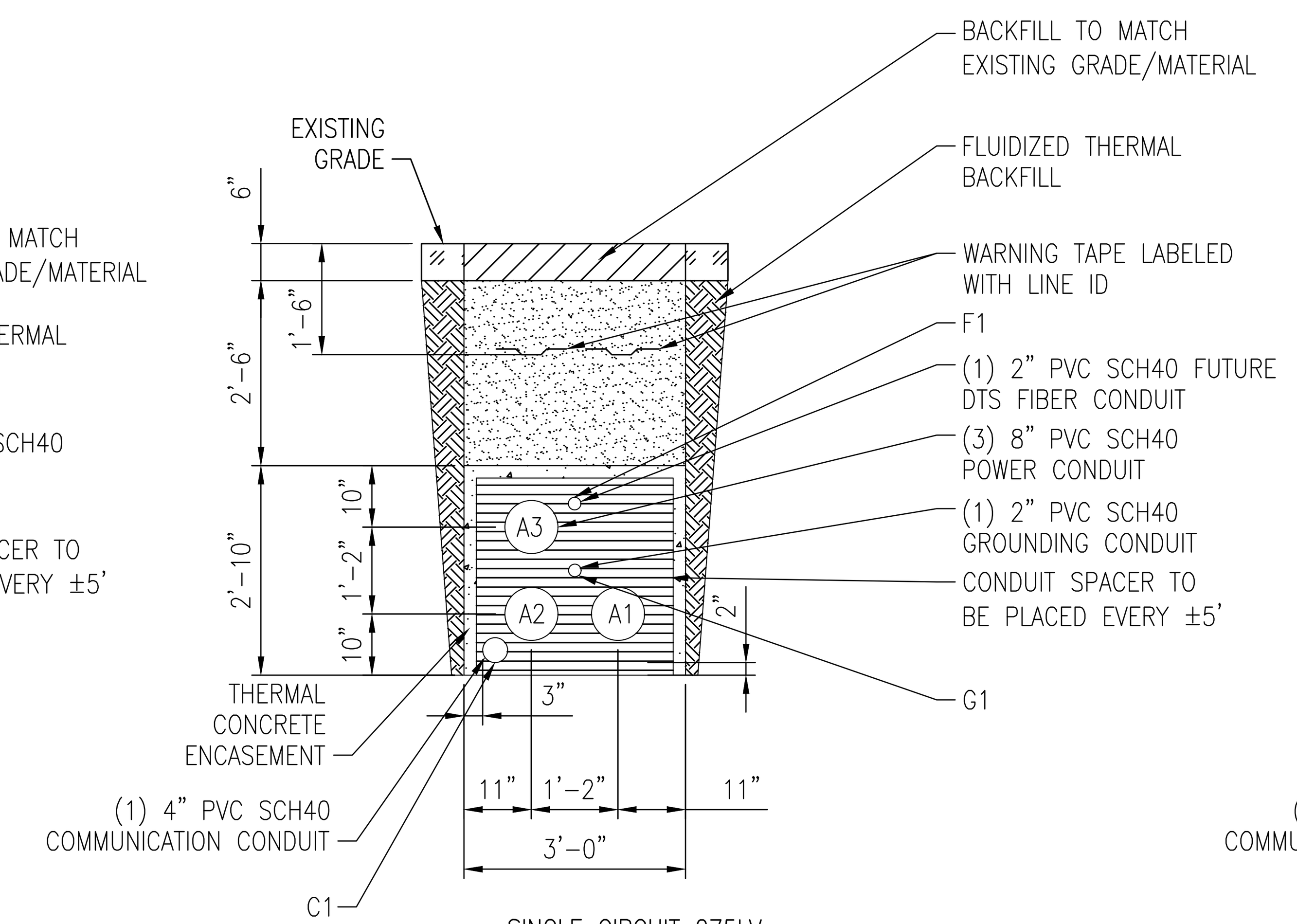
COMMUNICATION DUCT BANK

SECTION F
NTS



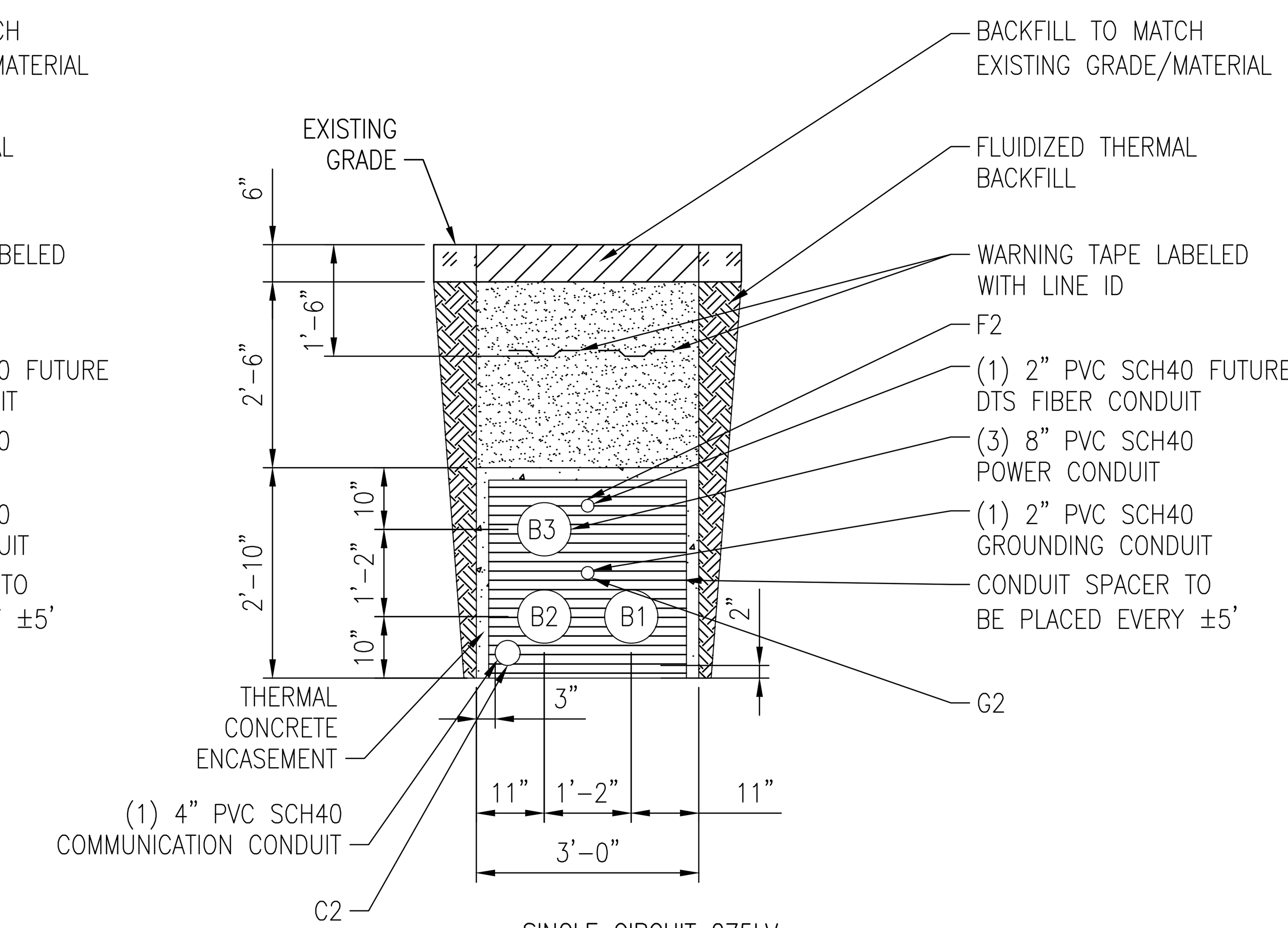
COMMUNICATION DUCT BANK

SECTION G
NTS



SINGLE CIRCUIT 275kV
DUCT BANK CROSS SECITON

SECTION H
NTS



SINGLE CIRCUIT 275kV
DUCT BANK CROSS SECTION

SECTION I
NTS

NOTES:

1. DIMENSIONAL ROUNDING, OUTSIDE DIMENSIONS ROUNDED UP TO THE NEAREST INCH.
2. DUCT BANK MINIMUM OF COVER SHALL BE 3'-0". UNLESS OTHERWISE APPROVED IN WRITING.

ISSUED FOR REVIEW-70%

PRELIMINARY - NOT FOR CONSTRUCTION

NO.	DATE	AS BUILT REVISIONS	BY	CHK	APP	APP
A	12/02/20	ISSUED FOR REVIEW-70%	JCB	MD	NS	–

REVISIONS DURING CONSTRUCTION

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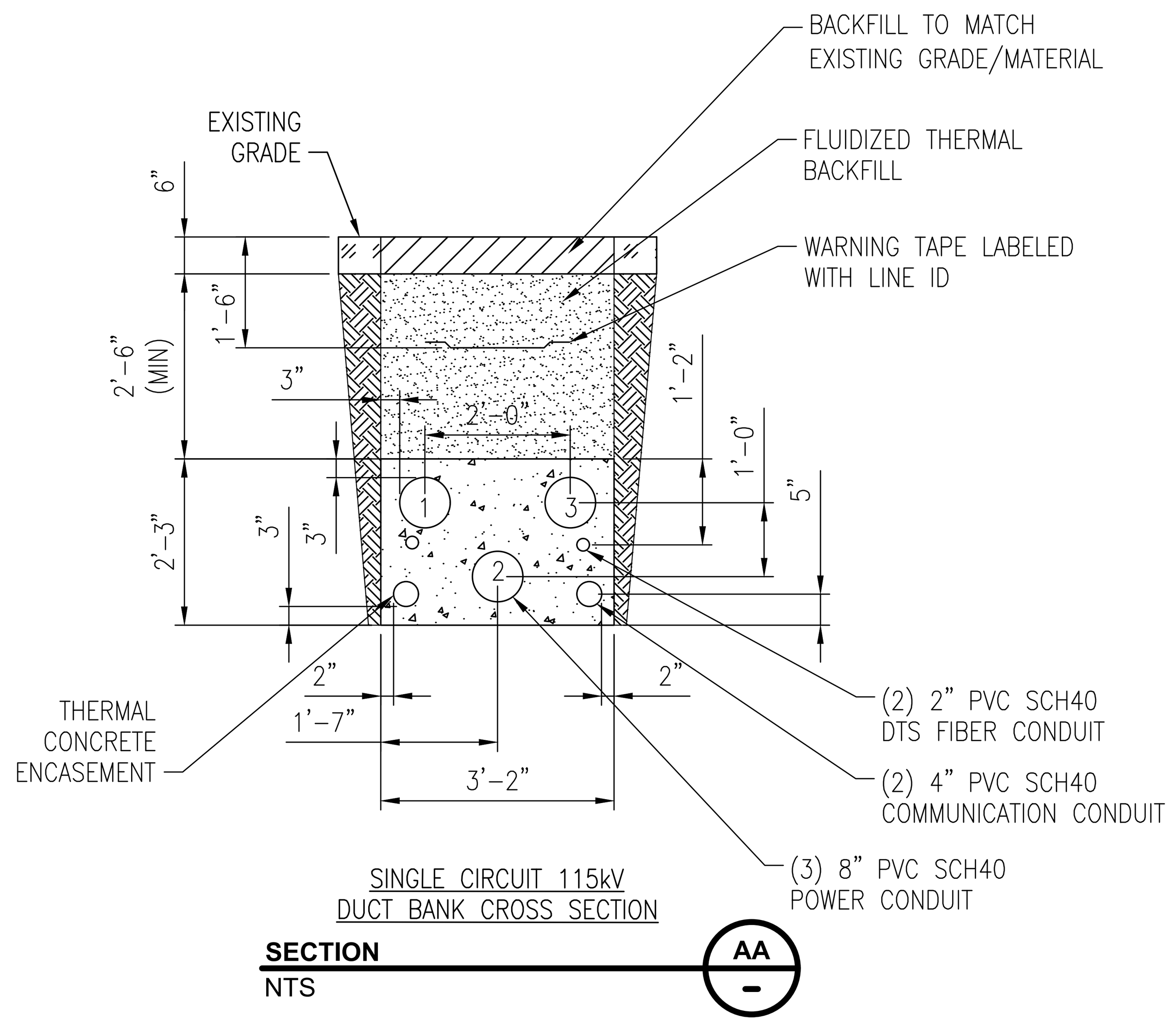
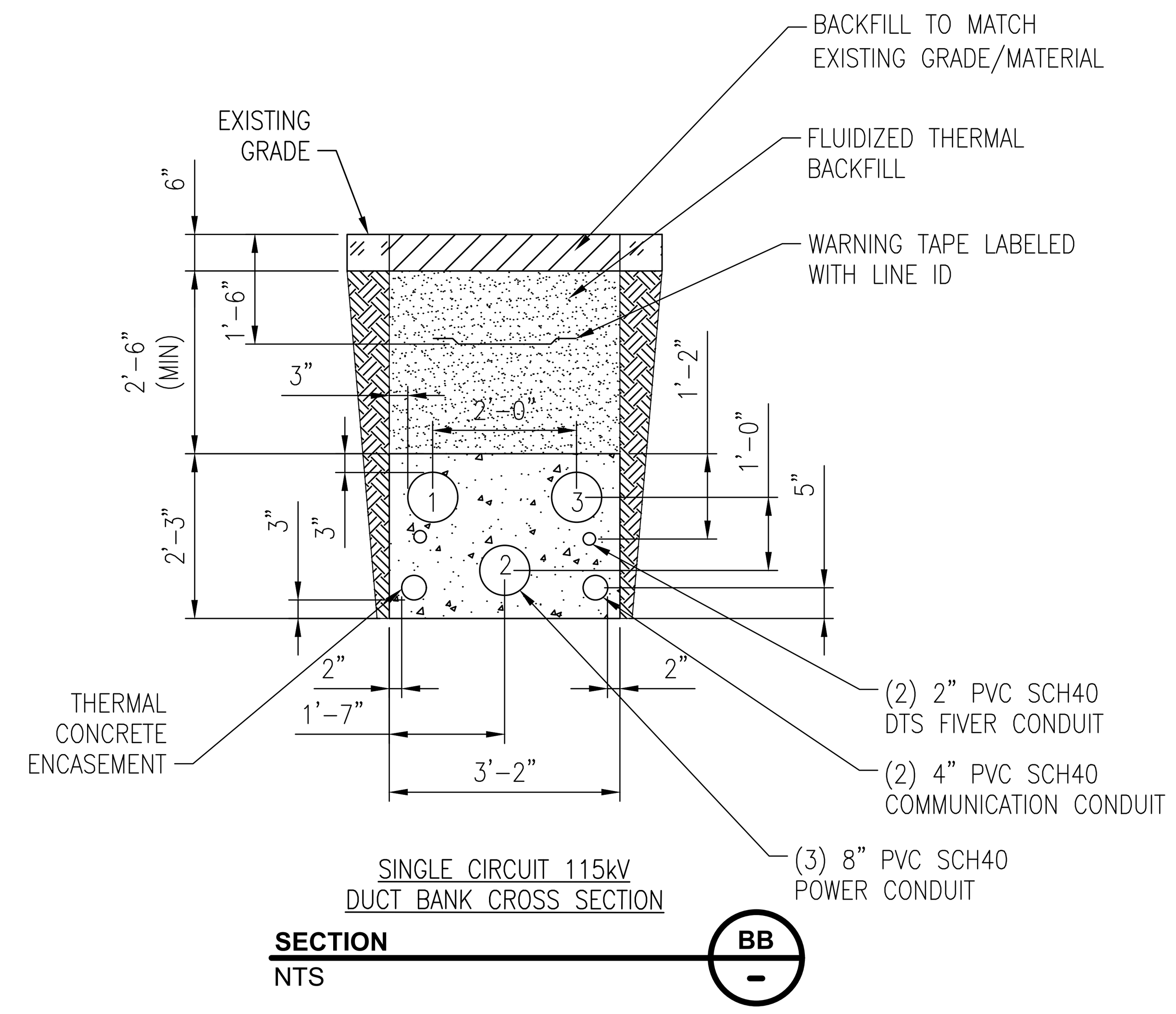
TITLE: REVOLUTION WIND

ONSHORE CABLE DUCT BANK CROSS SECTION DETAILS
NORTH KINGSTOWN, RHODE ISLAND

BY J. BARRINGER-BMcD	CHKD M. DAGENAIS-BMcD	APP N. SCOTT-BMcD	APP
DATE 09/30/20	DATE 09/30/20	DATE 09/30/20	DATE
H-SCALE N.T.S.	SIZE ARCH D	FIELD BOOK & PAGES	
V-SCALE N.T.S.	V.S.	R.E.DWG.	
R.E. PROJ. NUMBER		DWG NO. PG-20	





NOTES:

1. DIMENSIONAL ROUNDING, OUTSIDE DIMENSIONS ROUNDED UP TO THE NEAREST INCH.
2. DUCT BANK MINIMUM DEPTH OF COVER SHALL BE 3'-0". UNLESS OTHERWISE APPROVED IN WRITING.

ISSUED FOR REVIEW-70%

PRELIMINARY - NOT FOR CONSTRUCTION

NO.	DATE	AS BUILT REVISIONS	BY	CHK	APP	APP
A	12/02/20	ISSUED FOR REVIEW-70%	JCB	MD	NS	–

REVISIONS DURING CONSTRUCTION

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TITLE: REVOLUTION WIND

INTERCONNECT DUCT BANK CROSS SECTION DETAILS

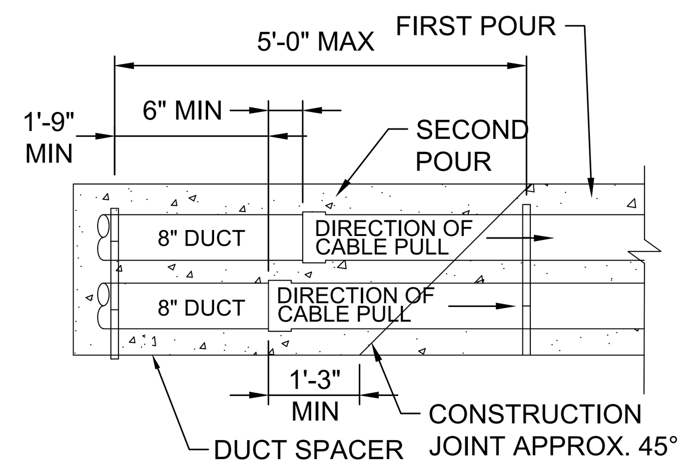
NORTH KINGSTOWN, RHODE ISLAND

BY J. BARRINGER-BMcD	CHKD M. DAGENAIS-BMcD	APP N. SCOTT-BMcD	APP
DATE 09/30/20	DATE 09/30/20	DATE 09/30/20	DATE
H-SCALE N.T.S.	SIZE ARCH D	FIELD BOOK & PAGES	
V-SCALE N.T.S.	V.S.	R.E.DWG.	
R.E. PROJ. NUMBER		DWG NO. PG-21	

ES VER: 05/2015

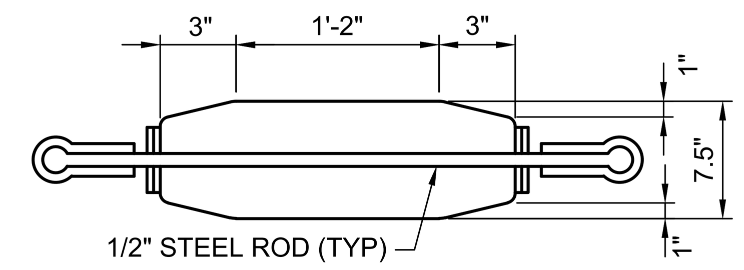
12/2/2020 1:47 PM – lnroberts – \\bmcd\dfs\Clients\TND\NUSC\126851_RevWindEng\Design\Underground\CADD\Working\21 INTERCONNECT DUCT BANK.dwg – CROSS SECTION

\\BMCD\DFS\CLIENTS\TND\NUSC\126851_REVWINDENG\DESIGN\UNDERGROUND\CADD\WORKING\21 INTERCONNECT DUCT BANK.DWG 12/2/2020 1:47 PM LNROBERTS



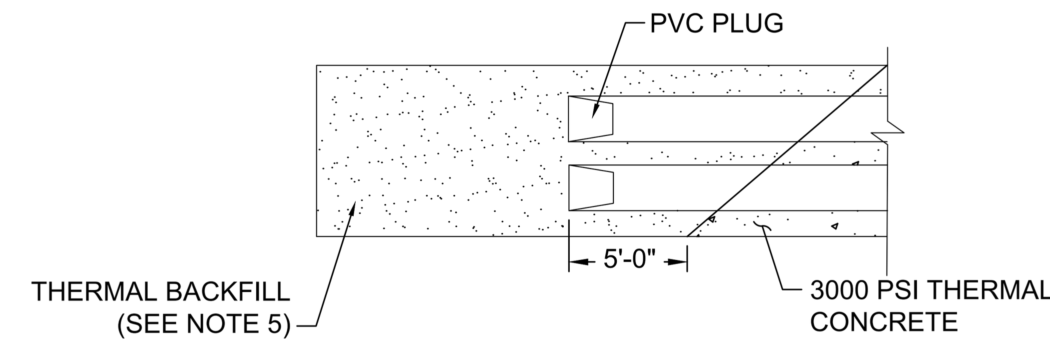
CONSTRUCTION JOINT
DETAIL

DETAIL 1
NTS -



TYPICAL MANDREL
DETAIL

DETAIL 2
NTS -

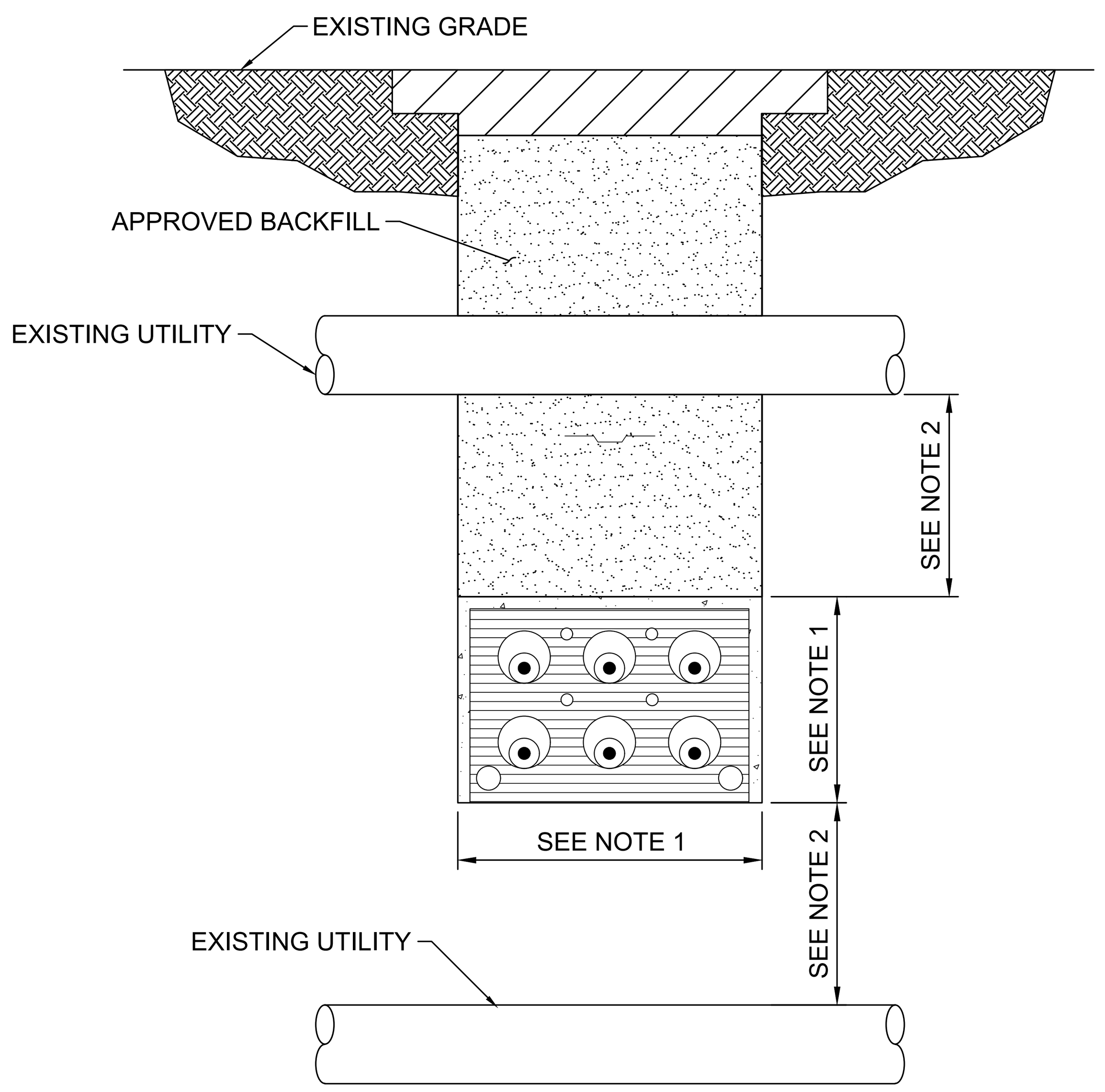


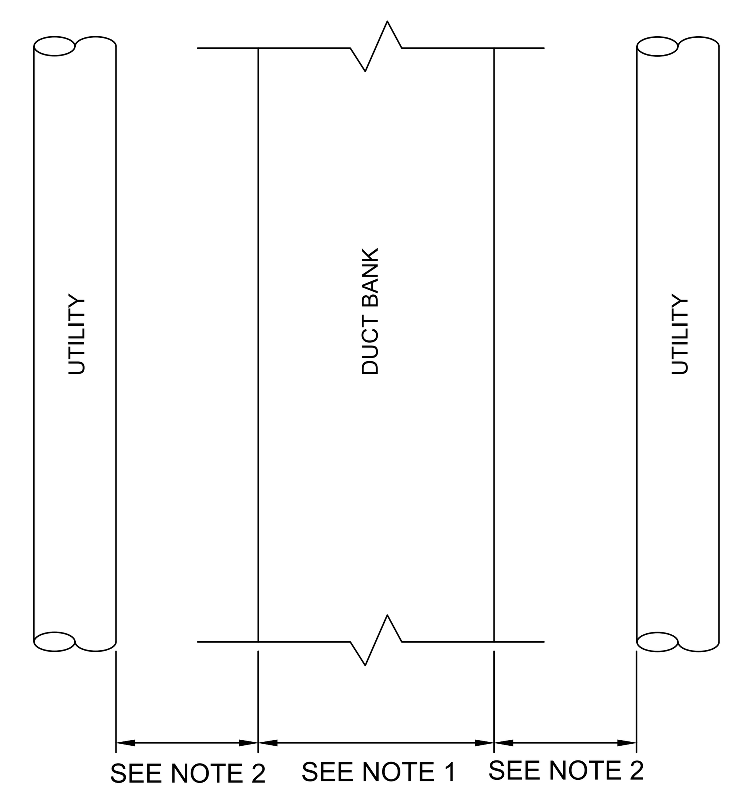
TEMPORARY CONDUIT
STUB OUT DETAILS

DETAIL 3
NTS -

NOTE:

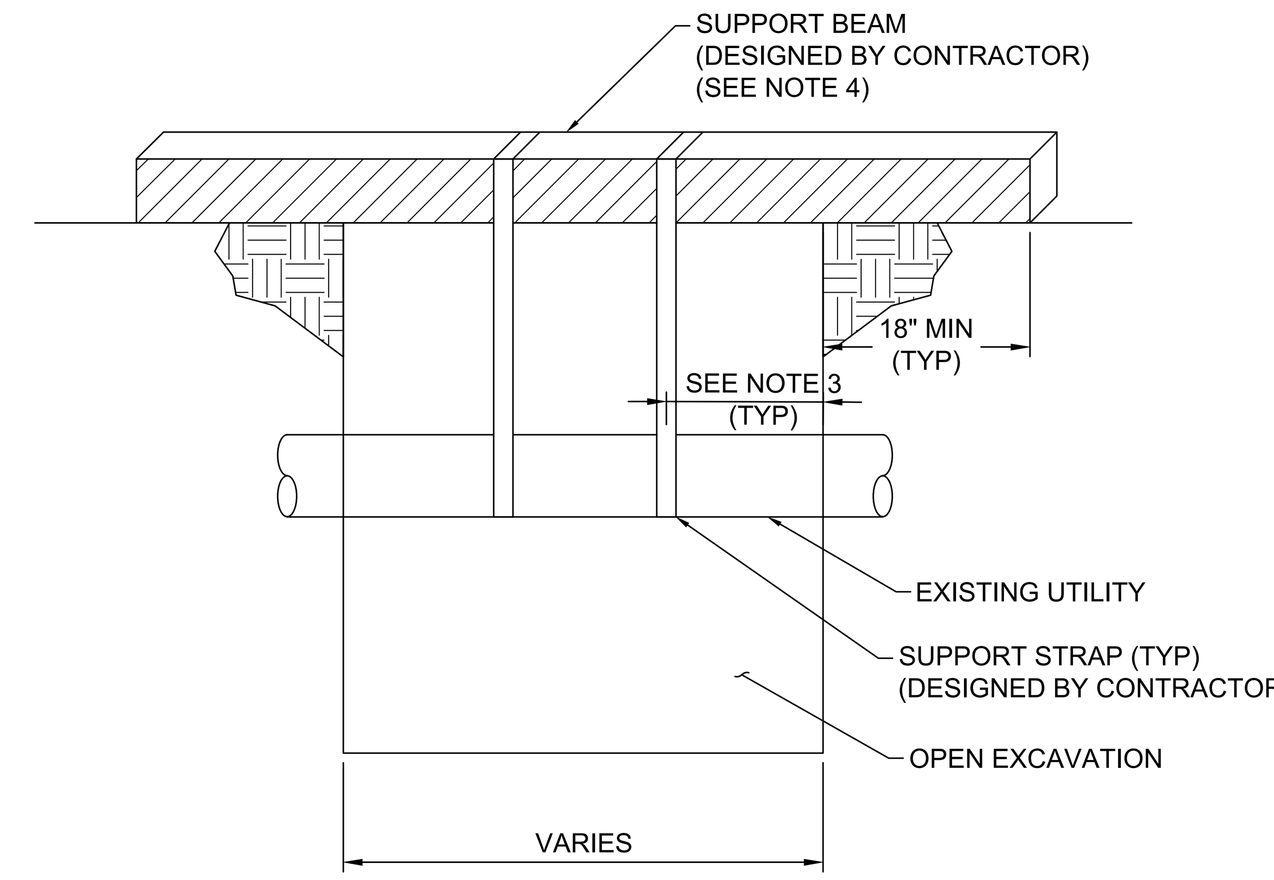
1. 2" AND 4" DUCTS NOT SHOWN FOR CLARITY.





TYPICAL HORIZONTAL UTILITY
CLEARANCE DETAIL

DETAIL 6
NTS -



TYPICAL PIPE SUPPORT ACROSS
OPEN EXCAVATION

DETAIL 7
NTS -

TYPICAL DUCT BANK WITH
UTILITY CLEARANCE

DETAIL 5
NTS -

GENERAL NOTES:

1. SEE DRAWING PG-20 AND PG-21 FOR CONDUIT SECTION.
2. 2'-0" MIN. CLEARANCE MAINTAINED UNLESS OTHERWISE NOTED ON PLAN AND PROFILE.
3. 2'-0" MAX SPAN, OR DIRECTED BY THE UTILITY WHICHEVER IS LESS.
4. CONTRACTOR SHALL SUBMIT METHOD OF SUPPORT TO RESPECTIVE UTILITY OWNERS FOR APPROVAL PRIOR TO CONSTRUCTION.
5. PROVIDE A MINIMUM OF 3'-0" OF THERMAL BACKFILL AROUND ALL SIDES OF CONDUITS.

ISSUED FOR REVIEW-70%

PRELIMINARY - NOT FOR CONSTRUCTION

PRELIMINARY:
FOR REFERENCE ONLY

REVISIONS DURING CONSTRUCTION

NO.	DATE	AS BUILT REVISIONS	BY	CHK	APP	APP
A	12/02/20	ISSUED FOR REVIEW-70%	JCB	MD	NS	–

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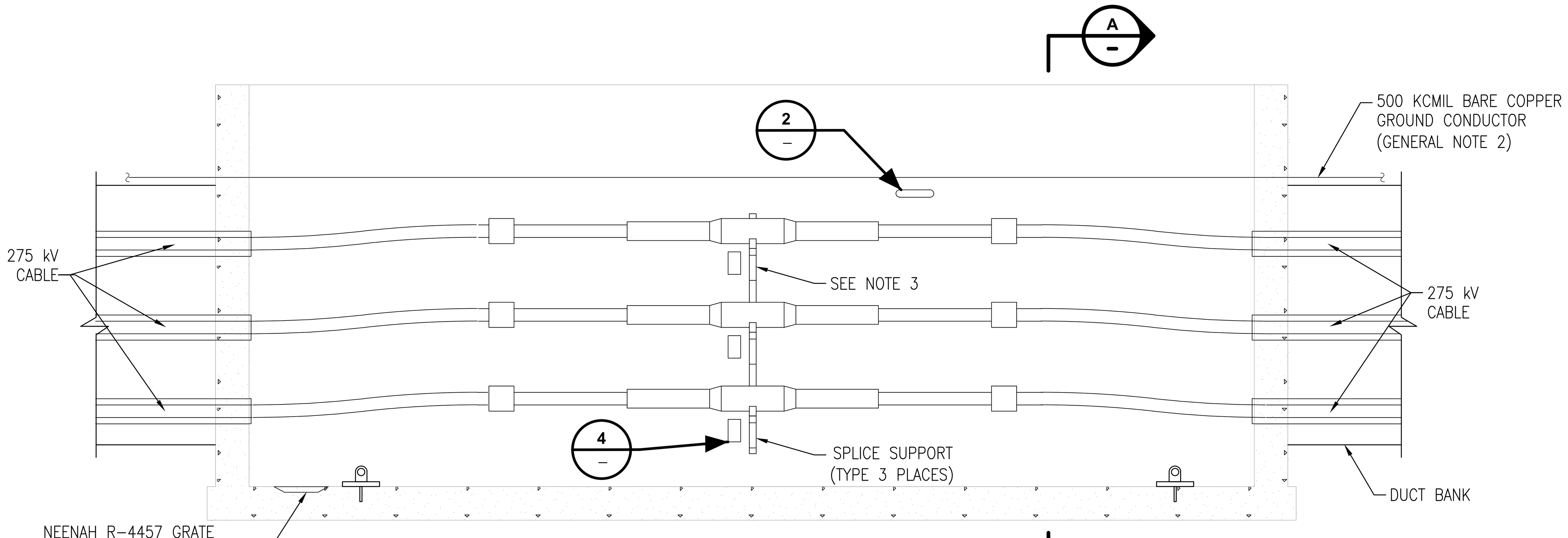
TITLE REVOLUTION WIND

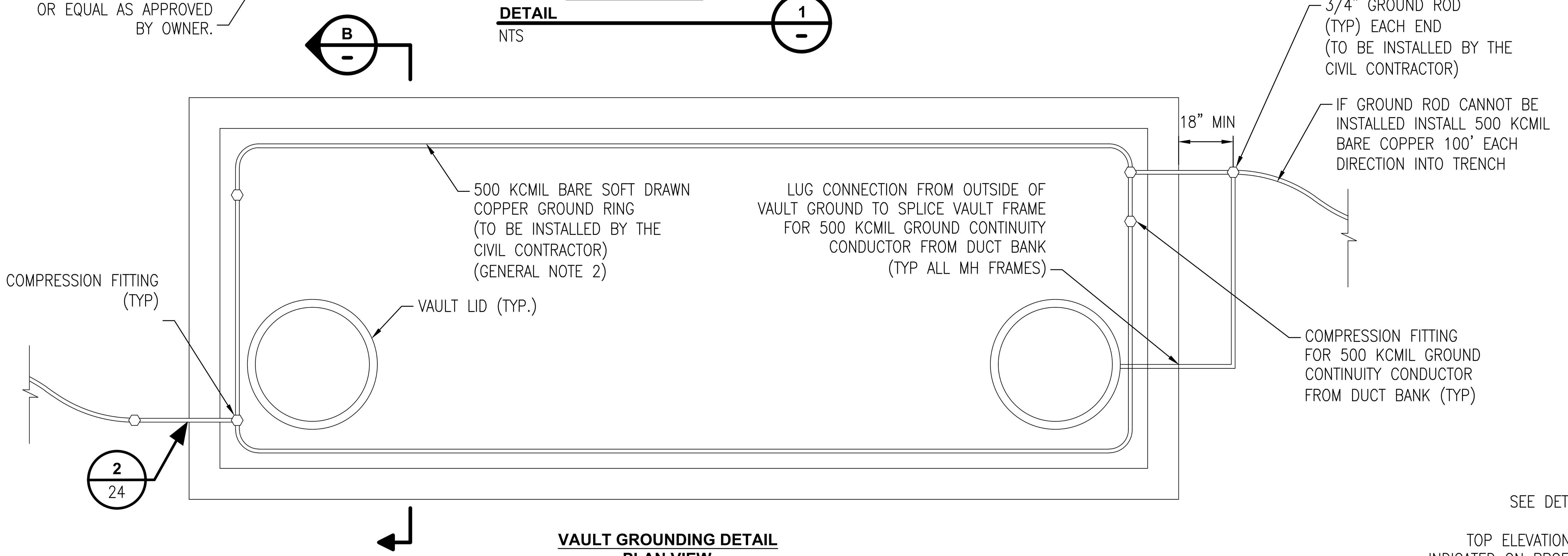
DUCT BANK SECTIONS
NORTH KINGSTOWN, RHODE ISLAND

BY J. BARRINGER-BMcD	CHKD M. DAGENAIS-BMcD	APP N. SCOTT-BMcD	APP
DATE 09/30/20	DATE 09/30/20	DATE 09/30/20	DATE
H-SCALE N.T.S.	SIZE ARCH D	FIELD BOOK & PAGES	
V-SCALE N.T.S.	V.S.	R.E.DWG.	
R.E. PROJ. NUMBER		DWG NO. PG-22	



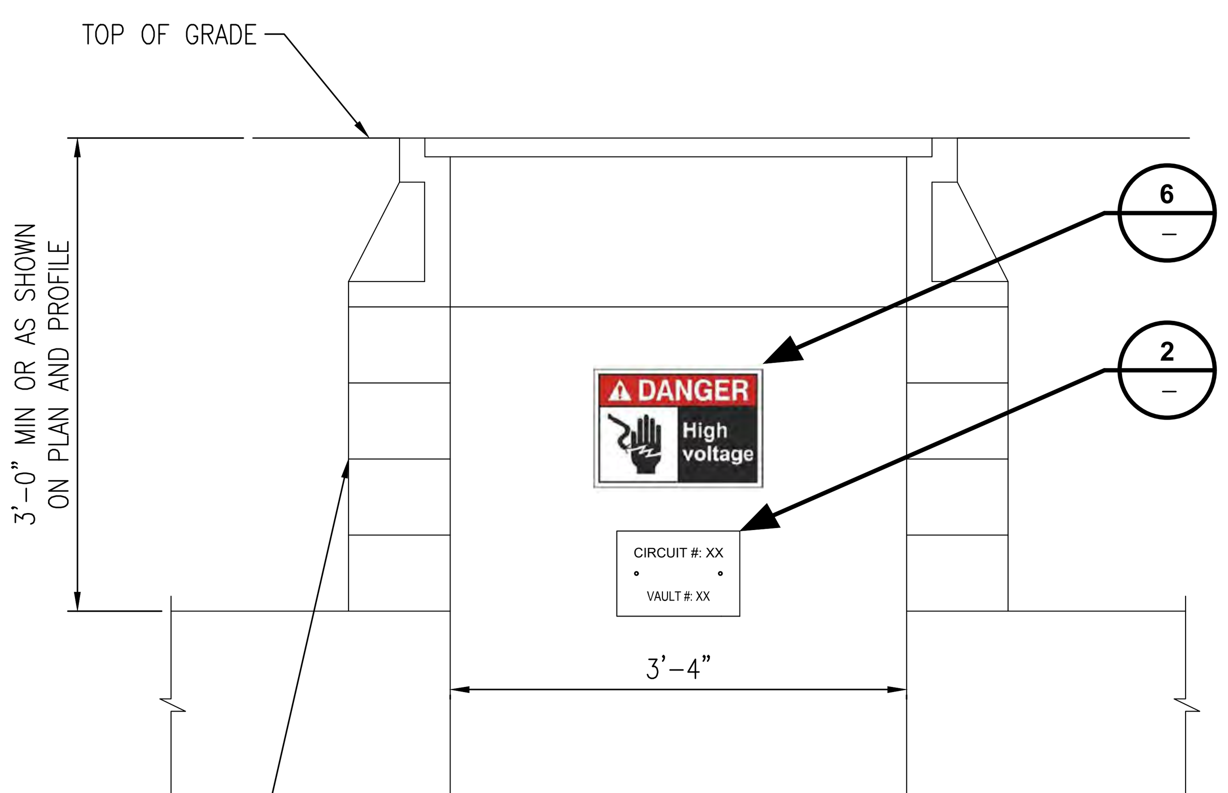
SPLICE VAULT ELEVATION VIEW

DETAIL 1
NTS



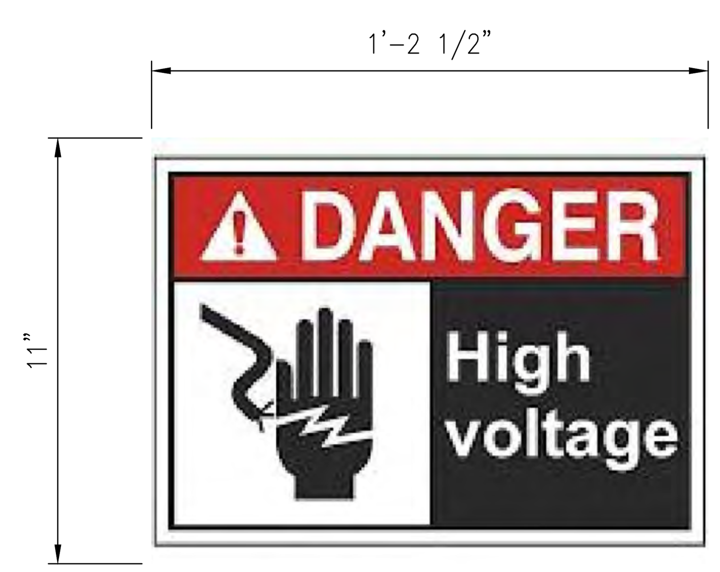
VAULT GROUNDING DETAIL PLAN VIEW

DETAIL 3
NTS



SPLICE VAULT CHIMNEY

DETAIL 7
NTS

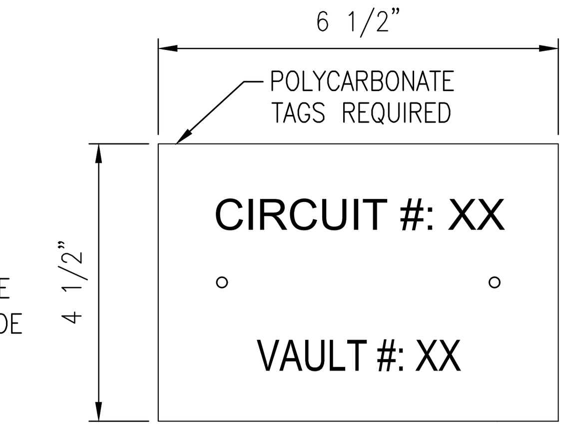


DANGER WARNING SIGN

DETAIL 6
NTS

NOTES:

1. CIVIL CONTRACTOR SHALL ATTACH POLYCARBONATE TAG 1'-6" BELOW FINISHED GRADE ON THE INSIDE OF THE CHIMNEY AND ON THE VAULT WALL OPPOSITE THE RACKING.

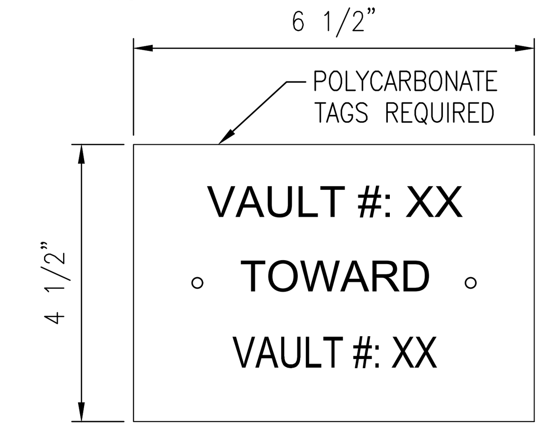


CIRCUIT IDENTIFICATION TAG

DETAIL 2
NTS

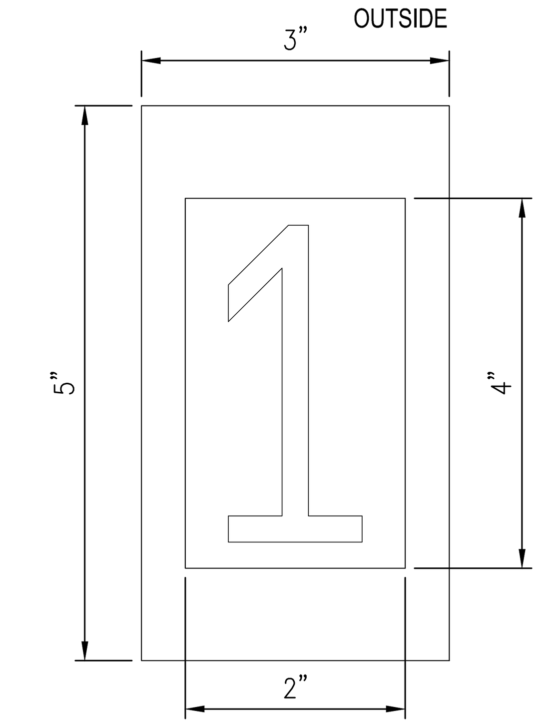
NOTES:

1. CIVIL CONTRACTOR SHALL ATTACH TAG 6" FROM THE CONDUIT ON EACH END WALL OF SPLICE VAULT AS SHOWN IN SECTION A WITH DELINEATION OF NEXT SPLICE VAULT IN THE CIRCUIT AND DISTANCE TO SPLICE VAULT.



TOWARD SIGN

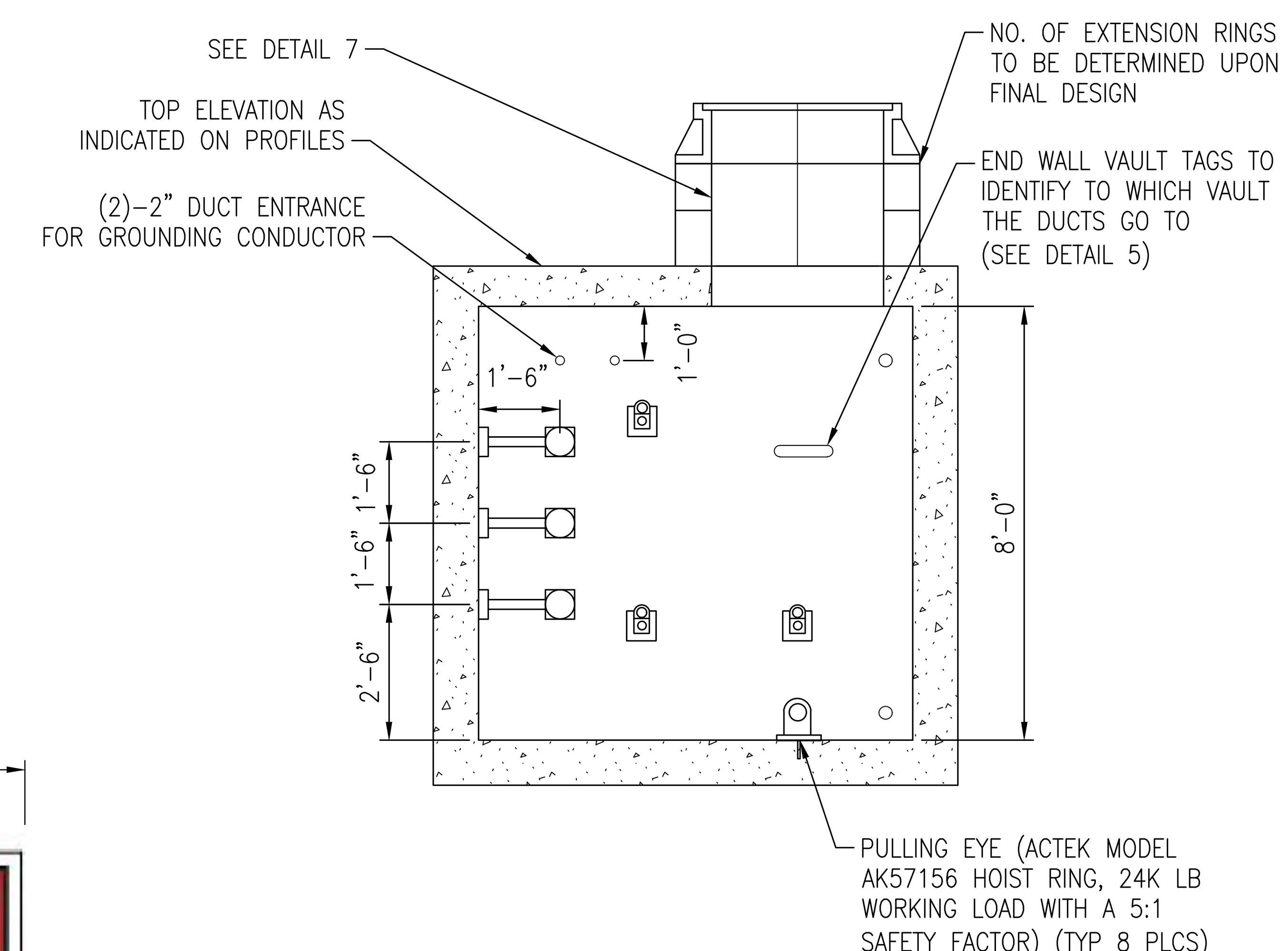
DETAIL 5
NTS



DETAIL 4
NTS

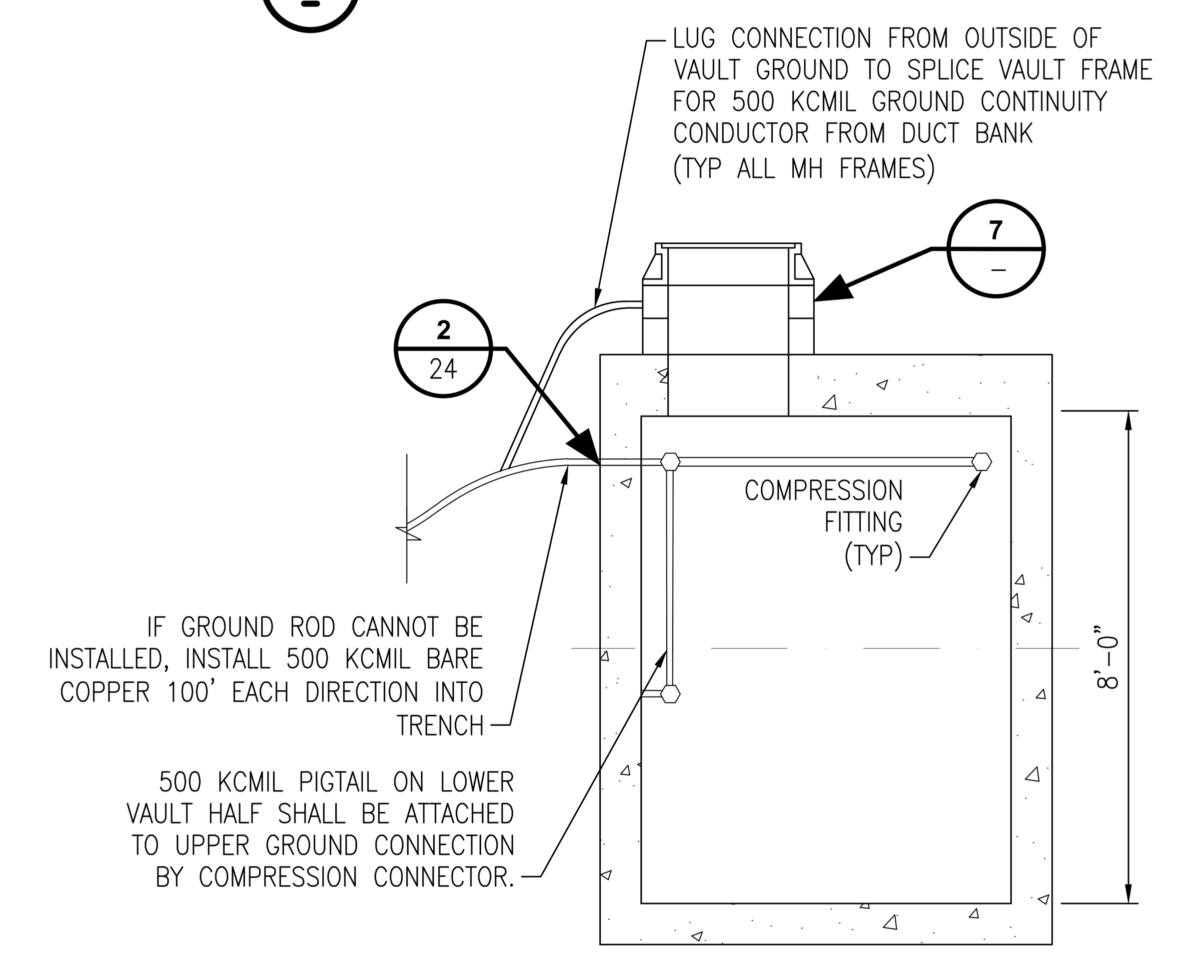
NOTES:

1. CHARACTER SHALL BE 4" HIGH BOLD TYPE.
2. CHARACTER SHALL BE CENTERED ON SIGN.
3. – BACKGROUND: WHITE
   – LETTERING: BLACK
   – CHARACTERS: 1, 2, & 3 AS SHOWN.



SPLICE VAULT

SECTION A
NTS



SPLICE VAULT

SECTION B
NTS

GENERAL NOTES:

1. GROUND PIGTAILS TO EXTEND A MINIMUM OF 18 INCHES FROM BOTH SIDES OF VAULT WALL PENETRATION.
2. GROUND CLIPS MAX 1' FROM ALL MANHOLE CORNERS, AND MAX 4' OC SPACING ALONG WALLS USE 1/2" PVC COATED. MALLEABLE IRON RIGID STEEL CONDUIT 1 HOLE STRAP WITH BACKSTRAP. ALL HARDWARE AND INSERTS TO BE STAINLESS STEEL.
3. ALL GROUND CONNECTIONS TO MANHOLE RACKS ETC. SHALL BE VIA A TINNED CU 1 HOLE.
4. PASS GROUND CONDUCTOR THROUGH VAULT WALL AND SUPPORT ALONG VAULT WALL AS HIGH AS POSSIBLE BUT NO MORE THAN 12" DOWN FROM VAULT CEILING.
5. BOND GROUNDS FROM EARTHING TO VAULT/DUCTBANK GROUND.
6. CABLE VENDOR IS TO PLACE PHASE DESIGNATIONS.
7. CABLE SUPPORT TO BE DESIGNED AND CONSTRUCTED BY CABLE VENDOR.

PRELIMINARY:
FOR REFERENCE ONLY

REVISIONS DURING CONSTRUCTION

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A	12/02/20	ISSUED FOR REVIEW-70%	JCB	MD	NS	–

Revolution Wind — Powered by Ørsted & Eversource

TITLE: REVOLUTION WIND
SPLICE VAULT DETAILS
NORTH KINGSTOWN, RHODE ISLAND

BY	CHK'D	APP	APP
J. BARRINGER-BMcD	M. DAGENAIS-BMcD	N. SCOTT-BMcD	
DATE 09/30/20	DATE 09/30/20	DATE 09/30/20	DATE

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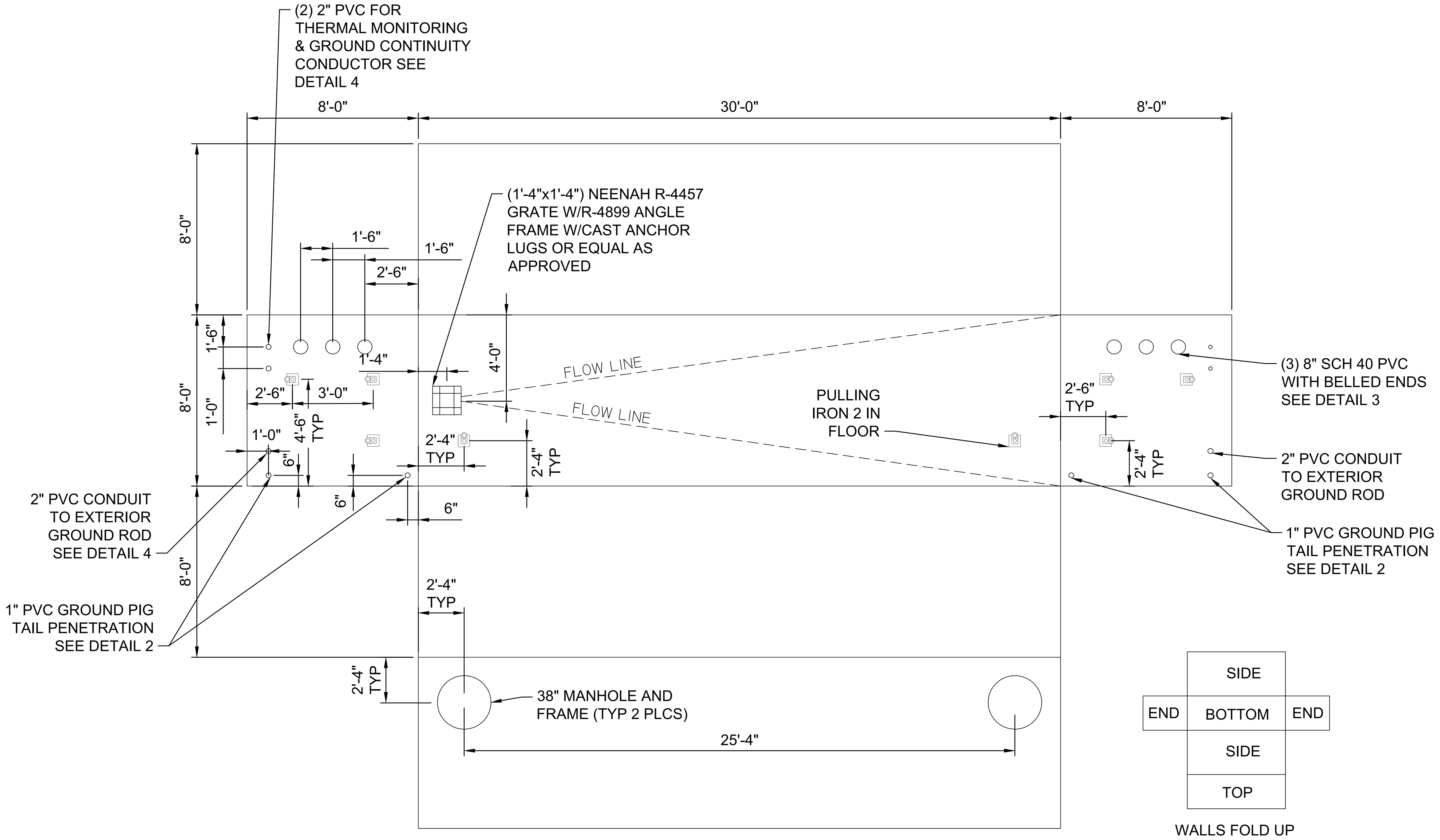
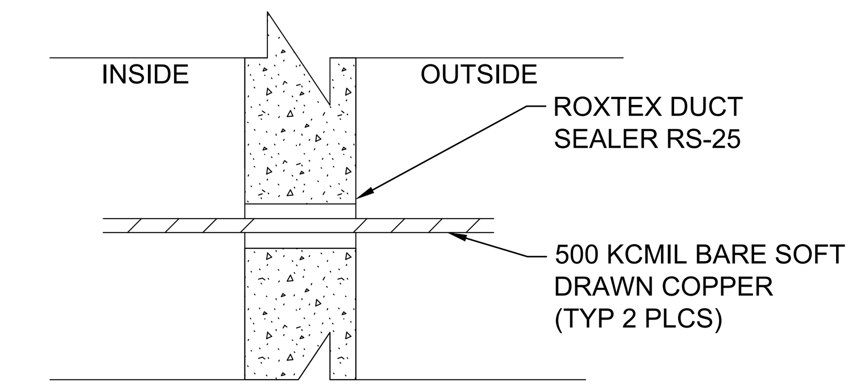
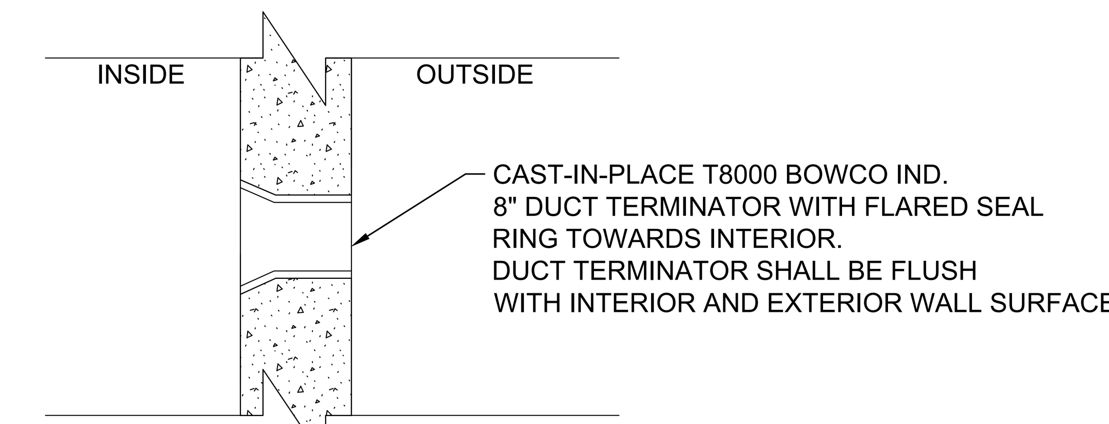
V-SCALE N.T.S. | V.S. | R.E.DWG. SHEET 1 OF 2
R.E. PROJ. NUMBER | DWG NO. PG-23



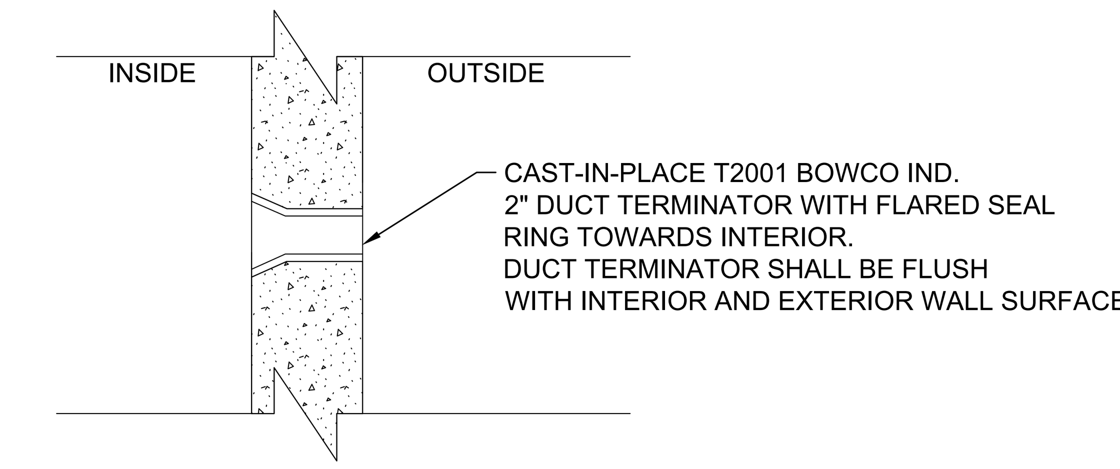
TYPICAL XLPE SPLICE VAULT DEVELOPMENT PLAN
DETAIL 1
NTS



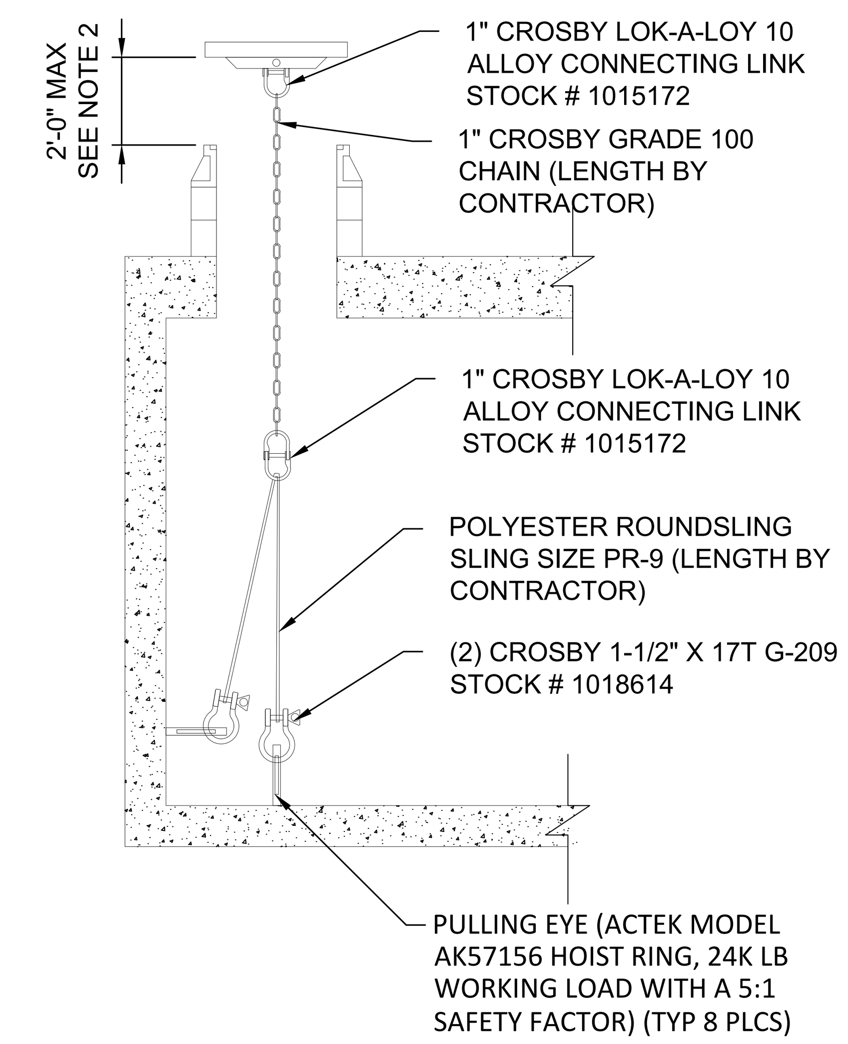
2" DUCT TERMINATOR DETAIL PROFILE VIEW
DETAIL 2
NTS



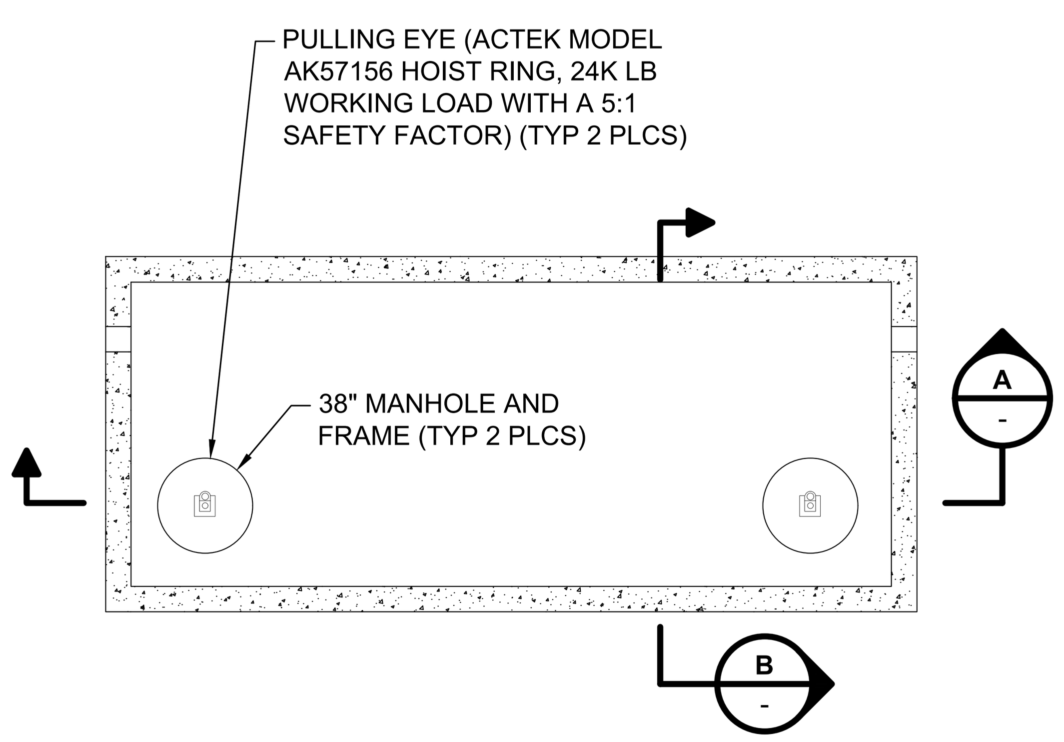
8" DUCT TERMINATOR DETAIL
DETAIL 3
NTS



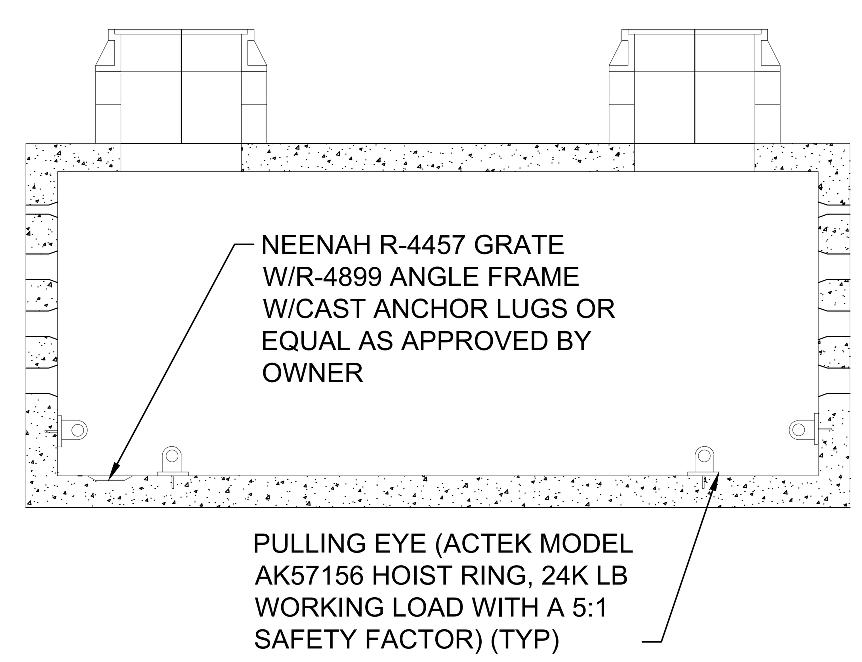
2" DUCT TERMINATOR DETAIL
DETAIL 4
NTS



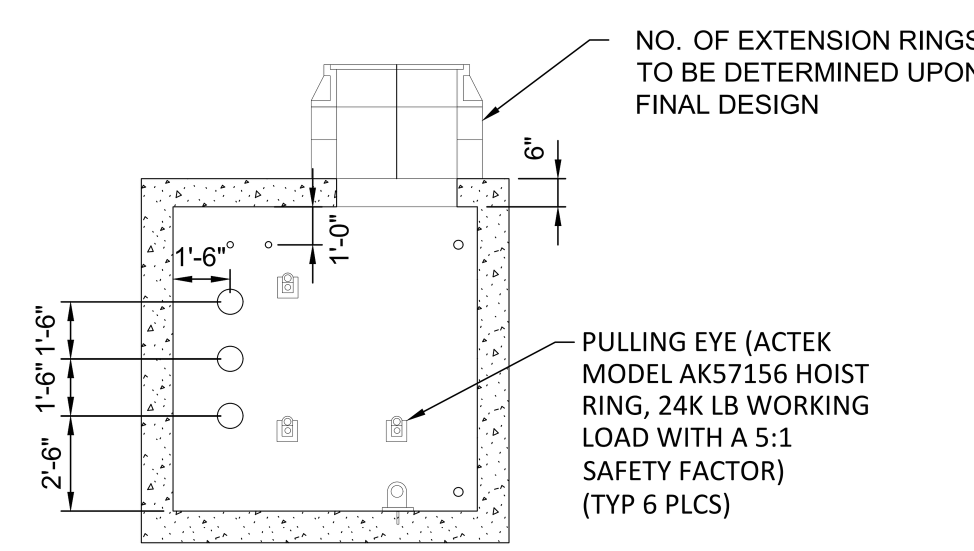
MANHOLE TETHER DETAIL
DETAIL 6
NTS



SPLICE VAULT PLAN VIEW
DETAIL 5
NTS



ELEVATION VIEW
SECTION A
NTS



SIDE ELEVATION VIEW
SECTION B
NTS

NOTES:

1. FERROUS REBAR WITHIN SPLICE CHAMBER WALLS SHALL NOT FORM A CLOSED LOOP AROUND ANY INDIVIDUAL 8" CONDUIT OPENING.
2. CONTRACTOR TO ADJUST TETHER SYSTEM FOR MAXIMUM COVER RISE OF 24".
3. MANHOLE DIMENSIONS SHOWN ARE INSIDE DIMENSIONS.
4. ALL PULLING EYES SHALL BE DESIGNED FOR MULTIDIRECTIONAL CABLE PULLS.
5. ALL PIPE SIZES ARE NOMINAL.

ISSUED FOR REVIEW-70%

PRELIMINARY - NOT FOR CONSTRUCTION

PRELIMINARY: FOR REFERENCE ONLY

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Revolution Wind | Powered by Ørsted & Eversource

TITLE: REVOLUTION WIND
SPLICE VAULT DETAILS
NORTH KINGSTOWN, RHODE ISLAND

BY	CHKD	APP	APP
J. BARRINGER-BMcD	M. DAGENAIS-BMcD	N. SCOTT-BMcD	
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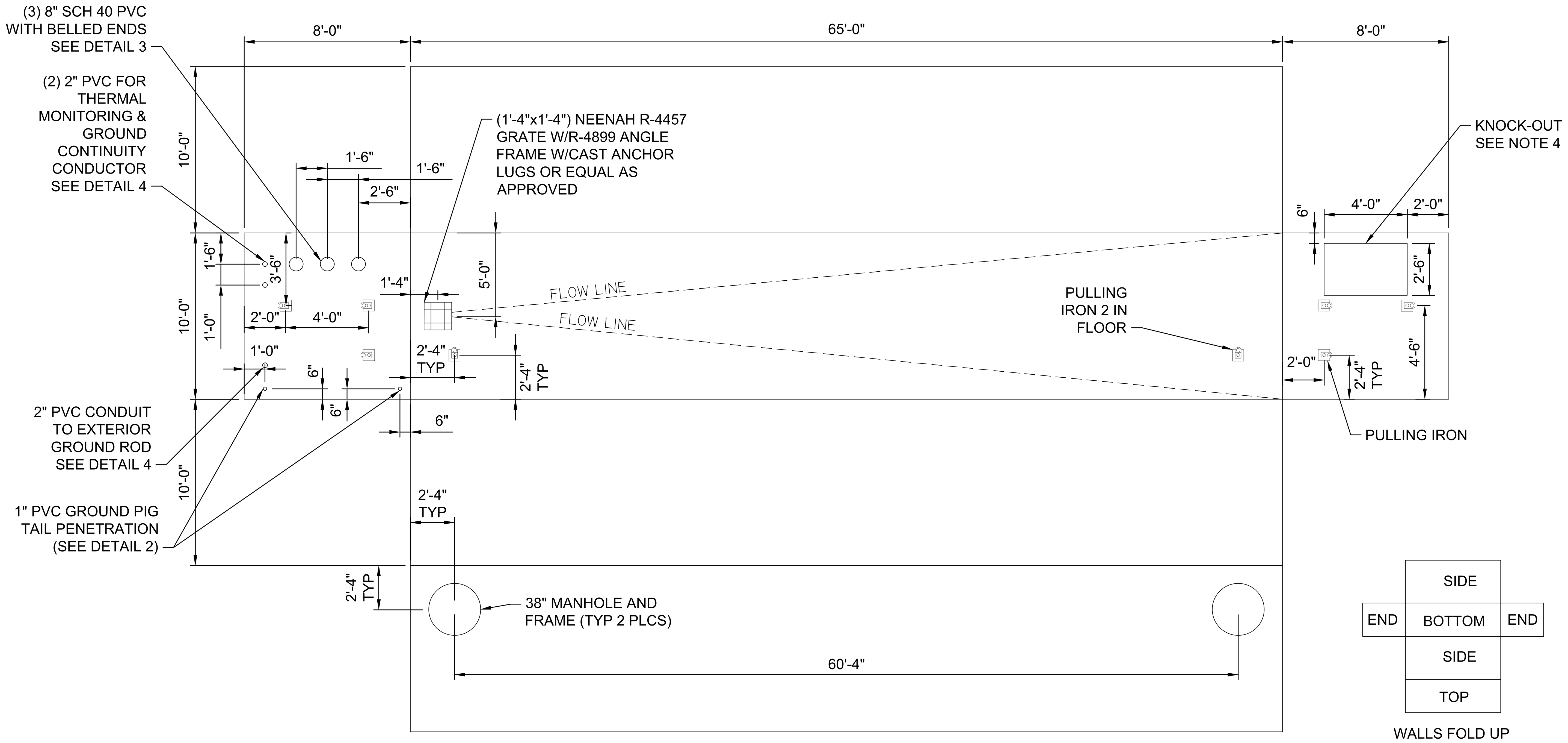
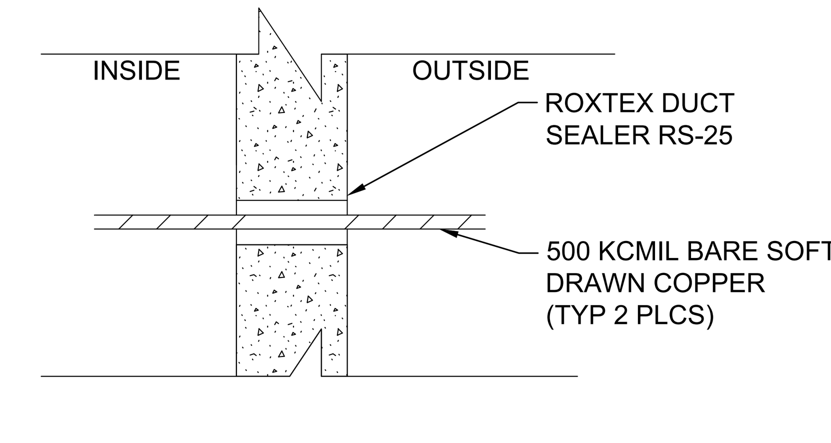
H-SCALE N.T.S.	SIZE ARCH D	FIELD BOOK & PAGES	
V-SCALE N.T.S.	V.S.	R.E.DWG.	
R.E. PROJ. NUMBER		DWG NO. PG-24	

ES VER: 05/2015



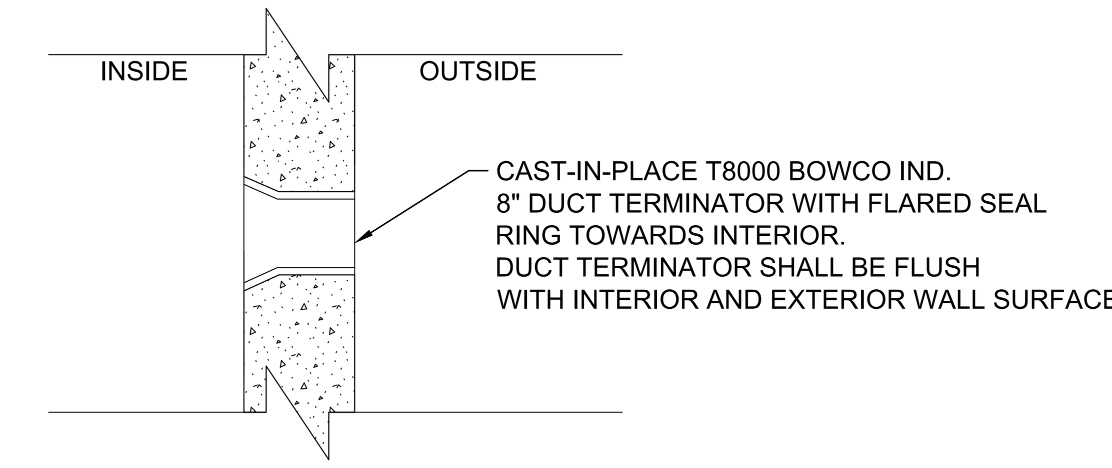
TYPICAL TRANSITION JOINT BAY PLAN

DETAIL 1
NTS -



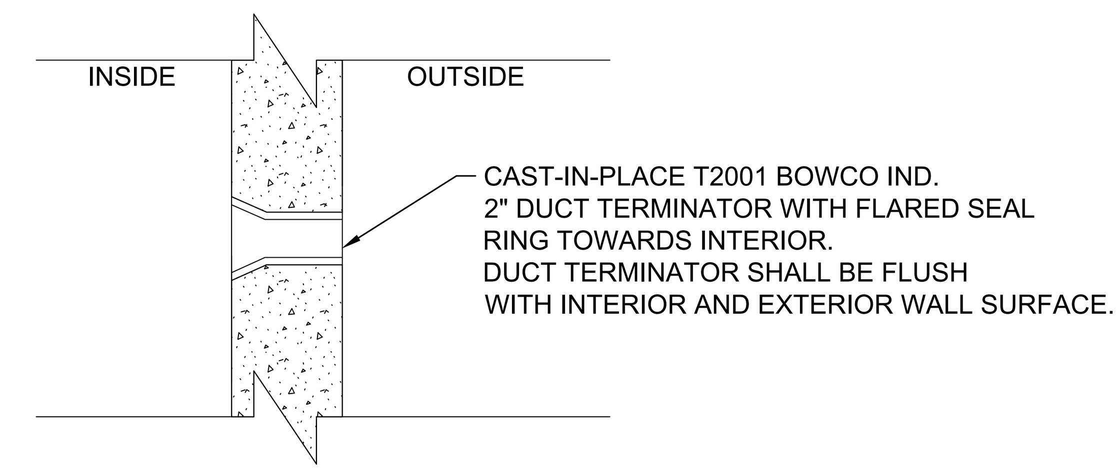
2" DUCT TERMINATOR DETAIL PROFILE VIEW

DETAIL 2
NTS -



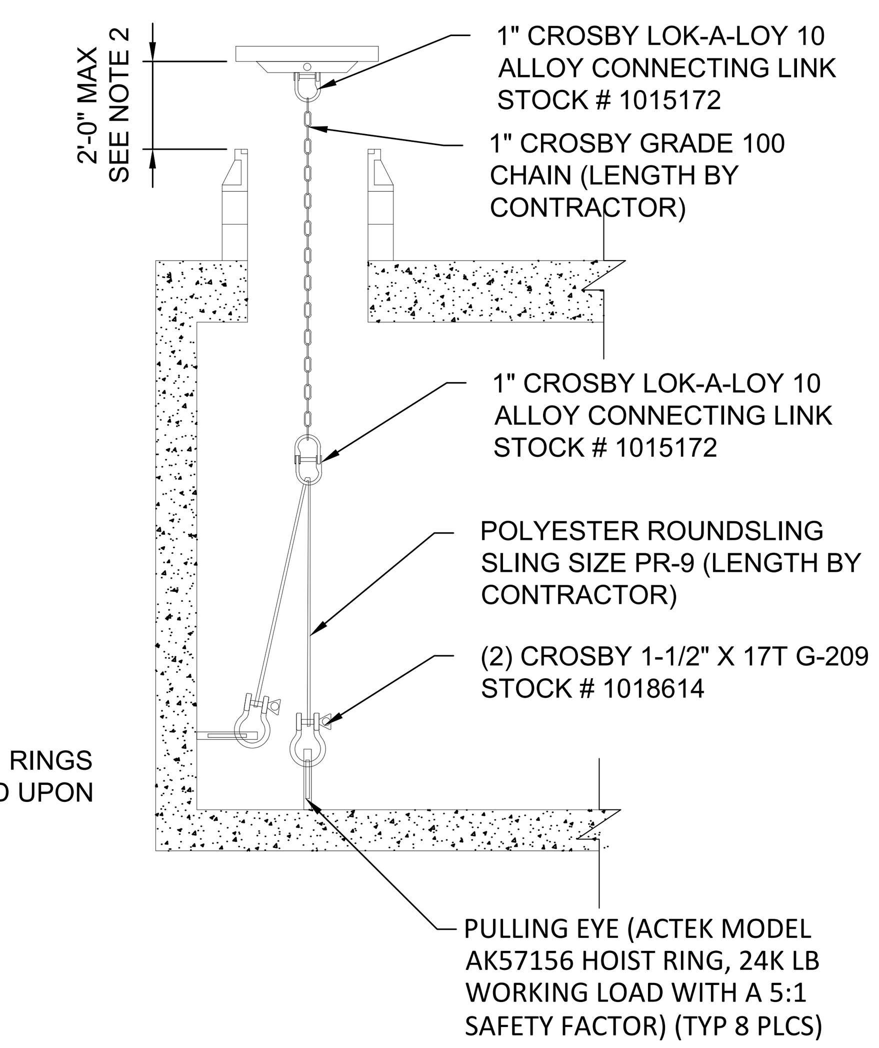
8" DUCT TERMINATOR DETAIL

DETAIL 3
NTS -



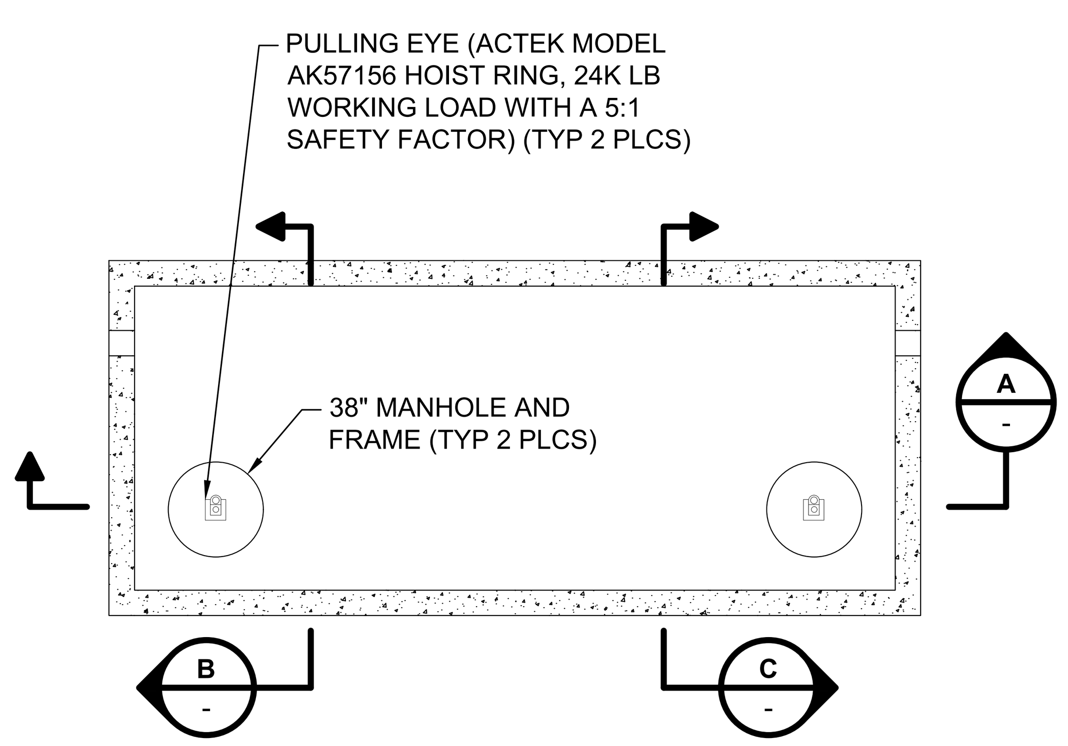
2" DUCT TERMINATOR DETAIL

DETAIL 4
NTS -



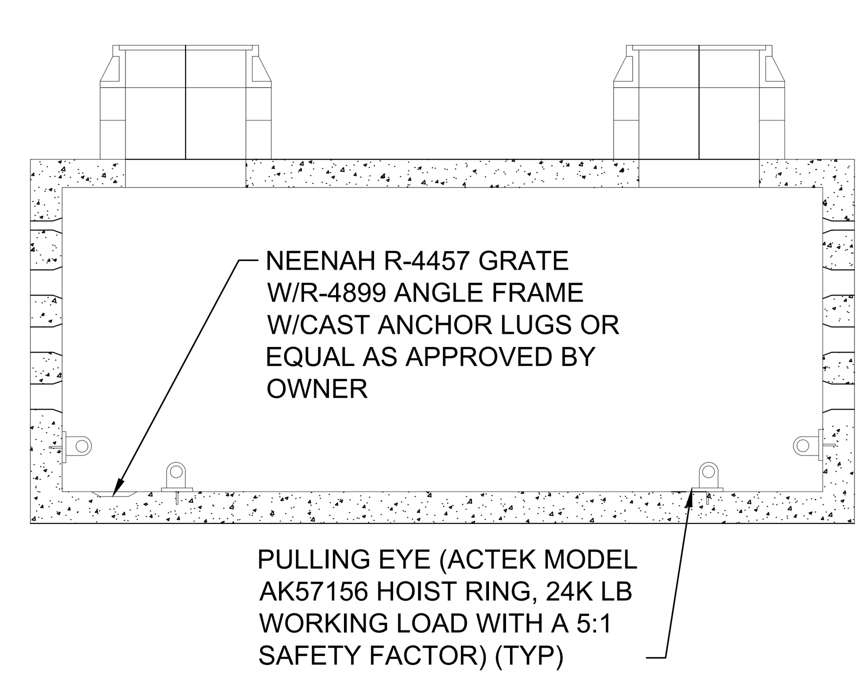
MANHOLE TETHER DETAIL

DETAIL 6
NTS -



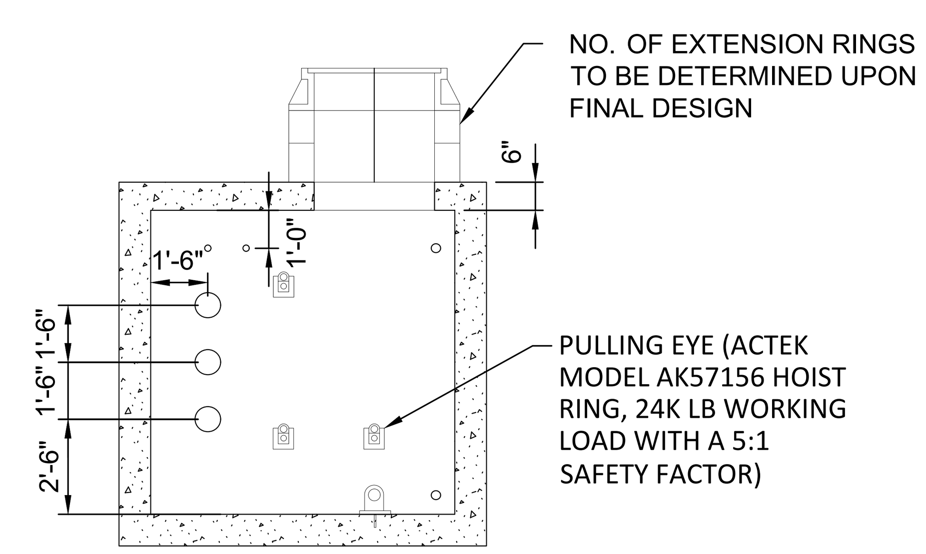
SPLICE VAULT PLAN VIEW

DETAIL 5
NTS -



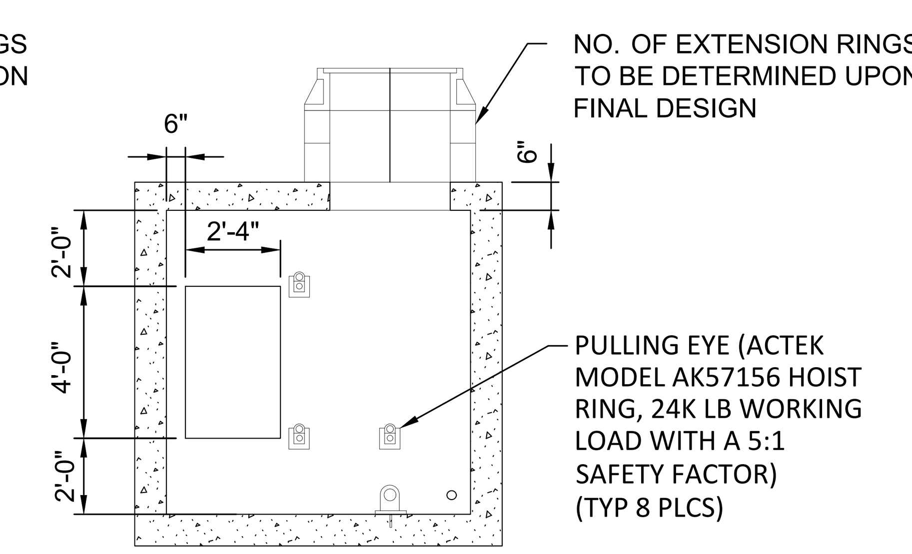
ELEVATION VIEW

SECTION A
NTS -



SIDE ELEVATION VIEW

SECTION B
NTS -



SIDE ELEVATION VIEW

SECTION C
NTS -

NOTES:

1. TRANSITION JOINT BAY DIMENSIONS SHOWN ARE INSIDE DIMENSIONS.
2. ALL PULLING EYES SHALL BE DESIGNED FOR MULTIDIRECTIONAL CABLE PULLS.
3. ALL PIPE SIZES ARE NOMINAL.
4. CONCRETE KNOCK-OUT SHALL BE FREE OF REINFORCEMENT AND SHALL BE AVAILABLE FOR FUTURE PENETRATION OF PIPE AND CONDUIT FOR THE REFERENCED DIMENSIONS.
5. FERROUS REBAR WITHIN SPLICE CHAMBER WALLS SHALL NOT FORM A CLOSED LOOP AROUND ANY INDIVIDUAL 8" CONDUIT OPENING.
6. CONTRACTOR TO ADJUST TETHER SYSTEM FOR MAXIMUM COVER RISE OF 24".

ISSUED FOR REVIEW-70%

PRELIMINARY - NOT FOR CONSTRUCTION

PRELIMINARY:
FOR REFERENCE ONLY

REVISIONS DURING CONSTRUCTION

NO.	DATE	AS BUILT REVISIONS	BY	CHK	APP	APP
A	12/02/20	ISSUED FOR REVIEW-70%	JCB	MD	NS	–

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TITLE REVOLUTION WIND

TRANSITION JOINT BAY DETAILS
NORTH KINGSTOWN, RHODE ISLAND

BY J. BARRINGER-BMcD	CHKD M. DAGENAIS-BMcD	APP N. SCOTT-BMcD	APP
DATE 09/30/20	DATE 09/30/20	DATE 09/30/20	DATE
H-SCALE N.T.S.	SIZE ARCH D	FIELD BOOK & PAGES	
V-SCALE N.T.S.	W.S.	R.E.DWG.	
R.E. PROJ. NUMBER		DWG NO. PG-25	

12/2/2020 2:44 PM – lnroberts – \\bmcd\dfs\Clients\TND\NUSC\126851_RevWindEng\Design\Underground\CADD\Working\25 TRANSITION JOINT BAY DETAILS.dwg – JOINT BAY

\\BMCD\DFS\CLIENTS\TND\NUSC\126851_REVWINDENG\DESIGN\UNDERGROUND\CADD\WORKING\25 TRANSITION JOINT BAY DETAILS.DWG 12/2/2020 2:44 PM LNROBERTS

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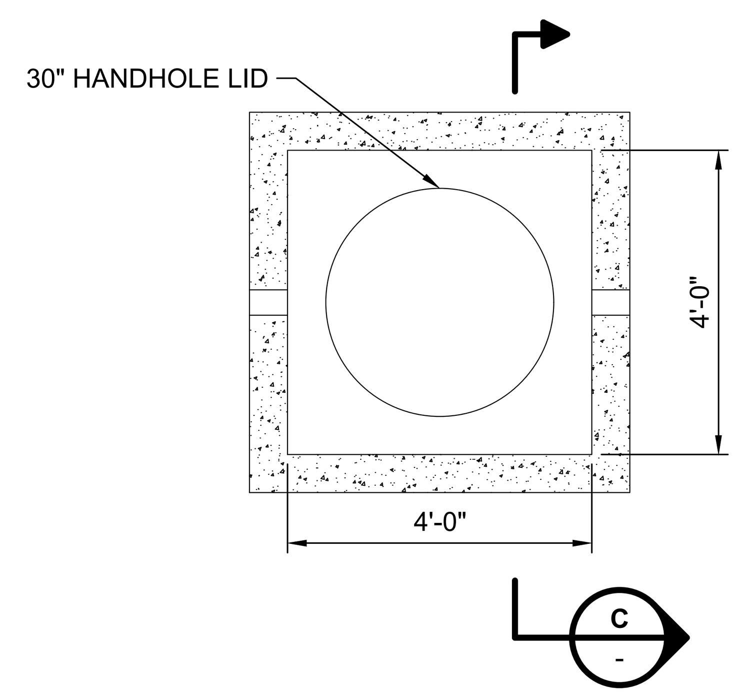
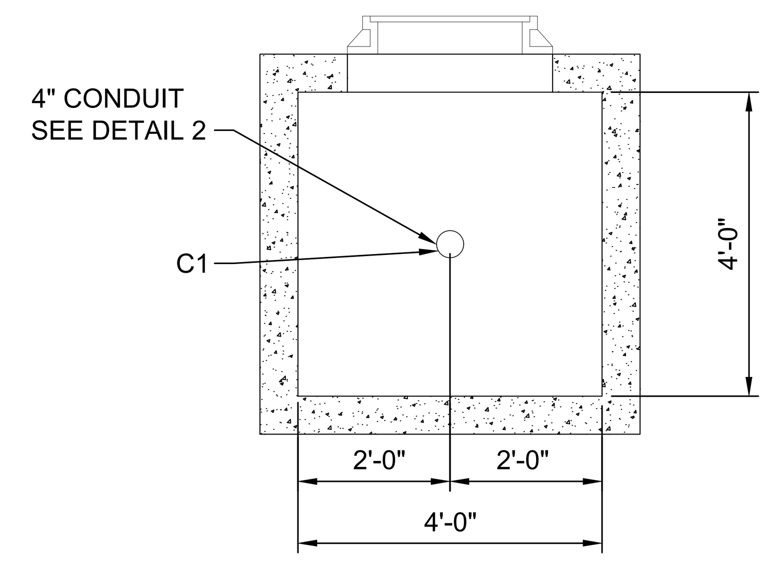


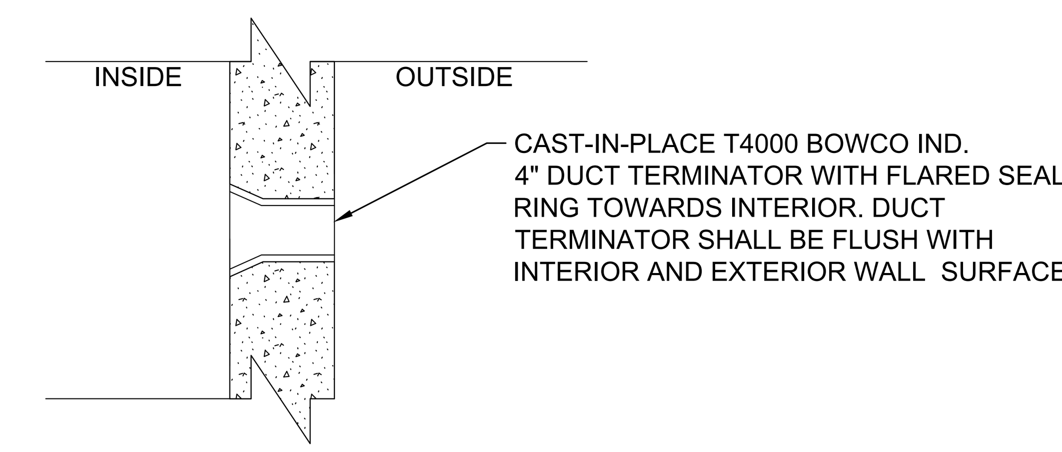
HANDHOLE PLAN VIEW

DETAIL 1 -
NTS



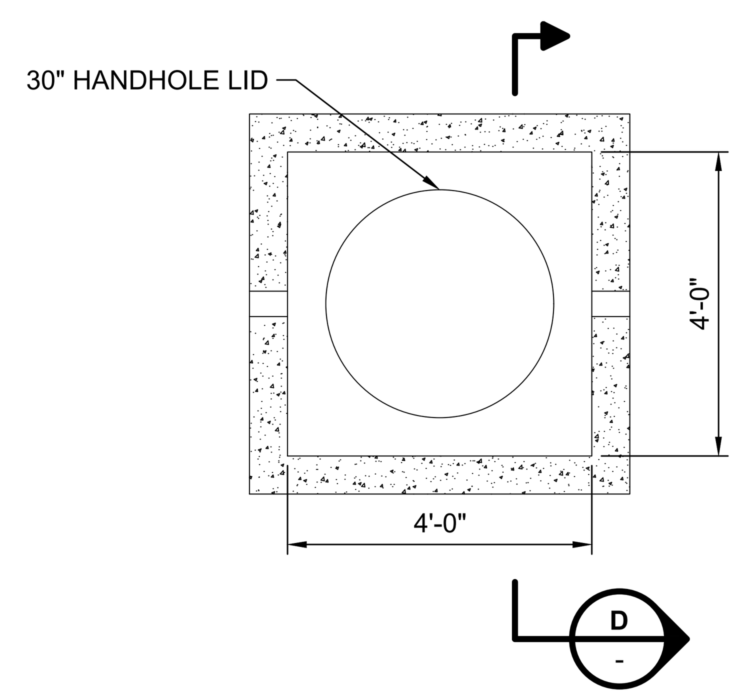
ELEVATION VIEW

SECTION C -
NTS



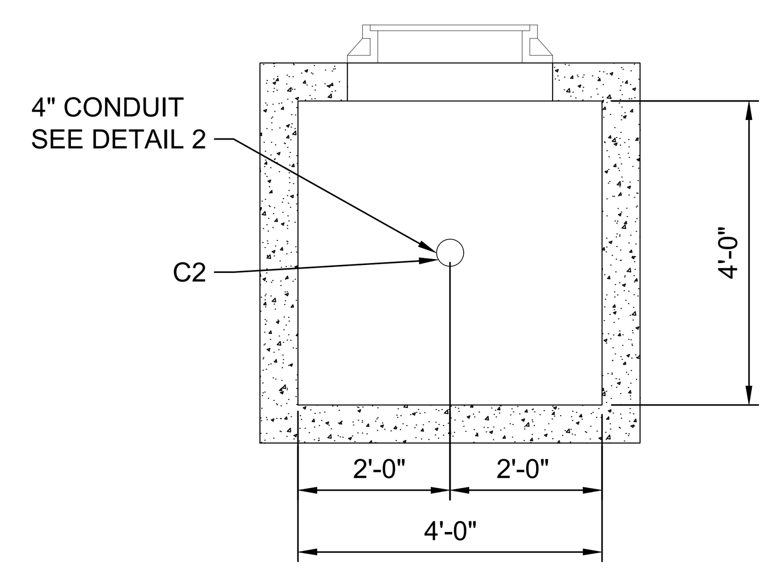
4" DUCT TERMINATOR DETAIL

DETAIL 2 -
NTS



HANDHOLE PLAN VIEW

DETAIL 3 -
NTS



ELEVATION VIEW

SECTION D -
NTS

PRELIMINARY:
FOR REFERENCE ONLY

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PRELIMINARY - NOT FOR CONSTRUCTION

REVISIONS DURING CONSTRUCTION

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TITLE: REVOLUTION WIND

HANDHOLE DETAILS
NORTH KINGSTOWN, RHODE ISLAND

BY J. BARRINGER-BMcD	CHKD M. DAGENAIS-BMcD	APP N. SCOTT-BMcD	APP
DATE 09/30/20	DATE 09/30/20	DATE 09/30/20	DATE
H-SCALE N.T.S.	SIZE ARCH D	FIELD BOOK & PAGES	
V-SCALE N.T.S.	V.S.	R.E.DWG.	
R.E. PROJ. NUMBER		DWG NO. PG-26	

11/30/2020 12:35 PM – lnroberts – \\bmcd\dfs\Clients\TND\NUSC\126851_RevWindEng\Design\Underground\CADD\Working\24 VAULT AND HANDHOLE DETAILS.dwg – HANDHOLE

\\BMCD\DFS\CLIENTS\TND\NUSC\126851_REVWINDENG\DESIGN\UNDERGROUND\CADD\WORKING\24 VAULT AND HANDHOLE DETAILS.DWG 11/30/2020 12:35 PM LNROBERTS

ES VER: 05/2015

11/30/2020 12:49 PM -- jbarringer -- \\bmcd\dfs\Clients\TND\NUSC\126851_RevWindEng\Design\Underground\CADD\Working\27 EXPORT RISER STRUCTURE DETAILS.dwg -- EXPORT RISER

TO DO PROVIDED

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PRELIMINARY:
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REVISIONS DURING CONSTRUCTION

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TITLE: REVOLUTION WIND

EXPORT RISER STRUCTURE DETAILS
NORTH KINGSTOWN, RHODE ISLAND

BY	CHK'D	APP	APP
J. BARRINGER-BMcD	M. DAGENAIS-BMcD	N. SCOTT-BMcD	
DATE 09/30/20	DATE 09/30/20	DATE 09/30/20	DATE
H-SCALE N.T.S.	SIZE ARCH D	FIELD BOOK & PAGES	
V-SCALE N.T.S.	V.S.	R.E.DWG.	
R.E. PROJ. NUMBER		DWG NO. PG-27	

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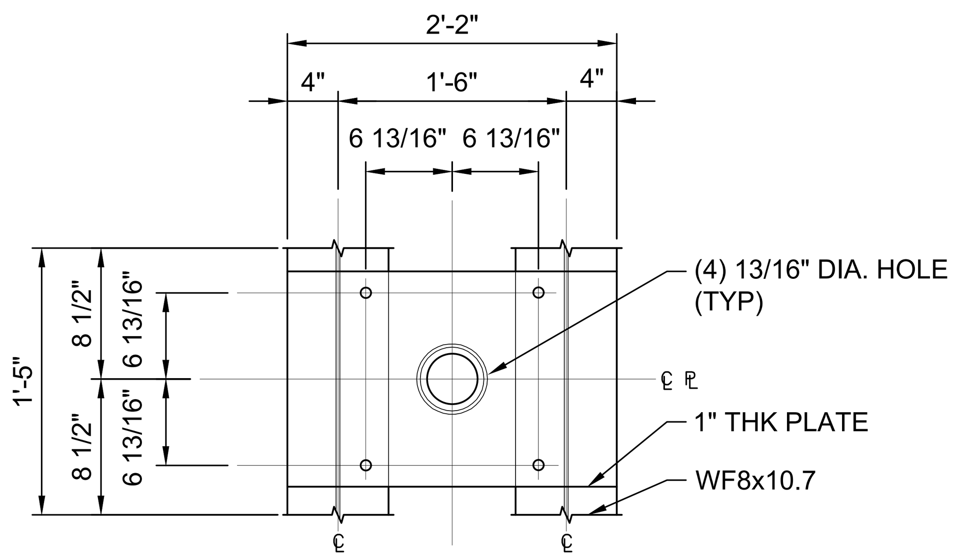
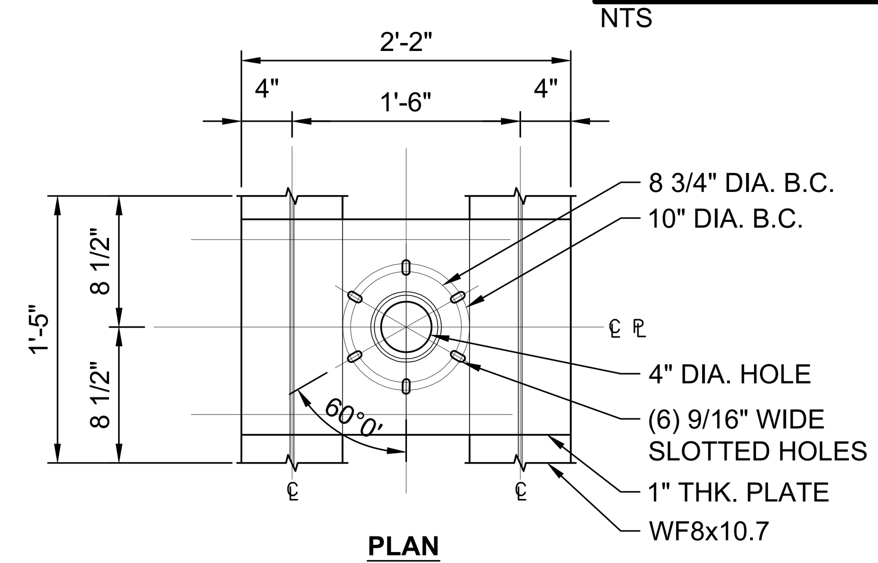
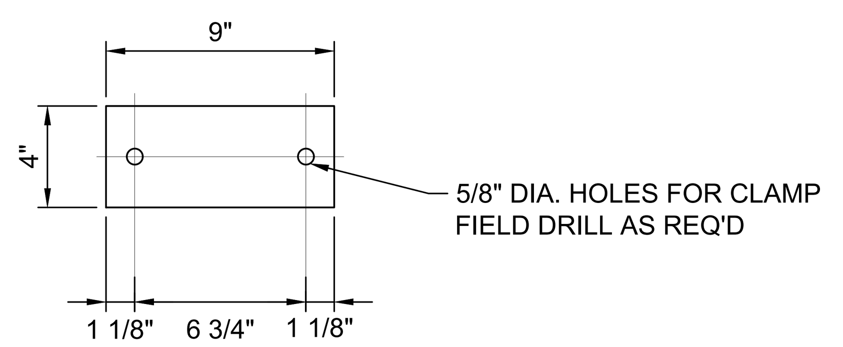


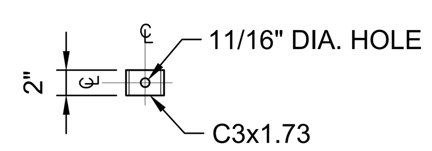
CABLE TERMINATOR MOUNT
DETAIL 3
NTS



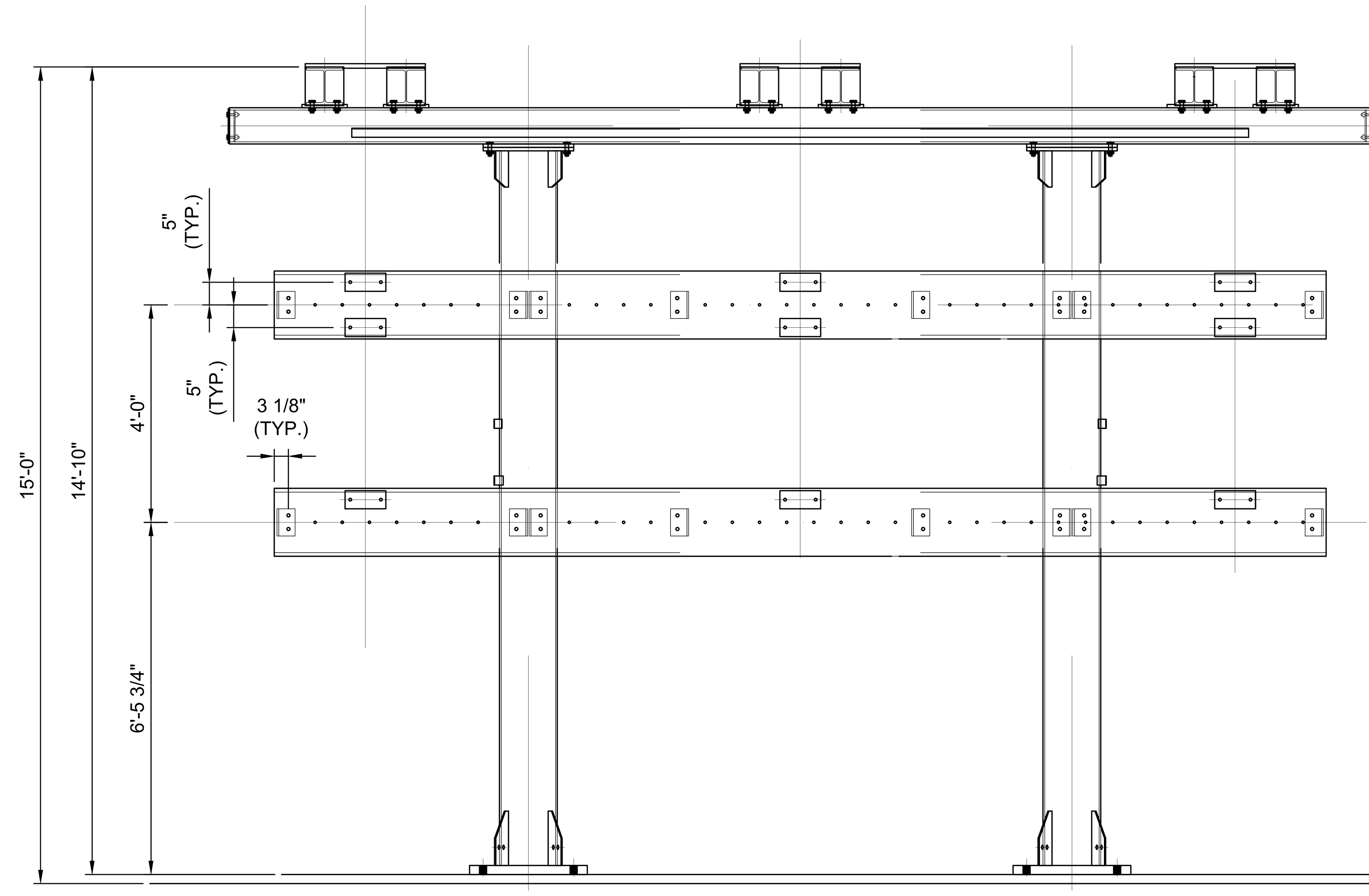
ARRESTER MOUNT
DETAIL 4
NTS



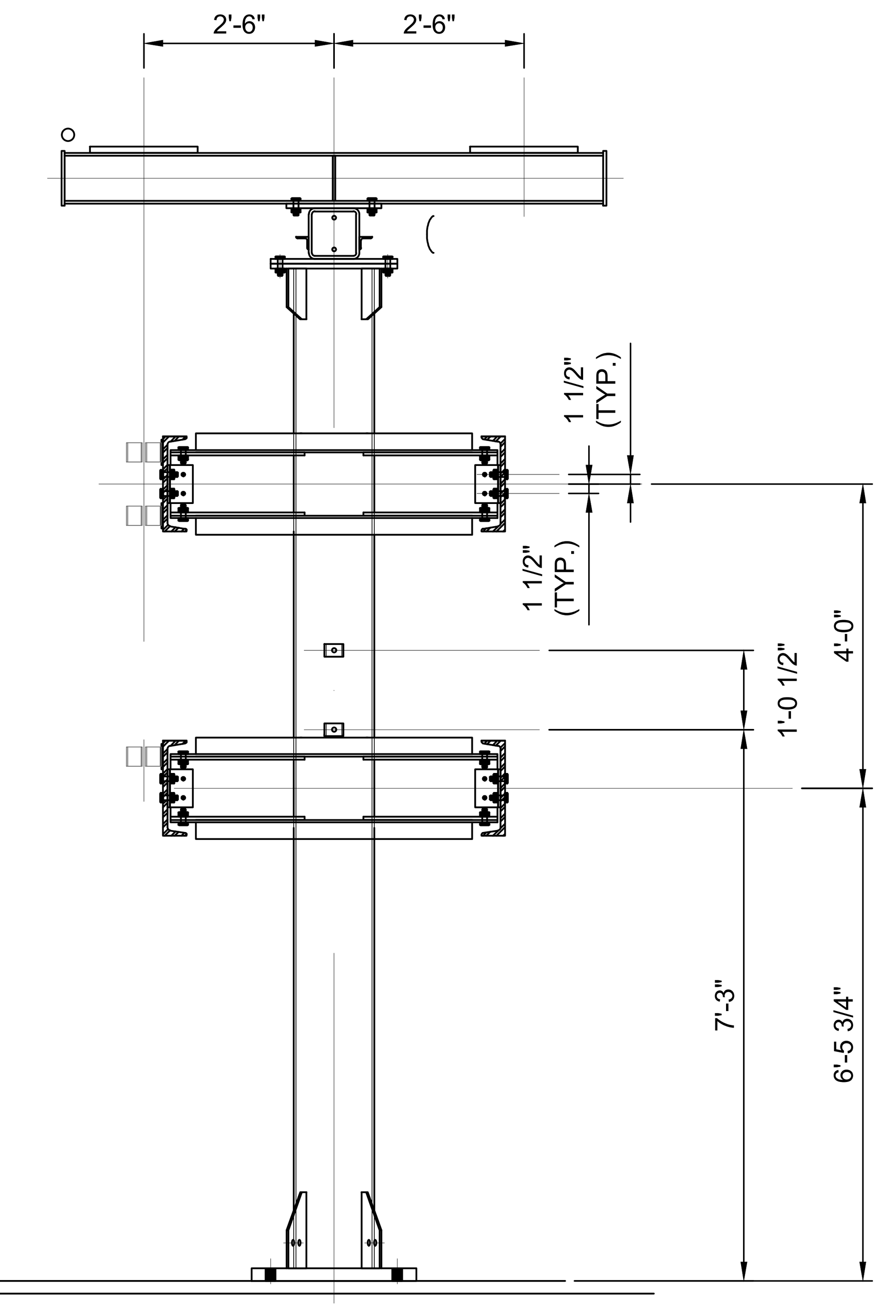
CLAMP SHIM PLATE
DETAIL 5
NTS



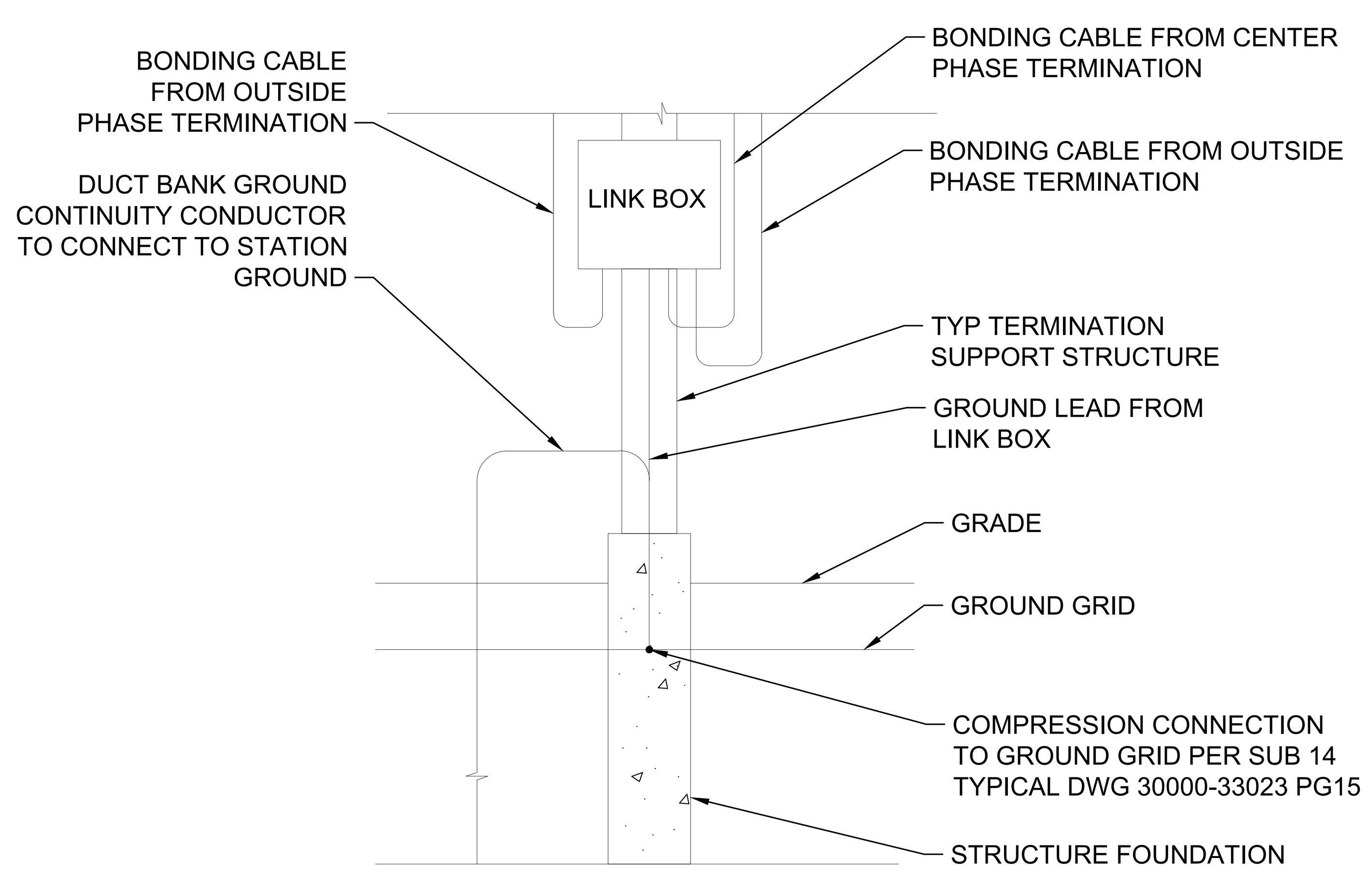
GROUNDING ATTACHMENT BRKT.
DETAIL 6
NTS



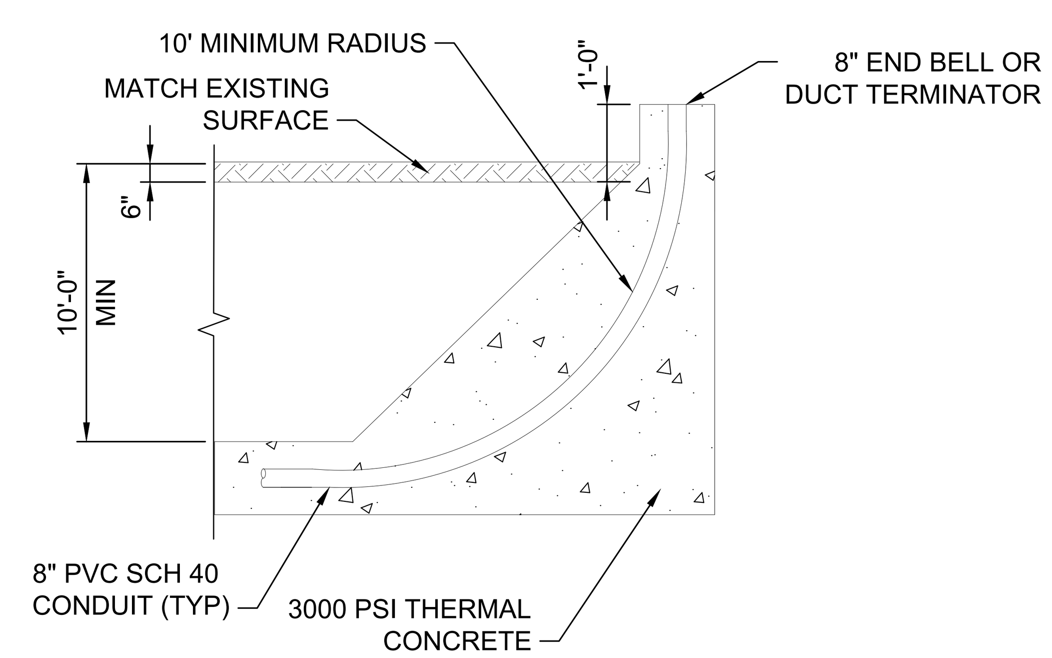
SUBSTATION FRONT VIEW
DETAIL 1
NTS



SUBSTATION SIDE VIEW
DETAIL 2
NTS



TYPICAL LINK BOX WIRING DIAGRAM
DETAIL 7
NTS



TERMINATION STRUCTURE SIDE ELEVATION
DETAIL 8
NTS

TERMINATION STRUCTURE NOTES:

1. FOR GENERAL NOTES, SEE DRAWING PG-02.
2. CABLE ACCESSORIES CONTRACTOR SHALL PROVIDE ALL MATERIALS TO COMPLETE CABLE AND CABLE BONDING INSTALLATION.
3. ANNULAR VOID BETWEEN CABLE AND CONDUIT SHALL BE SEALED WITH DUCT SEAL.
4. FOR CABLE ELEVATIONS SEE PLAN AND PROFILE DRAWINGS.

ISSUED FOR REVIEW-70%

PRELIMINARY - NOT FOR CONSTRUCTION

PRELIMINARY:
FOR REFERENCE ONLY

REVISIONS DURING CONSTRUCTION

NO.	DATE	AS BUILT REVISIONS	BY	CHK	APP	APP
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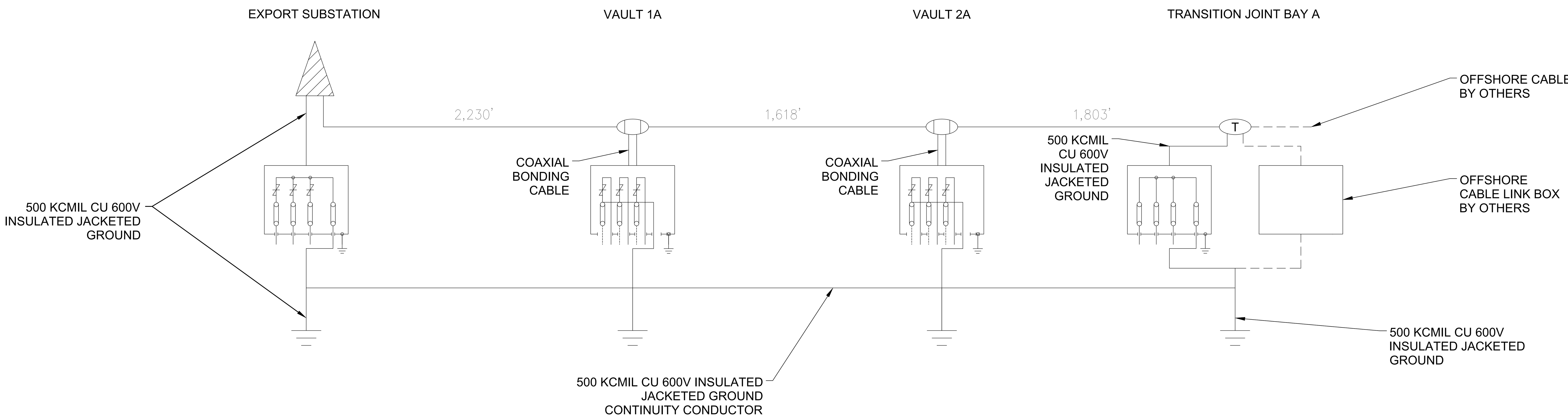
TITLE REVOLUTION WIND

INTERCONNECT RISER STRUCTURE DETAILS
NORTH KINGSTOWN, RHODE ISLAND

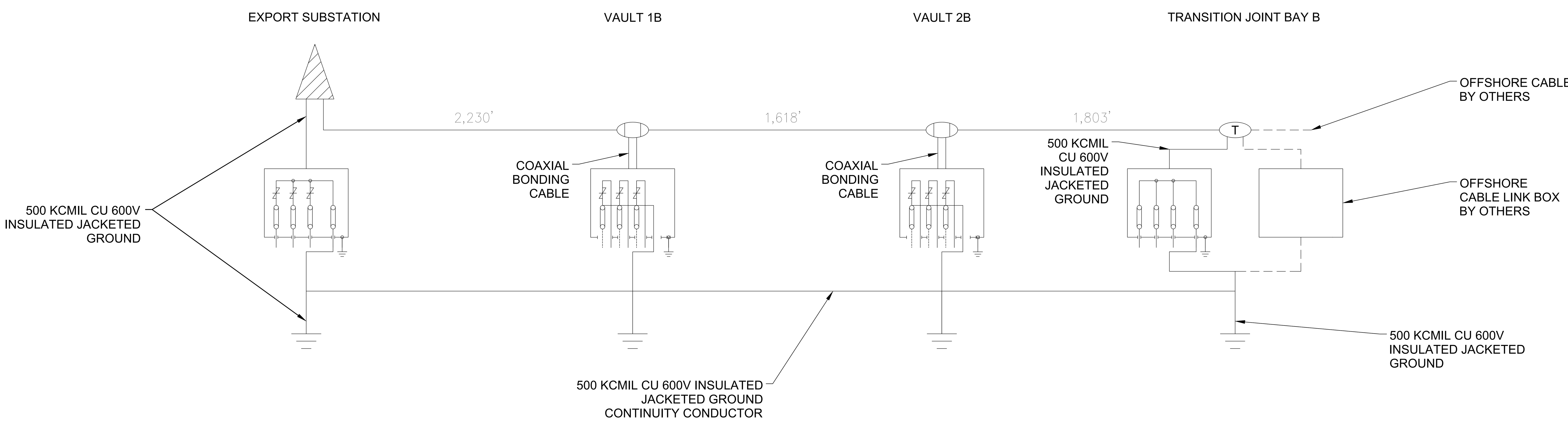
BY J. BARRINGER-BMcD	CHK'D M. DAGENAIS-BMcD	APP N. SCOTT-BMcD	APP
DATE 09/30/20	DATE 09/30/20	DATE 09/30/20	DATE
H-SCALE N.T.S.	SIZE ARCH D	FIELD BOOK & PAGES	
V-SCALE N.T.S.	W.S.	R.E.DWG.	
R.E. PROJ. NUMBER		DWG NO. PG-28	

ES VER: 05/2015
12/2/2020 10:49 AM – lnroberts – \\bmcd\dfs\Clients\TND\NUSC\126851_RevWindEng\Design\Underground\CADD\Working\28 INTERCONNECT RISER STRUCTURE DETAILS.dwg – INTERCONNECT RISER
\\BMCD\DFS\CLIENTS\TND\NUSC\126851_REVWINDENG\DESIGN\UNDERGROUND\CADD\WORKING\28 INTERCONNECT RISER STRUCTURE DETAILS.DWG 12/2/2020 10:49 AM LNROBERTS



CIRCUIT A
EXPORT SUBSTATION
TO TRANSITION JOINT BAY A

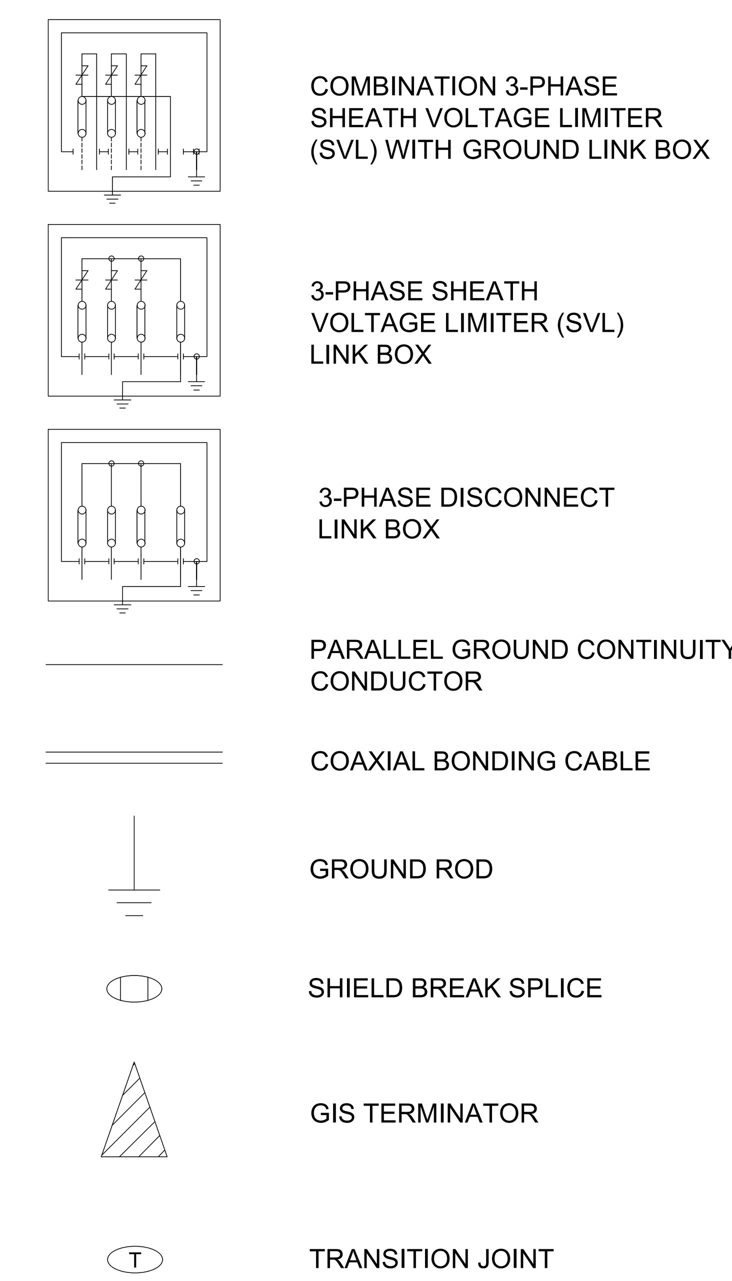
DETAIL 1 / -
NTS



CIRCUIT B
EXPORT SUBSTATION
TO TRANSITION JOINT BAY B

DETAIL 2 / -
NTS

LEGEND:



NOTES:

1. ALL LINK BOXES IN VAULTS TO HAVE VIEWING WINDOWS.

ISSUED FOR REVIEW-70%

PRELIMINARY - NOT FOR CONSTRUCTION

PRELIMINARY:
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REVISIONS DURING CONSTRUCTION

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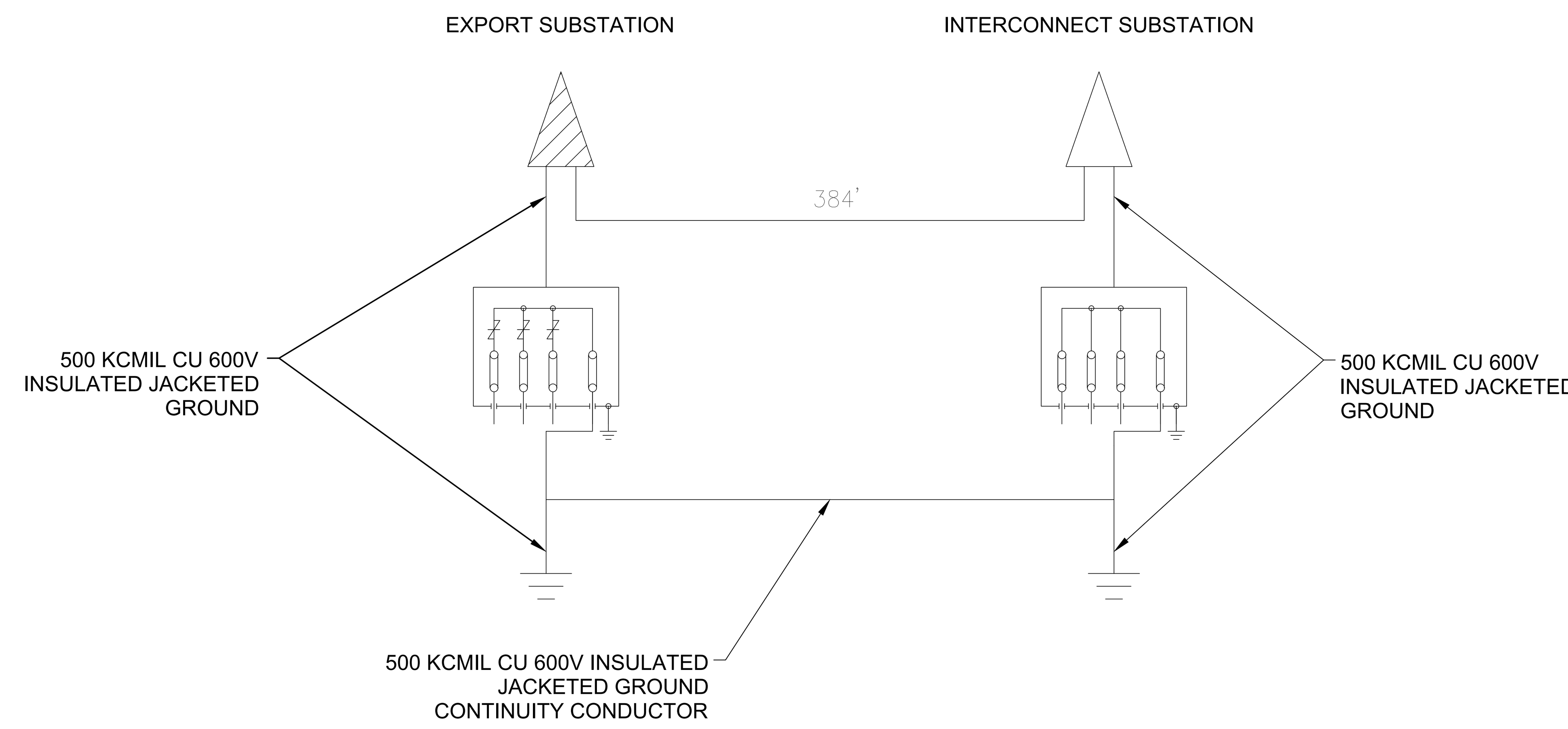
TITLE
REVOLUTION WIND
EXPORT CABLE BONDING DIAGRAMS
NORTH KINGSTOWN, RHODE ISLAND

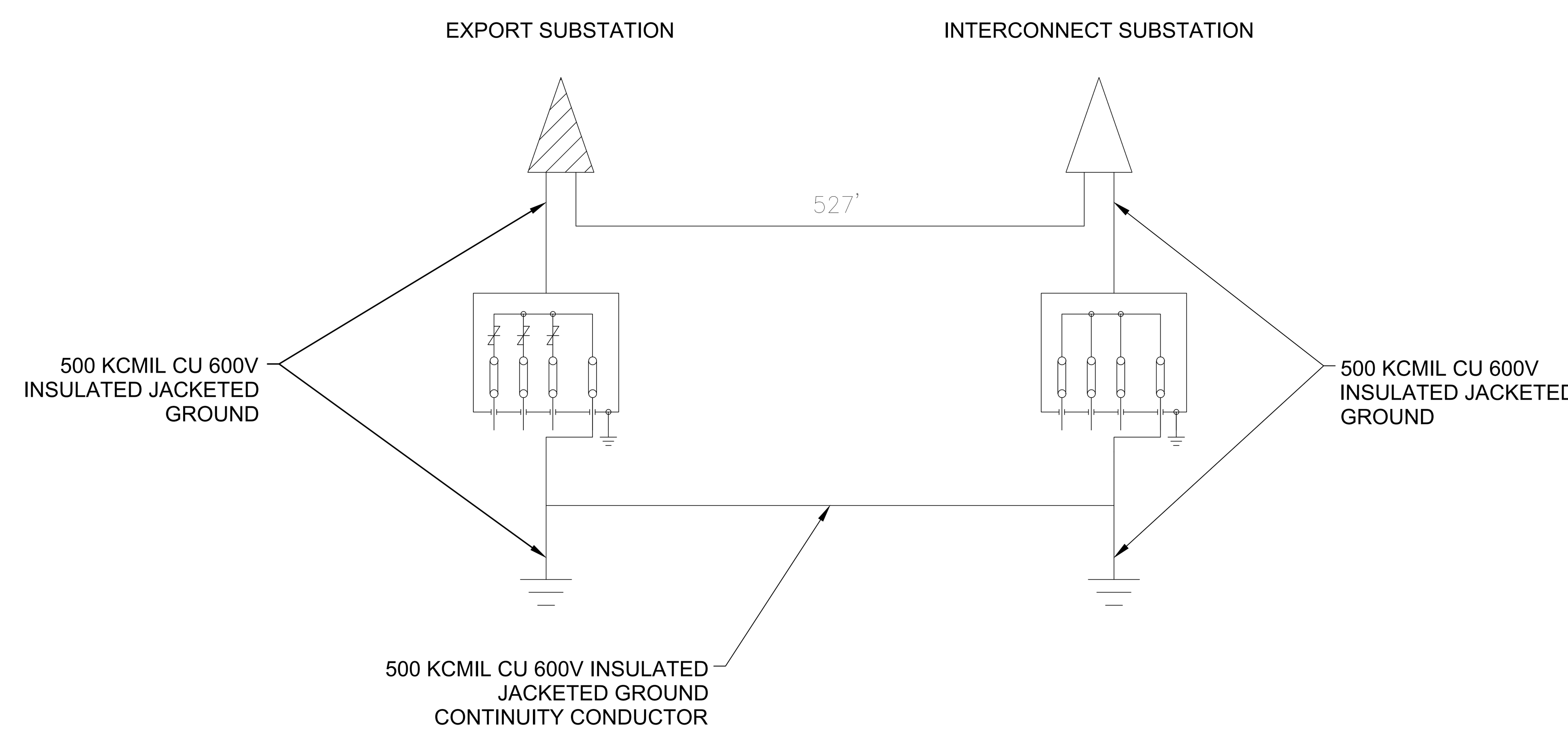
BY J. BARRINGER-BMcD	CHKD M. DAGENAIS-BMcD	APP N. SCOTT-BMcD	APP
DATE 09/30/20	DATE 09/30/20	DATE 09/30/20	DATE
H-SCALE N.T.S.	SIZE ARCH D	FIELD BOOK & PAGES	
V-SCALE N.T.S.	V.S.	R.E.DWG.	
R.E. PROJ. NUMBER		DWG NO. PG-29	



EXPORT SUBSTATION TO INTERCONNECT SUBSTATION

DETAIL 1

NTS -

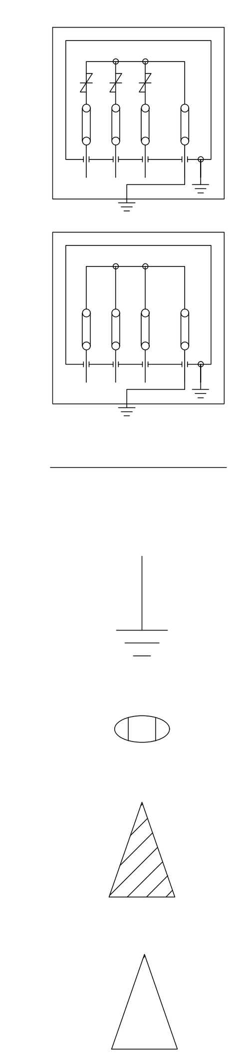


EXPORT SUBSTATION TO INTERCONNECT SUBSTATION

DETAIL 2

NTS -

LEGEND:



3-PHASE SHEATH VOLTAGE LIMITER (SVL) LINK BOX

3-PHASE DISCONNECT LINK BOX

PARALLEL GROUND CONTINUITY CONDUCTOR

GROUND ROD

SHIELD BREAK SPLICE

GIS TERMINATOR

OPEN AIR TERMINATOR

NOTES:

1. ALL LINK BOXES IN VAULTS TO HAVE VIEWING WINDOWS.

ISSUED FOR REVIEW-70%

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PRELIMINARY: FOR REFERENCE ONLY

REVISIONS DURING CONSTRUCTION

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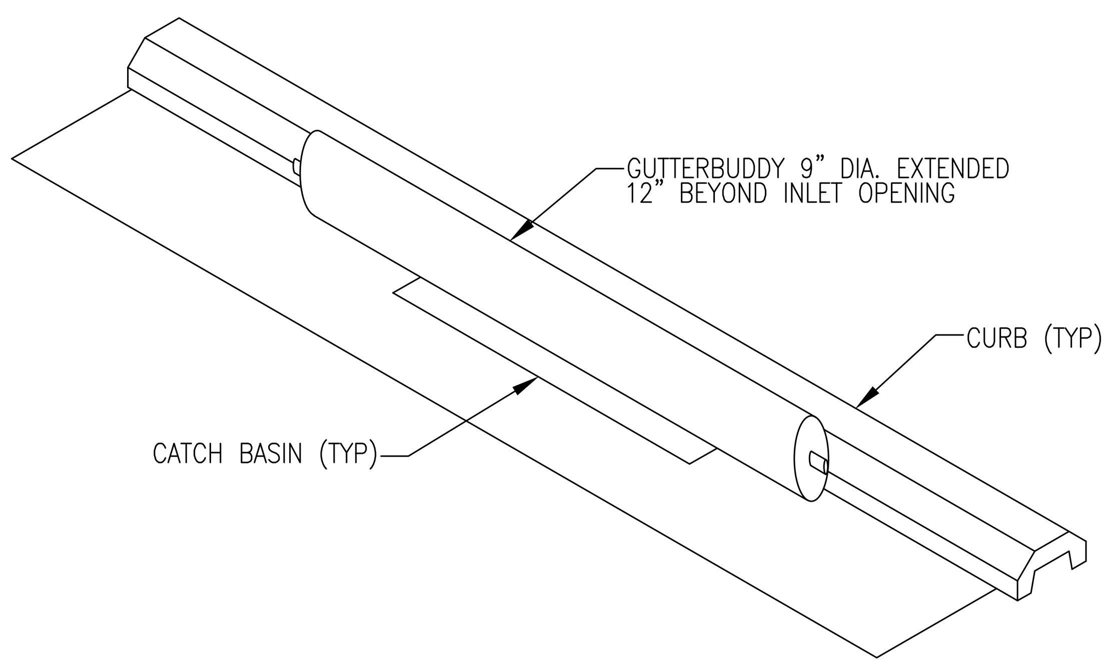
TITLE

REVOLUTION WIND
INTERCONNECT CABLE BONDING DIAGRAMS
NORTH KINGSTOWN, RHODE ISLAND

BY J. BARRINGER–BMcD	CHKD M. DAGENAIS–BMcD	APP N. SCOTT–BMcD	APP
DATE 09/30/20	DATE 09/30/20	DATE 09/30/20	DATE
H-SCALE N.T.S. / V-SCALE N.T.S.	SIZE ARCH D / V.S.	FIELD BOOK & PAGES / R.E.DWG.	
R.E. PROJ. NUMBER		DWG NO. PG-30	

ES VER: 05/2015

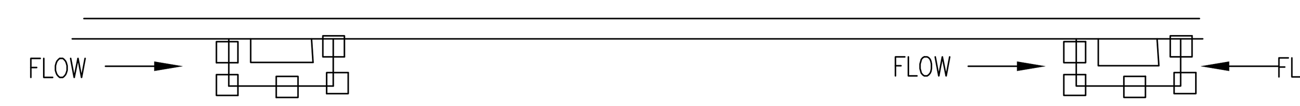
12/2/2020 10:48 AM – jbarringer – \\bmcd\dfs\Clients\TND\NUSC\126851_RevWindEng\Design\Underground\CADD\Working\32 REV_WIND BONDING SCHEMATIC.dwg – PG-30 BONDING DIAGRAMS INTERCONNECT CABLE



GUTTERBUDDY STORM DRAIN

DETAIL 1

TYPE 'C' C.B.



CURB FACE

SEDIMENTATION CONTROL SYSTEM

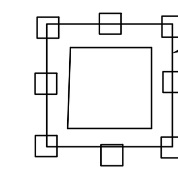
PLAN
FOR TYPE 'C' C.B
(ON GRADE)

PLAN
FOR TYPE 'C' CB
(AT LOW POINT)

NOTE:
SEDIMENTATION CONTROL SYSTEMS SHALL BE LOCATED AT ALL EXISTING OR PROPOSED BASINS WHICH ACCEPT FLOW FROM THE CONSTRUCTION AREA UNTIL TURF ESTABLISHMENT OR AS DIRECTED BY THE ENGINEER.

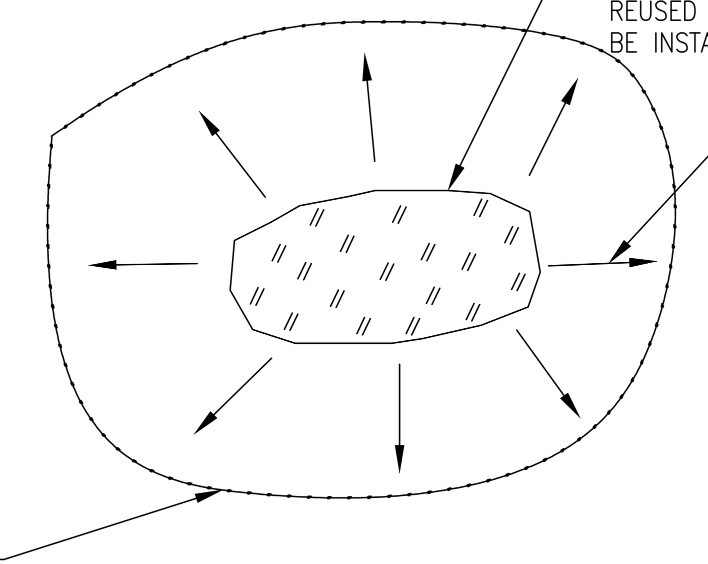
DETAIL 2

TYPE 'C-L' C.B.



SEDIMENTATION
CONTROL SYSTEM

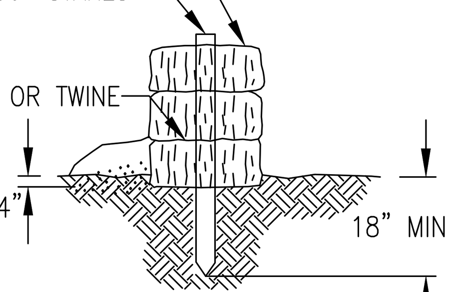
PLAN
FOR TYPE 'C-L' C.B.



MATERIALS STOCKPILE

DETAIL 3

NOTES:
1. ALL EXISTING EXCAVATED MATERIAL THAT IS NOT BEING REUSED IN THE WORK SHALL BE IMMEDIATELY REMOVED FROM THE SITE AND PROPERLY DISPOSED OF.
2. RESTORE STOCKPILE SITES TO PRE-EXISTING PROJECT CONDITION AND RESEED AS REQUIRED.
3. STOCKPILE HEIGHTS SHALL NOT EXCEED 35' STOCKPILE SLOPES SHALL BE 2:1 OR FLATTER.



STRAW BALE BARRIERS SHALL NOT BE USED FOR MORE THAN 3 MONTHS

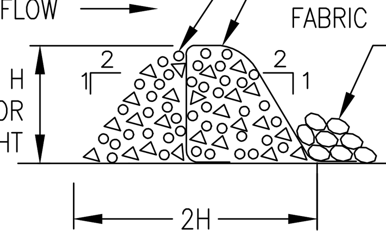
SEDIMENT SHALL BE REMOVED WHEN ACCUMULATIONS REACH 1/3 THE ABOVE GROUND HEIGHT OF THE BARRIER.

ANY SECTION OF STRAW BALE BARRIER WHICH HAS BEEN UNDERMINED OR TOPPED SHALL BE IMMEDIATELY REPLACED WITH A ROCK FILTER OUTLET.

HAYBALE BARRIER

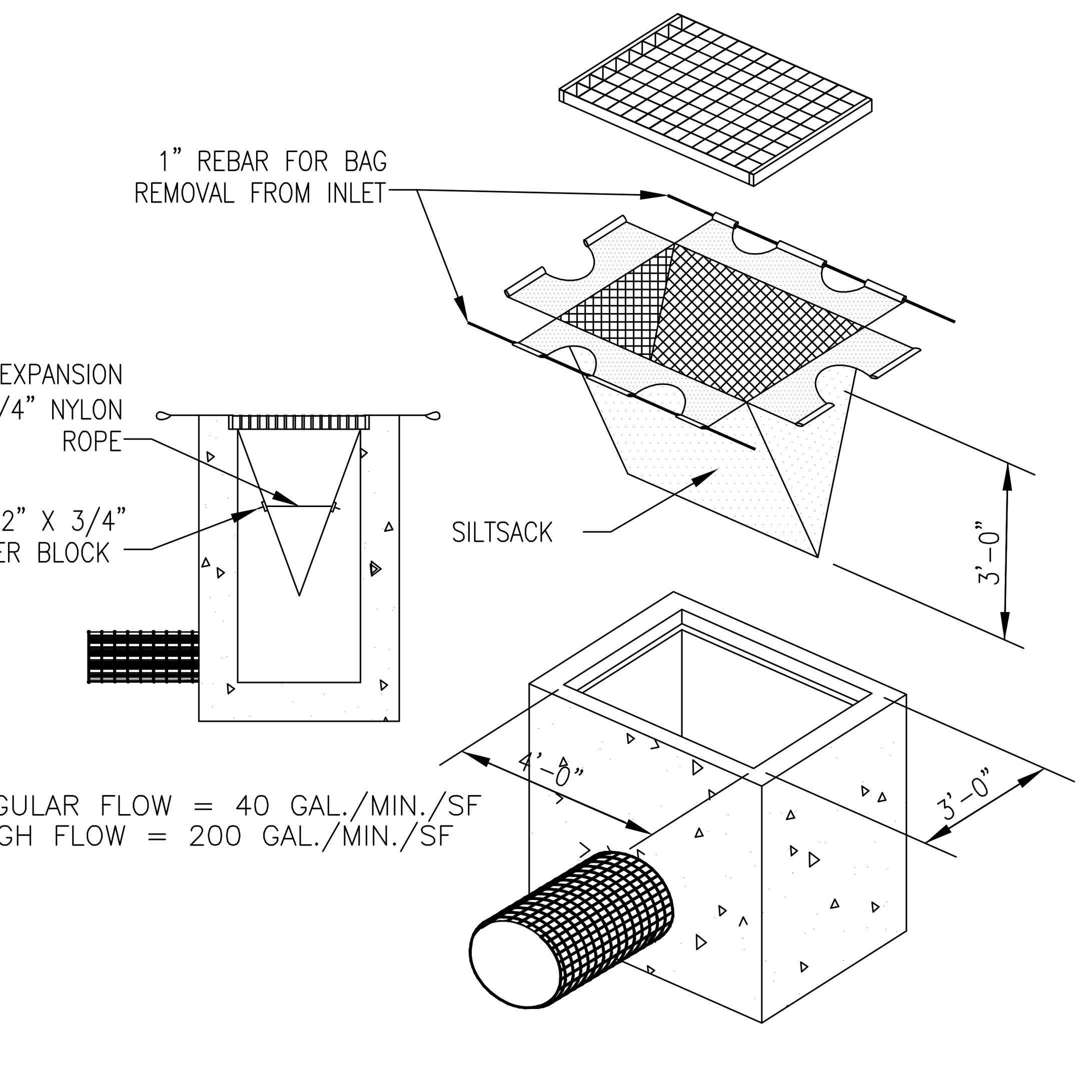
DETAIL 4

NOTE:
USE FOR IN-STREAM OR SWALE SEDIMENT INTERCEPTION. LOCATE NOT TO BACKWATER ONTO WORK AREA.



STONE FILTER BERM W/ FILTER FABRIC

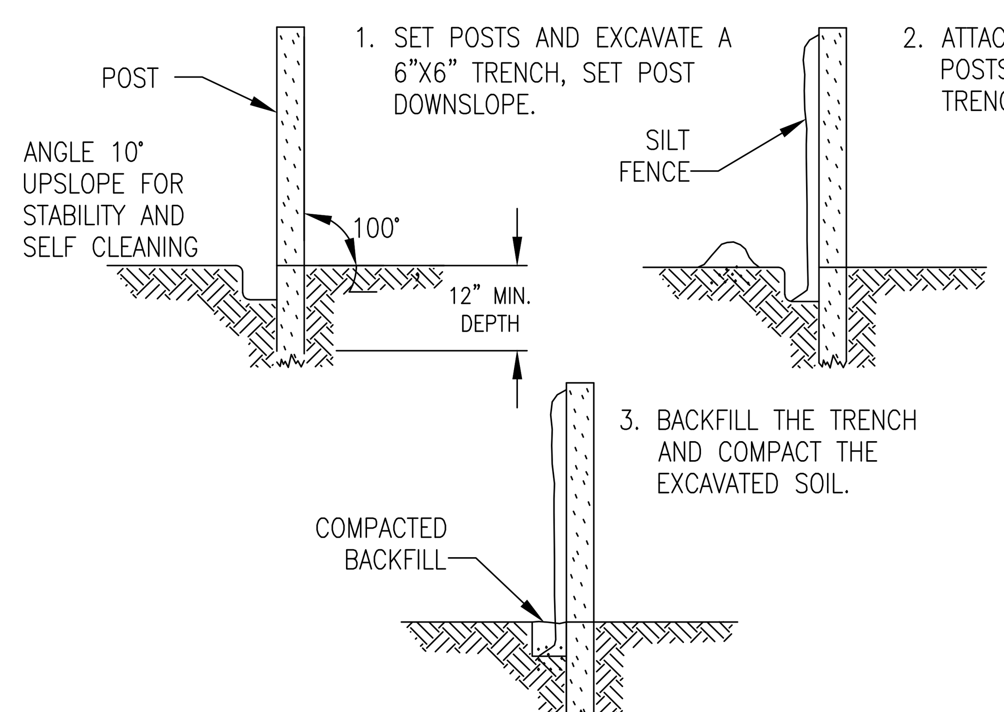
DETAIL 5



NOTE: REGULAR FLOW = 40 GAL./MIN./SF
HIGH FLOW = 200 GAL./MIN./SF

SILTSACK

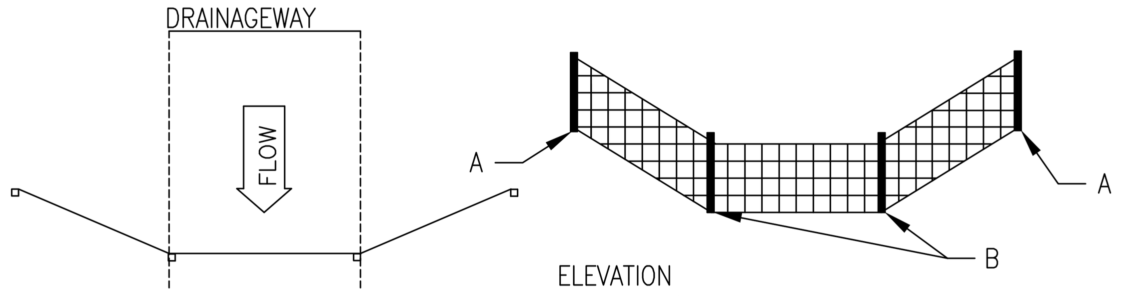
DETAIL 9



1. SET POSTS AND EXCAVATE A 6"X6" TRENCH, SET POST DOWNSLOPE.

2. ATTACH FILTER FABRIC TO THE POSTS AND EXTEND IT TO THE TRENCH.

3. BACKFILL THE TRENCH AND COMPACT THE EXCAVATED SOIL.

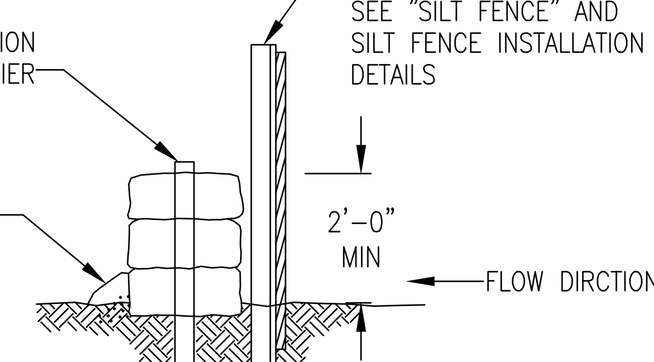


PLAN VIEW

ELEVATION
POINTS "A" SHALL BE HIGHER THAN POINT "B".

GEOTEXTILE SILT FENCE
BARRIER W/OUT HAYBALES

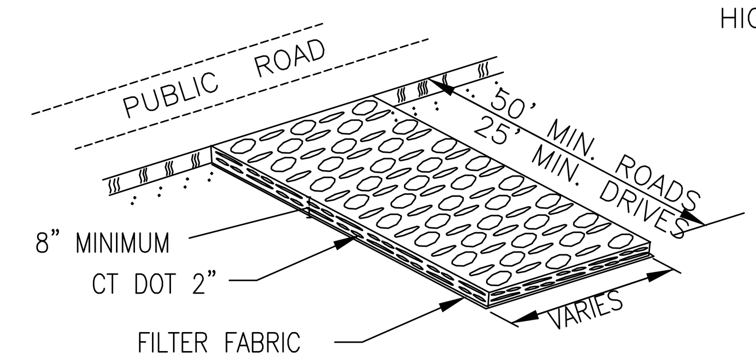
DETAIL 6



BACKFILL AND COMPACT THE EXCAVATED SOIL AS SHOWN ON THE UPHILL SIDE OF THE BARRIER TO PREVENT PIPING

GEOTEXTILE SILT FENCE
BARRIER W/ HAYBALES

DETAIL 7



CONSTRUCTION ENTRANCE

DETAIL 8

PRELIMINARY:
FOR REFERENCE ONLY

REVISIONS DURING CONSTRUCTION

NO.	DATE	AS BUILT REVISIONS	BY	CHK	APP	APP
A	12/02/20	ISSUED FOR REVIEW-70%	JCB	MD	NS	–

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TITLE
REVOLUTION WIND
TYPICAL EROSION CONTROL DRAWINGS
NORTH KINGSTOWN, RHODE ISLAND

BY J. BARRINGER-BMcD	CHK M. DAGENAIS-BMcD	APP N. SCOTT-BMcD	APP
DATE 09/30/20	DATE 09/30/20	DATE 09/30/20	DATE
H-SCALE N.T.S.	SIZE ARCH D	FIELD BOOK & PAGES	
V-SCALE N.T.S.	V.S.	R.E.DWG.	
R.E. PROJ. NUMBER		DWG NO.	PG-31

GENERAL NOTES:

SEQUENCE OF BMP INSTALLATION AND REMOVAL NOTES

CONSTRUCTION MUST BE IN ACCORDANCE WITH THE FOLLOWING SCHEDULE. THIS SCHEDULE IS DESIGNED TO MINIMIZE SOIL EROSION AND SEDIMENTATION. THE CONTRACTOR MAY DEVIATE SLIGHTLY FROM THE STAGING OF PERMANENT SITE IMPROVEMENTS, BUT NO DEVIATION FROM THE RELATIVE ORDER OF EROSION AND SEDIMENTATION CONTROL MEASURES WILL BE ALLOWED WITHOUT WRITTEN APPROVAL FROM LOCAL CONSERVATION DISTRICT (LCD) OR RISCC.

FACILITIES TO CONTROL THE TRANSPORT OF SOIL MATERIAL FROM THE CONSTRUCTION AREA SHALL BE INSTALLED PRIOR TO ANY EARTH DISTURBANCE.

NOTE: THE STAGING OF EARTHMOVING ACTIVITIES FOR THIS PROJECT IS A GENERAL DESCRIPTION OF THE WORK REQUIRED. ALL WORK SHALL BE COMPLETED IN ACCORDANCE WITH PROJECT OWNER STANDARDS, THE RISCC REGULATIONS, AND ALL OTHER APPLICABLE FEDERAL, STATE OR LOCAL REQUIREMENTS.

ALL EARTH DISTURBANCE ACTIVITIES SHALL PROCEED IN ACCORDANCE WITH THE FOLLOWING SEQUENCE. EACH STAGE SHALL BE COMPLETED BEFORE ANY FOLLOWING STAGE IS INITIATED (EXCEPT AS INDICATED BELOW). DEVIATION FROM THAT SEQUENCE MUST BE APPROVED IN WRITING FROM THE LOCAL CONSERVATION DISTRICT /DEPARTMENT OF ENVIRONMENTAL CONSERVATION (RISCC). CLEARING & GRUBBING SHALL BE LIMITED TO THOSE AREAS DESCRIBED IN EACH STAGE.

THE CONTRACTOR IS ADVISED THAT ALL WORK BE COMPLETED IN COMPLIANCE WITH THE RISCC WETLANDS PERMIT.

1. SCHEDULE WORK TO MINIMIZE THE LENGTH OF TIME THAT BARE SOIL WILL BE EXPOSED TO THE ELEMENTS.
2. FOLLOW THE CONSTRUCTION/EROSION CONTROL IMPLEMENTATION PLAN AS OUTLINED ON THE DRAWINGS.
3. IMPLEMENT CONTROL MEASURES AS SPECIFIED; HOWEVER, THE CONTRACTOR MAY INSERT ADDITIONAL CONSTRUCTION PHASES IN ORDER TO EXPEDITE HIS WORK.
4. IMMEDIATELY UPON DISCOVERING UNFORESEEN CIRCUMSTANCES POSING THE POTENTIAL FOR ACCELERATED EROSION AND/OR SEDIMENT POLLUTION, THE OPERATOR SHALL IMPLEMENT APPROPRIATE BMPS TO MINIMIZE THE POTENTIAL FOR EROSION AND SEDIMENT POLLUTION AND NOTIFY THE LCD/RISCC.
5. ALL OFF-SITE WASTE AND BORROW AREAS MUST HAVE AN E&S PLAN APPROVED BY THE LOCAL COUNTY CONSERVATION DISTRICT OR RISCC FULLY IMPLEMENTED PRIOR TO BEING ACTIVATED. THE CONTRACTOR WILL BE RESPONSIBLE FOR THE REMOVAL OF ANY EXCESS MATERIAL, NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM PERMIT CONDITIONS, AND/OR OTHER STATE AND FEDERAL REGULATIONS.
6. CONSTRUCTION SEQUENCE IS AS FOLLOWS:
7. PRE-CONSTRUCTION MEETING TO BE HELD BY PROJECT MANAGER, A REPRESENTATIVE FROM RHODE ISLAND STATE CONSERVATION COMMITEE (RISCC) (IF REQUIRED BY PERMIT CONDITIONS), ALL CONTRACTORS INVOLVED IN EARTH DISTURBANCE ACTIVITIES, AND THE OPERATOR'S ENGINEER PRIOR TO LAND DISTURBING ACTIVITIES. PROVIDE THE REQUIRED 7 DAY NOTICE FOR SCHEDULING OF THE PRE-CONSTRUCTION MEETING. ALL PARTIES LISTED ARE REQUIRED TO ATTEND.
8. CONTRACTOR TO INSTALL TEMPORARY CONSTRUCTION FENCE, TEMPORARY CONSTRUCTION ENTRANCE, AND SILT FENCE AROUND THE SITE.
9. CONTRACTOR TO BEGIN CLEARING AND GRUBBING OF THE SITE, CHIPS and TOPSOIL TO BE DISPOSED OF AT AN APPROVAL OFFSITE LOCATION.
10. CONTRACTOR TO PREPARE SITE FOR DRILLING OPERATION INCLUDING MOBILIZATION AND SET UP OF DRILLING EQUIPMENT AND OTHER NECESSARY ITEMS.
11. REMOVE SEDIMENT FROM BEHIND SILT FENCE, AS REQUIRED. REMOVAL SHALL BE ON A PERIODIC BASIS (EVERY SIGNIFICANT RAINFALL) OR AS NECESSARY TO ENSURE PROPER FUNCTION OF THE FILTER SOCK. INSPECTION OF EROSION CONTROL MEASURES SHALL BE ON A WEEKLY BASIS. SEDIMENT COLLECTED SHALL BE DEPOSITED AND SPREAD EVENLY UPLAND ON SLOPES DURING CONSTRUCTION.
12. CONTRACTOR TO BEGIN HORIZONTAL DIRECTIONAL DRILLING (HDD) OPERATIONS.
13. IMMEDIATELY AFTER EARTH DISTURBANCE ACTIVITIES CEASE LONGER THAN 14 DAYS IN ANY AREA OR SUBAREA OF THE PROJECT, THE OPERATOR SHALL STABILIZE ALL DISTURBED AREAS.
14. CONTRACTOR TO COMPLETE DRILLING OPERATIONS & RESTORE SITE PER THE PLAN.
15. DURING NON-GERMINATING MONTHS, PROTECTIVE BLANKETING SHALL BE APPLIED AS DESCRIBED IN THE PLAN. AREAS NOT AT FINISHED GRADE, WHICH WILL BE REACTIVATED WITHIN 1 YEAR, MAY BE STABILIZED IN ACCORDANCE WITH THE TEMPORARY STABILIZATION SPECIFICATIONS. THOSE AREAS WHICH WILL NOT BE REACTIVATED WITHIN 1 YEAR SHALL BE STABILIZED IN ACCORDANCE WITH THE PERMANENT STABILIZATION SPECIFICATIONS.
16. FINAL GRADES SHALL REFLECT PRE-CONSTRUCTION ELEVATIONS. BACKFILL AS NEEDED WITH A CLEAN LOAMY SAND AND SEED. PLACEMENT OF TOPSOIL, FERTILIZER, AND MULCH SHALL ONLY BE WITHIN THE DESIGNATED ROAD SHOULDER AREA, OUTSIDE THE LIMITS OF THE “CLEARING AREA”. A PROTECTIVE BLANKET OF COIR MAT 400, OR APPROVED EQUIVALENT, SHALL BE PLACED OVER SEED IN THE “CLEARING AREA”.SEED MIXTURE TO BE INSTALLED MARCH 15- MAY 15 OR AUGUST 15 - SEPTEMBER 30.
17. ALL AREAS THAT HAVE BEEN DISTURBED WHICH HAVE REACHED FINAL GRADE SHALL BE PERMANENTLY STABILIZED.
18. REMOVE SILT FENCE AFTER ALL EXPOSED SURFACES ARE STABILIZED. REMOVE TEMPORARY CONSTRUCTION FENCING.
19. AN AREA SHALL BE CONSIDERED TO HAVE ACHIEVED FINAL STABILIZATION WHEN IT HAS A MINIMUM UNIFORM 80% PERENNIAL VEGETATIVE COVER OR OTHER PERMANENT NON-VEGETATIVE COVER WITH A DENSITY SUFFICIENT TO RESIST ACCELERATED SURFACE EROSION AND SUBSURFACE CHARACTERISTICS SUFFICIENT TO RESIST SLIDING AND OTHER MOVEMENTS.

STANDARD EROSION & SEDIMENTATION CONTROL PLAN NOTES

1. ALL EARTH DISTURBANCES, INCLUDING CLEARING AND GRUBBING AS WELL AS CUTS AND FILLS SHALL BE DONE IN ACCORDANCE WITH THE APPROVED E&S PLAN. A COPY OF THE APPROVED DRAWINGS (STAMPED, SIGNED AND DATED BY THE REVIEWING AGENCY) MUST BE AVAILABLE AT THE PROJECT SITE AT ALL TIMES. THE REVIEWING AGENCY SHALL BE NOTIFIED OF ANY CHANGES TO THE APPROVED PLAN PRIOR TO IMPLEMENTATION OF THOSE CHANGES. THE REVIEWING AGENCY MAY REQUIRE A WRITTEN SUBMITTAL OF THOSE CHANGES FOR REVIEW AND APPROVAL AT ITS DISCRETION.
2. AT LEAST 7 DAYS PRIOR TO THE PRE-CONSTRUCTION MEETING, THE OWNER AND/OR OPERATOR SHALL INVITE ALL CONTRACTORS, THE LANDOWNER, APPROPRIATE MUNICIPAL OFFICIALS, THE E&S PLAN PREPARER, THE LICENSED PROFESSIONAL RESPONSIBLE FOR OVERSIGHT OF CRITICAL STAGES OF IMPLEMENTATION OF THE PCSM PLAN, AND A REPRESENTATIVE FROM THE RISCC TO AN ON-SITE PRE-CONSTRUCTION MEETING.
3. AT LEAST 72 HOURS PRIOR TO STARTING ANY EARTH DISTURBANCE ACTIVITIES, OR EXPANDING INTO AN AREA PREVIOUSLY UNMARKED, THE CONTRACTOR SHALL CONTACT 811 DIG SAFE RI (1-888-DIGSAFE) FOR THE LOCATION OF EXISTING UNDERGROUND UTILITIES.
4. ALL EARTH DISTURBANCE ACTIVITIES SHALL PROCEED IN ACCORDANCE WITH THE SEQUENCE PROVIDED ON THE PLAN DRAWINGS. DEVIATION FROM THAT SEQUENCE MUST BE APPROVED IN WRITING FROM THE RISCC PRIOR TO IMPLEMENTATION.
5. CLEARING, GRUBBING, AND TOPSOIL STRIPPING SHALL BE LIMITED TO THOSE AREAS DESCRIBED IN EACH STAGE OF THE CONSTRUCTION SEQUENCE. ALL MATERIAL CLEARED, GRUBBED, OR STRIPPED FROM THE SITE SHALL BE TRANSPORTED AND DISPOSED OFFSITE AT A PRE-APPROVED FACILITY. GENERAL SITE CLEARING, GRUBBING AND TOPSOIL STRIPPING MAY NOT COMMENCE IN ANY STAGE OR PHASE OF THE PROJECT UNTIL THE EROSION AND SEDIMENT BEST MANAGEMENT PRACTICES SPECIFIED BY THE BMP SEQUENCE FOR THAT STAGE OR PHASE HAVE BEEN INSTALLED AND ARE FUNCTIONING AS DESCRIBED IN THIS E&S PLAN.
6. AT NO TIME SHALL CONSTRUCTION VEHICLES BE ALLOWED TO ENTER AREAS OUTSIDE THE LIMIT OF DISTURBANCE BOUNDARIES SHOWN ON THE PLAN MAPS. THESE AREAS MUST BE CLEARLY MARKED AND FENCED OFF BEFORE CLEARING AND GRUBBING OPERATIONS BEGIN.
7. TOPSOIL AND CLEAN LOAMY SAND BACKFILL SHALL BE STOCKPILED IN SEPARATED PILES AT THE LOCATION(S) SHOWN ON THE PLAN MAPS(S) IN THE AMOUNT NECESSARY TO COMPLETE THE FINISH GRADING OF ALL EXPOSED AREAS THAT ARE TO BE STABILIZED BY VEGETATION. TOPSOIL SHALL ONLY BE UTILIZED FOR THE ESTABLISHMENT OF TURF GRASS WITHIN THE DESIGNATED ROAD SHOULDER AREA. EACH STOCKPILE SHALL BE PROTECTED IN THE MANNER SHOWN ON THE PLAN DRAWINGS. STOCKPILE HEIGHTS SHALL NOT EXCEED 35 FEET. STOCKPILE SLOPES SHALL BE 3H: 1V OR FLATTER. STOCKPILES SHALL BE PROTECTED FROM WIND AND WATER EROSION BY COVERING DAILY WITH A TARP AND SURROUNDING WITH SILT FENCE OR STRAW BALES.
8. IMMEDIATELY UPON DISCOVERING UNFORESEEN CIRCUMSTANCES POSING THE POTENTIAL FOR ACCELERATED EROSION AND/ORSEDIMENT POLLUTION, THE OPERATOR SHALL IMPLEMENT APPROPRIATE BEST MANAGEMENT PRACTICES TO MINIMIZE THE POTENTIAL FOR EROSION AND SEDIMENT POLLUTION AND NOTIFY THE RISCC.
9. ALL OFF-SITE WASTE AND BORROW AREAS MUST HAVE AN E&S PLAN APPROVED BY THE LOCAL AUTHORITY OR THE RISCC AND FULLY IMPLEMENTED PRIOR TO BEING ACTIVATED.
10. THE CONTRACTOR IS RESPONSIBLE FOR ENSURING THAT ANY MATERIAL BROUGHT ON SITE IS CLEAN FILL, AND DOES NOT CONTAIN ANY CONSTITUENTS THAT WOULD BE DELETERIOUS TO PLANT GROWTH OR AQUATIC ORGANISMS.
11. ALL PUMPING OF WATER FROM ANY WORK AREA SHALL BE DONE ACCORDING TO THE PROCEDURE DESCRIBED IN THIS PLAN, OVER UNDISTURBED VEGETATED AREAS AND AT A NON-EROSIVE VELOCITY.
12. UNTIL THE SITE IS STABILIZED, ALL EROSION AND SEDIMENT BMPS SHALL BE MAINTAINED PROPERLY. MAINTENANCE SHALL INCLUDE INSPECTIONS OF ALL EROSION AND SEDIMENT BMPS AFTER EACH RUNOFF EVENT AND ON A WEEKLY BASIS. ALL PREVENTATIVE AND REMEDIAL MAINTENANCE WORK, INCLUDING CLEAN OUT, REPAIR, REPLACEMENT, REGRADING, RESEEDING, REMULCHING AND RENETTING MUST BE PERFORMED IMMEDIATELY. IF THE E&S BMPS FAIL TO PERFORM AS EXPECTED, REPLACEMENT BMPS, OR MODIFICATIONS OF THOSE INSTALLED WILL BE REQUIRED.
13. A LOG SHOWING DATES THAT E&S BMPS WERE INSPECTED AS WELL AS ANY DEFICIENCIES FOUND AND THE DATE THEY WERE CORRECTED SHALL BE MAINTAINED ON THE SITE AND BE MADE AVAILABLE TO REGULATORY AGENCY OFFICIALS AT THE TIME OF INSPECTION.
14. SEDIMENT TRACKED ONTO ANY PUBLIC ROADWAY OR SIDEWALK SHALL BE RETURNED TO THE CONSTRUCTION SITE BY THE END OF EACH WORK DAY AND DISPOSED IN THE MANNER DESCRIBED IN THIS PLAN. IN NO CASE SHALL THE SEDIMENT BE WASHED, SHOVELED, OR SWEPT INTO ANY ROADSIDE DITCH, STORM SEWER, OR SURFACE WATER.
15. ALL SEDIMENT REMOVED FROM BMPS SHALL BE DISPOSED OF IN THE MANNER DESCRIBED IN THE PLAN.
16. ROADWAY SHOULDERS THAT WILL BE SEEDED TO GRASS TURF (MIX#1) ARE TO RECEIVE TOPSOIL, AND SHALL BE SCARIFIED TO A MINIMUM DEPTH OF 3 TO 5 INCHES -- 6 TO 12 INCHES ON COMPACTED SOILS -- PRIOR TO PLACEMENT OF TOPSOIL. ROADWAY SHOULDERS TO BE VEGETATED SHALL HAVE A MINIMUM 4 INCHES OF TOPSOIL IN PLACE PRIOR TO SEEDING. ALL OTHER DISTURBED AREAS THAT WILL BE SEEDED TO NATIVE GRASSES (SEED MIXTURES #2 & #3) SHALL BE SCARIFIED TO A MINIMUM DEPTH OF 6 INCHES PRIOR TO PLACEMENT OF CLEAN LOAMY SAND. A PROTECTIVE BLANKET OF COIR MAT 400, OR APPROVED EQUIVALENT, SHALL BE PLACED OVER SEED IN THE “CLEARING AREA”.
17. ALL FILL SOILS SHALL BE COMPACTED AS REQUIRED TO REDUCE EROSION, SLIPPAGE, SETTLEMENT, SUBSIDENCE OR OTHER RELATED PROBLEMS. FILL INTENDED TO SUPPORT BUILDINGS, STRUCTURES AND CONDUITS, ETC. SHALL BE COMPACTED IN ACCORDANCE WITH LOCAL REQUIREMENTS OR CODES.
18. ALL EARTHEN FILLS SHALL BE PLACED IN COMPACTED LAYERS NOT TO EXCEED 9 INCHES IN THICKNESS.
19. FILL SOILS SHALL BE FREE OF FROZEN PARTICLES, BRUSH, ROOTS, SOD, OR OTHER FOREIGN OR OBJECTIONABLE MATERIALS THAT WOULD INTERFERE WITH OR PREVENT CONSTRUCTION OF SATISFACTORY FILLS.
20. FROZEN MATERIALS OR SOFT, MUCKY, OR HIGHLY COMPRESSIBLE MATERIALS SHALL NOT BE INCORPORATED INTO FILLS.
21. FILL SHALL NOT BE PLACED OR COMPACTED ON SATURATED OR FROZEN SURFACES.
22. SEEPS OR SPRINGS ENCOUNTERED DURING CONSTRUCTION SHALL BE HANDLED IN ACCORDANCE WITH THE RI ECP STANDARD SPECIFICATION FOR SUBSURFACE DRAIN OR OTHER APPROVED METHOD.
23 ALL GRADED AREAS SHALL BE PERMANENTLY STABILIZED IMMEDIATELY UPON REACHING FINISHED GRADE. FINISHED GRADES SHALL REFLECT PRE-CONSTRUCTION CONDITIONS. SEEDED AREAS WITHIN 15 FEET OF A SURFACE WATER, OR AS OTHERWISE SHOWN ON THE PLAN DRAWINGS, SHALL BE COVERED WITH AN EROSION CONTROL BLANKET ACCORDING TO THE STANDARDS OF THIS PLAN.
24. IMMEDIATELY AFTER EARTH DISTURBANCE ACTIVITIES CEASE IN ANY AREA OR SUBAREA OF THE PROJECT, THE OPERATOR SHALL STABILIZE ALL DISTURBED AREAS. DURING NON-GERMINATING MONTHS, PROTECTIVE EROSION CONTROL BLANKETING SHALL BE APPLIED AS DESCRIBED IN THE PLAN. AREAS NOT AT FINISHED GRADE, WHICH WILL BE REACTIVATED WITHIN 1 YEAR, MAY BE STABILIZED IN ACCORDANCE WITH THE TEMPORARY STABILIZATION SPECIFICATIONS. THOSE AREAS WHICH WILL NOT BE REACTIVATED WITHIN 1 YEAR SHALL BE STABILIZED IN ACCORDANCE WITH THE PERMANENT STABILIZATION SPECIFICATIONS.
25. PERMANENT STABILIZATION IS DEFINED AS A MINIMUM UNIFORM, PERENNIAL 80% VEGETATIVE COVER OR OTHER PERMANENT NON-VEGETATIVE COVER WITH A DENSITY SUFFICIENT TO RESIST ACCELERATED EROSION. CUT AND FILL SLOPES SHALL BE CAPABLE OF RESISTING FAILURE DUE TO SLUMPING, SLIDING, OR OTHER MOVEMENTS.
26. E&S BMPS SHALL REMAIN FUNCTIONAL AS SUCH UNTIL ALL AREAS TRIBUTARY TO THEM ARE PERMANENTLY STABILIZED OR UNTIL THEY ARE REPLACED BY ANOTHER BMP APPROVED BY THE LOCAL CONSERVATION DISTRICT OR THE DEPARTMENT.
27. AFTER FINAL SITE STABILIZATION HAS BEEN ACHIEVED, TEMPORARY EROSION AND SEDIMENT BMPS MUST BE REMOVED OR CONVERTED TO PERMANENT POST CONSTRUCTION STORMWATER MANAGEMENT BMPS. AREAS DISTURBED DURING REMOVAL OR CONVERSION OF THE BMPS SHALL BE STABILIZED IMMEDIATELY. IN ORDER TO ENSURE RAPID REVEGETATION OF DISTURBED AREAS, SUCH REMOVAL/CONVERSIONS ARE TO BE DONE ONLY DURING THE GERMINATING SEASON.
28. FAILURE TO CORRECTLY INSTALL E&S BMPS, FAILURE TO PREVENT SEDIMENT-LADEN RUNOFF FROM LEAVING THE CONSTRUCTION SITE, OR FAILURE TO TAKE IMMEDIATE CORRECTIVE ACTION TO RESOLVE FAILURE OF E&S BMPS MAY RESULT IN ADMINISTRATIVE, CIVIL, AND/OR CRIMINAL PENALTIES.
29. CONCRETE WASH WATER SHALL IN NO CASE BE ALLOWED TO ENTER ANY SURFACE WATERS OR GROUNDWATER SYSTEMS.
30. EROSION CONTROL BLANKETING SHALL BE INSTALLED ON ALL SLOPES STEEPER THAN 3H:1V OR WITHIN 15 FEET OF A SURFACE WATER AND ON ALL OTHER DISTURBED AREAS SPECIFIED ON THE PLAN MAPS AND/OR DETAIL SHEETS.

NOTICES TO CONTRACTOR

1. THE CONTRACTOR SHALL VERIFY AND ADHERE TO ALL REQUIRED PERMITS PRIOR TO STARTING WORK.
2. THE CONTRACTOR SHALL ASSURE THAT THE APPROVED EROSION AND SEDIMENT CONTROL PLAN IS PROPERLY AND COMPLETELY IMPLEMENTED.
3. ALL WORK WITHIN THE PUBLIC RIGHT-OF-WAY SHALL BE COORDINATED WITH THE AGENCY HAVING JURISDICTION.

GENERAL EROSION & SEDIMENT CONTROL NOTES

1. AT MINIMUM, ALL BMPs ARE TO BE INSPECTED ON A WEEKLY BASIS AND AFTER EACH RUNOFF EVENT. A WRITTEN REPORT MUST ALSO BE COMPLETED, DOCUMENTING EACH INSPECTION AND, IF NECESSARY, ANY REPAIR, REPLACEMENT OR MAINTENANCE ACTIVITY.
2. INSPECT SNOW PLACEMENT AREAS DURING THE THAW CYCLE. INSTALL EROSION & SEDIMENT CONTROL BMPs DURING QUICK THAWS AND WHEN SNOW MELT RUNOFF IS CONCENTRATED OR IS CAUSING EROSION.
3. DISCHARGING SEDIMENT LADEN WATER WHICH WILL CAUSE OR CONTRIBUTE TO THE DEGRADATION OF A BENEFICIAL USE OF A WATER OF THE STATE FROM THE CONSTRUCTION SITE, A DEWATERING SITE, OR SEDIMENT BASIN/TRAP INTO ANY WATER BODY, WETLAND OR STORM DRAIN WITHOUT FILTRATION OR EQUIVALENT TREATMENT IS PROHIBITED.
4. DISCHARGES ORIGINATING FROM OFF-SITE SOURCES, WHICH FLOW THROUGH OR ACROSS THE AREAS DISTURBED BY CONSTRUCTION, SHALL BE DIVERTED AROUND THE ACTIVE CONSTRUCTION AREA WHENEVER POSSIBLE.
5. STAGING AREAS, ASSEMBLY AREAS, TEMPORARY EQUIPMENT AND NON-HAZARDOUS MATERIAL STORAGE AREAS SHALL BE LOCATED OUTSIDE THE 100-YR FLOOD ZONE. HAZARDOUS MATERIAL STORAGE AREAS SHALL BE LOCATED AT LEAST 100 FEET BACK FROM SURFACE WATER BODIES.
6. ALL EXCAVATED MATERIALS THAT WILL NOT BE USED ON THE SITE CANNOT BE STORED IN THE FLOODPLAIN AND MUST BE HAULED TO A DISPOSAL SITE LOCATED OUTSIDE OF THE FLOODPLAIN.
7. CONSTRUCTION STAGING AREAS AND TEMPORARY SOIL STOCKPILES SHALL BE LOCATED A MINIMUM OF 100 FEET AWAY FROM THE EDGE OF A WETLAND OR OTHERWISE RISCC APPROVED SEPARATION DISTANCE.
8. MEASURES SHALL BE TAKEN TO PREVENT TRENCHES FROM DRAINING A WETLAND OR CHANGING ITS HYDROLOGY.
9. IT IS DESIRED THAT THE AMOUNT AND DURATION OF ANY OPEN TRENCHING BE MINIMIZED DURING THE PROJECT.
10. IF STOCKPILES ARE EXPOSED FOR GREATER THAN 14 DAYS, THEY SHALL BE SEEDED WITH AN ANNUAL SEED MIXTURE AND MULCHED WITH STRAW AS SPECIFIED BY THE PROJECT OWNER.

INTERIM AND PERMANENT STABILIZATION

1. INTERIM STABILIZATION

   TEMPORARY SEEDING FOR INTERIM STABILIZATION IS A TYPE OF BMP THAT MUST BE PROVIDED WHERE LAND DISTURBANCE IS NECESSARY, AND EXPOSED FOR MORE THAN 14 DAYS UNLESS DIRECTED BY THE PROJECT OWNER.

   THE INSTALLATION OF AN EROSION CONTROL BLANKET UPON SEEDED AREAS IS CONSIDERED TO BE AN INTERIM STABILIZATION BMP TO PROTECT THE SEEDBED UNTIL VEGETATION IS ESTABLISHED.

2. PERMANENT STABILIZATION

   UPON COMPLETION OF ANY EARTH DISTURBANCE ACTIVITY, THE SITE SHALL BE IMMEDIATELY SEEDED, OR OTHERWISE PROTECTED FROM ACCELERATED EROSION AND SEDIMENTATION. A PROTECTIVE BLANKET OF COIR MAT 400, OR APPROVED EQUIVALENT, SHALL BE PLACED OVER SEED IN THE “CLEARING AREA”.

   THE STANDARD FOR VEGETATIVE COVER AS STABILIZATION IS PERENNIAL VEGETATION THAT IS ESTABLISHED WITH A UNIFORM COVERAGE DENSITY OF 80% ACROSS THE DISTURBED AREA. THE APPLICATION OF SEED IS DONE TO ACHIEVE PERMANENT STABILIZATION.

3. STABILIZATION DURING NON-GROWING SEASONS

   WHEN UTILITY CONSTRUCTION MUST BE DONE AND IS COMPLETED DURING A NON-GROWING SEASON, INTERIM STABILIZATION BMPs MUST BE IMPLEMENTED AND ADEQUATELY MAINTAINED. THE BMPs SHOULD BE INSPECTED WEEKLY (UNLESS SNOW COVERED) TO IDENTIFY AREAS THAT BECOME BARE.

   BARE AREAS SHOULD BE COVERED WITH A PROPERLY INSTALLED EROSION CONTROL BLANKET. ALL TEMPORARY EROSION AND SEDIMENT POLLUTION CONTROLS MUST BE MAINTAINED UNTIL PERENNIAL VEGETATION IS ESTABLISHED.

4. WHERE REQUIRED, ALONG THE ROAD SHOULDER, STRAW MULCH MUST BE APPLIED AT A MINIMUM OF 2.0 TONS PER ACRE. STRAW MULCH SHALL NOT BE APPLIED WITHIN THE DEGINATED “CLEARING AREAS”.
5. STRAW MULCH SHALL BE APPLIED IN LONG STRANDS, NOT FINELY CHOPPED OR BROKEN.
6. THE PLACEMENT OF FERTILIZER AND LIME SHALL ONLY BE WITHIN THE DESIGNATED ROAD SHOULDER, OUTSIDE THE LIMITS OF THE “CLEARING AREA”. PRIOR TO ANY SEEDING, LIME OR FERTILIZATION APPLICATION, A SOIL TEST SHALL BE PERFORMED TO DETERMINE THE pH FACTOR AND GUIDE THE APPLICATION RATE.
7. SEED DISTURBED AREAS PER THE EROSION AND SEDIMENT CONTROL PLANS. IN AREAS OF STEEP SLOPES OR OBVIOUS AREAS WHERE POTENTIAL EROSION MAY OCCUR, AN EROSION CONTROL MAT OR FLEXIBLE GROWTH MEDIUM (FGM) SHALL BE USED. FGM SHALL BE APPLIED PER MANUFACTURER SPECIFICATIONS. FERTILIZER AND MULCH SHALL ONLY BE WITHIN THE DESIGNATED ROAD SHOULDER AREA, OUTSIDE THE LIMITS OF THE “CLEARING AREA”.

PRELIMINARY:
FOR REFERENCE ONLY

REVISIONS DURING CONSTRUCTION

NO.	DATE	AS BUILT REVISIONS	BY	CHK	APP	APP
A	12/02/20	ISSUED FOR REVIEW–70%	JCB	MD	NS	–

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TITLE

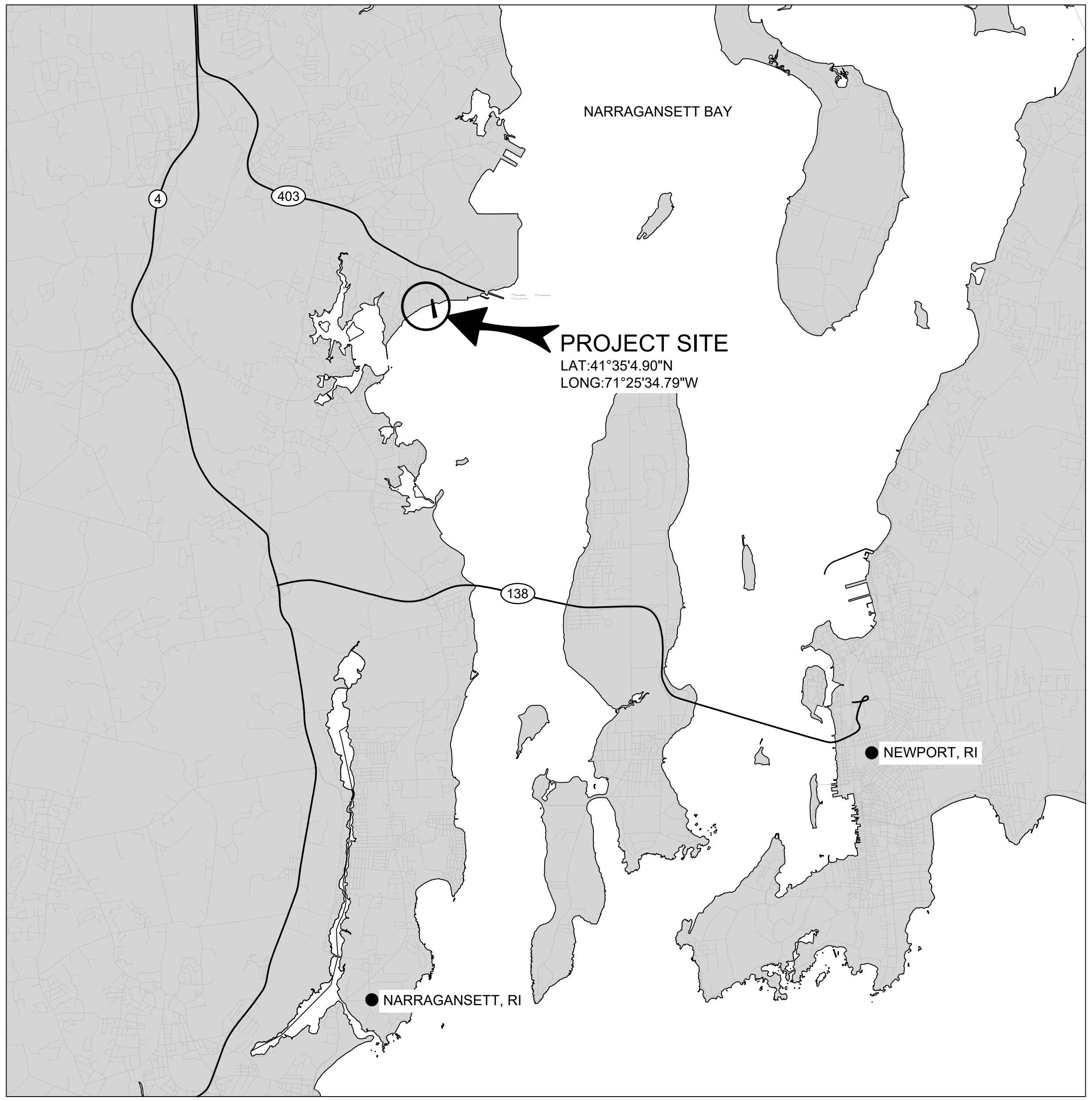
REVOLUTION WIND
EROSION CONTROL NOTES
NORTH KINGSTOWN, RHODE ISLAND

BY J. BARRINGER–BMcD	CHKD M. DAGENAIS–BMcD	APP N. SCOTT–BMcD	APP
DATE 09/30/20	DATE 09/30/20	DATE 09/30/20	DATE
H-SCALE N.T.S.	SIZE ARCH D	FIELD BOOK & PAGES	
V-SCALE N.T.S.	V.S.	R.E.DWG.	
R.E. PROJ. NUMBER		DWG NO. PG-32	

Landfall Plans

ØRSTED - REVOLUTION WIND

OPEN CUT LANDFALL DESIGN



VICINITY MAP

0 6,000 12,000
SCALE IN FEET

DRAWING INDEX	
NAME	SHEET #
COVER SHEET	1
GENERAL NOTES	2
EXISTING SITE PLAN	3
PROPOSED SITE PLAN	4
PROFILES	5
SECTIONS 1	6
SECTIONS 2	7

LOCATION MAP

0 200 400
SCALE IN FEET

30% DESIGN

MOTT MACDONALD
134 Capital Drive
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Client

Rev	Date	Drawn	Description	Ch'k'd	App'd
0	12/23/20	TM	30% Design	KB	

CHRISTOPHER A. COCKSHAW No. 9816 REGISTERED PROFESSIONAL ENGINEER CIVIL

NOT FOR CONSTRUCTION

Designed	A. Porter	Eng check	A. Porter
Drawn	T. Morrison	Coordination	
Dwg check		Approved	
Scale at ANSI D: As Noted	Status	Rev	Security

Project Number: 507103127 | B/O: 1 | Total: 7

Drawing Number

Title: Orsted US Engineering FA
Open Cut Landfall Design
Revolution Wind

Cover Sheet

...\12_MA_Marine\7 - Design\CAD\G - Design\Orsted Basemap 165 ft Apart.dwg Dec 23, 2020 - 12:07PM MOR69830

GENERAL NOTES

1. TO BE DEVELOPED

30% DESIGN

MOTT MACDONALD

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Client

Rev	Date	Drawn	Description	Ch'k'd	App'd
0	12/23/20	TM	30% Design	KB	

CHRISTOPHER A. COCKSHAW
No. 9816
REGISTERED PROFESSIONAL ENGINEER CIVIL

NOT FOR CONSTRUCTION

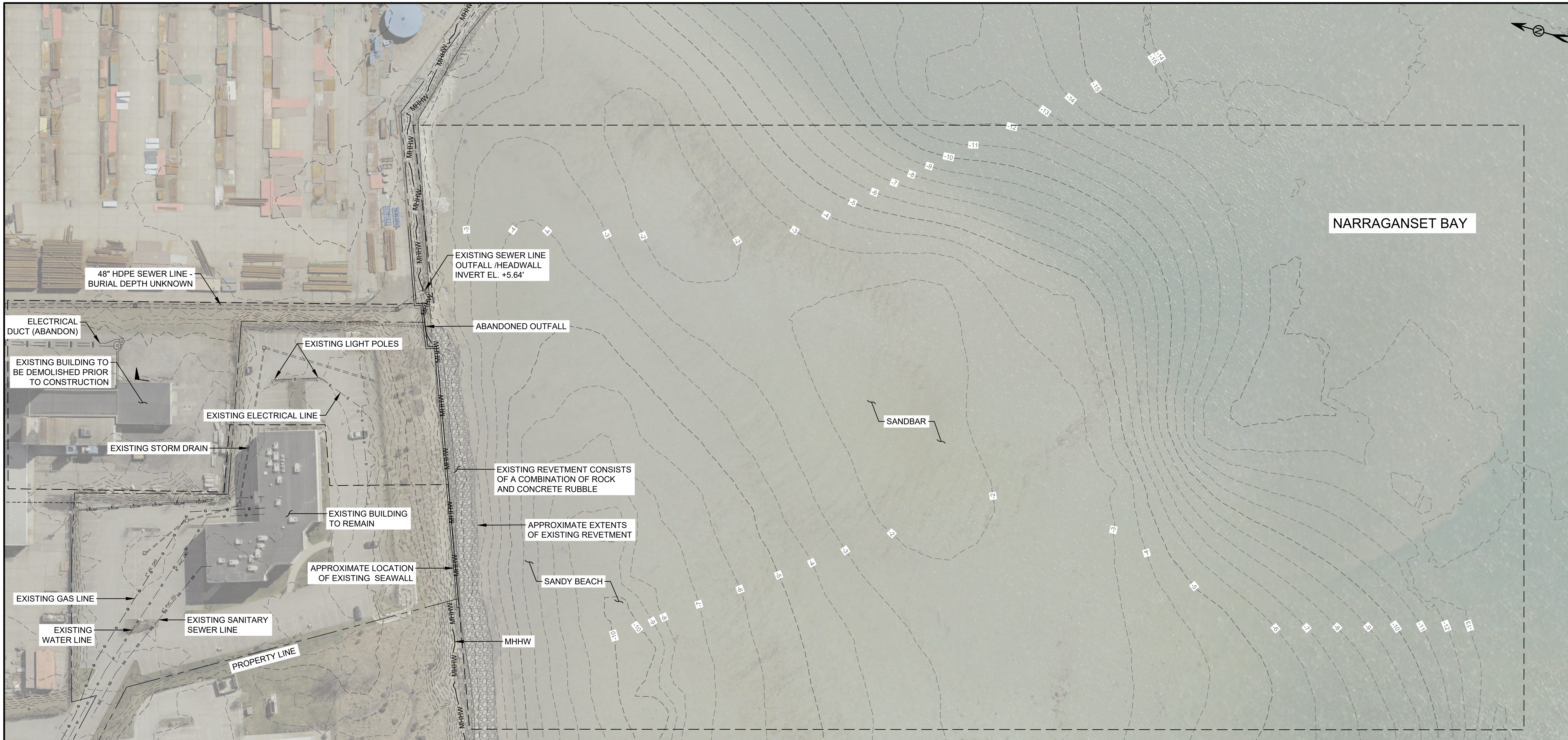
Project Number: 507103127 | B/O: 2 | Total: 7

Designed: A. Porter | Eng check: A. Porter
Drawn: T. Morrison | Coordination:
Dwg check: | Approved:
Scale at ANSI D: As Noted | Status: | Rev: | Security:

Drawing Number

Title: Orsted US Engineering FA
Open Cut Landfall Design
Revolution Wind

General Notes



DATUMS

VERTICAL: MLLW, FT
HORIZONTAL: NAD83 RHODE ISLAND STATE PLANE, FT

TIDAL DATUM	
MEAN LOWER LOW WATER (MLLW)	0.00'
MEAN SEA LEVEL (MSL)	1.87'
MEAN HIGHER HIGH WATER (MHHW)	4.11'

NOTES

1. BATHYMETRIC AND TOPOGRAPHIC SURVEY PROVIDED BY ORSTED. DETAILED TOPOGRAPHIC AND UTILITY SURVEY PLANNED PRIOR TO FINAL DESIGN.
2. UTILITY INFORMATION AND PROPERTY LINE DATA PROVIDED BY ORSTED.
3. EXISTING CATCH BASIN INVERTS UNKNOWN.
4. PARCEL BOUNDARIES SHOWN ARE BASED ON DATA PROVIDED BY ORSTED.
5. EXISTING IMAGERY SHOWN IS FROM GOOGLE EARTH DATED APRIL 2020.

EXISTING SITE PLAN

0 50 100
SCALE IN FEET

30% DESIGN

MOTT MACDONALD
134 Capital Drive
Suite D
West Springfield, MA 01089

T (413) 535 0135

www.mottmac.com

Client

Rev	Date	Drawn	Description	Ch'k'd	App'd
0	12/23/20	TM	30% Design	KB	

CHRISTOPHER A. COOKSHAW No. 9816 REGISTERED PROFESSIONAL ENGINEER CIVIL

NOT FOR CONSTRUCTION

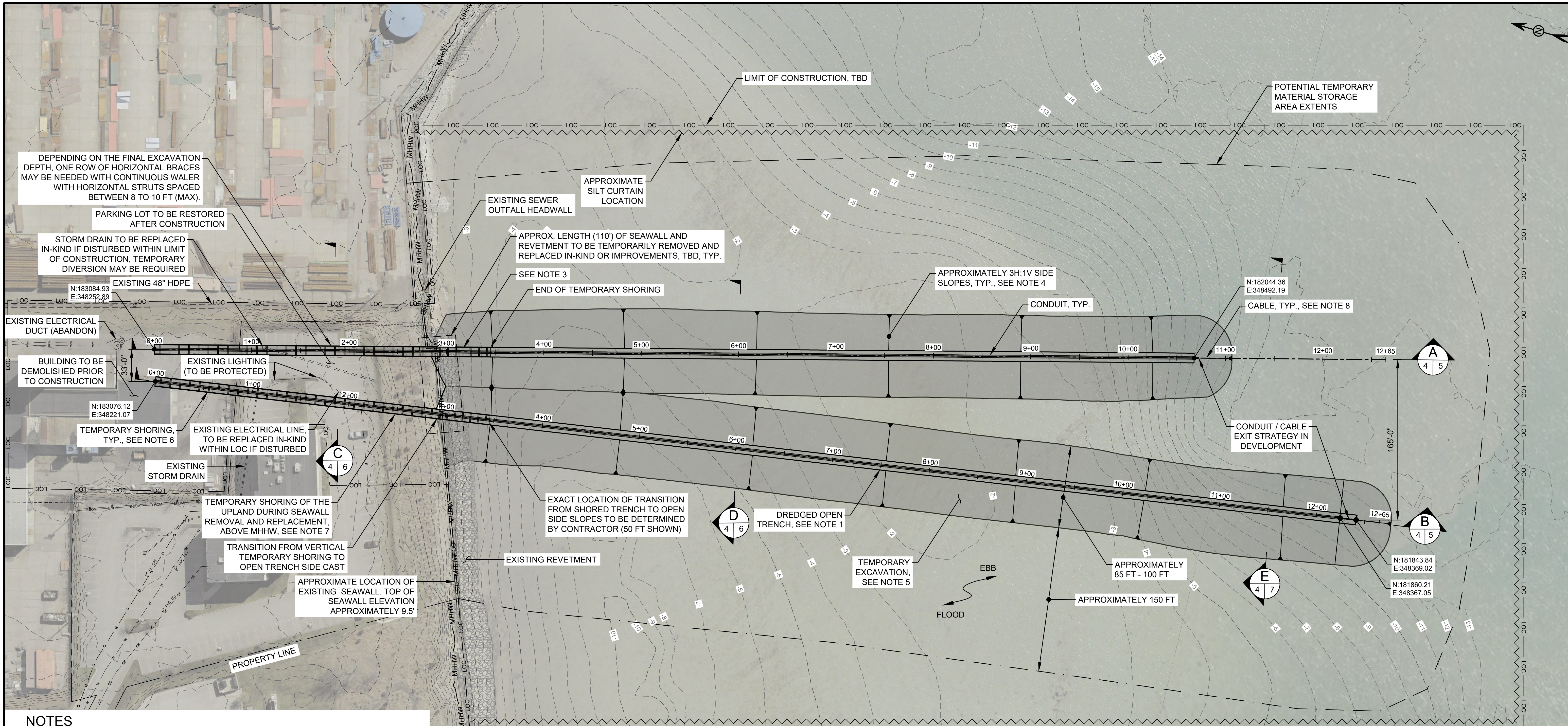
Designed	A. Porter	Eng check	A. Porter
Drawn	T. Morrison	Coordination	
Dwg check		Approved	
Scale at ANSI D: As Noted	Status	Rev	Security

Project Number 507103127 | B/O 3 | Total 7

Drawing Number

Title
Orsted US Engineering FA
Open Cut Landfall Design
Revolution Wind

Existing Site Plan



NOTES

1. TEMPORARY SHEETPILE MAY BE INSTALLED WITHIN POTENTIAL STORAGE AREA EXTENTS OF EXCAVATION PRISM, TO REDUCE EXCAVATION FOOTPRINT.
2. ALIGNMENTS ARE PRELIMINARY ONLY AND SUBJECT TO REFINEMENT.
3. TRENCH AT SEAWALL MAY NEED TWO ROWS OF HORIZONTAL BRACES. CONTINUOUS WALER WITH HORIZONTAL STRUTS SPACED BETWEEN 8 TO 10 FT (MAX).
4. DEPENDING ON GEOLOGICAL INVESTIGATION, STABLE SLOPE OF OPEN CUT MAY BE REVISED.
5. TEMPORARY EXCAVATION TO ALLOW FOR INSTALLATION OF HDPE CONDUIT. NATIVE MATERIAL BACKFILLED AFTER INSTALL OF HDPE PIPE. IMPORTED MATERIAL MAY BE REQUIRED DEPENDING ON DISPERSION OF NATIVE SEDIMENTS OUTSIDE THE PROJECT AREA.
6. DEPENDING ON THE FINAL EXCAVATION DEPTH, SHEETPILE SYSTEM MAY NOT BE NEEDED FROM STA 0+00 TO 1+00. EXTENTS AND SPACING OF TEMPORARY SHORING TO BE DETERMINED BY CONTRACTOR.
7. PAVEMENT AND VEGETATION TO BE RESTORED POST CONSTRUCTION IF DISTURBED WITHIN LIMIT OF CONSTRUCTION.
8. CABLE BURIAL DEPTH STILL TBD BASED ON SEDIMENT AND CABLE DESIGN.
9. TEMPORARY SEDIMENT AND EROSION CONTROL MEASURE TO FOLLOW RHODE ISLAND SOIL EROSION AND SEDIMENT CONTROL HANDBOOK.

DATUMS

VERTICAL: MLLW
HORIZONTAL: NAD83 RHODE ISLAND STATE PLANE, FT

TEMPORARY EXCAVATION

IN-WATER (SOUTH OF SEAWALL)	52,000 CY
UPLAND (NORTH OF SEAWALL)	3,900 CY

TOTAL DISTURBED AREA

TRENCH	200,000 SF
TEMPORARY STORAGE	400,000 SF

OVERALL SITE PLAN

0 50 100
SCALE IN FEET

IMPORTED MATERIAL VOLUME

IN-WATER (SOUTH OF SEAWALL)	0 - 25,000 CY (~50% LOSS FACTOR)
UPLAND (NORTH OF SEAWALL)	0 - 3,900 CY (~100% LOSS FACTOR)

30% DESIGN

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0	12/23/20	TM	30% Design	KB	

CHRISTOPHER A. COCKSHAW No. 9816 REGISTERED PROFESSIONAL ENGINEER CIVIL

NOT FOR CONSTRUCTION

Designed	A. Porter	Eng check	A. Porter
Drawn	T. Morrison	Coordination	
Dwg check		Approved	

Scale at ANSI D: As Noted | Status | Rev | Security

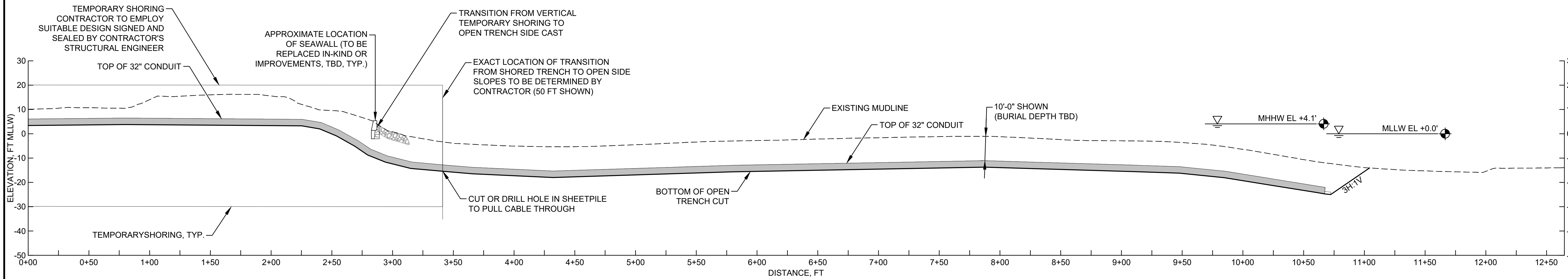
Project Number: 507103127 | B/O: 4 | Total: 7

Drawing Number

Title: Orsted US Engineering FA
Open Cut Landfall Design
Revolution Wind

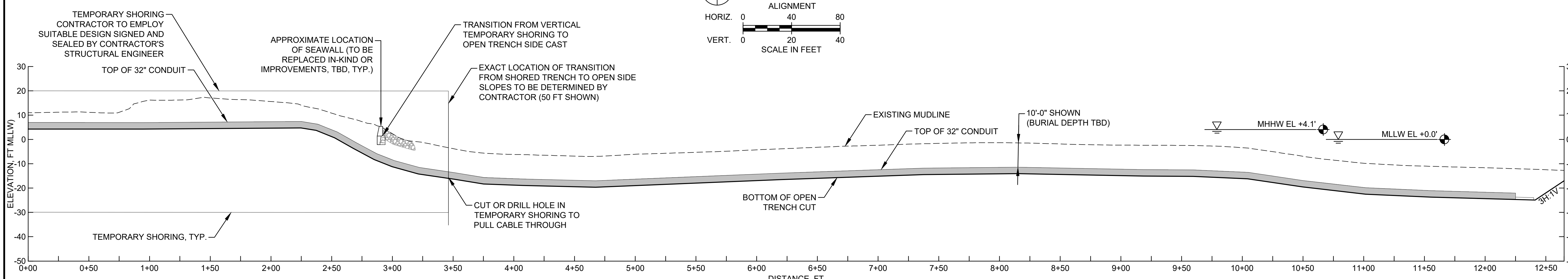
Proposed Site Plan

p:\...\12_MA_Marine\7 - Design\CAD\G - Design\Orsted Basemap 165 ft Apart.dwg Dec 23, 2020 - 12:08PM MOR69830



SECTION A
4 | 5
EAST CABLE ALIGNMENT

HORIZ. 0 40 80
VERT. 0 20 40
SCALE IN FEET



SECTION B
4 | 5
WEST CABLE ALIGNMENT

HORIZ. 0 40 80
VERT. 0 20 40
SCALE IN FEET

30% DESIGN

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Client

Rev	Date	Drawn	Description	Ch'k'd	App'd
0	12/23/20	TM	30% Design	KB	

CHRISTOPHER A. COCKSHAW No. 9816 REGISTERED PROFESSIONAL ENGINEER CIVIL

NOT FOR CONSTRUCTION

Designed	A. Porter	Eng check	A. Porter
Drawn	T. Morrison	Coordination	
Dwg check		Approved	

Scale at ANSI D: As Noted | Status | Rev | Security

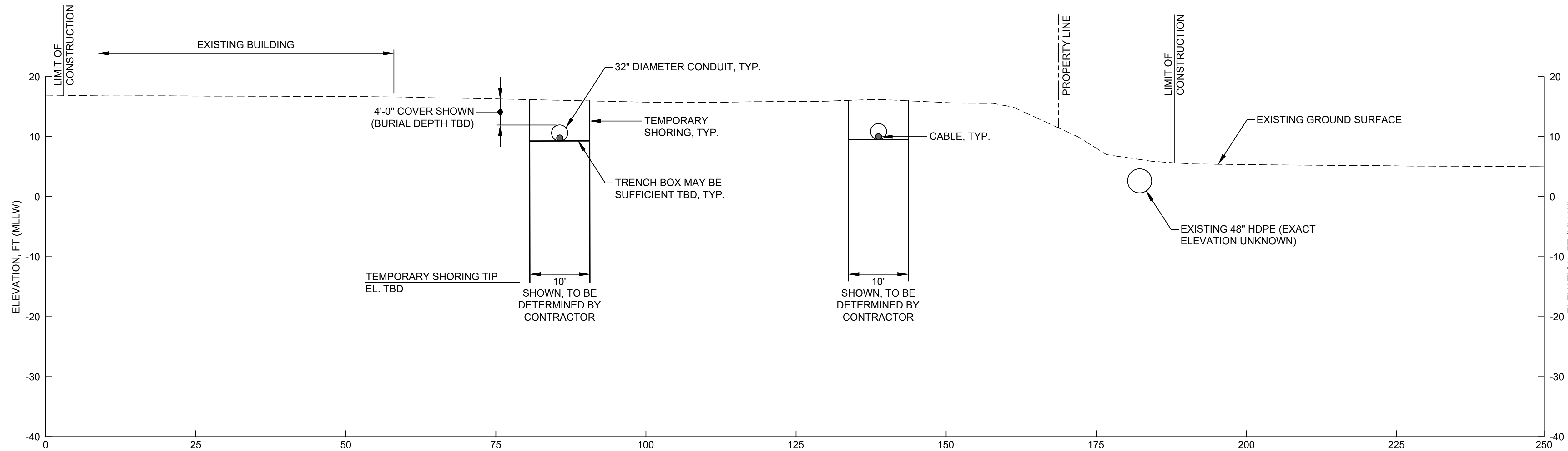
Project Number: 507103127 | B/O: 5 | Total: 7

Drawing Number

Title
Orsted US Engineering FA
Open Cut Landfall Design
Revolution Wind

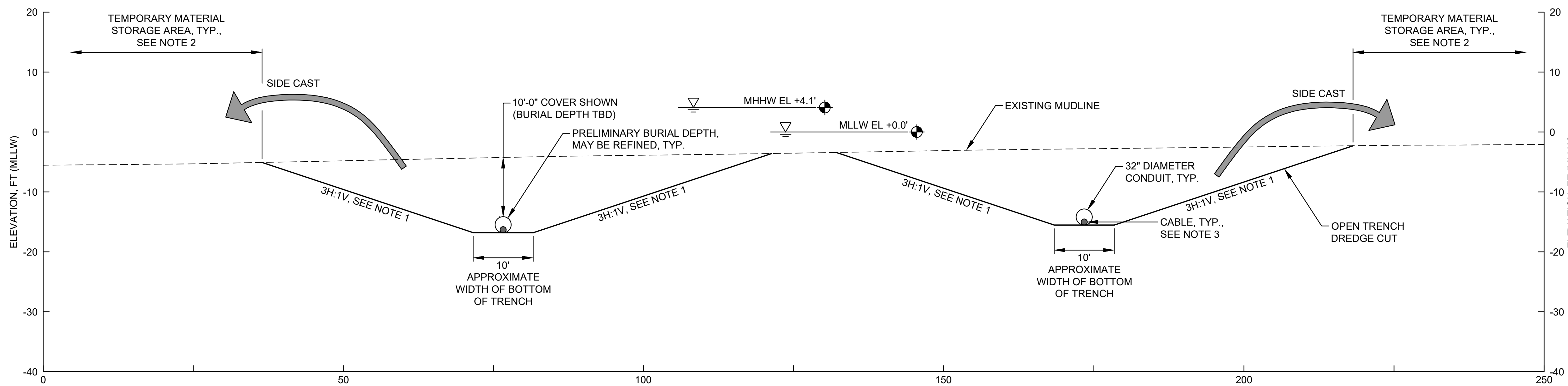
Profiles

...\12_MA_Marine\7 - Design\CAD\G - Design\Orsted Basemap 165 ft Apart.dwg Dec 23, 2020 - 12:12PM MOR69830



C 4 6 SECTION

0 10 20 SCALE IN FEET



D 4 6 SECTION

0 10 20 SCALE IN FEET

NOTES

1. 3H:1V SIDE SLOPES ASSUMED TO BE STABLE SIDE SLOPE PENDING GEOLOGICAL AND SEABED MOBILITY INVESTIGATIONS.
2. TEMPORARY MATERIAL STORAGE MAYBE ABOVE OR BELOW MLLW.
3. CABLE BURIAL DEPTH STILL TBD BASED ON SEDIMENT AND CABLE DESIGN.

30% DESIGN

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Client

Rev	Date	Drawn	Description	Ch'k'd	App'd
0	12/23/20	TM	30% Design	KB	

CHRISTOPHER A. COCKSHAW No. 9816 REGISTERED PROFESSIONAL ENGINEER CIVIL

NOT FOR CONSTRUCTION

Designed	A. Porter	Eng check	A. Porter
Drawn	T. Morrison	Coordination	
Dwg check		Approved	

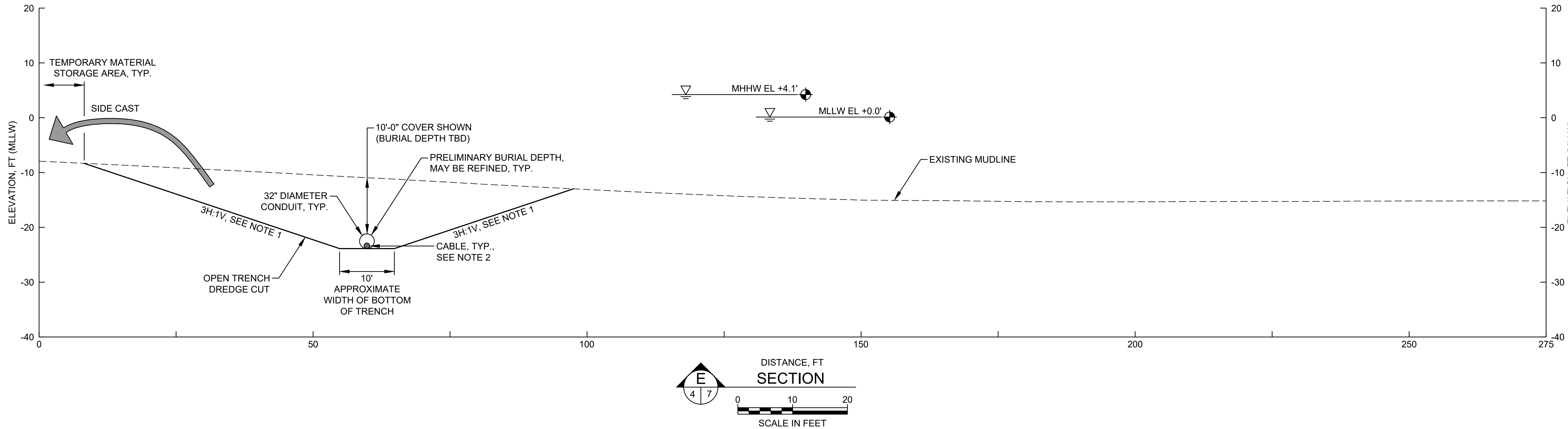
Scale at ANSI D: As Noted | Status | Rev | Security

Project Number: 507103127 | B/O: 6 | Total: 7

Drawing Number

Title: Orsted US Engineering FA Open Cut Landfall Design Revolution Wind

Sections 1



NOTES

1. 3H:1V SIDE SLOPES ASSUMED TO BE STABLE SIDE SLOPE PENDING GEOLOGICAL AND SEABED MOBILITY INVESTIGATIONS.
2. CABLE BURIAL DEPTH STILL TBD BASED ON SEDIMENT AND CABLE DESIGN.

30% DESIGN

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Suite D
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Client

Rev	Date	Drawn	Description	Ch'k'd	App'd
0	12/23/20	TM	30% Design	KB	

CHRISTOPHER A. COCKSHAW No. 9816 REGISTERED PROFESSIONAL ENGINEER CIVIL

NOT FOR CONSTRUCTION

Designed	A. Porter	Eng check	A. Porter
Drawn	T. Morrison	Coordination	
Dwg check		Approved	

Scale at ANSI D: As Noted | Status | Rev | Security

Project Number: 507103127 | B/O: 7 | Total: 7

Drawing Number

Title: Orsted US Engineering FA
Open Cut Landfall Design
Revolution Wind

Sections 2

REV01 - QUONSET POINT
CALCULATION OF SOIL DISPLACEMENT FOR HDD

HDD entry pit excavation	
Assumed parameters:	
Depth (m)	2
Length (m)	3
Width (m)	3

Calculation (per entry pit):	
L x W X D	18

Total volume displaced by excavation (approx) for 2 x entry pits:
36 m³

Volume of HDD soil displacement	
Assumed parameters:	
Diameter of pipe OD (mm)	900
Multiplication ratio of pipe to HDD bore	1.5
Assumed length of HDD bore 1 (m)	388
Assumed length of HDD bore 2 (m)	329

Calculation (per drill line):	
$\pi r^2 \times L$	
r (m)	0.675
L bore 1 (rounded up to nearest 10) (m)	390
L bore 2 (rounded up to nearest 10) (m)	330

Volume displaced HDD bore 1 (m³)	558
Volume displaced HDD bore 2 (m³)	472

Volume displaced by HDD (approx):
1030 m³

HDD exit pit excavation	
Assumed parameters:	
Depth (m)	3
Length (m)	50
Width (m)	10

Calculation (per exit pit):	
L x W X D	1500

Total volume displaced by excavation (approx) for 2 x exit pits:
3000 m³

Total volume displaced by HDD operation including onshore and offshore excavation (approx):
4066 m³

The calculations have been derived based on some basic project assumptions and provide an indication of the approximate volume of spoil to be displaced by both the HDD operation and also the offshore excavations.

No allowance has been made for the length over the actual drill line at this stage and the volume assumes the linear length.

The bore diameter has been determined on the basis of a ratio of x 1.5 to pipe diameter. It is recognised that this provides a 'worst case' scenario and some reduction may result from a lower multiplication factor.

The offshore excavation assumes the pit dimensions based on a 'cube' and does not take into account the gradient of the slopes of the excavation and therefore incorporates an additional allowance for the purposes of consenting. The final dimensions of the pit shall be determined in due course to compliment the final arrangement of the duct end and interface with the installation contractor.

Revolution Wind | Powered by Ørsted & Eversource

DORECO documennt number:	06563484
Revision:	A
Date:	12-Oct-2020
Created by:	REBCO
Checked by:	XTROP
Approved by:	DAMAR

CHRISTOPHER A. COCKSHAW
No. 9816
REGISTERED PROFESSIONAL ENGINEER CIVIL

This PE stamp only certifies that this HDD conceptual calculation has been prepared under the oversight and review of a professional engineer licensed in the State of Rhode Island. This PE stamp does not certify an approved calculation to support a preliminary design.

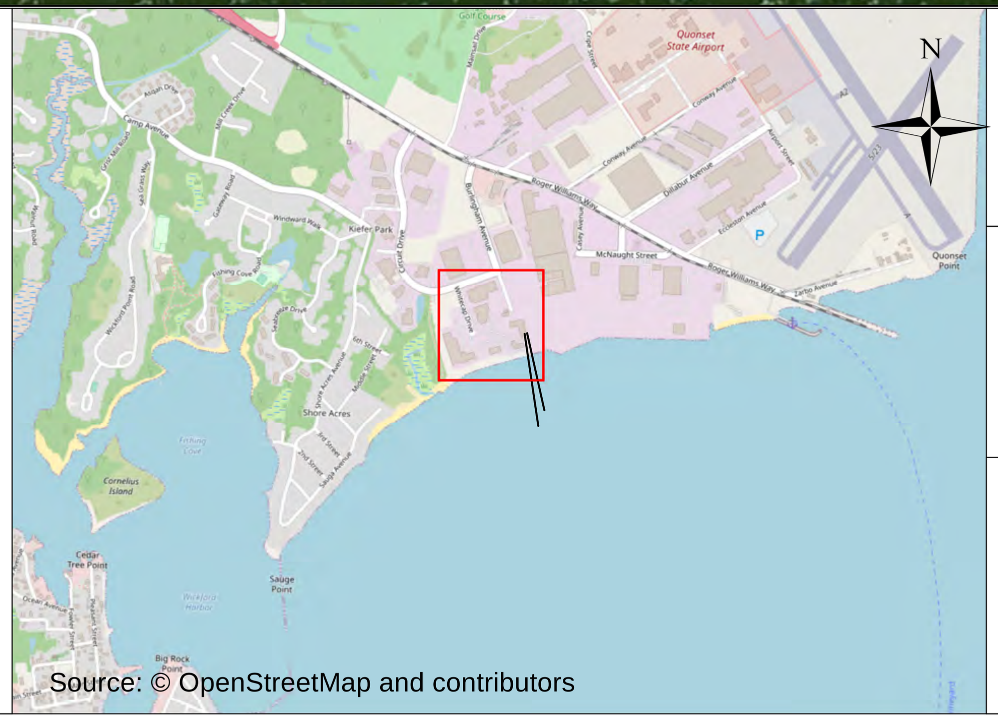
Legend

- Indicative Alignment
- Proposed Land Parcels
- Current Land Parcels

Notes:
1) Preliminary design, not for construction.
2) Sources: NOAA, © OpenStreetMap (and) contributors, CC-BY-SA
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community. Land Parcels: Eversource.
3) Alignment depth and location will be determined based on final engineering design.

CHRISTOPHER A. COCKSHAW No. 9816 REGISTERED PROFESSIONAL ENGINEER CIVIL

This PE stamp only certifies that this HDD concept is feasible and has been prepared under the oversight and review of a professional engineer licensed in the State of Rhode Island. This PE stamp does not certify an approved preliminary design. This drawing is for permitting only and not for construction.



Source: © OpenStreetMap and contributors

Land Parcels
Pre and Post Land Swap

Date: 16/10/2020
Created by: XDAEF
Checked by: XCHGG
Approved by: DAMAR

Revolution Wind

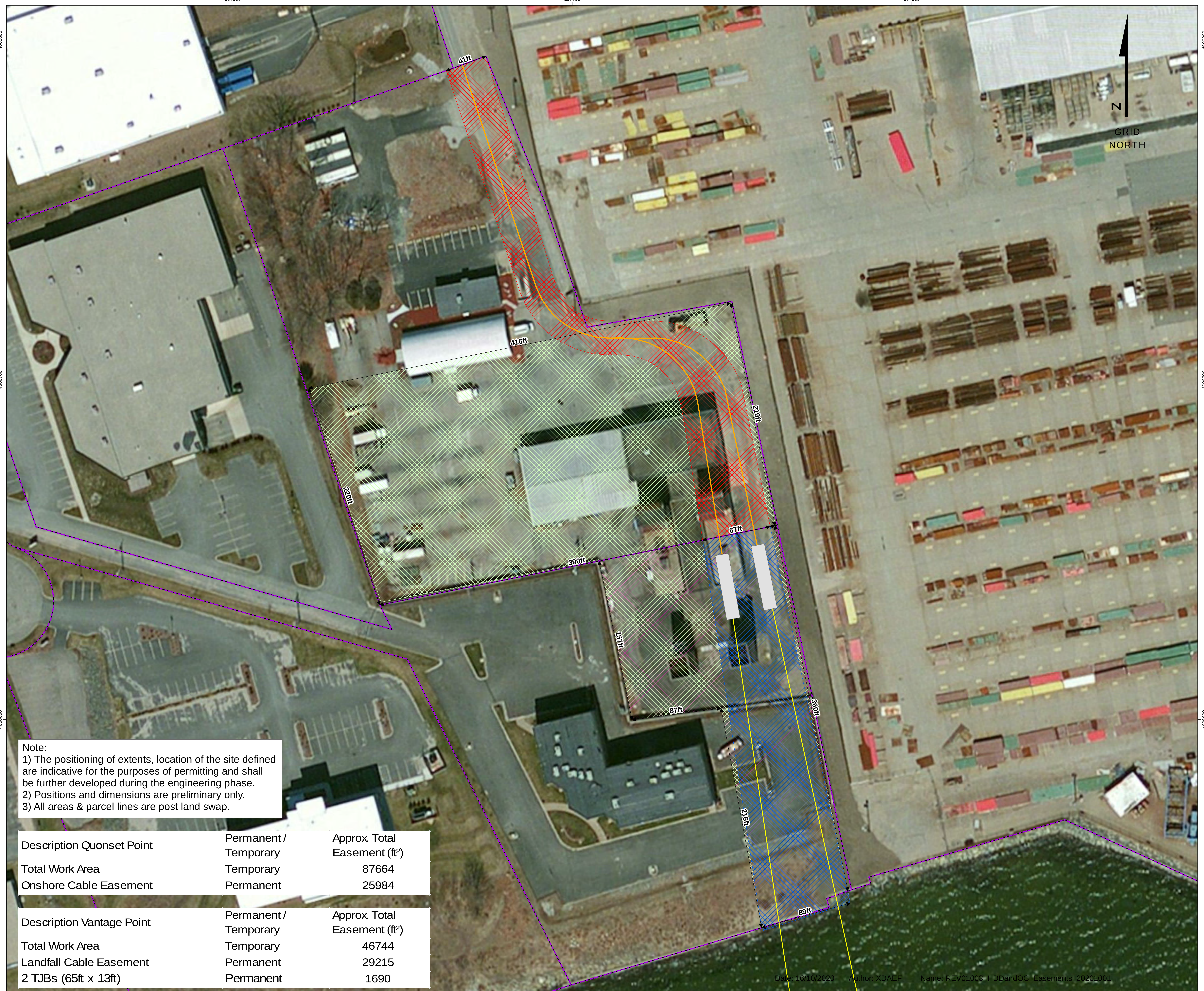
Powered by Ørsted & Eversource

Reference system: NAD83 (2011)

Projection: UTM Zone 19N
Scale @ 24x36 in

0 25 50 75 100 125 m
0 100 200 300 400 500 ft

Document Name: REV01002_LandParcels_20201001



Note:
1) The positioning of extents, location of the site defined are indicative for the purposes of permitting and shall be further developed during the engineering phase.
2) Positions and dimensions are preliminary only.
3) All areas & parcel lines are post land swap.

Description Quonset Point	Permanent / Temporary	Approx. Total Easement (ft²)
Total Work Area	Temporary	87664
Onshore Cable Easement	Permanent	25984

Description Vantage Point	Permanent / Temporary	Approx. Total Easement (ft²)
Total Work Area	Temporary	46744
Landfall Cable Easement	Permanent	29215
2 TJBs (65ft x 13ft)	Permanent	1690

Revolution Wind
Potential HDD and OC Site Layout

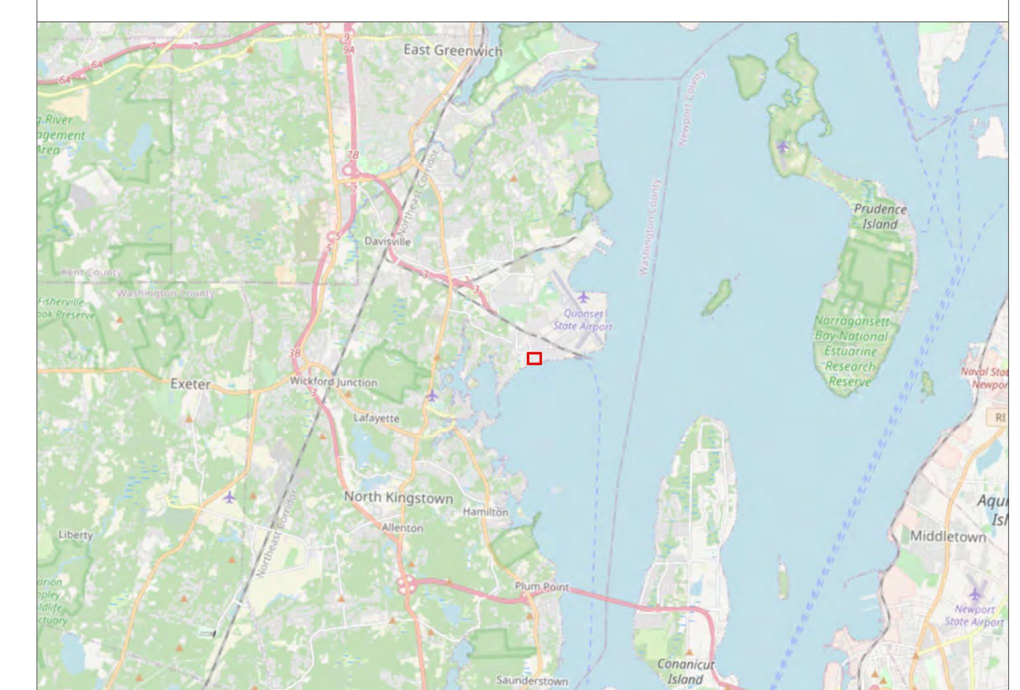
- Permanent Indicative Onshore Cable
- Permanent Indicative Landfall Cable
- Preliminay Land Parcels
- TJB

Quonset Point
- Work Area
- Onshore Cable Easement

Vantage Point
- Work Area
- Landfall Cable Easement

CHRISTOPHER A. COCKSHAW
No. 9816
REGISTERED PROFESSIONAL ENGINEER CIVIL

This PE stamp only certifies that this HDD concept is feasible and has been prepared under the oversight and review of a professional engineer licensed in the State of Rhode Island. This PE stamp does not certify an approved preliminary design. This drawing is for permitting only and not for construction.



Reference system: NAD83 (2011)
Projection: UTM Zone 19N

Scale@36x24 in:
1:500

0 10 20 30 40 50 Meters

0 50 100 150 200 Feet

REV	REMARK	DATE
....	First Issue	15/09/2020
1	Updated	16/10/2020

Created by: XDAEF
Checked by: XAMIJ/ CHGG
Approved by: REBCO/DAMAR

Revolution Wind | Powered by Ørsted & Eversource

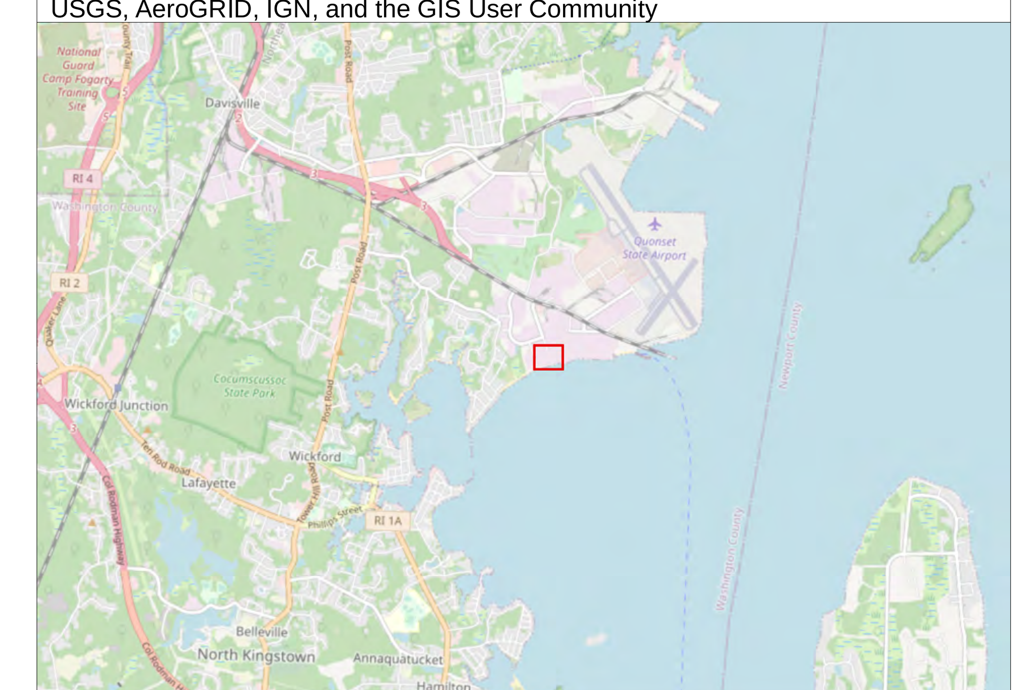
Revolution Wind
Potential HDD or OC Site Layout

- Sediment Controls
- Onshore Cables
- Offshore Cables
- TJB
- Temporary Work Area

CHRISTOPHER A. COOKSHAW
No. 9816
REGISTERED PROFESSIONAL ENGINEER
CIVIL

This PE stamp only certifies that this HDD concept is feasible and has been prepared under the oversight and review of a professional engineer licensed in the State of Rhode Island. This PE stamp does not certify an approved preliminary design. This drawing is for permitting only and not for construction.

Service Layer Credits: © OpenStreetMap (and) contributors, CC-BY-SA
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



Reference system: NAD83 (2011)
Projection: UTM Zone 19N

Scale@24x36 in: 1:500

0 10 20 30 40 50 Meters

0 50 100 150 200 Feet

REV	REMARK	DATE
....	First Issue	8/10/2020
1	Update	16/10/2020

Created by: XDAEF
Checked by: XAMIJ/ XCHGG
Approved by: REBCO/DAMAR

Revolution Wind
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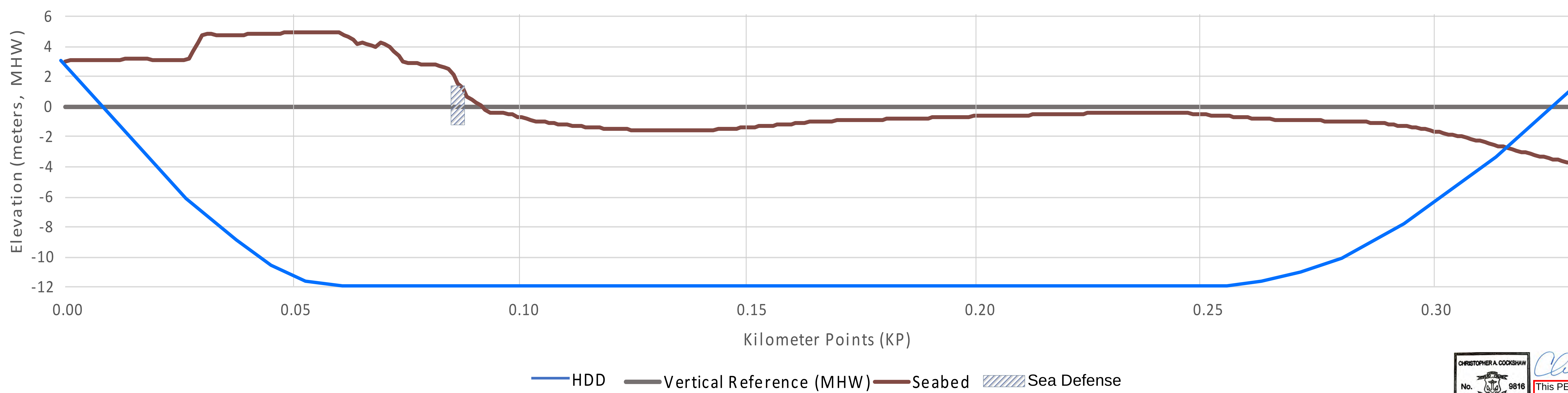

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This PE stamp only certifies that this HDD concept is feasible and has been prepared under the oversight and review of a professional engineer licensed in the State of Rhode Island. This PE stamp does not certify an approved preliminary design. This drawing is for permitting only and not for construction.

Legend

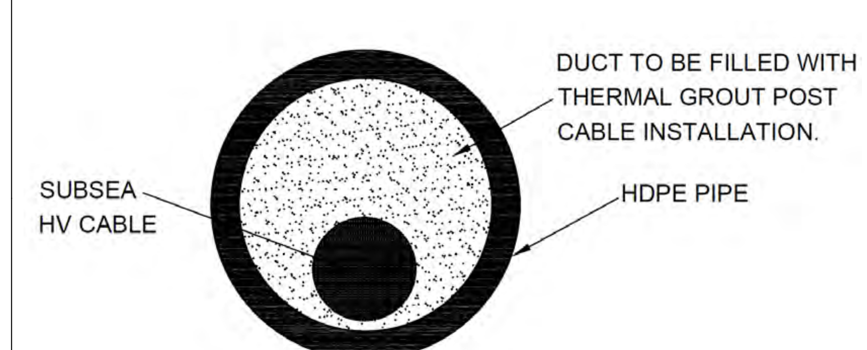
- Kilometer Point (KP)
- Indicative HDD Alignment
- Preliminay Land Parcels
- Contours (1m)
- Contours (5m)

Utilities

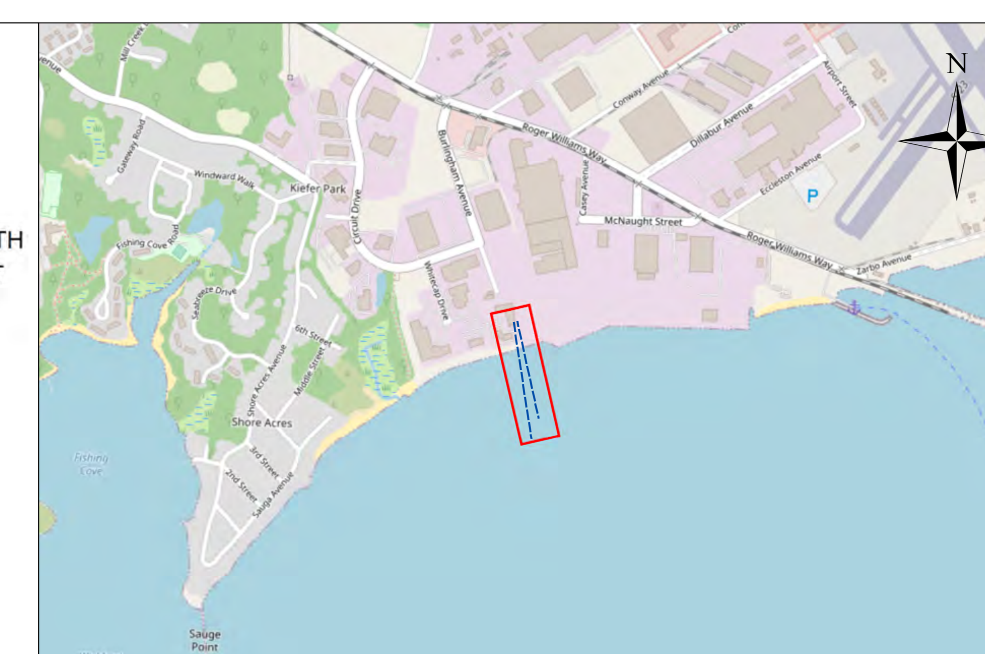
- Abandoned Electric Line
- Abandoned Fuel Line
- Abandoned Storm Drain
- Abandoned Water Line
- Existing Catch Basin
- Existing Communications Line
- Existing Electric Line
- Existing Natural Gas Line
- Existing Sanitary and Manhole
- Existing Storm Drain
- Existing Water Line

Notes:
1) Preliminary design, not for construction.
2) This drawing has been prepared to show the profile of the proposed HDD and export cable area with burial depth. It should be noted that the design shall be subject to detailed engineering by a specialist contractor and as such, may differ from that shown.
3) The elevation data used in this drawing is derived from products by NOAA. The source DEMs are referenced vertically to the North American Vertical Datum of NAVD88. The Tidal Datum is MHW.
4) HDD depth and location will be determined based on final engineering design.
5) Please see PWD Drawing Archives - 19333 Blue Beach.pdf for a detailed and to-scale drawing of the Sea Defense.
6) Sources: NOAA, © OpenStreetMap (and) contributors, CC-BY-SA
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community.

Installation Cross Section



The above image is not to scale and shows the final arrangement upon completion of the cable installation.



Source: © OpenStreetMap and contributors

Quonset Point HDD East

Date: 16/10/2020
Created by: XDAEF
Checked by: XCHGG
Approved by: DAMAR

Revolution Wind — Powered by Ørsted & Eversource

Reference system: NAD83 (2011)
Projection: UTM Zone 19N
Scale @ 24x36 in

0 10 20 30 40 50 60 m
0 25 50 75 100 125 150 175 200 ft

Document Name: REV01005_QuonsetPoint_East_20201001

CHRISTOPHER A. COCKSHAW No. 9816 REGISTERED PROFESSIONAL ENGINEER CIVIL

This PE stamp only certifies that this HDD concept is feasible and has been prepared under the oversight and review of a professional engineer licensed in the State of Rhode Island. This PE stamp does not certify an approved preliminary design. This drawing is for permitting only and not for construction.

Legend

- Kilometer Point (KP)
- Indicative HDD Alignment
- Proposed Land Parcels
- Contours (1m)
- Contours (5m)

Utilities

- Abandoned Electric Line
- Abandoned Fuel Line
- Abandoned Storm Drain
- Abandoned Water Line
- Existing Catch Basin
- Existing Communications Line
- Existing Electric Line
- Existing Natural Gas Line
- Existing Sanitary and Manhole
- Existing Storm Drain
- Existing Water Line

Notes:

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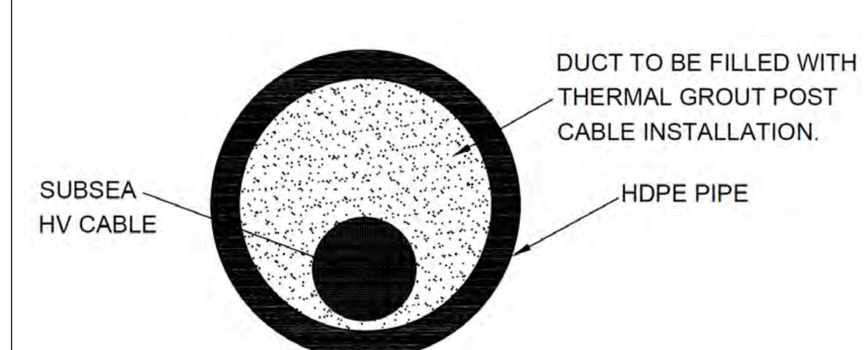
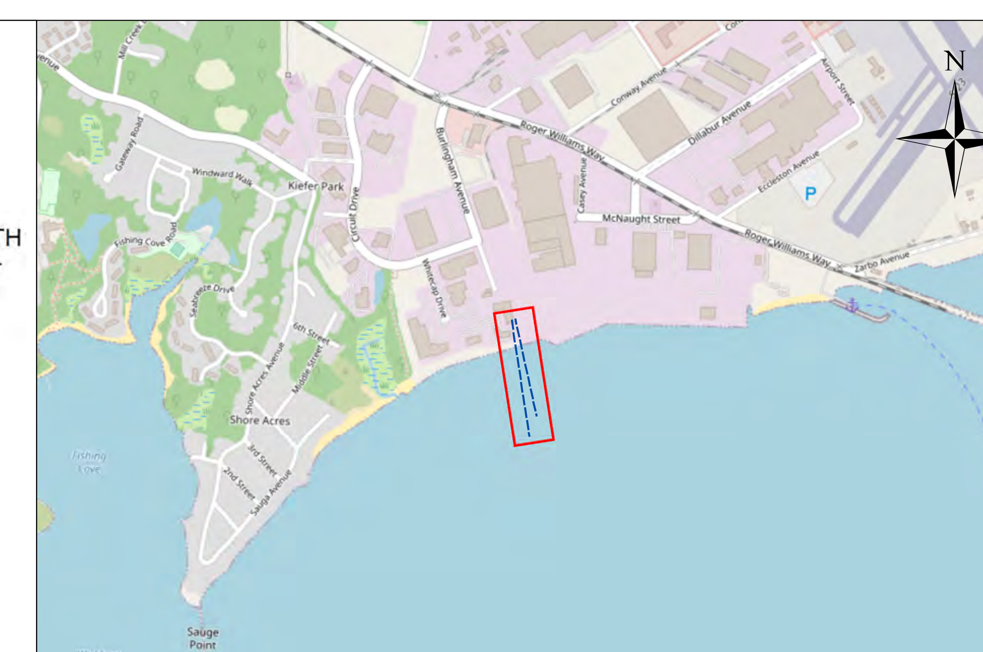
2) This drawing has been prepared to show the profile of the proposed HDD and export cable area with burial depth. It should be noted that the design shall be subject to detailed engineering by a specialist contractor and as such, may differ from that shown.
3)The elevation data used in this drawing is derived from products by NOAA. The source DEMs are referenced vertically to the North American Vertical Datum of MHW.
4) HDD depth and location will be determined based on final engineering design.
5) Please see PWD Drawing Archives - 19333 Blue Beach.pdf for a detailed and to-scale drawing of the Sea Defense.
6) Sources: NOAA, © OpenStreetMap (and) contributors, CC-BY-SA Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community.

Installation Cross Section



The above image is not to scale and shows the final arrangement upon completion of the cable installation.



Source: © OpenStreetMap and contributors

Quonset Point HDD West

Date: 16/10/2020
Created by: XDAEF
Checked by: XCHGG
Approved by: DAMAR

Revolution Wind | Powered by Ørsted & Eversource

Reference system: NAD83 (2011)

Projection: UTM Zone 19N
Scale @ 24x36 in

0 10 20 30 40 50 60 m
0 25 50 75 100 125 150 175 200 ft

Document Name: REV01006_QuonsetPoint_West_20201001

Revolution Wind Export Cable Plans

Legend

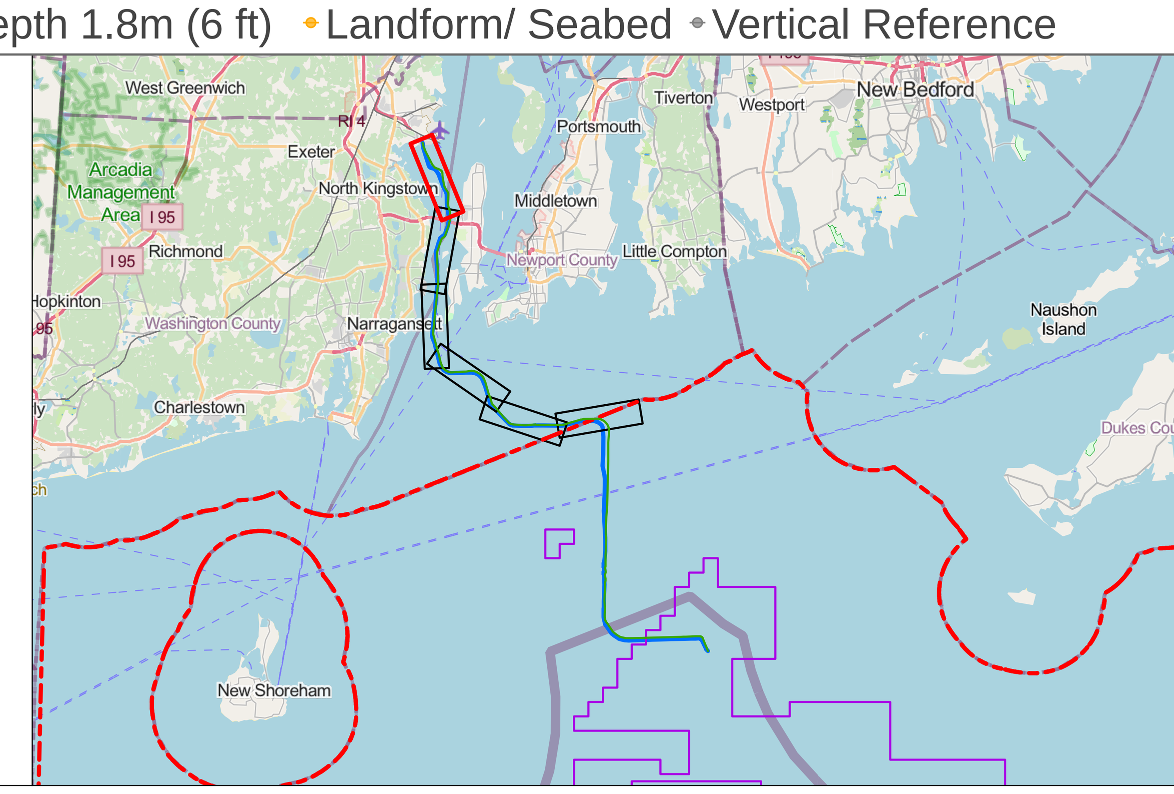
- Kilometer Point (KP)
- Revolution Wind Export Cable (RWEC) Corridor
- Indicative Circuit 1 Cable Burial Profile
- Indicative Circuit 2 Cable
- 3 NM State Water Limit
- BOEM Lease OCS-A 0486

Elevation Contours in Meters

- Intermediate (5 m)
- Major (10 m)

Notes:

1) Preliminary design, not for construction, and is pending final micro route engineering.
2) Burial of the RWEC will typically target a depth of 4 to 6 ft (1.2 to 1.8 m) below seabed. The target burial depth for the RWEC will be determined based on an assessment of seabed conditions, seabed mobility, the risk of interaction with external hazards such as fishing gear and vessel anchors, and a site-specific Cable Burial Risk Assessment.
3) The RWEC Corridor will consist of two distinct buried marine circuits. Micro-siting within the corridor will be completed by the installation contractor.
4) The Indicative Cable Burial Profile shown in this drawing is subject to change based on final cable routing.
5) The elevation data shown in the chart is derived from 2019 Bathymetry from Fugro in MLLW.
6) The elevation contour data used in this drawing is derived from NOAA DEM products (CoNED 2016 Topobathy in MLLW).
8) Sources: NOAA, NASCA, NPS, BOEM and (c) OpenStreetMap and contributors, Creative Commons-Share Alike License (CC-BY-SA).



Indicative Cable Burial Profile - Circuit 1 (Page 1 of 6)

Date: 21/12/2020
Created by: XDAEF
Checked by: XCHGG
Accepted by: KIRTR
Approved by: KIRTR

Revolution Wind | Powered by Ørsted & Eversource

0 0.15 0.3 0.45 Kilometers

0 0.15 0.3 Nautical Miles

Reference system: NAD83 (2011)
Projection: UTM Zone 19N
Vertical reference: NAVD88

Legend

- Kilometer Point (KP)
- Revolution Wind Export Cable (RWEC) Corridor
- Indicative Circuit 1 Cable Burial Profile
- Indicative Circuit 2 Cable
- 3 NM State Water Limit
- BOEM Lease OCS-A 0486

Elevation Contours in Meters

- Intermediate (5 m)
- Major (10 m)

Notes:

1) Preliminary design, not for construction, and is pending final micro route engineering.
2) Burial of the RWEC will typically target a depth of 4 to 6 ft (1.2 to 1.8 m) below seabed. The target burial depth for the RWEC will be determined based on an assessment of seabed conditions, seabed mobility, the risk of interaction with external hazards such as fishing gear and vessel anchors, and a site-specific Cable Burial Risk Assessment.
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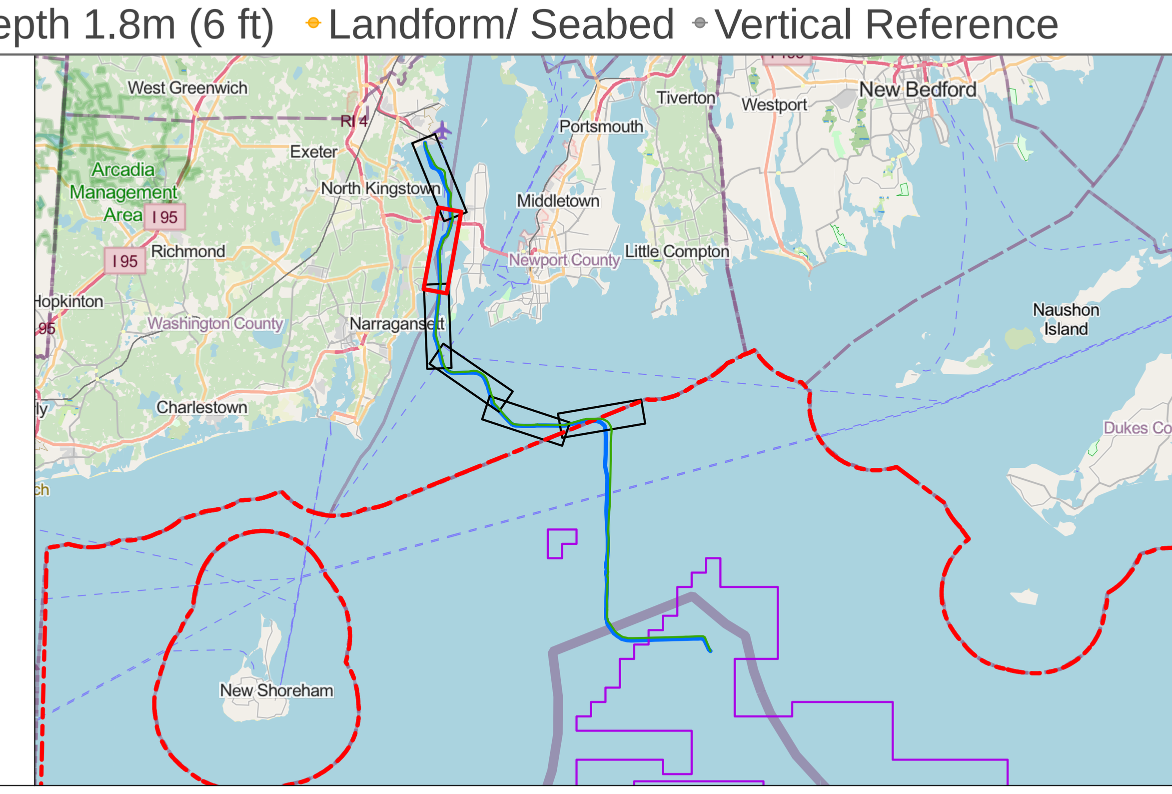
8) Sources: NOAA, NASCA, NPS, BOEM and (c) OpenStreetMap and contributors, Creative Commons-Share Alike License (CC-BY-SA).



Indicative Cable Burial Profile - Circuit 1 (Page 2 of 6)

Date: 21/12/2020
Created by: XDAEF
Checked by: XCHGG
Accepted by: KIRTR
Approved by: KIRTR

Revolution Wind | Powered by Ørsted & Eversource

0 0.15 0.3 0.45 Kilometers
0 0.15 0.3 Nautical Miles

Reference system: NAD83 (2011)
Projection: UTM Zone 19N
Vertical reference: NAVD88

Legend

- Kilometer Point (KP)
- Revolution Wind Export Cable (RWEC) Corridor
- Indicative Circuit 1 Cable Burial Profile
- Indicative Circuit 2 Cable
- 3 NM State Water Limit
- BOEM Lease OCS-A 0486

Elevation Contours in Meters

- Intermediate (5 m)
- Major (10 m)

Notes:

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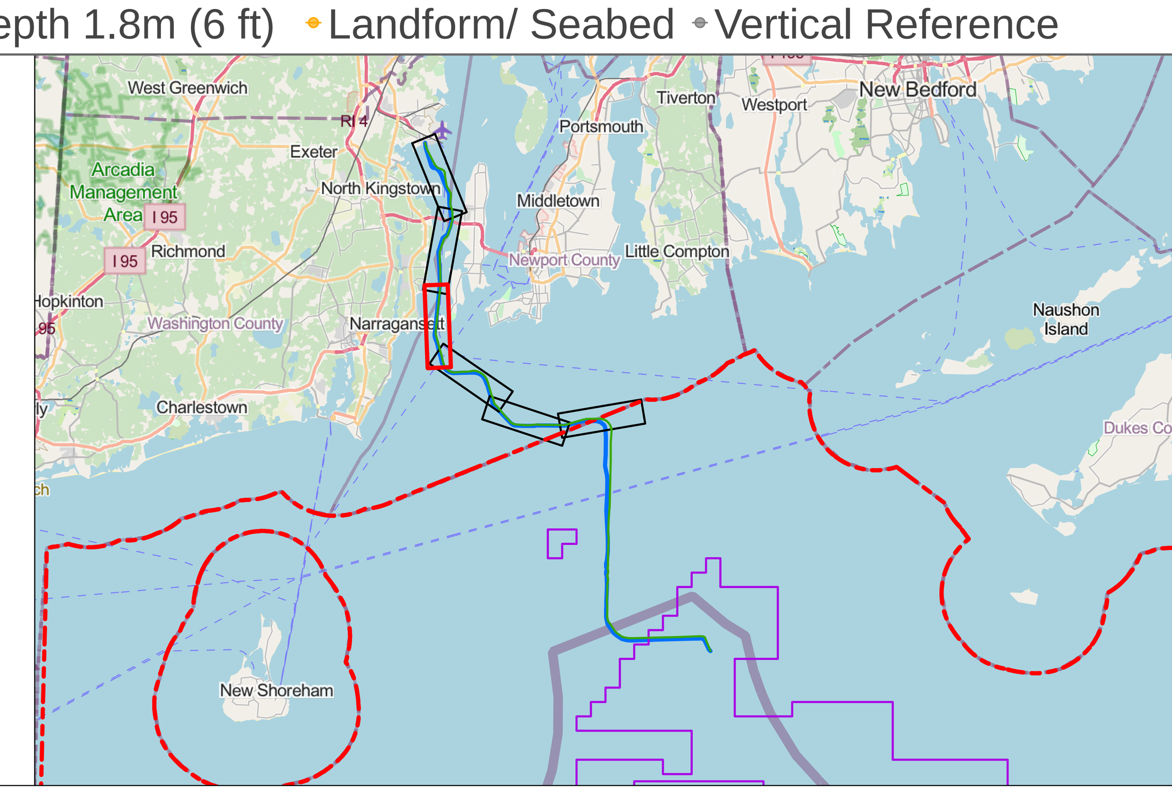

Indicative Cable Burial Profile - Circuit 1 (Page 3 of 6)

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Revolution Wind | Powered by Ørsted & Eversource

0 0.15 0.3 0.45 Kilometers

0 0.15 0.3 Nautical Miles

Reference system: NAD83 (2011)
Projection: UTM Zone 19N
Vertical reference: NAVD88

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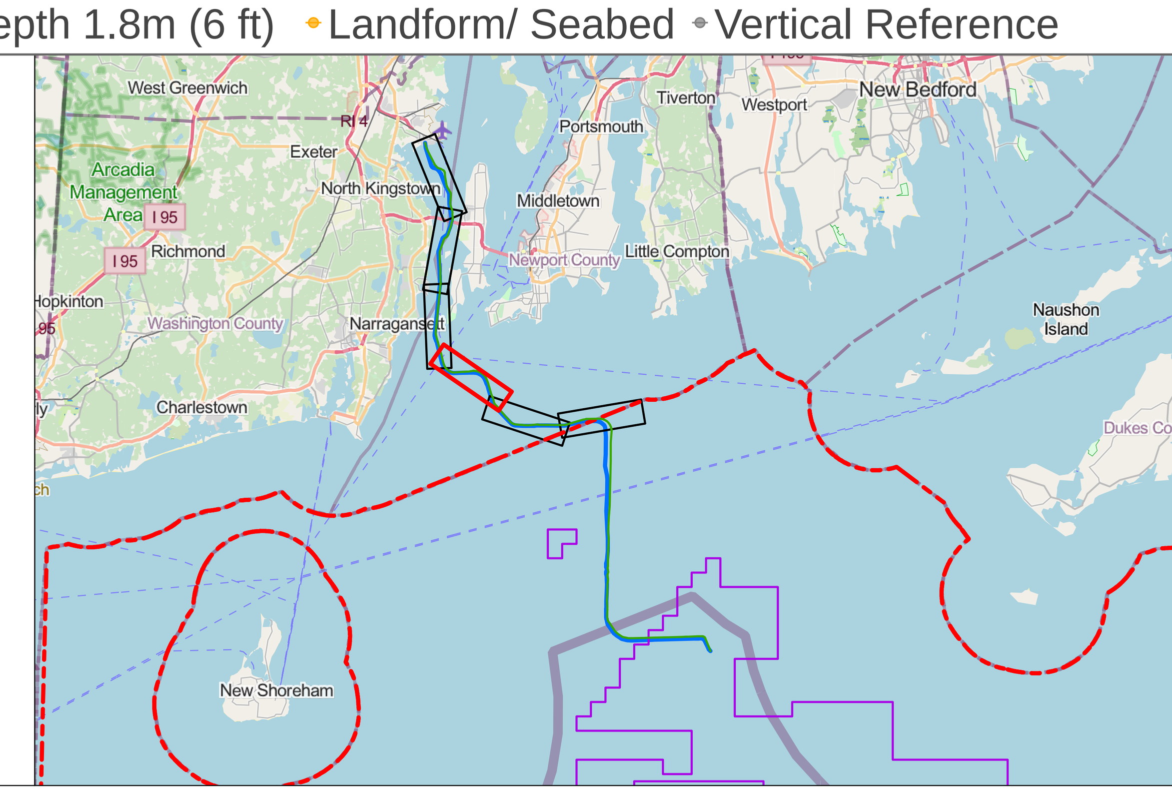

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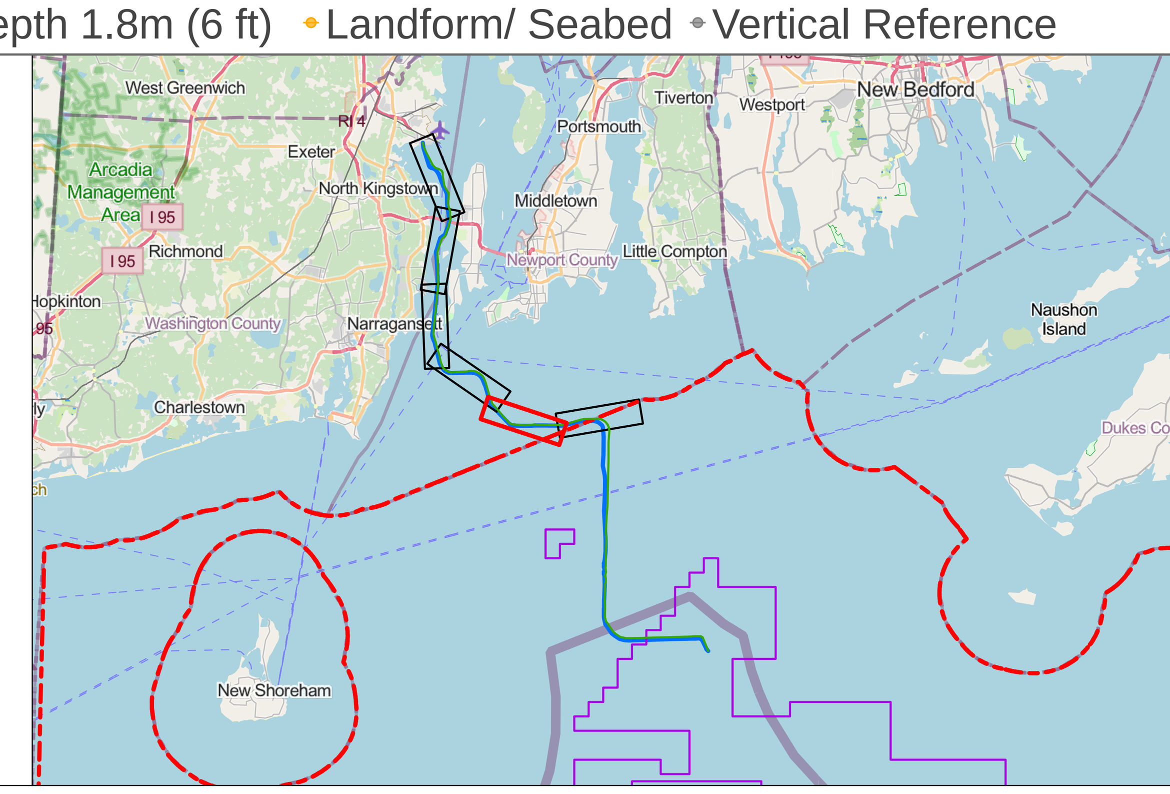

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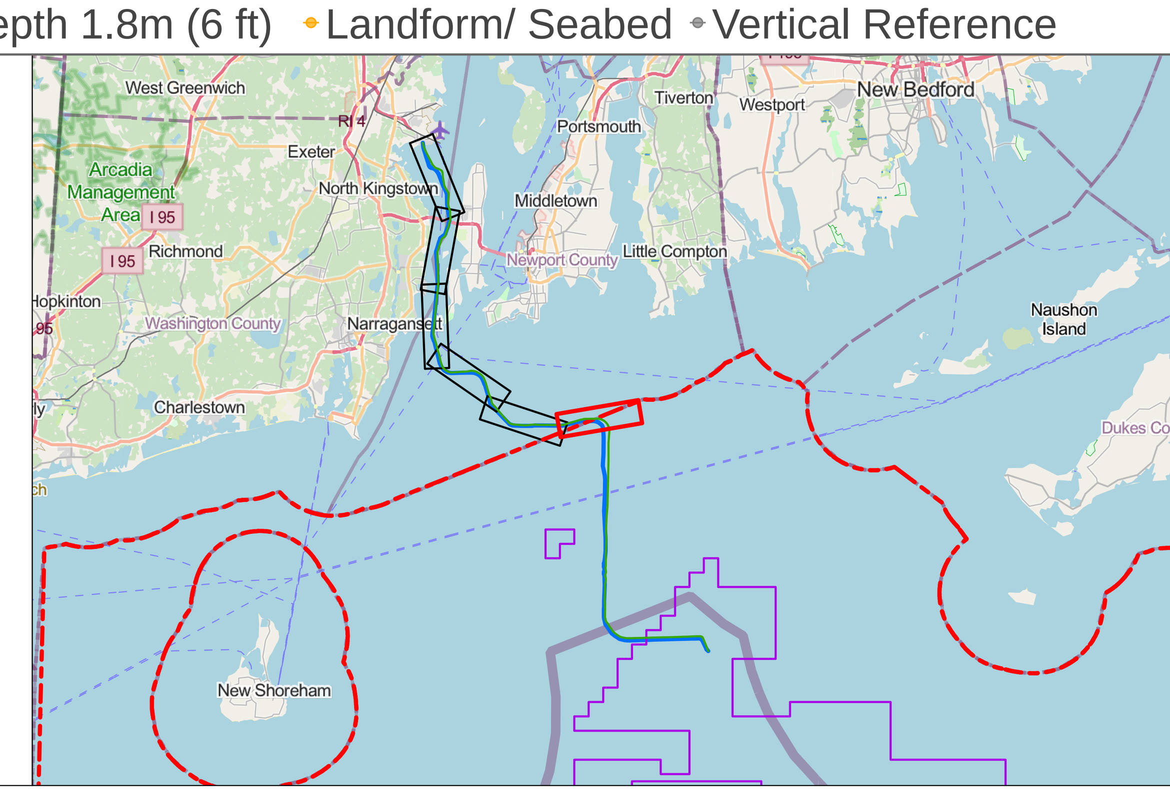

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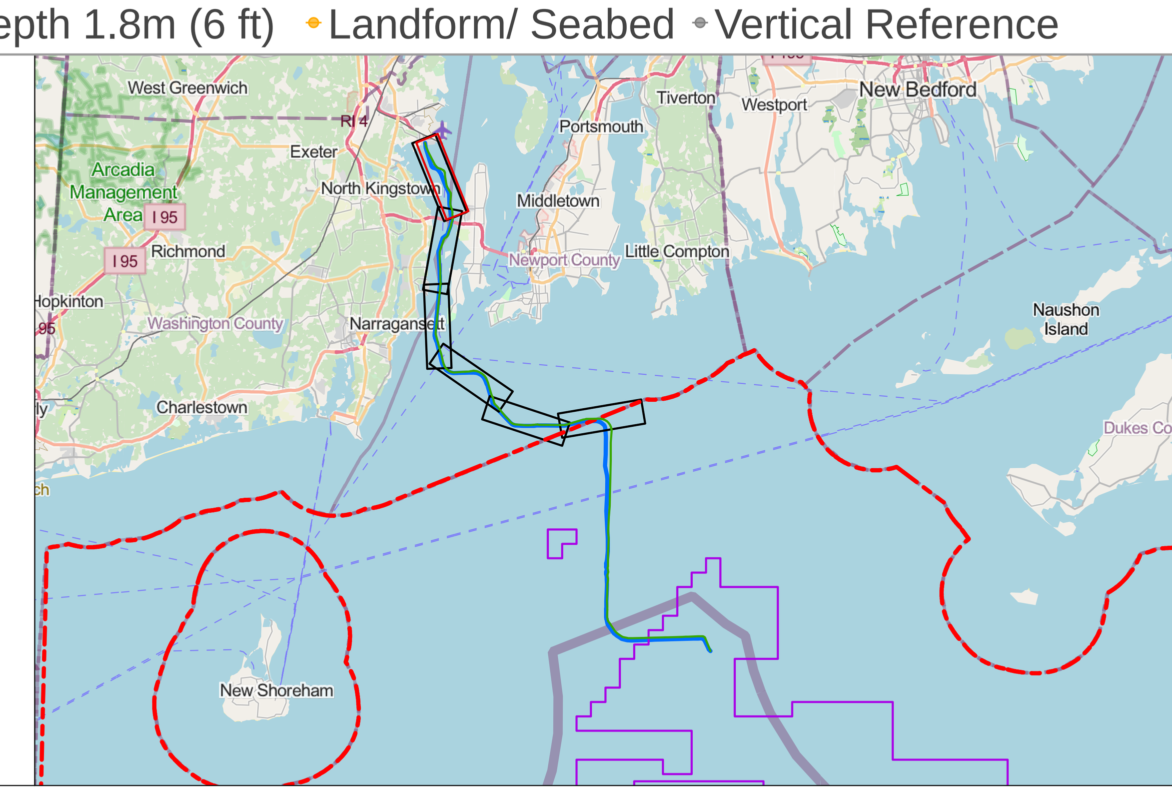

Indicative Cable Burial Profile - Circuit 2
(Page 1 of 6)

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0 0.3 0.6 Kilometers
0 0.15 0.3 Nautical Miles

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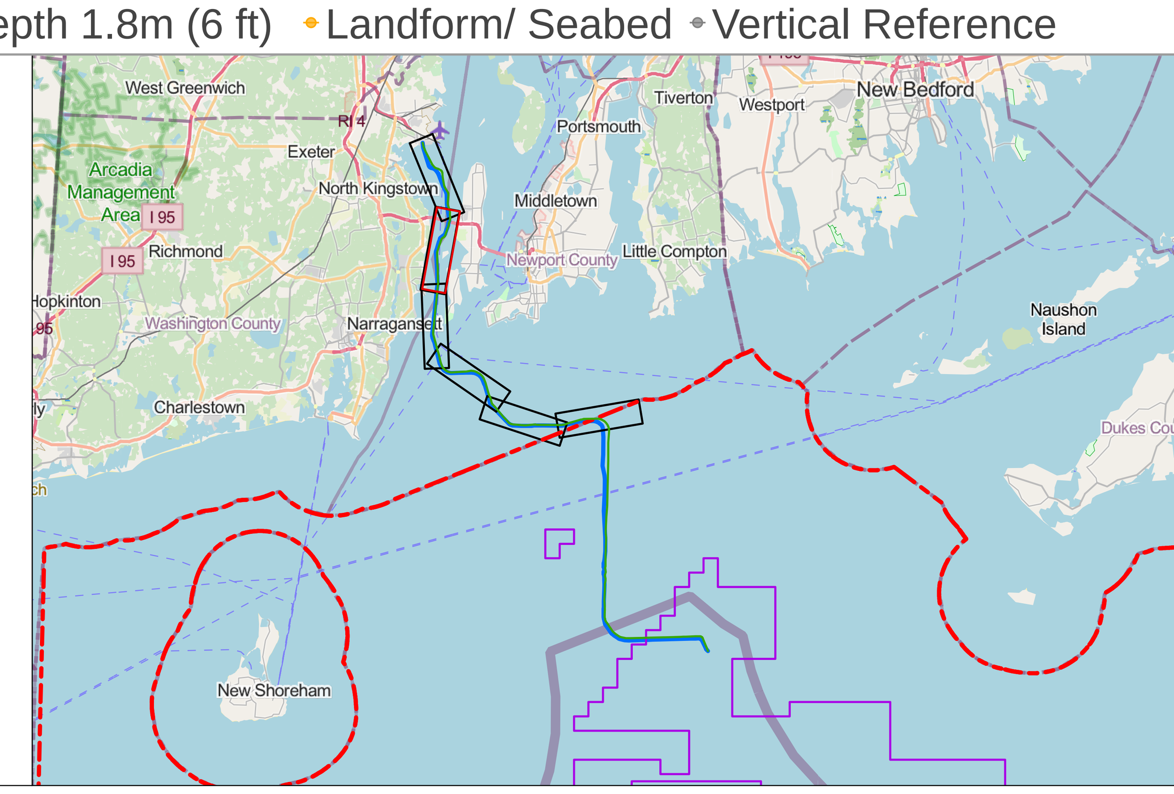

Indicative Cable Burial Profile - Circuit 2 (Page 2 of 6)

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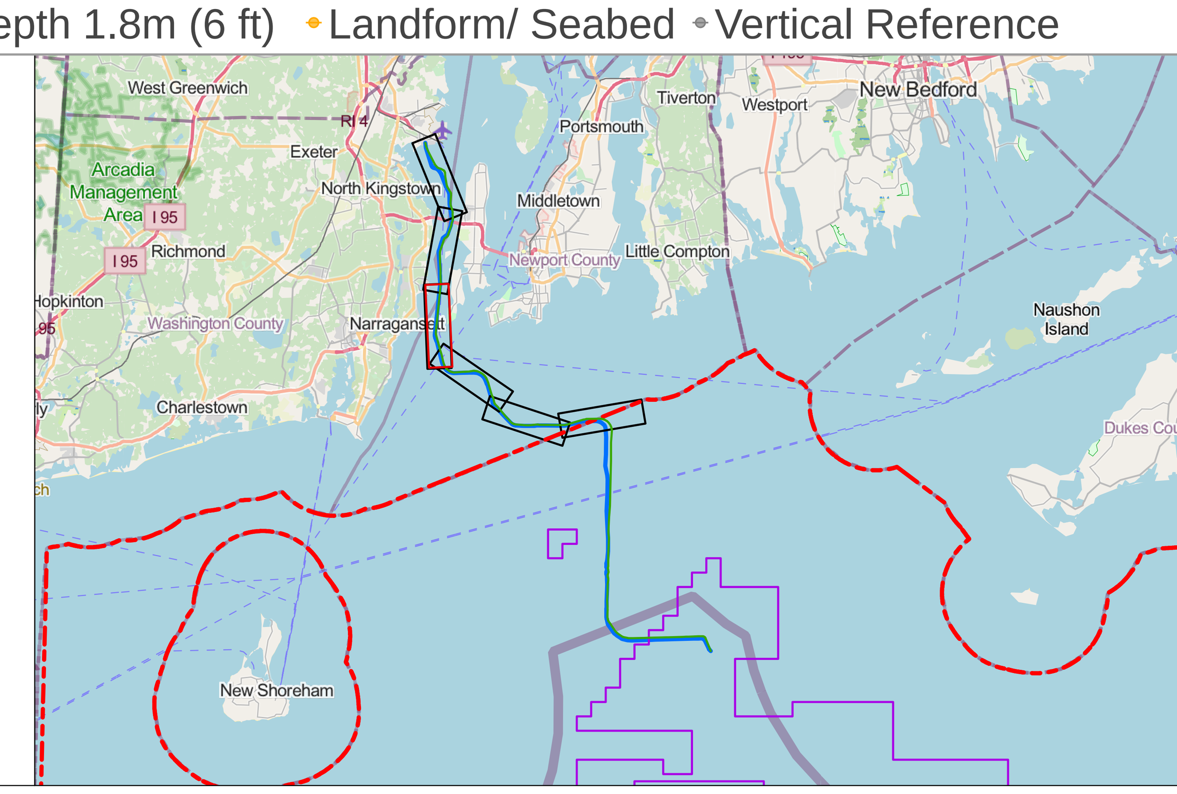

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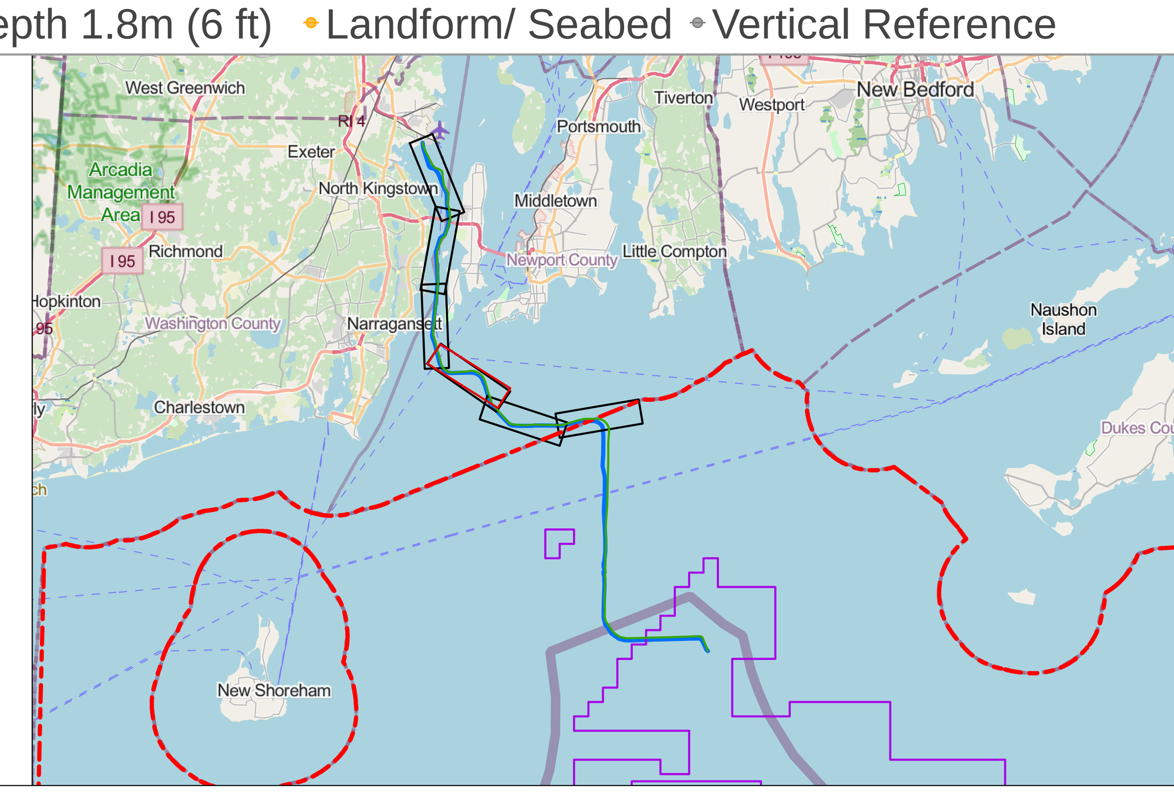

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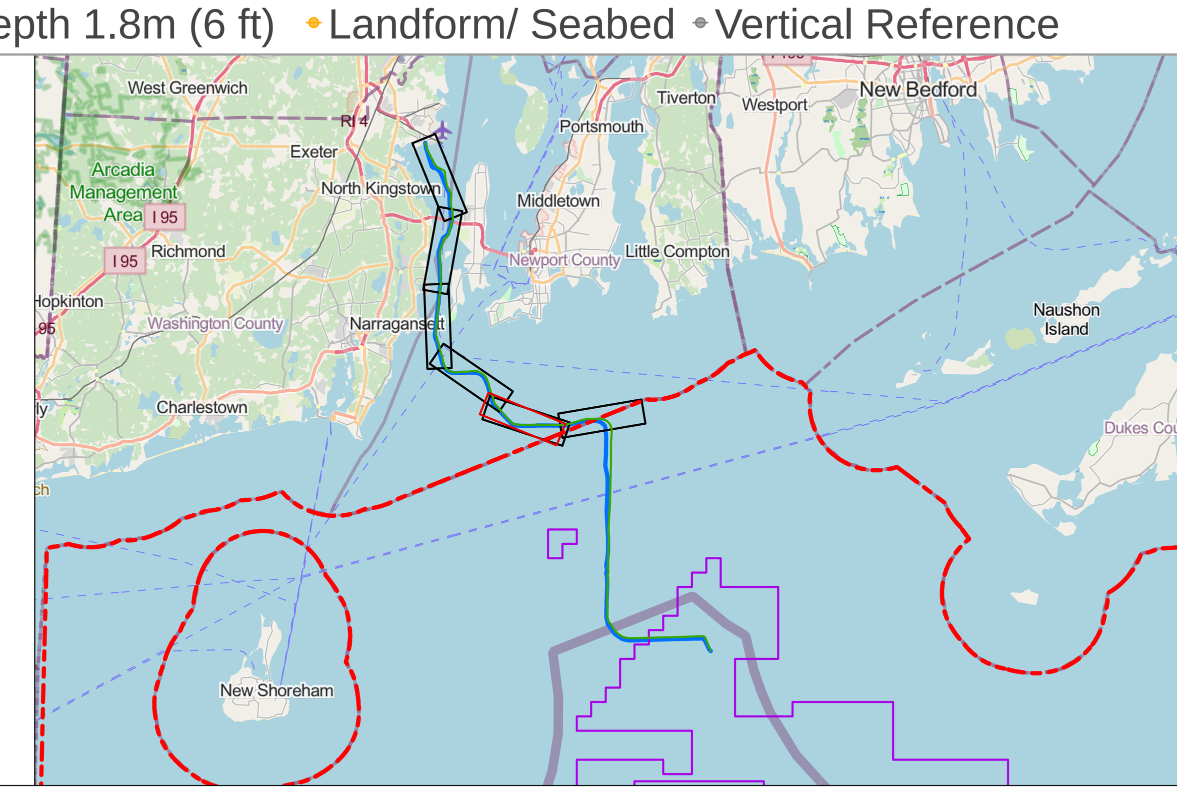

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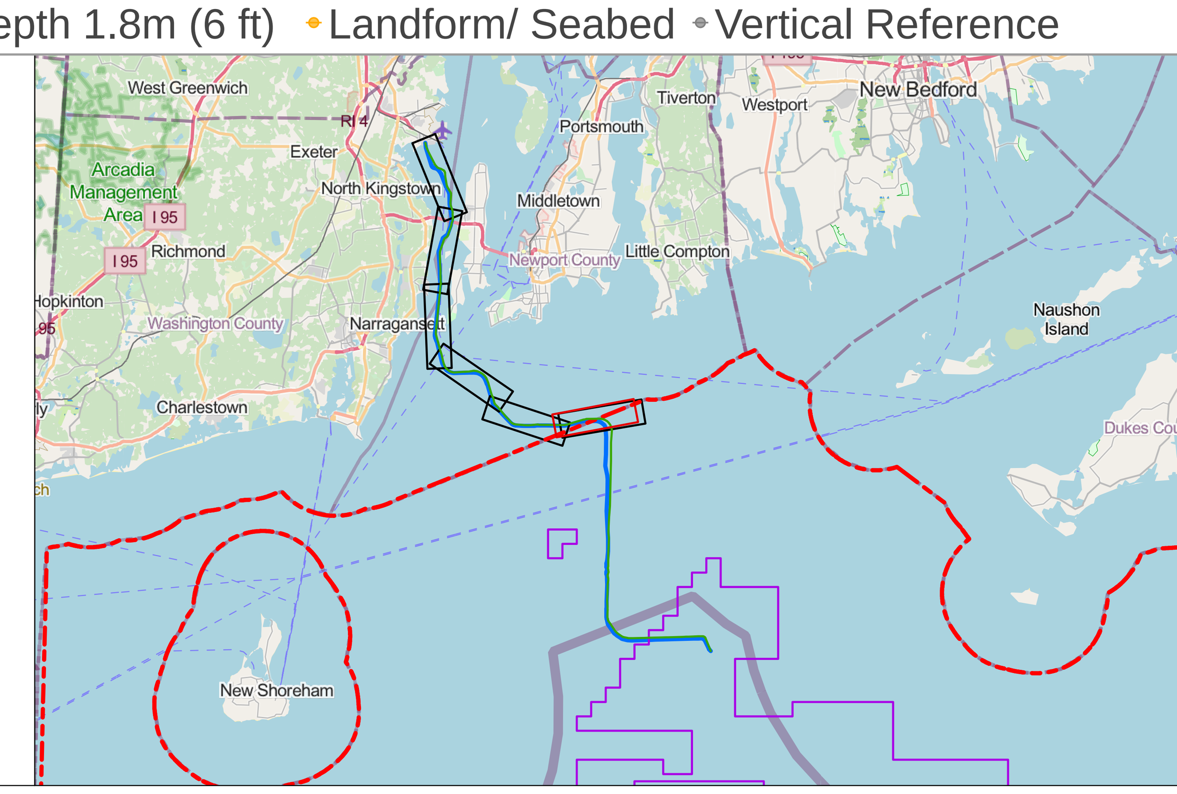

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RevWind Exhibit 1(A)(ii)

Education and Outreach

Appendix B:
Education and Outreach

Appendix B

Revolution Wind Educational Materials

- Project Fact Sheet
- Virtual Open House Posters
- Virtual Open House Engagement
- Virtual Open House Media Coverage
- Virtual Open House Tweets

FACT SHEET

Revolution Wind

Revolution Wind | Powered by Ørsted & Eversource

Project Overview

Revolution Wind is a 704 MW offshore wind farm that will provide clean, affordable power to Connecticut and Rhode Island.

The site is located more than 15 miles south of the Rhode Island coast, 32 miles southeast of the Connecticut coast and 12 miles southwest of Martha's Vineyard.

Project survey work and permitting is underway, with local construction work on Revolution Wind slated to begin as early as 2023.

→ **WHO**

50/50 partnership between Ørsted and Eversource

→ **WHAT**

704 MW offshore wind farm – 304 MW to Connecticut and 400 MW to Rhode Island

→ **WHEN**

Construction could begin as early as 2023

→ **WHERE**

More than 15 miles south of the Rhode Island coast and 32 miles southeast of the Connecticut coast

→ **WHY**

Providing Connecticut and Rhode Island residents 100% renewable energy to help conserve the New England environment

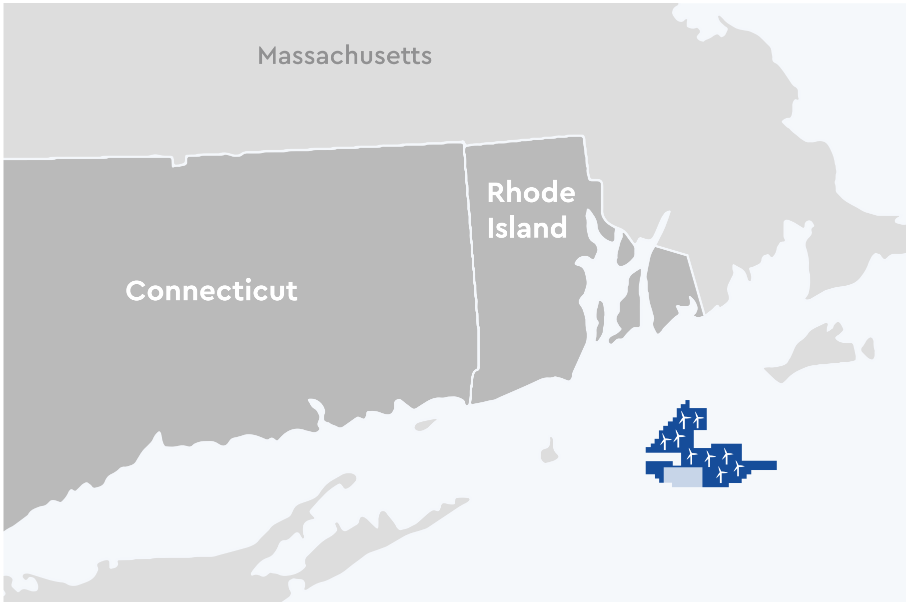
Local investment

Together with the State of Connecticut and Connecticut Port Authority, Ørsted and Eversource have committed $77.5 million of the $157 public-private partnership to re-develop New London State Pier into a heavy-lift cargo and deep-water port with easy access to offshore wind lease areas. This redevelopment of State Pier will create approximately 460 construction jobs. State Pier will be used for wind turbine staging and construction activities for Revolution Wind and other Ørsted and Eversource projects.

In addition, Ørsted and Eversource will invest $40 million in improvements to Rhode Island's port infrastructure. The use of State Pier, ProvPort, and Quonset to support the offshore wind industry will not only bring jobs to each port, but also additional economic activity along the waterfront areas, boosting local businesses who provide goods and services within the vicinity of the ports.

Ørsted and Eversource are committed to supporting offshore wind education and supply chain and workforce development for the growing offshore wind industry in Connecticut and Rhode Island – positioning both states as offshore wind leaders and launching the region's next great maritime industry.

Revolution Wind | Powered by Ørsted & Eversource



Revolution Wind will help both Connecticut and Rhode Island meet their ambitious clean energy goals.

Cost-effective renewable energy

Revolution Wind will help both Connecticut and Rhode Island meet their ambitious clean energy goals in an affordable way by providing 400 MW of offshore wind power to Rhode Island and 304 MW to Connecticut.

Rhode Island is notable with the most ambitious clean energy goal in the nation: 100 percent renewables by 2030. Connecticut will source 100 percent of its electricity from zero carbon resources by 2040.

Revolution Wind will generate enough clean energy to power more than 350,000 Connecticut and Rhode Island homes and displace, by eliminating future emissions, more than one million metric tons of carbon pollution – the equivalent to taking more than 150,000 cars off the road.

Offshore wind is an increasingly cost-effective form of clean energy that stabilizes energy prices for customers. When energy usage is highest, the wind farm will complement existing energy sources to help ensure the area has enough power during peak hours.

About Ørsted and Eversource

Revolution Wind brings unparalleled experience in developing offshore wind to Connecticut and Rhode Island, as a 50/50 partnership between Ørsted, the global leader in offshore wind and a global leader in climate action, and Eversource, a national energy leader with homegrown expertise in regional energy transmission, including more than 100 years of experience delivering power to the region. Ørsted – which was recently ranked the most sustainable company in the world and will be the world's first major energy company to become carbon-neutral by 2025 – envisions a world run entirely on green energy. Eversource is one of the nation's most responsible companies, as ranked by Newsweek, Forbes and JUST Capital and has committed to becoming carbon neutral by 2030, faster than any other utility in the U.S.

CONTACT US

Address

Ørsted
56 Exchange Terrace
Suite 300
Providence, RI 02903

Eversource Energy
107 Selden St
Berlin, CT 06037

Email
info@revolution-wind.com

Website
revolution-wind.com

Project Overview

Ørsted and Eversource's Revolution Wind project is a next-generation offshore wind farm that will contribute to the ambitious clean energy goals of Rhode Island and Connecticut, support port infrastructure investment and create good-paying jobs.

What

- 704-megawatts of clean energy: 400-megawatts for Rhode Island and 304-megawatts for Connecticut.
- Enough clean energy to power more than 350,000 Rhode Island and Connecticut homes each year.

When

Once permits are in-hand, local construction work on Revolution Wind could begin as early as 2023.

Survey work is already underway, both onshore and offshore.

Where

The wind turbines will be located in federal waters about 15 miles south of the Rhode Island coast and 32 miles southeast of the Connecticut coast, about midway between Block Island and Martha's Vineyard, Massachusetts.

The project's underground transmission cable will make landfall at Quonset Business Park, in North Kingstown, where it will interconnect with a substation in North Kingstown and supply renewable energy to the grid.

Environmental Assessments and Permitting

Revolution Wind is committed to building a project that meets all environmental standards. The extensive permitting process requires approval from agencies at all levels of government – local, state and federal. The public will have opportunities to provide input at multiple points in the process.

Our extensive environmental surveys explore such topics as:

- Geotechnical assessments of the onshore cable route
- Archeological and cultural resources
- Historical properties
- Wetlands
- Avian and bat species
- Visual impact assessment
- Marine mammals and other marine life
- Marine habitats
- Seafloor assessment
- Commercial and recreational fisheries assessment
- Marine activities and navigation

The project will require permits and/or review from local, state and federal agencies including:

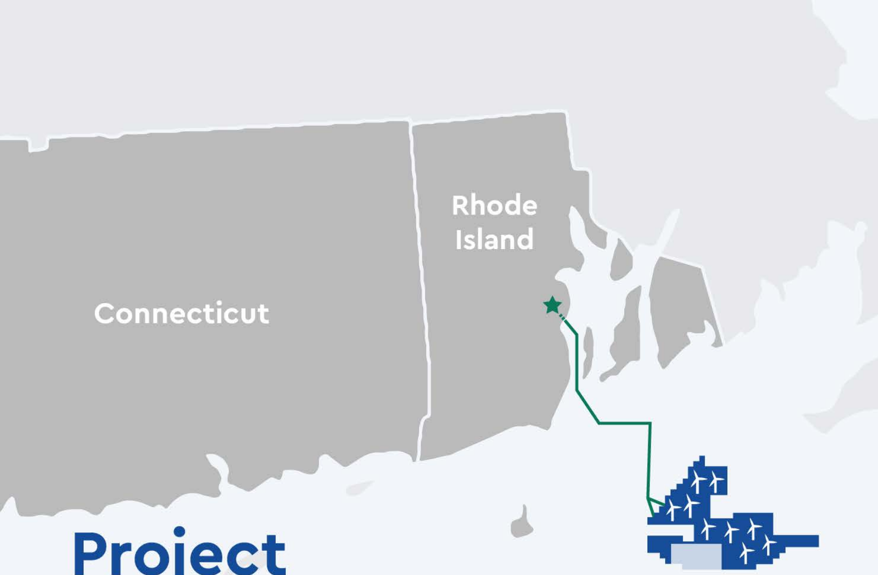
- Town of North Kingstown
- Quonset Development Corporation
- RI Coastal Resources Management Council
- RI Energy Facility Siting Board
- RI Department of Environmental Management
- U.S. Bureau of Ocean Energy Management
- U.S. Army Corps of Engineers
- U.S. Coast Guard
- U.S. Environmental Protection Agency
- U.S. Fish and Wildlife Service
- Federal Aviation Administration

Commitment to Safety

Safety is our top priority. Revolution Wind will meet or exceed all applicable federal, state and local safety codes and industry standards.

Some of the measures we'll take:

- The highest-level safety features are incorporated into the onshore substation design, including applicable fire suppression systems.
- Onshore transmission cables will be buried below ground, encased in a concrete duct bank to protect the cable and the public. The offshore cables will be buried at sufficient depths to avoid and limit any hazards or interference with the use of the shore by the general public.
- All worksites will be secured to meet or exceed all applicable safety codes.
- Electromagnetic fields (EMF) have been modeled for the onshore and offshore cables demonstrating that anticipated levels are well below the guidelines established by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) and recommended by the World Health Organization.
- Mariners will be informed of offshore construction activities, vessel movements and how construction may impact the area.



Project Components

Revolution Wind will have several major components that will require both onshore and offshore work:

Onshore:

- Onshore substation
- Interconnection facility
- Transmission underground export cables
- The transmission cables will make landfall at Quonset Business Park in the town of North Kingstown, Rhode Island and will travel one mile underground to a new onshore substation near National Grid's existing Davisville Substation.

Offshore:

- Offshore substation(s)
- Inter-array cables
- Wind turbines
- Transmission cables

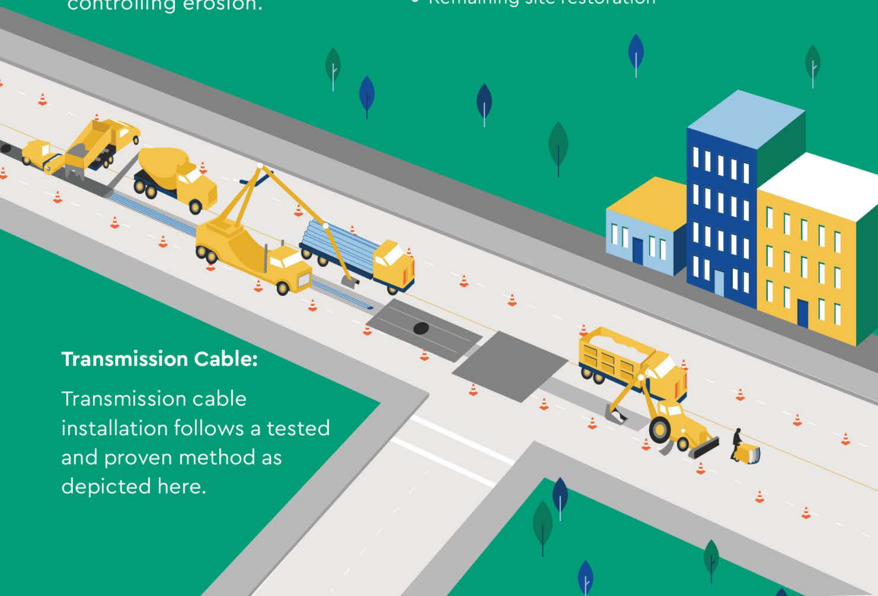
Onshore Project Construction

Revolution Wind will require onshore infrastructure to reliably bring the power from the turbines to the onshore grid. To do this, the project team will need to construct key onshore components which include:

New substation:

Work at the onshore substation site will take about a year to complete, with attention paid to protecting natural resources and controlling erosion.

1. Site development work
2. Foundation work
3. Electrical equipment delivery and installation
4. Commissioning
5. Remaining site restoration



Transmission Cable:

Transmission cable installation follows a tested and proven method as depicted here.

Project Timeline

April 2016

Site Assessment Plan (SAP) is filed with Bureau of Ocean Energy Management (BOEM), allowing installation of a meteorological buoy to collect data to support the design and engineering of offshore wind project components.

October 2017

BOEM approves SAP.

March 2020

Construction and Operations Plan (COP) submitted to BOEM for review and approval.

December 2020 to March 2021

Applications filed with Rhode Island State Agencies including the Energy Facility Siting Board, Coastal Resources Management Council and Rhode Island Department of Environmental Management.

January 2023 to March 2023

All federal, state, and local permit approvals expected. Construction expected to begin with the installation of the onshore components. Offshore construction also expected to begin, with foundation installation starting in early 2023.

As early as the end of 2023

Wind farm commissioned and operational.

Press in attendance:

Alex Kuffner, **Providence Journal**
Rosemary Connelli, **Block Island Times**
Tim Faulkner, **ecoRI**
Cameron Merritt, **North Kingstown Independent**
Tim Studebaker, **ABC6**

PROMOTED TWEET HIGHLIGHTS

How The Ad Performed by the Numbers

Impressions	Engagements	Clicks	Impressions Increase	Followers
100,443	608	522	2010%	+15

- The ad reached over **100,000 impressions**, or times it appeared on a timeline over the course of the advertisement
- The over **2000% increase** in impressions is almost entirely because of running the ad over our organic content
- The tweet helped gain 15 new followers or **9% of all total followers** for the account (159)
- The ad also provided over **520 direct clicks** on the registration site
- The ad performed all of these metrics and only spent roughly $1,130 as the changes to the budget and content caused the ad to continue to enter the review protocol from Twitter

DIGITAL PROGRAM HIGHLIGHTS

Placements	Impressions	Clicks	CTR %
Local News Sites- Display/Mobile Banner	22,4184	186	0.08
Audience Targeted, geo-targeting, Display/Mobile Banners (RI, Charlestown; Exeter; Hopkinton; Jamestown; Middletown; Narragansett; Newport; North Kingstown; Portsmouth; Richmond; South Kingstown; Westerly)	545,172	517	0.09
Audience Targeted, geo-targeting, *Added Value*Display/Mobile Banners	54,594	26	0.05
TOTAL:	823,950	729	0.09%

Revolution Wind Virtual Information Sessions

- Earned industry average CTR of 0.09%
- Drove over 700 clicks from the display ads
- Almost 825,000 impressions, creating general awareness were delivered

The NK Standard-Times

The NK Standard-Times
November 12, 2020

Revolution Wind team to host virtual information sessions

NORTH KINGSTOWN – Next week, the offshore wind project Revolution Wind will be hosting virtual informational sessions for the North Kingstown community and other Rhode Islanders. The sessions will be live online on Wednesday, Nov. 18 at 1 p.m. and Thursday, Nov. 19 at 6 p.m.

During the sessions, the Revolution Wind team from Ørsted and Eversource will share project updates, including details on our planned transmission cable route in North Kingstown, and answer questions from the community.

Members of the public are all invited to attend. Those interested in attending should register at revolution-wind.com.

The Block Island Times
November 11, 2020

Online information session on next offshore wind project

The public is invited to an online discussion about the next large-scale offshore wind farm project, Revolution Wind, that will bring energy to more than 350,000 homes in Rhode Island and Connecticut.

The information sessions will take place on Wednesday, Nov. 18 at 1 p.m. and again on Thursday, Nov. 19 at 6 p.m. Both sessions will be held live. Participants can go to revolution-wind.com to access the registration link. Once registered, Eventbrite will provide details on how to join the session. According to Ørsted, which is developing the project with Eversource, a recording of the sessions and an opportunity to comment will remain available until Dec. 31.

According to Ørsted, the project's wind turbines will be located more than 15 miles south of the Rhode Island coast and 22 miles southeast of the Connecticut coast. An underground transmission cable from the wind farm will land in North Kingstown.

Patch

Patch

North Kingstown|Local Event

Revolution Wind Info Session: Intro to the RI Project Components

Victoria Cordeiro, Neighbor

Revolution Wind | Powered by Ørsted & Eversource

Event Details

The offshore wind project Revolution Wind will be hosting virtual informational sessions for the North Kingstown community and other Rhode Islanders. The sessions will be live online on:

Wednesday, Nov. 18 at 1 p.m.

Thursday, Nov. 19 at 6 p.m.

The Revolution Wind team from Ørsted and Eversource will share project updates, including details on our planned transmission cable route in North Kingstown, and answer questions from the community. Those interested in attending should **register at revolution-wind.com.** For those who can't make either time, a recording of the session will be available to view online following the event.

Revolution Wind Virtual Information Sessions

independentri.com THE INDEPENDENT Lighting the way
NARRAGANSETT • NORTH KINGSTOWN • SOUTH KINGSTOWN

Revolution Wind Info Session: Intro to the RI Project Components

This event occurred on Thursday, November 19th, 2020 @ 6:00 pm – 8:00 pm

Free

https://revolution-wind.com/

The offshore wind project Revolution Wind will be hosting virtual informational sessions for the North Kingstown community and other Rhode Islanders. The sessions will be live online on:

Wednesday, Nov. 18 at 1 p.m.

Thursday, Nov. 19 at 6 p.m.

The Revolution Wind team from Ørsted and Eversource will share project updates, including details on our planned transmission cable route in North Kingstown, and answer questions from the community. Those interested in attending should **register at revolution-wind.com.** For those who can't make either time, a recording of the session will be available to view online following the event.

Revolution Wind Virtual Information Sessions

EcoRI

Revolution Wind Virtual Info Meeting

Wednesday, November 18, 2020
1:00 PM – 2:30 PM

About: The Revolution Wind team from Ørsted and Eversource will share project updates — including details on the planned transmission cable route in North Kingstown — and answer questions from the community. Media and members of the public are invited to attend. If you cannot attend, this information session will be taped so that you can watch online at your convenience. To register, click here.

Revolution Wind Virtual Info Meeting

Thursday, November 19, 2020
6:00 PM – 7:30 PM

Online
(map)

About: The Revolution Wind team from Ørsted and Eversource will share project updates — including details on the planned transmission cable route in North Kingstown — and answer questions from the community. Media and members of the public are invited to attend. If you cannot attend, this information session will be taped so that you can watch online at your convenience. To register, click here.

Revolution Wind Virtual Information Sessions

THE UNIVERSITY OF RHODE ISLAND

Revolution Wind Info Session: An Introduction to the RI Project Components

Please join us for an information session with the team behind Revolution Wind, the 704-megawatt offshore wind project that will bring more clean, renewable energy to Rhode Island and Connecticut.

At this information session, we will highlight the Rhode Island-based components of the project including the electrical infrastructure to be installed onshore and in Rhode Island state waters.

The community's feedback is highly valued; we want to hear from you.

Wednesday, November 18 at 1:00pm to 3:00pm
Virtual Event

EVENT TYPE

Conference/Workshop

CO-SPONSORS

Coastal Resources Center

WEBSITE

https://www.eventbrite.com/e/revoluti...

GROUP

Offshore Renewable Energy

SUBSCRIBE

Revolution Wind Virtual Information Sessions

401 Tech Bridge @401TechBridge · Nov 13

Learn more about progress in the wind industry with @RevWind

Revolution Wind @RevWind · Nov 11

Join us! We're hosting a Virtual Information Session on November 18 at 1:00 p.m. and on November 19 at 6:00pm to introduce ourselves to the Rhode Island community and share some #RevolutionWind project updates. Register -> eventbrite.com/e/revolution-w...

RHODE ISLAND NEWS

New wind farm in development between Block Island and Martha's Vineyard

The new wind farm could contain up to 100 wind turbines, and would produce 350,000 homes' worth of power in RI and CT.

November 18, 2020 6:10 pm

Tim Studebaker

By: Tim Studebaker

Facebook: @TStudebakerABC6

Twitter: @TStudebakerABC6

Email: tstudebaker@abc6.com

QUONSET, R.I. (WLNE) – A new wind farm 15 miles off the Rhode Island coast, between Block Island and Martha's Vineyard, could become home to up to 100 new wind turbines in the next few years.

Kellen Ingalls with the company Orsted says, "Revolution Wind will produce enough clean energy to power 350,000 homes and displace, by eliminating future emissions, more than 1,000,000 metric tons of carbon pollution."

The farm would connect to the power grid through a transmission line at Quonset Industrial Park in North Kingstown, and provide power to both Rhode Island and Connecticut. It's a partnership between the power company Eversource, and Orsted, the company that owns and operates the Block Island Wind Farm.

Ingalls says, “Both Rhode Island and Connecticut have ambitious clean energy goals that are essential to combating climate change.”

The two companies began holding online public information sessions Wednesday afternoon, answering questions from the public about job creation, awarding contracts to local companies, and the fishing and boating industries. The turbines will be spaced in a one mile by one mile grid.

Ingalls says, “That spacing is consistent with requests from members of the fishing community and other maritime stakeholders.”

They’ll also be making $40,000,000 dollars worth of infrastructure investments in ProvPort and Quonset. Construction could begin as soon as 2023

Ingalls says, “So that’ll position both states as offshore wind leaders, and it’ll launch the region’s next great maritime industry.”

They’ll hold another session Thursday evening and the videos are available for the public to watch anytime.

Visit their website for more information: revolution-wind.com/

Late Correction: The original version of this story stated that up to 50 wind turbines would be built as part of the Revolution Wind project, based on original communication from a company spokesperson. That company spokesperson has since corrected the total number of potential turbines from 50 to 100.

The Providence Journal

RI's wind-farm plan poised to advance in '21

Alex Kuffner
The Providence Journal

0:06
1:00

PROVIDENCE – Much was made of the Raimondo administration's selection in ơəƠ of a proposal for a massive offshore wind farm off the Rhode Island coast that would power as much as a quarter of the state's electric load.

The project, known as Revolution Wind, cleared a key hurdle a year later when state regulators approved a contract for the wind farm to sell power to National Grid, Rhode Island's dominant electric utility. And developers Orsted and Eversource Energy would get another boost when Connecticut also agreed to buy power from the wind farm, a move that nearly doubled the size of the project to ͣ ə́ megawatts.

But since those very big and very public milestones, things have been relatively quiet for a project that could cost more than $ơ billion to build.

The paucity of action is largely due to a hold-up in the federal permitting process for offshore wind projects amid concerns raised by commercial fishermen that arrays of towering turbines off the southern New England coast would interfere with fishing activities.

But a Biden presidency is expected to boost renewables overall, and a decision could come in a matter of weeks for the benchmark Vineyard Wind project, the first offshore wind farm to go before the U.S. Department of the Interior's Bureau of Ocean Energy Management. A favorable ruling on the proposal could break the logjam for Revolution Wind and other projects.

Orsted and Eversource are gearing up for a series of steps forward in ʊəʊƠ that notably includes an expectation that BOEM will put their application — known as a Construction and Operations Plan — out for public comment.

The developments, detailed in a virtual open house the companies held on Wednesday, will also include filings to Rhode Island state agencies for a transmission cable that would connect the project's wind turbines — as many as Œə mounted on towers in an area between Block Island and Martha's Vineyard — to the onshore electric grid.

The plan is to run the cable north under the Rhode Island Sound seafloor, through the west passage of Narragansett Bay and on to the Quonset Business Park in North Kingstown. The cable would snake its way either through a cut in an existing seawall or in a hole drilled underneath it and then continue underground about a mile to a National Grid substation located in the state-owned business park.

The project partners expect to submit the cable documents to the state Energy Facility Siting Board, the Department of Environmental Management and the Coastal Resources Management Council this winter.

The cable route and landfall location were largely dictated by the proximity of an electrical substation that has capacity to handle the power from the wind farm, according to Ken Bowes, vice president of offshore wind siting and permitting at Eversource. Other sites under consideration included Brayton Point, where a coal-burning power plant was recently demolished.

Bowes said he expects a rigorous but fair process before the Rhode Island permitting agencies.

"They want to see this project go forward and they see the value of it," he said in a conference call after the public forum.

At the meeting, Kellen Ingalls, project development director for Orsted, said the Revolution project would power ˀ ˓ ə,əəə homes and displace at least one million metric tons of carbon pollution – the equivalent of taking Ọ ə,əəə cars off the road. It comes as Rhode Island, home to the only offshore wind farm in the nation, aims to increase its use not only of offshore wind energy but of all types of renewable power.

–It comes down to the kind of future we want to see for ourselves,“ he said. –This is a clean, renewable way to power our lives.“

Revolution Wind Twitter

Revolution Wind @RevWind · Nov 27

If you couldn't attend our #RevolutionWind virtual Info Session last week, be sure to catch up on all our RI project updates here: seekbeak.com/v/5VjYlopkzob

1 retweet · 10 likes

Revolution Wind Twitter

Revolution Wind @RevWind · Nov 19

Join us *TONIGHT* at 6 p.m. for a community Virtual Info Session to learn more about #RevolutionWind Rhode Island.Register ->

Revolution Wind Info Session: An Introduction to the RI Project Comp...

Please join us for an information session with the team behind Revolution Wind

eventbrite.com

1 2

Revolution Wind Twitter

Revolution Wind @RevWind · Nov 11

Join us! We're hosting a Virtual Information Session on November 18 at 1:00 p.m. and on November 19 at 6:00pm to introduce ourselves to the Rhode Island community and share some #RevolutionWind project updates. Register -> eventbrite.com/e/revolution-w...

7 15

Revolution Wind Twitter

Revolution Wind @RevWind · Oct 14

Our partnership with @CTPortAuthority to redevelop New London State Pier has been recognized by @PortTechnology as a top U.S. port infrastructure project that's building for the future: porttechnology.org/news/us-ports-... #RevolutionWind #CToffshorewind

US ports building for the future - Port Technology International

The importance of port investment and development has been made clear across the globe, not least in the US where ports have had a ...

porttechnology.org

6

Revolution Wind @RevWind · Oct 6

Major new step in growing the U.S. offshore wind industry: We're Investing in building the country's first flagged Service Operations Vessel, which will support #RevolutionWind. renews.biz/63491/orsted-e...

2 7

Revolution Wind Twitter

Revolution Wind @RevWind · Jul 28

Connecticut's offshore wind industry continues to make great strides as our partner @CTPortAuthority seeks a construction manager for State Pier. #CToffshorewind #RevolutionWind

Learn more here:

Ørsted and Eversource partner Connecticut Port Authority moves forward with RFQ for State Pier...
revolution-wind.com

2 6

Revolution Wind Twitter

Revolution Wind @RevWind · Jul 21

Rhode Island workers built the nation's first – and now second! – offshore wind crew transfer vessel. Next up for the crew at Senesco Marine at @QuonsetRI: Building the crew vessel for #RevolutionWind!

> **Ørsted U.S.** @OrstedUS · Jul 16
>
> The Windserve Odyssey, a crew transfer vessel, is making a splash! The Odyssey will soon travel from a Rhode Island shipyard to Virginia to join the closeout of construction and commissioning on the #CVOW project.

1 7 8

Revolution Wind Twitter

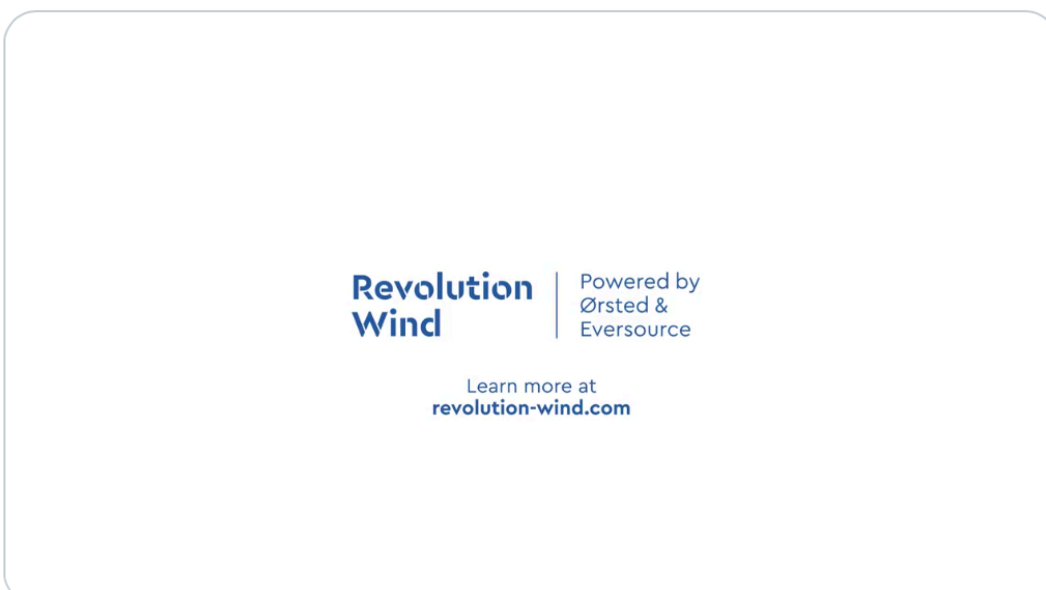
Revolution Wind @RevWind · Jun 25

Revolution Wind will provide Rhode Island and Connecticut with enough clean energy to power more than 350K homes!

4 9

Revolution Wind @RevWind · Jun 16

Revolution Wind will help Rhode Island and Connecticut meet their ambitious clean energy goals, bringing more offshore wind energy to the region that launched this new U.S. industry @ #BlockIslandWindFarm. Follow us here for to learn more. #RevolutionWind



5 15

Revolution Wind Twitter

Revolution Wind @RevWind · Sep 24

#RevolutionWind will mean hundreds of new construction and operations jobs in Rhode Island + Connecticut -- in one of the nation's most promising new jobs sectors!

> **American Wind Energy Association** @AWEA · Sep 3
>
> #WindPower Fact of the Day: #Wind is creating the careers of the future. According to @BLS_gov, wind technician is the second fastest growing career in the country. bit.ly/2xExJtc #jobs

1 · 4

Revolution Wind @RevWind · Aug 12

"This is really a tremendous opportunity for offshore wind to be a very strong foundational pillar of the post-COVID economic recovery" in #RI, says @OrstedUS's Matthew Morrissey, via @ProvBusNews

POWERING UP: Offshore wind sector gains momen...
Stark white walls, blank computer screens and empty desk chairs weren't what the executives at ...
pbn.com

2 · 7

Revolution Wind Twitter

Revolution Wind @RevWind · Aug 6

The major investments and new local jobs we're bringing to Rhode Island + Connecticut for #RevolutionWind will help with the states' long-term economic recovery. Read more about why advancing the blue economy is so important:

Ocean investment could aid post-Covid-19 economic recovery

A new report by the World Resources Institute shows how investment in sustainable ocean management could support industries impacted...

cnn.com

2 3

Appendix B: Summary of Stakeholder Meetings

Date	Entity	Topic
August 2018	Bureau of Ocean Energy Management (BOEM)	Geotechnical and Geophysical Pre-survey Meeting
August 2018	BOEM, Shinnecock Indian Nation, Wampanoag Tribe of Gay Head, Mashantucket Pequot Tribal Nation, Mashpee Wampanoag Tribe	Tribal Pre-survey Meeting for Geotechnical and Geophysical Surveys
September 2018	Commercial Fisheries Center of Rhode Island (CFCRI)	Fisheries Monitoring and Project Update
September 2018	U.S. Coast Guard (USCG)	Project Introduction Meeting
October 2018	RI Coastal Resources Management Council (RI CRMC) Bay SAMP Subcommittee	Project Update
December 2018	U.S. Naval Undersea Warfare Center (NUWC)	Project Update
March 2019	Massachusetts Habitat Working Group	Project Update
April 2019	RI CRMC	Project Update
May 2019	BOEM, Shinnecock Indian Nation, Wampanoag Tribe of Gay Head, Mashantucket Pequot Tribal Nation, Mashpee Wampanoag Tribe	Tribal Pre-survey Meeting for Geotechnical and Geophysical Surveys
July 2019	BOEM	Revolution Wind Kick Off Meeting
July 2019	National Oceanic and Atmospheric Administration (NOAA) – Greater Atlantic Regional Fisheries Office (GARFO)	Introduction Meeting to the Project
August 2019	BOEM	Geotechnical and Geophysical Pre-Survey Meeting
September 2019	USCG	Project Introduction Navigational Risk Assessment kick-off
September 2019	Rhode Island Department of Environmental Management (RIDEM)	Project Introduction
November 2019	Massachusetts Fisheries Working Group	Project Update
December 2019	BOEM	Underwater Acoustic Modeling Approach Meeting
December 2019	NOAA/National Marine Fisheries Service (NMFS), BOEM	Underwater Acoustic Modeling Approach Meeting
December 2020	Massachusetts Habitat Working Group	Project Update
December 2019	Shinnecock Indian Nation, Wampanoag Tribe of Gay Head, Mashantucket Pequot Tribal Nation, Mashpee Wampanoag Tribe	Cultural Core Tribal Review
January 2020	Quonset Business Development (QDC)	Initiate weekly Project update meetings and real estate discussions

Date	Entity	Topic
January 2020	BOEM	Review and Update of Geophysical Data Protocol
January 2020	RI CRMC Cable Working Group	Update on export cable route through Narragansett Bay
February 2020	BOEM	Review and Update of Geophysical Data protocol and Marine Archaeological Assessment
February 2020	RI CRMC Cable Working Group	Project Update
February 2020	RI CRMC Fisheries Advisory Board	Project Update
February 2020	Shinnecock Indian Nation, Wampanoag Tribe of Gay Head, Mashantucket Pequot Tribal Nation, Mashpee Wampanoag Tribe, BOEM	Tribal Pre-Survey Meeting for 2020 Geophysical and Geotechnical Surveys
February 2020	BOEM	2020 Geophysical Pre-Survey meeting
February 2020	Wampanoag Tribe of Gay Head Aquinnah	Project Introduction
March 2020	RI CRMC USCG	Review of planned export cable corridor through the West Passage
March 2020	U. S. Army Corps of Engineers (USACE)	Project Update
March 2020	Rhode Island Energy Facility Siting Board (RI EFSB)	Project Introduction
April 2020	RI Pilot Commission	Review of planned export cable corridor in the vicinity of Pilot Boarding Area
April 2020	RI CRMC	Project Update
May 2020	U.S. Navy Undersea Warfare Center (NUWC)	Review of planned export cable corridor in the vicinity of NUWC's torpedo testing range
May 2020	RI CRMC	Review of Proposed Fisheries Monitoring Plan
May 2020	RI CRMC	Project Update (Focus on landfall)
May 2020	Town of North Kingstown	Initiated Host Community Agreement discussion
September 2019	Rhode Island Department of Environmental Management (RIDEM)	Project Introduction
November 2019	Massachusetts Fisheries Working Group	Project Update
December 2019	BOEM	Underwater Acoustic Modeling Approach Meeting
December 2019	NOAA/National Marine Fisheries Service (NMFS), BOEM	Underwater Acoustic Modeling Approach Meeting
December 2020	Massachusetts Habitat Working Group	Project Update
December 2019	Shinnecock Indian Nation, Wampanoag Tribe of Gay Head, Mashantucket Pequot Tribal Nation, Mashpee Wampanoag Tribe	Cultural Core Tribal Review

Date	Entity	Topic
January 2020	Quonset Business Development (QDC)	Initiate weekly Project update meetings and real estate discussions
January 2020	BOEM	Review and Update of Geophysical Data Protocol
January 2020	RI CRMC Cable Working Group	Update on export cable route through Narragansett Bay
February 2020	BOEM	Review and Update of Geophysical Data protocol and Marine Archaeological Assessment
February 2020	RI CRMC Cable Working Group	Project Update
February 2020	RI CRMC Fisheries Advisory Board	Project Update
February 2020	Shinnecock Indian Nation, Wampanoag Tribe of Gay Head, Mashantucket Pequot Tribal Nation, Mashpee Wampanoag Tribe, BOEM	Tribal Pre-Survey Meeting for 2020 Geophysical and Geotechnical Surveys
February 2020	BOEM	2020 Geophysical Pre-Survey meeting
February 2020	Wampanoag Tribe of Gay Head Aquinnah	Project Introduction
March 2020	RI CRMC USCG	Review of planned export cable corridor through the West Passage
March 2020	U. S. Army Corps of Engineers (USACE)	Project Update
March 2020	Rhode Island Energy Facility Siting Board (RI EFSB)	Project Introduction
April 2020	RI Pilot Commission	Review of planned export cable corridor in the vicinity of Pilot Boarding Area
April 2020	RI CRMC	Project Update
May 2020	U.S. Navy Undersea Warfare Center (NUWC)	Review of planned export cable corridor in the vicinity of NUWC's torpedo testing range
May 2020	RI CRMC	Review of Proposed Fisheries Monitoring Plan
May 2020	RI CRMC	Project Update (Focus on landfall)
May 2020	Town of North Kingstown	Initiated Host Community Agreement discussion
May 2020	U.S. Environmental Protection Agency (US EPA)	Project Introduction
June 2020	Town of North Kingstown	General check-in/project update
June 2020	Massachusetts Division of Marine Fisheries (MADMF)/Massachusetts Office of Coastal Zone Management (MACZM)	Review of Proposed Fisheries Monitoring Plan
June 2020	RIDEM	Review of Proposed Fisheries Monitoring Plan

Date	Entity	Topic
June 2020	Responsible Offshore Science Alliance (ROSA)/Responsible Offshore Development Alliance (RODA)	Review of Proposed Fisheries Monitoring Plan
July 2020	Town of North Kingstown	General check-in/project update
July 2020	BOEM/NOAA/NMFS	Review of Proposed Fisheries Monitoring Plan
July 2020	RI Bridge and Turnpike Authority (RIBTA)	Discuss the siting of the export cable under the Jamestown Verrazzano Bridge
August 2020	RIBTA	Discuss the siting of the export cable under the Jamestown Verrazzano Bridge
August 2020	RI CRMC/RIDEM	Project Update (Focus on Onshore Substation)
September 2020	RI EFSB	Project Update
September 2020	BOEM	Geophysical Data Review Workshop
November 2020	Town of North Kingstown	General check-in/project update; notification of planned open houses
November 2020	RI CRMC	Project Update (Focus on landfall installation options)
November 2020	USACE	Project Update (Focus on landfall installation options)
November 2020	RIDEM	Project Update (Focus on landfall installation options)
December 2020	BOEM/NMFS/NOAA	Project Update (Focus on landfall installation options)
December 2020	BOEM	Project Update (Focus on Interconnection Facility)
December 2020	RI CRMC/RIDEM	Project Update (Focus on Onshore Substation and Interconnection Facility)

RevWind Exhibit 1(A)(iii)

Project Costs

CONFIDENTIAL

Appendix C:
Project Costs (CONFIDENTIAL)

Revolution Wind, LLC
EFSB Docket No. ____
In Re: Application of Revolution Wind, LLC for
License to Construct and Alter Major Energy Facilities
(Revolution Wind Project)

CONFIDENTIAL INFORMATION

Appendix C is the Project Cost. It contains confidential financial information. Revolution Wind has requested protective treatment of this confidential document in its entirety.

RevWind Exhibit 1(A)(iv)

Observed and Potential Wildlife in the Project Area

Appendix D1: Observed and Potential Wildlife in the Project Area

Observed and Potential Wildlife in the Project Area

Observed and Potential Bird Species

	Inland Key Habitats					Coastal Key Habitats	
	Ruderal Grassland/ Shrubland	Ruderal Forested Swamp	Mixed Oak/White Pine Forest	Oak Forest	Pitch Pine Woodland/ Barren	Coastal Beach	Tidal Salt Marsh
Bald Eagle (BCC)						**P**	**P**
Great egret(S-C)						**P**	**P**
Snowy egret(S-C)						**P**	**O**
American oystercatcher(S-C) (BCC)						**P**	
Glossy ibis(S-C)						**P**	**P**
Great blue heron[B]	**P**						**P**
Black-crowned night heron(S-C)						**P**	**P**
Yellow-crowned night heron(S-C)						**P**	**P**
Green heron[B]		**P**				**P**	**P**
Tricolored heron						**P**	**P**
Herring gull (BCC)						**O**	
Ring-billed gull (BCC)						**O**	
Great Black-Backed Gull (BCC)						**P**	
Northern Gannet (BCC)						**P**	
Double-crested cormorant[B] (BCC)						**O**	

P = Potential to occur O = observed by VHB during Summer 2019 **P/O** = GCN Species in the 2015 RIWAP. B = breeding in Rhode Island M = migrant/visitor
S-E = State-endangered S-T= State-threatened S-C = State Concern F-E = Federally endangered F-T = Federally Threatened BCC = Bird of Conservation Concern

Source: DeGraaf, Richard M. and Mariko Yamasaki. 2001. New England Wildlife: Habitat, Natural History and Distribution, University Press of New England, Hanover, New Hampshire, 2001.
RIDEM, The Rhode Island Nature Conservancy, University of Rhode Island. 2015. Rhode Island Wildlife Action Plan. http://www.dem.ri.gov/programs/fish-wildlife/wildlifehuntered/swap15.php

	Inland Key Habitats					Coastal Key Habitats	
	Ruderal Grassland/ Shrubland	Ruderal Forested Swamp	Mixed Oak/White Pine Forest	Oak Forest	Pitch Pine Woodland/ Barren	Coastal Beach	Tidal Salt Marsh
Great cormorant[M]						**O**	
Common tern (BCC)						**P**	
Roseate Tern (F-E)						**P**	
Least tern(S-T) (BCC)						**P**	
Ruddy turnstone						**P**	
Sanderling						**P**	
Dunlin						**P**	
Buff-Breasted Sandpiper (BCC)							
White-rumped sandpiper						**P**	
Purple sandpiper						**P**	
Least sandpiper						**P**	
Semipalmated sandpiper (BCC)						**P**	
Semipalmated plover						**P**	
Piping plover(F-E; S-E)[M]						**P**	
Short-billed dowitcher (BCC)						**P**	
Black-bellied plover						**P**	
Greater yellowlegs						**P**	**P**
Nelson's sparrow[M]							**P**
Saltmarsh sparrow							**P**

P = Potential to occur O = observed by VHB during Summer 2019 **P/O** = GCN Species in the 2015 RIWAP. B = breeding in Rhode Island M = migrant/visitor
S-E = State-endangered S-T= State-threatened S-C = State Concern F-E = Federally endangered F-T = Federally Threatened BCC = Bird of Conservation Concern
Source: DeGraaf, Richard M. and Mariko Yamasaki. 2001. New England Wildlife: Habitat, Natural History and Distribution, University Press of New England, Hanover, New Hampshire, 2001.
RIDEM, The Rhode Island Nature Conservancy, University of Rhode Island. 2015. Rhode Island Wildlife Action Plan. http://www.dem.ri.gov/programs/fish-wildlife/wildlifehuntered/swap15.php

	Inland Key Habitats					Coastal Key Habitats	
	Ruderal Grassland/ Shrubland	Ruderal Forested Swamp	Mixed Oak/White Pine Forest	Oak Forest	Pitch Pine Woodland/ Barren	Coastal Beach	Tidal Salt Marsh
Seaside sparrow(S-C)							**P**
American black duck							**P**
Clapper rail(S-C)							**P**
Willet(S-C)							**P**
Osprey(S-C)						**O**	**O**
Turkey vulture[B]	**P**	**P**	**P**	**P**	**P**		
Canada Goose[B]	**P**					**O**	**O**
Mallard[B]						**O**	
Lesser scaup						**P**	
Greater scaup						**P**	
Canvasback						**P**	
Atlantic brant						**P**	
Bufflehead						**P**	
Common goldeneye						**P**	
Common Loon						**P**	
Red-throated Loon (BCC)						**P**	
Black scoter						**P**	
White-winged scoter (BCC)						**P**	
Surf scoter (BCC)						**P**	

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	Inland Key Habitats					Coastal Key Habitats	
	Ruderal Grassland/ Shrubland	Ruderal Forested Swamp	Mixed Oak/White Pine Forest	Oak Forest	Pitch Pine Woodland/ Barren	Coastal Beach	Tidal Salt Marsh
Red-breasted merganser (BCC)						**P**	
Horned grebe						**P**	
Common eider (BCC)						**P**	
Sharp-shinned Hawk[M] (S-E)	**P**	**P**	**P**	**P**	**P**		
Cooper's Hawk[B]	**P**	**P**	**P**	**P**	**P**		
Northern Goshawk[M] (S-C)	**P**	**P**	**P**	**P**	**P**		
Red-shouldered Hawk[B]	**P**	**O**	**O**	**O**	**P**		
Broad-winged Hawk[B]	**P**	**P**	**P**	**P**	**P**		
Red-tailed Hawk[B]	**P**	**O**	**O**	**P**	**P**		
Rough-legged Hawk[M]	**P**	**P**	**P**	**P**	**P**		
American Kestrel[B]	**P**	**P**	**P**	**P**	**P**		
Ring-necked Pheasant[B]	**P**	**P**	**P**	**P**	**P**		
Wild Turkey[B]	**P**	**P**	**P**	**P**	**P**		
Northern Bobwhite[B]	**P**	**P**	**P**	**P**	**P**		
Killdeer[B]	**P**					**O**	
Spotted Sandpiper[B]						**P**	
American Woodcock[B]	**P**	**P**	**P**	**P**	**P**		
Rock Pigeon[B]	**P**					**O**	
Mourning Dove[B]	**P**	**P**	**P**	**P**	**P**	**P**	

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	Ruderal Grassland/ Shrubland	Ruderal Forested Swamp	Mixed Oak/White Pine Forest	Oak Forest	Pitch Pine Woodland/ Barren	Coastal Beach	Tidal Salt Marsh
Black-billed Cuckoo[B (BCC)]	**P**	**P**	**P**	**P**	**P**	**P**	
Yellow-billed Cuckoo[B]	**P**	**P**	**P**	**P**	**P**		
Eastern Screech-Owl[B]	**P**	**P**	**P**	**P**	**P**		
Great Horned Owl[B]	**P**	**P**	**P**	**P**	**P**		
Barred Owl[B]	**P**	**O**	**P**		**P**		
Northern Saw-whet Owl[B]	**P**	**P**					
Common Nighthawk [B]	**P**	**P**	**P**	**P**	**P**		
Eastern whip-poor-will[B]	**P**	**P**	**P**	**P**	**P**		
Chimney Swift[B]	**P**	**P**	**P**	**P**	**P**		
Ruby-throated Hummingbird[B]	**P**	**P**	**P**	**P**	**P**		**P**
Belted Kingfisher[B]							**P**
Red-bellied Woodpecker[B]		**O**	**P**	**P**	**P**		
Pileated Woodpecker[B(S-C)]		**P**	**P**	**P**	**P**		
Yellow-bellied Sapsucker[B]		**P**	**P**	**P**	**P**		
Downy Woodpecker[B]		**O**	**O**	**P**	**P**		
Hairy Woodpecker[B]		**P**	**P**	**P**	**P**		
Northern Flicker[B]	**P**	**P**	**P**	**P**	**P**		
Eastern Wood-Pewee[B]		**O**	**O**	**P**	**P**		
Acadian Flycatcher[B(S-C)]		**P**	**P**	**P**	**P**		

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Willow Flycatcher[B]	**P**	**P**	**P**	**P**	**P**		
Least Flycatcher[B]		**P**	**P**	**P**	**P**		
Eastern Phoebe[B]	**P**	**O**	**O**	**P**	**P**		
Great Crested Flycatcher[B]		**P**	**P**	**P**	**P**		
Eastern Kingbird[B]	**P**	**P**	**P**	**P**	**P**		
Northern Shrike[M]	**P**	**P**	**P**	**P**	**P**		
White-eyed Vireo[B]		**P**	**P**	**P**	**P**		
Yellow-throated Vireo[B]		**P**	**P**	**P**	**P**		
Warbling Vireo[B]		**O**	**O**	**O**	**P**		
Red-eyed Vireo[B]	**P**	**O**	**O**				
Blue-headed vireo		**P**	**P**	**P**	**P**		
Blue Jay[B]	**P**	**O**	**O**	**P**	**P**		
American Crow[B]	**P**	**O**	**O**	**O**	**P**		
Fish Crow[B]						**O**	**O**
Horned Lark [B (S-C)]	**P**						
Purple Martin[B]	**P**		**P**	**P**	**P**	**O**	**P**
Tree Swallow[B]	**P**	**P**	**P**	**P**	**P**	**O**	**P**
Northern Rough-winged Swallow[B]	**P**	**P**	**P**	**P**	**P**		**P**
Bank Swallow[B]	**P**					**P**	**P**

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Barn Swallow[B]	**P**					**O**	**O**
Black-capped Chickadee[B]	**P**	**O**	**O**	**P**	**P**		
Tufted Titmouse[B]		**O**	**O**	**P**	**P**		
Red-breasted Nuthatch[B]		**P**	**P**	**P**	**P**		
White-breasted Nuthatch[B]		**P**	**P**	**P**	**P**		
Brown Creeper[B]		**P**	**P**	**P**	**P**		
Carolina Wren[B]	**O**	**O**	**O**	**O**	**O**		
House Wren[B]	**P**	**P**	**P**	**P**	**P**		
Winter Wren[B]	**P**	**P**	**P**	**P**	**P**	**P**	
Golden-crowned Kinglet[B]		**P**	**P**	**P**	**P**		
Ruby-crowned Kinglet[M]		**P**	**P**	**P**	**P**		
Blue-gray Gnatcatcher[B]		**P**	**P**	**P**	**P**		
Eastern Bluebird[B]	**P**	**P**	**P**	**P**	**P**		
Veery[B]		**P**	**P**	**P**	**P**		
Hermit Thrush[B]		**P**	**P**	**P**	**P**		
Wood Thrush[B (BCC)]		**P**	**P**	**P**	**P**		
American Robin[B]	**P**	**O**	**O**	**O**	**P**		
Gray Catbird[B]	**P**	**O**	**O**	**P**	**P**		
Northern Mockingbird[B]	**P**	**O**	**O**	**P**	**P**	**O**	**O**

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Brown Thrasher[B]	**P**	**P**	**P**	**P**	**P**		
European Starling[B]	**P**	**P**	**P**	**P**	**P**	**O**	**O**
Cedar Waxwing[B]		**P**	**P**	**P**	**P**		
Blue-winged Warbler[B]	**P**						
Northern parula[M(S-T)]		**P**	**P**	**P**	**P**		
Black-and-white warbler[B]		**P**	**P**	**P**	**P**		
Golden-winged Warbler[B]		**P**	**P**	**P**	**P**		
Nashville Warbler[B]	**P**	**P**	**P**	**P**	**P**		
Yellow Warbler[B]	**O**	**P**	**O**	**O**	**P**		
Yellow-rumped warbler[M]		**O**	**P**	**P**	**P**		
Chestnut-sided Warbler[B]	**P**	**P**	**P**	**P**	**P**		
Black-throated Green Warbler[B]		**P**	**P**	**P**	**P**		
Black-throated blue warbler[B(S-T)]		**P**	**P**	**P**	**P**		
Blackburnian warbler [M(S-T)]		**P**	**P**	**P**	**P**		
Pine Warbler[B]		**P**	**P**	**P**	**O**		
Prairie Warbler[B (BCC)]	**P**				**P**		
American Redstart[B]	**P**	**O**	**O**	**P**	**P**		
Worm-eating Warbler[B]	**P**	**O**	**P**	**P**	**P**		
Ovenbird[B]	**P**	**P**	**P**	**P**	**P**		

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Northern Waterthrush[B]		**P**					
Louisiana Waterthrush[B]		**P**					
Common Yellowthroat[B]	**P**	**O**	**O**	**P**	**P**		
Hooded Warbler[B]		**P**	**P**	**P**	**P**		
Canada Warbler[B (BCC)]		**P**	**P**	**P**	**P**		
Cerulean warbler[B(S-E)]		**P**	**P**	**P**	**P**		
Scarlet Tanager[B]		**P**	**P**	**P**	**P**		
Eastern Towhee[B]	**P**	**P**	**P**	**P**	**P**		
American Tree Sparrow[M]	**P**	**P**	**P**	**P**	**P**		
Chipping Sparrow[B]	**P**	**P**	**P**	**P**	**P**		
Field Sparrow[B]	**P**						
Savannah Sparrow[B]	**P**						
Fox Sparrow[M]	**P**	**P**	**P**	**P**	**P**		
Song Sparrow[B]	**P**	**O**	**O**	**O**	**P**	**O**	**O**
Swamp Sparrow[B]	**P**	**P**					
White-throated Sparrow[M]	**P**	**P**	**P**	**P**	**P**		
Dark-eyed Junco[M]	**P**	**P**	**P**	**P**	**P**		
Lapland Longspur[M]	**P**						
Snow Bunting[M]						**P**	

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Northern Cardinal[B]	**P**	**O**	**O**	**P**	**P**		
Rose-breasted Grosbeak[B]		**P**	**P**	**P**	**P**		
Indigo Bunting[B]	**P**						
Bobolink[B (S-SC)]	**P**						
Red-winged Blackbird[B]	**P**						**O**
Rusty Blackbird [(BCC)]	**P**	**P**	**P**	**P**			
Eastern Meadowlark[B]	**P**						
Common Grackle[B]	**P**	**P**	**O**	**O**	**P**	**P**	**P**
Brown-headed Cowbird[B]	**P**	**P**	**P**	**P**	**P**		**O**
Orchard Oriole		**P**	**P**	**P**	**P**		
Baltimore Oriole[B]		**P**	**P**	**P**	**P**		
Pine Grosbeak[M]		**P**	**P**	**P**			
Purple Finch[M]		**P**	**P**	**P**	**P**		
House Finch[B]	**P**	**O**	**P**	**O**	**P**		
Common Redpoll[M]	**P**	**P**	**P**	**P**	**P**		
Pine Siskin[M]	**P**	**P**	**P**	**P**	**P**		
American Goldfinch[B]	**P**	**O**	**O**	**P**	**P**	**O**	**P**
Evening Grosbeak[M]	**P**	**P**	**P**	**P**	**P**		
House Sparrow[B]	**O**	**P**	**P**	**O**	**P**	**P**	**P**

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Observed and Potential Amphibian and Reptile Species

	Inland Key Habitats					Coastal Key Habitats	
	Ruderal Grassland/ Shrubland	Ruderal Forested Swamp	Mixed Oak/White Pine Forest	Oak Forest	Pitch Pine Woodland/ Barren	Coastal Beach	Tidal Salt Marsh
Marbled Salamander[B]		**P**	**P**	**P**	**P**		
Spotted Salamander[B]		**P**	**P**	**P**	**P**		
Red Spotted Newt[B]		**P**	**P**	**P**	**P**		
Northern Dusky Salamander[B]		**P**	**P**	**P**	**P**		
Northern Redback Salamander[B]		**P**	**P**	**P**	**P**		
Four-toed Salamander[B]		**P**	**P**	**P**	**P**		
Northern Two-Lined Salamander[B]		**P**	**P**	**P**	**P**		
American Toad[B]	**P**	**P**	**P**	**P**	**P**		
Fowler's Toad[B]	**P**	**P**	**P**	**P**	**P**		
Northern Spring Peeper[B]	**P**	**P**	**P**	**P**	**P**		
Gray Treefrog[B]		**P**	**P**	**P**	**P**		
American Bullfrog[B]							
Green Frog[B]		**P**					
Wood Frog[B]	**P**	**P**	**P**	**P**			
Pickerel Frog[B]	**P**	**P**	**P**	**P**			
Common Snapping Turtle[B]	**P**	**P**	**P**	**P**			

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Painted Turtle[B]	**P**	**P**					
Spotted Turtle[B]	**P**	**P**	**P**	**P**			
Wood Turtle[B (S-C)]	**P**	**P**	**P**	**P**	**P**		
Eastern Box Turtle[B]	**P**	**P**	**P**	**P**	**P**		
Common Musk Turtle[B]	**P**	**P**	**P**	**P**	**P**		
Diamondback Terrapin[B(S-E)]						**P**	**P**
Northern Water Snake[B]	**P**	**P**	**P**	**P**	**P**		
Northern Red-bellied Snake[B]	**P**	**P**	**P**	**P**	**P**		
Common Garter Snake[B]	**P**	**P**	**P**	**P**	**P**		
Eastern Ribbon Snake[B (S-SC)]	**P**	**P**	**P**	**P**	**P**		
Eastern Hognose Snake[B]	**P**	**P**	**P**	**P**	**P**		
Northern Ringneck Snake[B]	**P**	**P**	**P**	**P**	**P**		
Eastern Worm Snake[B]	**P**	**P**	**P**	**P**	**P**		
Northern Black Racer[B]	**P**	**P**	**P**	**P**	**P**		
Eastern Smooth Green Snake[B]	**P**	**P**	**P**	**P**	**P**		
Northern Brownsnake[B]	**P**	**P**	**P**	**P**	**P**		
Black Rat Snake[B]	**P**	**P**	**P**	**P**	**P**		
Eastern Milk Snake[B]	**P**	**P**	**P**	**P**	**P**		

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Observed and Potential Mammal Species

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	Ruderal Grassland/ Shrubland	Ruderal Forested Swamp	Mixed Oak/White Pine Forest	Oak Forest	Pitch Pine Woodland/ Barren	Coastal Beach	Tidal Salt Marsh
Virginia Opossum[B]	**P**	**P**	**P**	**P**	**P**	**P**	**P**
Masked Shrew [B]	**P**	**P**	**P**	**P**	**P**		**P**
Water Shrew[B(S-C)]	**P**	**P**	**P**	**P**	**P**	**P**	**P**
Northern Short-tailed Shrew[B]		**P**	**P**	**P**	**P**		
Smoky Shrew[B(S-C)]	**P**	**P**	**P**	**P**	**P**		
Star-nosed Mole[B]	**P**	**P**	**P**	**P**	**P**		
Little Brown Bat[B]	**P**	**P**	**P**	**P**	**P**		**P**
Silver-haired Bat[B]	**P**	**P**	**P**	**P**	**P**		**P**
Tricolored bat[B]	**P**	**P**	**P**	**P**	**P**		**P**
Big Brown Bat[B]	**P**	**P**	**P**	**P**	**P**		**P**
Eastern Red Bat[B]	**P**	**P**	**P**	**P**	**P**		**P**
Hoary Bat[M (S-SC)]	**P**	**P**	**P**	**P**	**P**		**P**
Northern Long-eared Bat[B (F-T)]	**P**	**P**	**P**	**P**	**P**		**P**
Eastern Cottontail[B]	**P**	**P**	**P**	**P**	**P**	**P**	**P**
New England Cottontail[B(S-C)]	**P**	**P**	**P**	**P**	**P**		

P = Potential to occur O = observed by VHB during Summer 2019 **P/O** = GCN Species in the 2015 RIWAP. B = breeding in Rhode Island M = migrant/visitor
S-E = State-endangered S-T= State-threatened S-C = State Concern F-E = Federally endangered F-T = Federally Threatened BCC = Bird of Conservation Concern

Source: DeGraaf, Richard M. and Mariko Yamasaki. 2001. New England Wildlife: Habitat, Natural History and Distribution, University Press of New England, Hanover, New Hampshire, 2001.
RIDEM, The Rhode Island Nature Conservancy, University of Rhode Island. 2015. Rhode Island Wildlife Action Plan. http://www.dem.ri.gov/programs/fish-wildlife/wildlifehuntered/swap15.php

	Inland Key Habitats					Coastal Key Habitats	
	Ruderal Grassland/ Shrubland	Ruderal Forested Swamp	Mixed Oak/White Pine Forest	Oak Forest	Pitch Pine Woodland/ Barren	Coastal Beach	Tidal Salt Marsh
Snowshoe Hare[B]	**P**	**P**	**P**	**P**	**P**	**P**	
Eastern Chipmunk[B]	**O**	**O**	**O**	**O**	**O**		
Woodchuck[B]	**P**	**P**	**P**	**P**	**P**		
Gray Squirrel[B]	**O**	**O**	**O**	**O**	**O**		
Red Squirrel[B]	**P**	**P**	**P**	**P**	**P**		
Southern Flying Squirrel[B]		**P**	**P**	**P**	**P**		
White-footed Mouse[B]	**P**	**P**	**P**	**P**	**P**		**P**
Southern Red-backed Vole[B]	**P**	**P**	**P**	**P**	**P**		**P**
Meadow Vole[B]	**P**	**P**	**P**	**P**	**P**		**P**
Woodland Vole[B]	**P**	**P**	**P**	**p**	**P**		
Muskrat[B]		**P**	**P**	**P**	**P**	**P**	**P**
Southern Bog Lemming[B]	**P**	**P**	**P**	**P**	**P**		
Norway Rat[B]	**P**	**P**	**P**	**P**	**P**	**P**	**P**
House Mouse	**P**	**P**	**P**	**P**	**P**	**P**	**P**
Meadow Jumping Mouse[B]	**P**	**P**	**P**	**P**	**P**		
Coyote[B]	**P**	**P**	**P**	**P**	**P**	**P**	**P**
Red Fox[B]	**P**	**P**	**P**	**P**	**P**	**P**	**P**

P = Potential to occur O = observed by VHB during Summer 2019 **P/O** = GCN Species in the 2015 RIWAP. B = breeding in Rhode Island M = migrant/visitor
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	Inland Key Habitats					Coastal Key Habitats	
	Ruderal Grassland/ Shrubland	Ruderal Forested Swamp	Mixed Oak/White Pine Forest	Oak Forest	Pitch Pine Woodland/ Barren	Coastal Beach	Tidal Salt Marsh
Gray Fox[B]	**P**	**P**	**P**	**P**	**P**	**P**	**P**
Raccoon[B]	**P**	**P**	**P**	**P**	**P**	**P**	**P**
Ermine (Short-tailed weasel)[B]	**P**	**P**	**P**	**P**	**P**	**P**	**P**
Fisher[B]	**P**	**P**	**O**				
Long-tailed Weasel[B]	**P**	**P**	**P**	**P**	**P**	**P**	**P**
Mink[B]	**P**	**P**	**P**	**P**	**P**	**P**	**P**
Striped Skunk[B]	**P**	**P**	**P**	**P**	**P**	**P**	**O**
White-tailed Deer[B]	**P**	**O**	**O**	**P**	**P**	**P**	**P**
Black Bear[B]	**P**	**P**	**P**	**P**	**P**	**P**	
Bobcat[B(S-T)]	**P**	**P**	**P**	**P**	**P**	**P**	

P = Potential to occur   O = observed by VHB during Summer 2019 **P/O** = GCN Species in the 2015 RIWAP. B = breeding in Rhode Island   M = migrant/visitor
S-E = State-endangered   S-T= State-threatened   S-C = State Concern   F-E = Federally endangered   F-T = Federally Threatened   BCC = Bird of Conservation Concern
Source: DeGraaf, Richard M. and Mariko Yamasaki. 2001. New England Wildlife: Habitat, Natural History and Distribution, University Press of New England, Hanover, New Hampshire, 2001.
RIDEM, The Rhode Island Nature Conservancy, University of Rhode Island. 2015. Rhode Island Wildlife Action Plan. http://www.dem.ri.gov/programs/fish-wildlife/wildlifehuntered/swap15.php

RevWind Exhibit 1(A)(v)

Common Habitat Types for Finfish Species Known to Occur in the Region

Appendix D2:
Common Habitat Types for Finfish Species Known to Occur in the Region

Common Habitat Types for Finfish Species Known to Occur in the Region

Species	Habitat Type by Life Stage
DEMERSAL/BENTHIC	
Atlantic cod	Juveniles: Cobble substrates both nearshore and offshore; wide temperature ranges. Adults: On or near the bottom along rocky slopes of ledges; depths between 131 and 426 ft (40 and 130 m) but also midwater.
Atlantic sea herring	Eggs: Spawned at depths of 131 to 262 ft (40 to 80 m) on George's Bank on gravel (preferred); sand, rocks, shell fragments, aquatic macrophytes, and lobster pot structures.
Atlantic sturgeon	Juveniles: In the wintertime, juveniles congregate in a deep-water habitat in estuaries. Most are found over clay, sand, and silt substrates. Adults: Primarily a marine species that is found close to shore; however, it does migrate long distances.
Black sea bass	Juveniles: Collected at depths of 65 to 787 ft (20 to 240 m) in channel environments. Adults: At depths of 98 to 787 ft (30 to 240 m) in shipwrecks, rocky and artificial reefs, mussel beds, and other structures along the bottom.
Cunner	All Life Stages: Coastal fish that prefers eel grass, rock pools, or pilings at depths 13 to 23 ft (4 to 7 m).
Haddock	Adults: Pebble gravel bottom at depths of 131 to 492 ft (40 to 150 m).
Little skate	All Life Stages: Sandy/gravely bottoms at a depth range of less than 233 to 298 ft (71 to 91 m).
Monkfish	Juveniles/Adults: Bottom habitat, sand/shell mix, gravel or mud along the continental shelf, depths 82 to 656 ft (25 to 200 m).
Northern sea robin	Juveniles and Adults: Smooth, hard-packed bottom.
Ocean pout	All Life Stages: Bottom habitats with rocky shelter from the intertidal continental shelf to 656 ft (200 m) deep.
Pollock	All Life Stages: Schooling fish living at various depths from near the surface to at least 600 ft (182 m) deep.
Red hake	Juveniles: Use of shells and substrate as shelter; found less than 393 ft (120 m) to low tide line.
Sand lance	All Life Stages: Throughout water column over sandy substrates.
Scup	Juveniles: Nearshore in sandy, silty-sand, mud, mussel beds, and eel grass at depths of 16 to 55 ft (5 to 17 m). Adults: Soft, sandy bottom, near structures (ledges, artificial reefs, mussel beds) at a depth range less than 98 ft (30 m).
Sea raven	All Life Stages: Prefer rocky ground; hard clay, pebbles, or sand from 300 to 630 ft (91 to 192 m) deep.
Silver hake	Eggs: Surface waters over continental shelf at depths of 164 to 492 ft (50 to 150 m). Larvae: Surface waters over the continental shelf at depths of 164 to 426 ft (50 to 130 m).

Species	Habitat Type by Life Stage
Smooth dogfish	All Life Stages: Mostly nearshore but some have a depth range of 870 to 990 ft (145 to 165 m); prefer bottom habitats.
Spiny dogfish	All Life Stages: Collected over sand, mud, and mud-sand transitions at depths ranging from 3 to 1,640 ft (1 to 500 m); do not travel to maximum depths in the fall.
Striped bass	All Life Stages: Open waters along rocky shores and sandy beaches.
Summer flounder	Adults: Prefer sandy habitats; captured from shoreline to 82 ft (25 m) deep.
Tautog	All Life Stages: Require complex, structured habitats with a hard bottom substrate; depths of 82 to 989 ft (25 to 30 m).
Tilefish	All Life Stages: 262- to 590-ft (80- to 180-m) depth along the outer part of the continental shelf to upper part of continental shelf.
Silver hake	Juveniles: Bottom habitats; all substrate types; depths of 65 to 885 ft (20 to 270 m). Adults: Bottom habitats; all substrate types; depths of 98 to 1,066 ft (30 to 325 m).
Windowpane flounder	Juveniles and Adults: Fine, sandy sediment; nearshore less than 246 ft (75 m) deep.
Winter flounder	Eggs: Nearshore; mud to sand or gravel. Emerging evidence that spawning occurs offshore. Larvae: Nearshore; fine sand to gravel. Juveniles: 59 to 88 ft (18 to 27 m) deep; mud or sand-shell. Adults: Mostly nearshore up to 98 ft (30 m) deep; mud, sand, cobble, rocks, or boulders substrate.
Winter skate	All Life Stages: Prefer sandy or gravelly substrates; spring depths from 3 to 984 ft (1 to 300 m); fall depths from 3 to 1,312 ft (1 to 400 m).
Wolffish	All Life Stages: Occupy complex habitats with large stones or rocks at a depth range of 131 to 787 ft (40 to 240 m).
Yellowtail flounder	Juveniles: Sand or sand and mud; depth range of 16 to 410 ft (5 to 125 m). Adults: Sand or sand and mud; depth range of 32 to 1,181 ft (10 to 360 m).
PELAGIC	
Albacore tuna	All Life Stages: Deepwater habitats; depth range of 0 to 1,968 ft (0 to 600 m).
Alewife	Adults: Shorelines; shallower waters near estuaries.
American eel	Larvae: Drift with Gulf Stream toward Atlantic Coast. Juveniles: Glass eels and elvers migrate to brackish waters; some remain in marine waters. Adults: Freshwater, coastal, and marine waters.
American plaice	Eggs and Larvae: Open waters; depth maximum 328 ft (100 m). Juveniles and Adults: High concentrations around 328 ft (100-m) deep; prefer sand and gravel substrates.
American shad	Juveniles: Nearshore open waters. Adults: Open ocean.
Atlantic bonito	All Life Stages: Open waters both nearshore and offshore.
Atlantic butterfish	Eggs: Surface waters along the edge of the continental shelf to estuaries and bays.

Species	Habitat Type by Life Stage
	Larvae and Juveniles: Surface waters from continental shelf to bays. Adults: Surface waters from depths of 885 to 1,377 ft (270 to 420 m).
Atlantic cod	Eggs: Bays, harbors, offshore banks; float near water surface. Larvae: Open ocean and continental shelf area.
Atlantic halibut	Eggs: Offshore drift suspended in the water column. Larvae: Nearshore areas near the water surface.
Atlantic mackerel	Eggs: Shoreward side of the continental shelf; 32 to 1,066 ft (10 to 325 m) deep. Larvae: Offshore waters and open bays; 32 to 426 ft (10 to 130 m) deep. Juveniles: Nearshore areas; 164 to 229 ft (50 to 70 m) deep. Adults: Offshore, 32 to 1,115 ft (10 to 340 m) deep.
Atlantic menhaden	All Life Stages: Nearshore and offshore.
Atlantic sea herring	All Life Stages: High energy environments; gravel seafloors.
Atlantic silverside	Juveniles and Adults: Found at great depths offshore from late fall through early spring. In the summer, they are found along the shore, within a few ft of the shoreline along sandy or gravel shores.
Basking shark	All Life Stages: Coastal and offshore; sometimes enters inshore bays.
Bay anchovy	Eggs/Larvae: Eggs are found throughout the water column but tend to be concentrated near the surface. Larvae move upstream to lower salinity waters in the spring and then move to more saline waters in the fall. Juveniles and Adults: shallow and moderately deep offshore waters, nearshore waters off sand beaches, open bays, and muddy coves.
Black sea bass	Eggs: Coastal, upper water column. Larvae: Nearshore, mouths of estuaries, upper water column.
Blueback herring	Adults: High energy environments; gravel seafloors.
Bluefin tuna	All Life Stages: Nearshore and offshore.
Bluefish	Eggs: Across continental shelf; transported further offshore. Larvae: Near edge of continental shelf; associated with surface. Juveniles: Nearshore; associated with surface. Adults: Nearshore to offshore.
Blue shark	All Life Stages: Nearshore and offshore, surface dwelling, concentrated near fishing activity.
Common thresher shark	Juveniles: Shallower waters over the continental shelf (less than 656 ft [200 m] deep) in areas of upwelling or mixing. Adults: Present near and offshore, but more common nearshore, in areas of upwelling or mixing.
Conger eel	All Life Stages: Near the coastline to the edge of the continental shelf, 300 to 852 ft (91 to 260 m) deep.
Dusky shark	All Life Stages: Nearshore and offshore.
Haddock	Eggs: Near the surface of water column. Larvae: Depths of 32 to 164 ft (10 to 50 m) with a maximum depth of 492 ft (150 m).
Monkfish	Eggs: Surface waters in areas that have depths of 49 to 3,280 ft (15 to 1000 m). Larvae: Pelagic waters in areas that have depths of 49 to 3,280 ft (15 to 1000 m).

Species	Habitat Type by Life Stage
Northern sea robin	Eggs and Larvae: Pelagic waters of the continental shelf.
Red hake	Eggs: Water column within the inner shelf. Larvae: Coastal waters less than 656 ft (200 m) in depth.
Sandbar shark	All Life Stages: Waters on continental shelves, oceanic banks, and island terraces, but also found in harbors, estuaries, at the mouths of bays and rivers, and shallow turbid water. Mostly at 65 to 213 ft (20 to 65 m) deep.
Sand tiger shark	All Life Stages: Nearshore ranging in depths from 6 to 626 ft (2 to 191 m); inhabit surf zone, shallow bays, and rocky reefs, and deeper areas around the OCS.
Shortfin mako shark	All Life Stages: Various areas of the water column; ranging depths, maximum depth 2,427 ft (740 m).
Skipjack tuna	All Life Stages: Epipelagic, oceanic species.
Spot	All Life Stages: Coastal, nearshore, and offshore continental shelf areas.
Summer flounder	Eggs and Larvae: Nearshore areas within eel grass beds and pilings.
Tiger shark	All Life Stages: Coastal, nearshore, and offshore continental shelf areas.
Weakfish	All Life Stages: Nearshore, shallow waters along open sandy shores and estuaries.
White shark	All Life Stages: Nearshore and offshore, mostly spotted near the surface.
Windowpane flounder	Eggs and Larvae: Occupy multiple areas in water column less than 229 ft (70 m) depths.
Winter flounder	Larvae: Both nearshore and offshore.
Witch flounder	Eggs: Deep; pelagic waters 164 to 278 ft (50- to 85-m) depths. Larvae: 0- to 820-ft (0- to 250-m) depths.
Yellowfin tuna	All Life Stages: epipelagic, oceanic fish found in the upper 328 ft (100 m) of the water column.
Yellowtail flounder	Eggs: Pelagic - near-surface continental shelf waters. Larvae: Pelagic - mid-water column; movement limited to currents.

Sources: Auster and Stuart, 1986; Collette and Klein-MacPhee, 2002; Malek et al., 2016

Common Prey Species of Juvenile and Adult Finfish Species

Species	Habitat Type by Life Stage
DEMERSAL/BENTHIC	
Atlantic cod	Benthic invertebrates
Atlantic halibut	Silver hake, sand lance, ocean pout, and alewife
Atlantic sturgeon	Benthic invertebrates
Black sea bass	Invertebrates and zooplankton
Cunner	Pipefish, mummichog, and invertebrates
Haddock	Amphipods
Little skate	Sand lance, alewife, herring, cunner, silversides, tomcod, and silver hake
Monkfish	Sand lance and monkfish
Northern sea robin	Shrimp, crabs, amphipods, squid, bivalve mollusks, and segmented worms
Ocean pout	Sand dollars
Pollock	Herring and crustaceans
Red hake	Crustaceans
Sand lance	Plankton
Scup	Fish eggs and invertebrates
Sea raven	Herring, lance, sculpins, tautog, silver hake, and both sculpin and sea- raven eggs
Silver hake	Crustaceans
Smooth dogfish	Crustaceans, particularly lobsters
Spiny dogfish	Squid and fish
Striped bass	Menhaden, anchovy, spot, amphipods, and sand lance
Summer flounder	Windowpane, winter flounder, northern pipefish, Atlantic menhaden, bay anchovy, red hake, silver hake, scup, Atlantic silverside, American sand lance, bluefish, weakfish, mummichog, rock crabs, squid, and shrimp
Tautog	Copepods and shellfish
Tilefish	Crabs, squid, shrimp, shelled mollusks, annelid worms, sea urchins, sea cucumbers, and sea anemones
Windowpane flounder	Invertebrates
Winter flounder	Clams
Winter skate	Smaller skates, eels, alewife, blueback herring, menhaden, smelt, sand lance, chub mackerel, butterfish, cunner, sculpins, silver hake, and tomcod.
Wolffish	Mollusks and shellfish
Yellowtail flounder	Invertebrates
PELAGIC	
Albacore tuna	Longfin and shortfin squid and crustaceans
Alewife	Herring, eels, sand lance, cunners, and alewife
American eel	Small fish of many varieties, shrimp, crabs, lobsters, and smaller crustacea
American plaice	Sand dollars

Species	Habitat Type by Life Stage
American shad	Various fish
Atlantic bonito	Mackerels, menhaden, and sand lance
Atlantic butterfish	Small fish, squid, and crustaceans
Atlantic mackerel	Copepods and crustaceans
Atlantic menhaden	Diatoms and crustaceans
Atlantic sea herring	Copepods
Atlantic silverside	Zooplankton, copepods, shrimp, amphipods, young squid, worms, insects, and algae
Basking shark	Small crustaceans
Bay anchovy	Mysid shrimp, copepods, small crustaceans and mollusks, and larval fish
Blueback herring	Zooplankton
Bluefin tuna	Herring and eels
Bluefish	Invertebrates and crustaceans
Blue shark	Herring, mackerel, spiny dogfish, and various others
Common thresher shark	Pelagic fish and squid
Conger eel	Butterfish, herring, eels, and invertebrates
Dusky shark	Various pelagic fish
Sandbar shark	Menhaden and crustaceans
Sand tiger shark	Small sharks, rays, squid, and lobster
Shortfin mako shark	Mackerels, tuna, and bonito
Skipjack tuna	Pelagic fish and invertebrates
Spot	Bristle worms, mollusks, crustaceans, and plant and animal detritus
Tiger shark	Fish and squid
Weakfish	Crabs, amphipods, mysid and decapod shrimps, squid, shelled mollusks, and annelid worms, menhaden, butterfish, herring, scup, anchovies, silversides, and mummichog
White shark	Fish, rays, squid, other sharks, and marine mammals
Yellowfin tuna	Large pelagic fish and squid

EFH Designations for Species in the RWEC-RI

Species	Life Stages within RWF	Life Stages within RWEC-OCS	Life Stages within RWEC-RI
NEW ENGLAND FINFISH			
Atlantic cod (*Gadus morhua*)	Egg, Larvae, Juvenile, Adult	Egg, Larvae, Juvenile, Adult	Egg, Larvae, Juvenile Adult
Atlantic herring (*Clupea harengus*)	Larvae, Juvenile, Adult	Larvae, Juvenile, Adult	Larvae, Juvenile, Adult
Atlantic wolfish *(Anarhichas lupus)*	Egg, Larvae, Juvenile, Adult	-	-
Haddock (*Melanogrammus aeglefinus*)	Egg, Larvae, Juvenile	Larvae, Juvenile	-
Monkfish (*Lophius americanus*)	Egg, Larvae, Juvenile, Adult	Egg, Larvae, Juvenile, Adult	Egg, Larvae
Ocean pout (*Zoarces americanus*)	Egg, Juvenile, Adult	Egg, Juvenile, Adult	Egg, Juvenile, Adult
Pollock (*Pollachius virens*)	Egg, Larvae, Juvenile	Egg, Larvae, Juvenile	Juvenile
Red hake (*Urophycis chuss*)	Egg, Larvae, Juvenile, Adult	Egg, Larvae, Juvenile, Adult	Egg, Larvae, Juvenile, Adult
Silver hake (*Merluccius bilinearis*)	Egg, Larvae, Juvenile, Adult	Egg, Larvae, Juvenile, Adult	Egg, Larvae, Adult
White hake (*Urophycis tenuis*)	Larvae, Juvenile	Larvae, Juvenile	Juvenile
Windowpane flounder (*Scophthalmus aquosus*)	Egg, Larvae, Juvenile, Adult	Egg, Larvae, Juvenile, Adult	Egg, Larvae, Juvenile, Adult
Winter flounder (*Pseudopleuronectes americanus*)	Larvae, Juvenile, Adult	Larvae, Juvenile, Adult	Egg, Larvae, Juvenile, Adult
Witch flounder (*Glyptocephalus cynoglossus*)	Egg, Larvae	Egg, Larvae	-
Yellowtail flounder (*Limanda ferruginea*)	Egg, Larvae, Juvenile, Adult	Egg, Larvae, Juvenile, Adult	Juvenile, Adult
MID-ATLANTIC FINFISH			
Atlantic butterfish (*Peprilus triacanthus*)	Egg, Larvae, Juvenile, Adult	Egg, Larvae, Juvenile, Adult	Egg, Larvae, Juvenile, Adult
Atlantic mackerel (*Scomber scombrus*)	Egg, Larvae, Juvenile	Egg, Larvae, Juvenile	Egg, Larvae, Juvenile, Adult
Black sea bass (*Centropristis striata*)	Juvenile, Adult	Juvenile, Adult	Juvenile, Adult
Bluefish (*Pomatomus saltatrix*)	Egg, Larvae, Juvenile, Adult	Egg, Larvae, Juvenile, Adult	Juvenile, Adult

Species	Life Stages within RWF	Life Stages within RWEC-OCS	Life Stages within RWEC-RI
Scup (*Stenotomus chrysops*)	Juvenile, Adult	Juvenile, Adult	Egg, Larvae, Juvenile, Adult
Summer flounder (*Paralichthys dentatus*)	Egg, Larvae, Juvenile, Adult	Egg, Larvae, Juvenile, Adult	Larvae, Juvenile, Adult
INVERTEBRATES			
Atlantic sea scallop (Placopecten magellanicus)	Egg, Larvae, Juvenile, Adult	Egg, Larvae, Juvenile, Adult	Egg, Larvae, Juvenile, Adult
Atlantic surfclam (Spisula solidissima)	-	Adult	Juvenile, Adult
Longfin inshore squid (Doryteuthis pealeii)	Egg, Juvenile, Adult	Egg, Juvenile, Adult	Egg, Juvenile, Adult
Northern shortfin squid (Illex illecebrosus)	Adult	-	-
Ocean quahog (Arctica islandica)	Juvenile, Adult	Juvenile, Adult	-
HIGHLY MIGRATORY SPECIES			
Albacore tuna (*Thunnus alalunga*)	Juvenile, Adult	Juvenile, Adult	Juvenile
Bluefin tuna (*Thunnus thynnus*)	Juvenile, Adult	Juvenile, Adult	Juvenile, Adult
Skipjack tuna (*Katsuwonus pelamis*)	Juvenile, Adult	Adult	Adult
Yellowfin tuna (*Thunnus albacares*)	Juvenile, Adult	Juvenile, Adult	Juvenile
SKATES			
Little skate (Leucoraja erinacea)	Juvenile, Adult	Juvenile, Adult	Juvenile, Adult
Winter skate (Leucoraja ocellata)	Juvenile, Adult	Juvenile, Adult	Juvenile, Adult
SHARKS			
Basking shark (Cetorhinus maximus)	Neonate, Juvenile, Adult	Neonate, Juvenile, Adult	-
Blue shark (Prionace glauca)	Neonate, Juvenile, Adult	Neonate, Juvenile, Adult	-
Common thresher shark (Alopias vulpinus)	Neonate, Juvenile, Adult	Neonate, Juvenile, Adult	Neonate, Juvenile, Adult
Dusky shark (Carcharhinus obscurus)	Neonate, Juvenile, Adult	Neonate, Juvenile, Adult	-
Sand tiger shark (Carcharias taurus)	Neonate, Juvenile	Neonate, Juvenile	Neonate, Juvenile

Species	Life Stages within RWF	Life Stages within RWEC-OCS	Life Stages within RWEC-RI
Sandbar shark (Carcharhinus plumbeus)	Juvenile, Adult	Juvenile, Adult	Juvenile, Adult
Shortfin mako shark (Isurus oxyrinchus)	Neonate, Juvenile, Adult	Neonate, Juvenile, Adult	-
Smoothhound shark complex (Atlantic stock) (Mustelus canis)	Neonate, Juvenile, Adult	Neonate, Juvenile, Adult	Neonate, Juvenile, Adult
Spiny dogfish (Squalus acanthias)	Sub-adult male, Sub-adult female, Adult male, Adult female	Sub-adult male, Sub-adult female, Adult male, Adult female	Sub-adult female, Adult male
White shark (Carcharodon carcharias)	Neonate, Juvenile, Adult	Neonate, Juvenile, Adult	Neonate

Sources: Auster and Stuart, 1986; Collette and Klein-MacPhee, 2002; Florida Fish and Wildlife Conservation Commission, 2019; Florida Museum of Natural History, 2017; Knickel, 2018; NOAA Fisheries, 2007; USFWS, 2019; URI EDC, 2017

RevWind Exhibit 1(A)(vi)

Visual Resource Assessment, Revolution Wind Onshore Facilities

Appendix E:
Visual Resource Assessment, Revolution Wind Onshore Facilities

Technical Report

Visual Resource Assessment

Revolution Wind Onshore Facilities

Prepared for:

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56 Exchange Terrace, Suite 300
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Prepared by:

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December 2020

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Figures

Tables

1.0 INTRODUCTION

1.1 Purpose of the Investigation

Environmental Design & Research, Landscape Architecture, Engineering & Environmental Services, D.P.C. (EDR) was retained by Revolution Wind, LLC (the Applicant) to prepare a Visual Resource Assessment for the proposed Onshore Facilities associated with the Revolution Wind Farm Project. The Onshore Facilities include the following components:

- A landfall location located at Quonset Point in North Kingstown, Rhode Island.
- Up to two underground transmission circuits.
- A new Onshore Substation (OnSS) located adjacent to the existing Davisville Substation with up to two interconnection circuits (overhead or underground) connecting the OnSS to the existing substation.
- A new Interconnection Facility (ICF) also adjacent to the existing Davisville Substation.

This report addresses the potential impacts to visually sensitive resources associated with the visible components of the Onshore Facilities, which include the proposed OnSS and ICF, collectively referred to in this Visual Resource Assessment (VRA) as the “Project”. The Onshore Facilities proposed to be buried underground may involve temporary visual impacts associated with the construction and decommissioning phase of the Project. However, long term operational impacts will not result from these underground circuits, and are therefore, not addressed in this VRA. The location of the proposed Onshore Facilities are shown on Figure 1.1-1.

The purpose of this VRA is to:

- Define the visual character of the Project visual study area (VSA).
- Inventory and evaluate existing visual resources and viewer groups within the VSA.
- Describe the appearance of the visible components of the proposed Project.
- Document existing views within the VSA.
- Evaluate potential Project visibility within the VSA.
- Assess the potential effects on visual resources associated with the proposed Project.

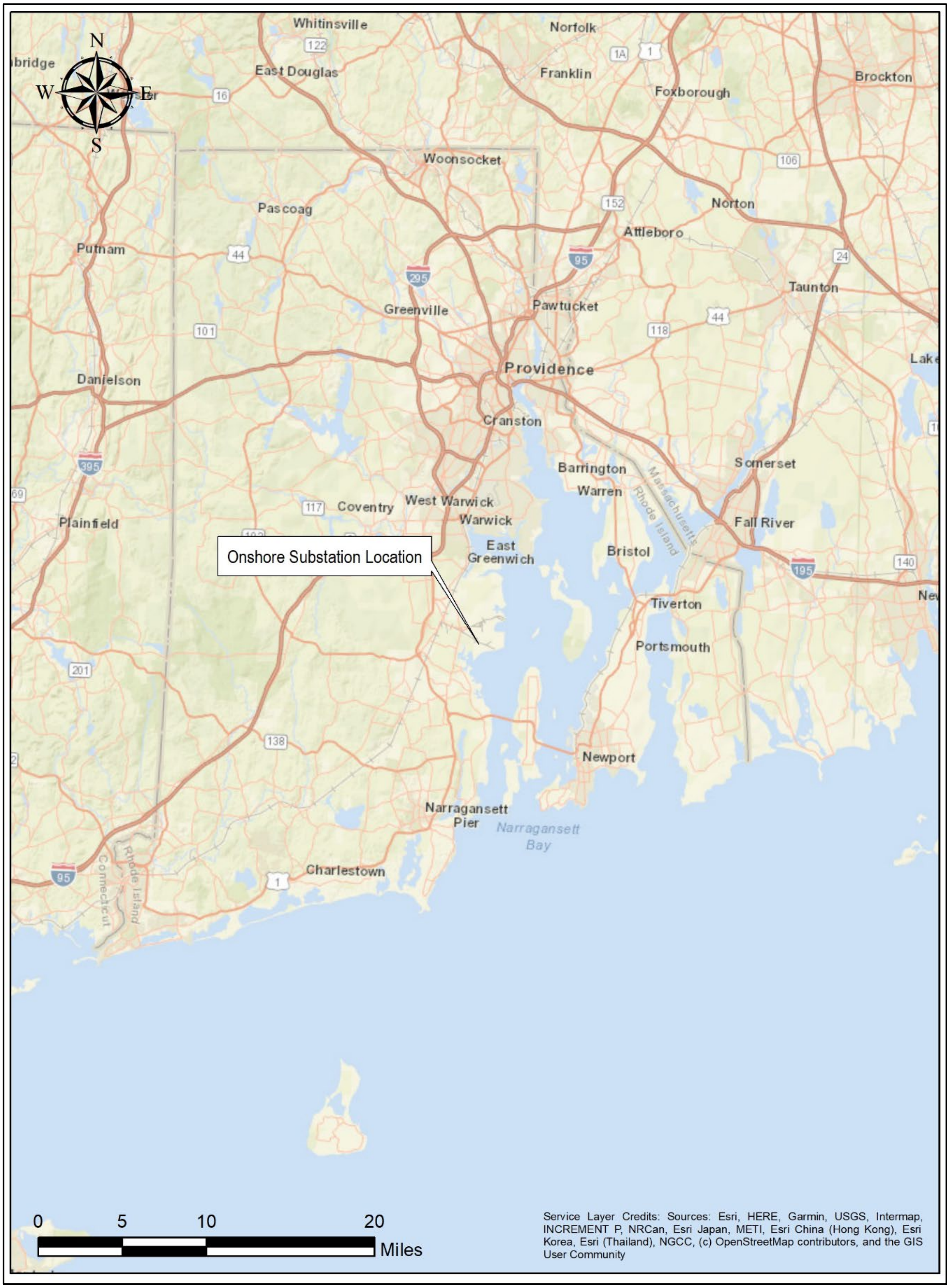

Figure 1.1-1. Regional Project Location

1.2 Project Location and Description

The Project is located in the Town of North Kingstown, Washington County, Rhode Island. The OnSS and ICF collectively occupy approximately 12 acres of currently forested land in the Quonset Business Park, adjacent to the existing Davisville Substation. Equipment within the OnSS and ICF will include transformers, switchgear, up to two control houses, and transmission structures required to facilitate interconnection with the existing electrical grid. The tallest components within the OnSS and ICF are the overhead transmission structures, which measure approximately 80 feet (24 m) above ground level (AGL).

1.2.1 Visual Study Area

In order to define the maximum area of potential visual effect associated with the Project, EDR defined the VSA as all areas within 3 miles of the Project's limit of disturbance. The VSA includes approximately 30.5 square miles within the Town of North Kingstown and small portions of Warwick and East Greenwich, Rhode Island. In addition, the VSA includes a portion of Narragansett Bay. The VSA was used to characterize the landscape, assess potential Project visibility, and identify visually sensitive resources of national, regional, and statewide significance.

Figure 1.2-1. Visual Study Area

1.2.2 Existing Landscape Character

Definition of landscape character within a given VSA provides a useful framework for the analysis of a facility's potential visual effects. Landscape types (LTs) within the VSA were categorized based on the similarity of various features, including landform, vegetation, water, and/or land use patterns, in accordance with established visual resource assessment methodologies (Smardon et al., 1988; USDA Forest Service, 1995; USDOT Federal Highway Administration, 1981; USDI Bureau of Land Management, 1980). The USGS National Land Cover Dataset (NLCD) was used to help define the character and location of various LTs within the VSA (see Figure 1.2-1). The landscape types defined within the VSA are presented in Table 1.2-1.

Table 1.2-1 Landscape Types Within the VSA

Landscape Type	Acres Within VSA	Percent of VSA
Open Water	6848.4	35.1
Developed Land	5801.5	29.7
Forest	5001.7	25.6
Open Space	1545.0	7.9
Wetlands	193.4	1.0
Beach	67.2	0.3
Agricultural Land	50.9	0.3
Total	**19,508.2**	**100**

Open water is the most prevalent LT within the VSA due to the presence of Narragansett Bay. Narragansett Bay makes up approximately 35% of the VSA and includes portions of West Passage, Mill Creek, Fishing Cove, Wickford Harbor, and Bissel Cove. The Open Water LT is generally defined by broad expanses of open water including coves, harbors, and river estuaries prevalent along this portion of the bay. Both Prudence and Conanicut Islands define the West Passage and land is typically visible in all directions from any given point on the bay. Views over the water are generally longer distance than in other LTs within the VSA due to the lack of foreground screening features.

Developed Land comprises the second largest proportion of the VSA, making up approximately 30% of the total area. This LT is primarily comprised of industrial land associated with the Quonset Business Park, Quonset Point Naval Air Station, the Quonset Davisville Business Park, and other commercial and industrial areas within the Town of North Kingstown. Developed areas also include dense suburban residential developments located north and west of the business parks along the State Route 403, Interstate Route 1, and Davisville Road corridors within the VSA. Open views within this LT are generally limited by the presence of foreground buildings and vegetation.

The Forest LT occurs in small pockets around and including the Project site, but collectively makes up almost 26% of the VSA. Larger contiguous areas of forest land occur in the southern and western portions of the VSA and are associated with Cocumcussoc State Park, Black Swamp, and Calf Pasture Beach. Forest land also occurs between suburban residential developments in the northern portion of the VSA and include several wetlands unsuitable for residential development. Views within the Forest LT are generally restricted by the dense forest canopy and understory vegetation.

Open Space occurs throughout approximately 8% of the VSA and includes areas that are developed for the purpose of recreation, stormwater management, or managed vacant land. The largest representative example in this VSA is the North Kingstown Golf Course, located adjacent to and north of the Project site. Open space areas have a greater potential for outward, long-distance views than other terrestrial LTs within the VSA.

The remaining LTs collectively make up approximately 1.6% of the entire VSA and are scattered throughout in non-contiguous areas, thus making them a minor and inconsequential constituent of the VSA.

1.2.3 Distance Zones

Distance zones are typically defined in visual studies to divide the VSA into distinct classifications based on the various levels of landscape detail that can be perceived by a viewer. Three distinct distance zones were developed for this purpose. To define these zones, EDR consulted several well-established agency protocols, including those published by the U.S. Forest Service (USFS), Bureau of Land Management (BLM), and U.S. Department of Transportation (USDOT), to determine the appropriate extent of each distance zone. It is important to note that the distance zones recommended by each of these protocols were considered in the context of this VSA. For example, the BLM recommends a combined foreground-middle ground zone extending from 0 to 5 miles. While this may be appropriate in a western landscape with frequent, unscreened views over very long distances, it does not translate to eastern landscapes where views are often contained within 1.0 mile of the viewer. Conversely, the USFS (1995) suggests the foreground be defined as an area extending 0.5 mile from the viewer. Due to the characteristics of the specific landscape being evaluated in this VRA, EDR defined distance zones within the VSA (as measured from the proposed Project) as follows:

- Near-Foreground: 0 to 0.5 mile. At this distance, a viewer is able to perceive details of an object with clarity. Surface textures, small features, and the full intensity and value of color can be seen on foreground objects.

- Foreground: 0.5 to 1.5 miles. At this distance, elements in the landscape tend to retain visual prominence, but detailed textures become less distinct. Larger scale landscape elements remain as a series of recognizable and distinguishable landscape patterns, colors, and textures.

- Middle Ground: 1.5 to 3.0 miles. The middle ground is usually the predominant distance at which landscapes are seen. At these distances, a viewer can perceive individual structures and trees but not in great detail. This is the zone where the parts of the landscape start to join together; individual hills become a range, individual trees merge into a forest, and buildings appear as simple geometric forms. Colors will be distinguishable but subdued by a bluish cast and softer tones than those in the foreground. Contrast in texture between landscape elements will also be reduced.

The area of each LT falling within each distance zone in the VSA is summarized in Table 1.2-2. As shown in this table, the distribution of LTs within the individual distance zones varies significantly. Due to the presence of Narragansett Bay, the Open Water LS makes up between 27% and 39% of the Foreground and Middle Ground zones, respectively. However, Open Water makes up only 1% of the Near Foreground. Developed land makes up the greatest percentage of the Near Foreground and Foreground zones, at 64% and 46% respectively. This is largely due to the presence of existing commercial and industrial facilities located within the Quonset Business Park. Forest also makes up a significant portion of each distance zone with 29% in the Middle Ground, 17% in the Foreground, and 18% in the Near Foreground.

Table 1.2-2 Landscape Types Occurring in Each Distance Zone

Landscape Type	Percent of LS with the Near Foreground	Percent of LS with the Foreground	Percent of LS with the Middle Ground
Open Water	1.0	27.2	39.4
Forest	18.2	17.0	28.7
Developed Land	64.0	46.4	22.7
Open Space	15.2	7.3	7.7
Wetlands	1.5	1.7	0.7
Beach	0.0	0.4	0.4
Agricultural	0.1	0.0	0.3
Total	100	100	100

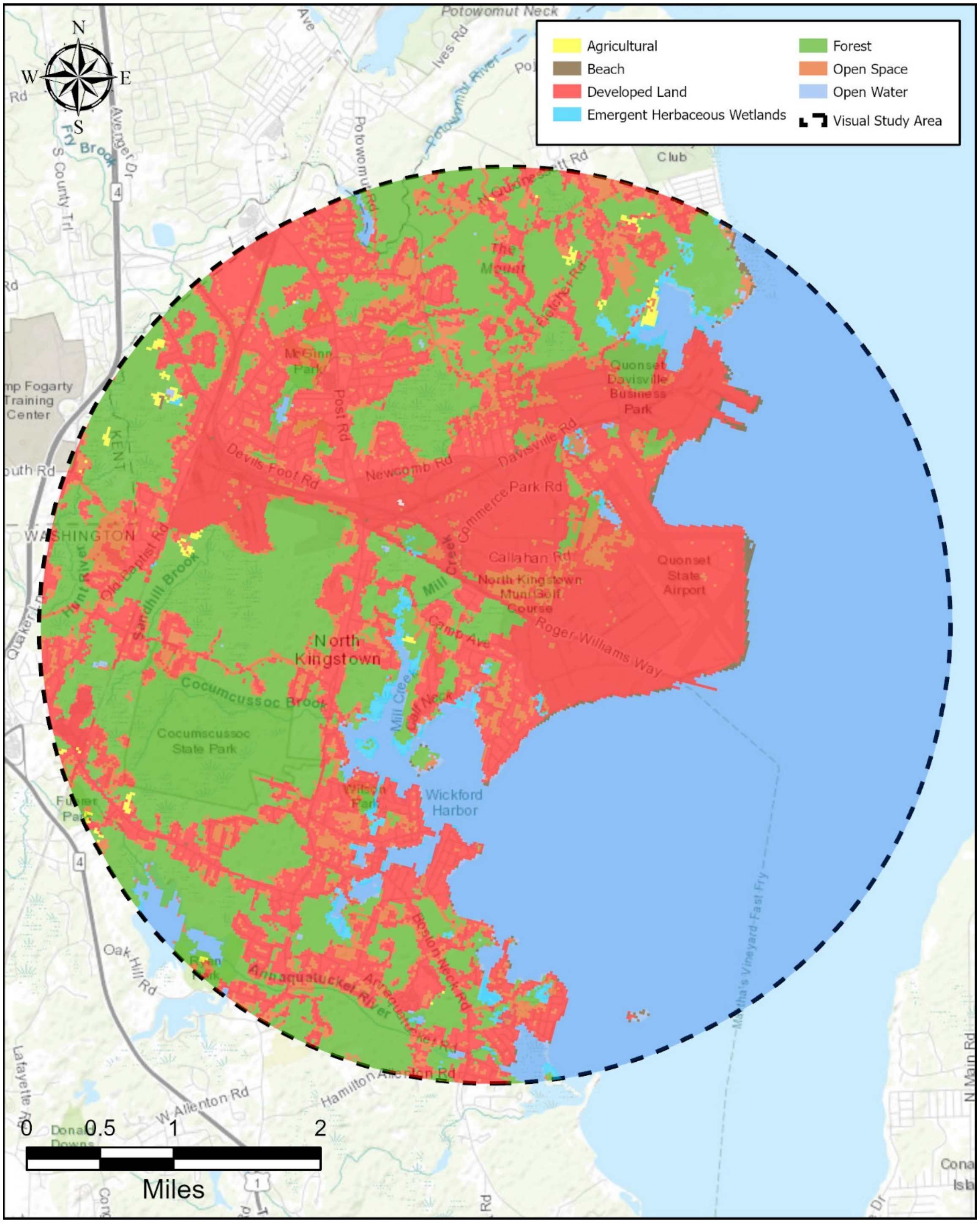

Figure 1.2-2. NLCD Cover Types within the Visual Study Area

1.2.4 Visually Sensitive Resources

The identification of visually sensitive resources is an important step in determining locations which may be particularly sensitive to visual change. These resources have generally been identified by national, state, or local governments, organizations, and/or Native American tribes as important sites which are afforded some level of recognition or protection. Avoiding or minimizing impacts to these resources is an important consideration in the planning stages of a project. For this VRA, an inventory of visually sensitive resources within the VSA was prepared. This inventory determined that the VSA includes 95 visually sensitive resources (VSRs), which are listed by category in Table 1.2-2 and depicted in Figure 1.2-2, below. Appendix A includes a complete list of individual resources.

Table 1.2-2 Visually Sensitive Resources within the VSA

Type of Resource	Number of Resources within the VSA
Historic Resources (State or National Register of Historic Places)	17
Rhode Island Historical Cemeteries	63
State Parks	1
Rhode Island State Scenic Areas	4
State Nature Preserve	1
Public Boat Launch and Fishing Access	5
State Lands	2
Ferry Ports	1
Major Waterbodies	1
Total	**95**

In addition to the publicly assessable resources identified within the VSA, the residential areas directly adjacent to the proposed Project are also considered visually sensitive resources in this visual analysis. These resources include approximately 10 residences along the south side of Camp Avenue. While these resources are not formally designated as VSRs, the residents in this location are as little as 150 feet from the Project site and are likely sensitive to any changes in the views available from their homes. As such, the construction and operation of the OnSS and ICF may result in visual effects to these users.

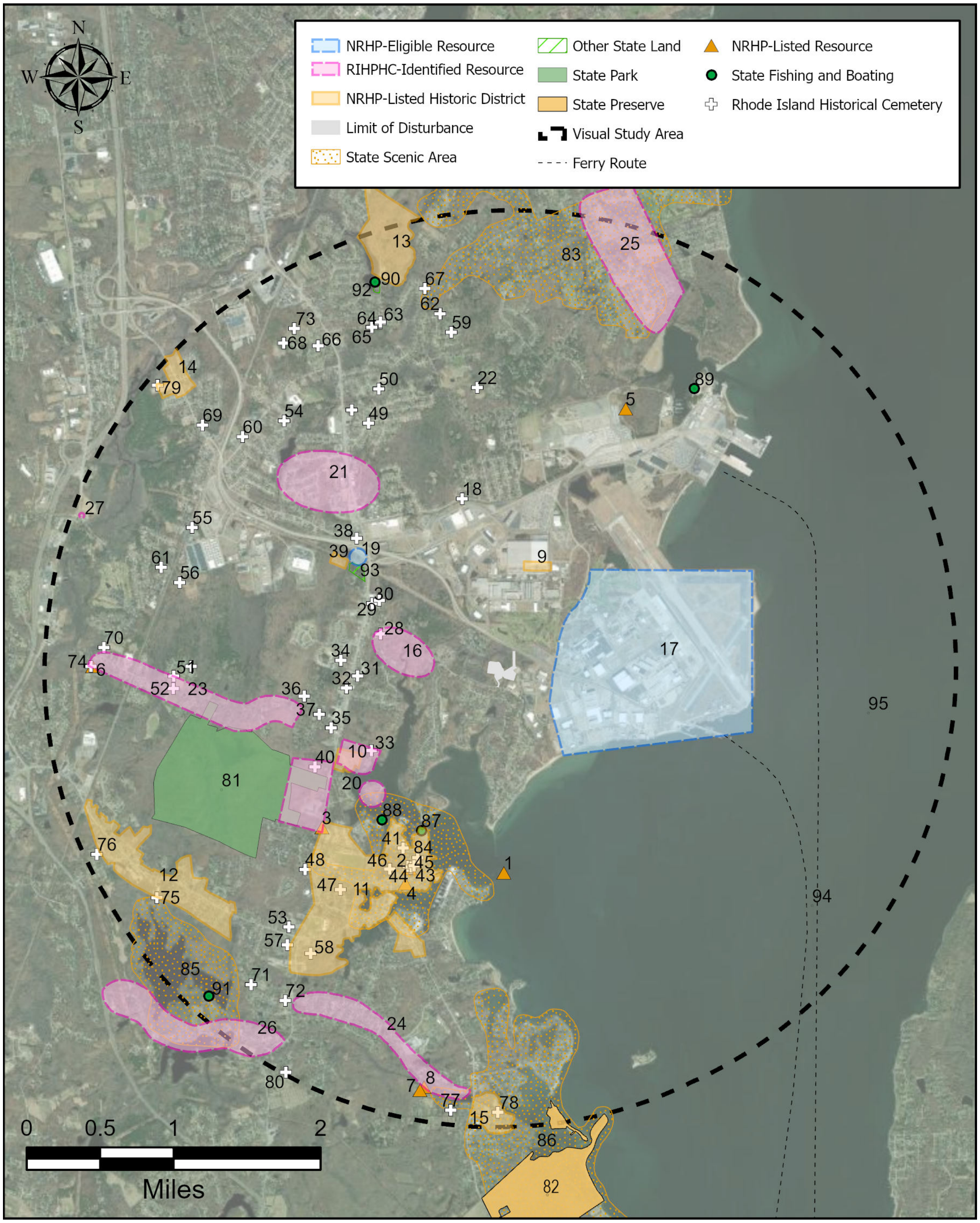

Figure 1.2-3. Visually Sensitive Resources Within the Visual Study Area

2.0 VISUAL RESOURCE ASSESSMENT

The specific techniques used to assess potential Project visibility and visual effects, along with the results of those assessments are described below.

2.1 Viewshed Analysis

2.1.1 Viewshed Analysis Methodology

To determine the geographic areas of potential visibility of the Project, EDR used a lidar-based viewshed analysis. This analysis considers the height of proposed above-ground Project components, along with a digital surface model (DSM) representing ground level elevations, vegetation, and structures present in the VSA. The DSM was derived from the 2011 American Recovery and Reinvestment Act lidar dataset with a horizontal resolution of one meter. A geographic information systems (GIS) analysis of these data was conducted to determine whether a direct line of sight would be available from ground level vantage points to the Project. If a direct line of sight is available, the position is coded as visible. Heights used in the viewshed calculations were based on 35 sample points within the OnSS ranging in height from 20 feet to 80 feet which represents the lightning masts, overhead transmission structures (the tallest facility structures), and the major enclosed structures (see Figure 2.1-1). The resulting geographic areas of potential Project visibility are referred to the Project zone of visual influence (ZVI) and will be the focus of the VRA.

To assure an accurate assessment of potential Project visibility, a few modifications were made to the lidar-derived DSM prior to analysis. Transmission lines and road-side utility lines that are reflected in the lidar data are mis-represented in the DSM as solid walls/screening features. In order to correct this inaccuracy, DSM elevation values within transmission line corridors and within 50 feet of road centerlines were replaced with bare earth elevation values. Additionally, all areas within the Project limit of disturbance were modeled with an assumption of no vegetation to reflect the bare-earth elevation in these locations. This modified DSM was then used as a base layer for the viewshed analysis. Once the viewshed analysis was completed, a conditional statement was used within ArcGIS® to set Project visibility to zero in locations where the DSM elevation exceeded the bare earth elevation by 6 feet or more, indicating the presence of vegetation or structures that exceed viewer height. This was done for two reasons; 1) in locations where trees or structures are present in the DSM, the viewshed would reflect visibility from the vantage point of standing on the tree top or building roof, which is not the intent of this analysis, and 2) to reflect the fact that ground-level vantage points within buildings or areas of vegetation exceeding 6 feet in height generally will be screened from views of the Project.

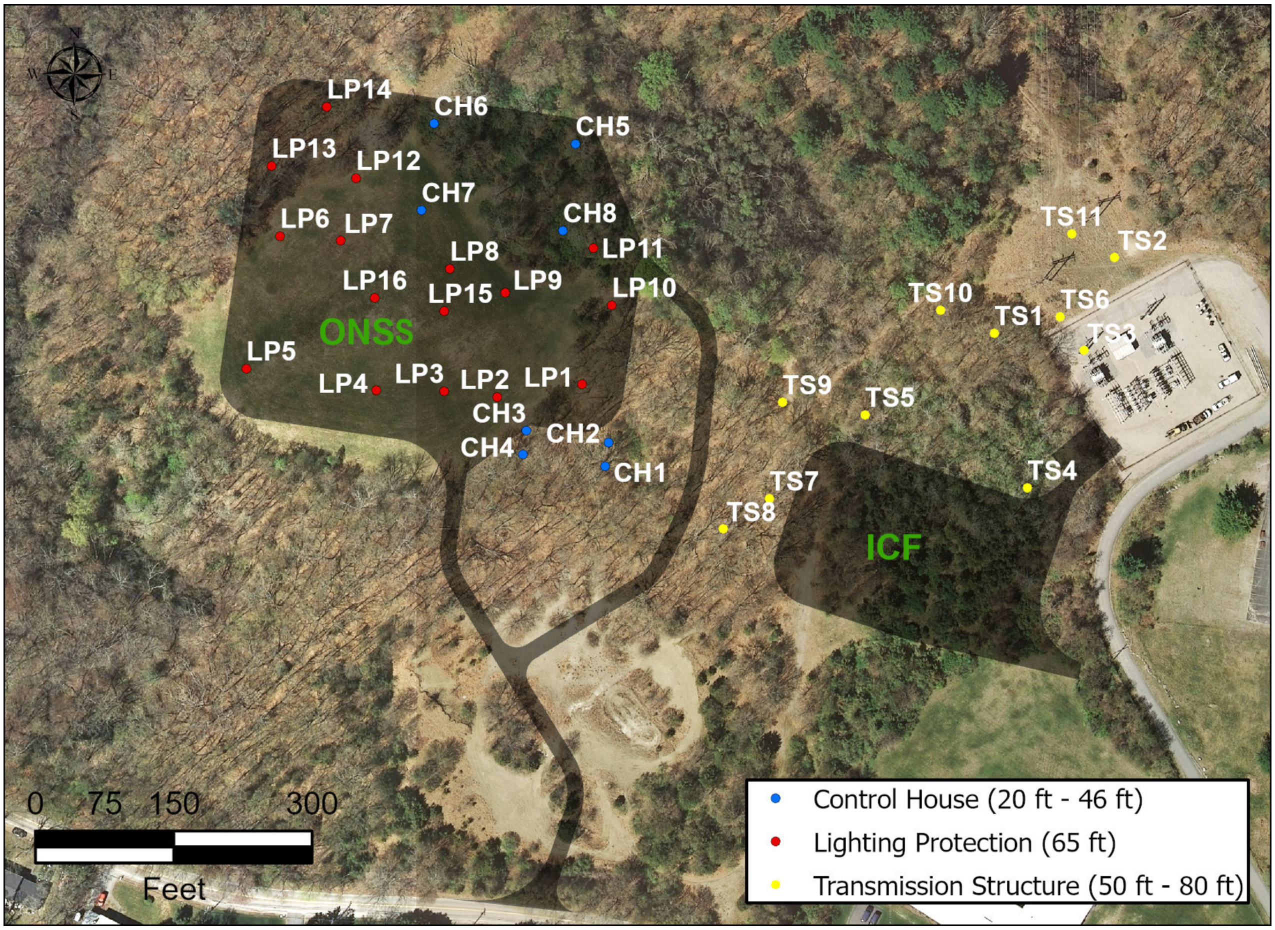

Figure 2.1-1. Viewshed Sample Points and Height Assumptions

2.1.2 Viewshed Analysis Results

The viewshed analysis results suggest that approximately 15% of the VSA could have some level of Project visibility. The greatest potential for Project visibility within the VSA occurs on portions of Narragansett Bay in the Foreground and Middle Ground zones. This visibility is largely the result of available long-distance views over open water, unincumbered by foreground features such as vegetation and buildings. The viewshed analysis also indicates potential visibility the immediate vicinity of the Project (within the Near Foreground zone). This generally includes discrete views between buildings and along portions of private and public roads within the Quonset Point Business Park. However, as noted in Section 2.1.2 the viewshed analysis assumes a 50-foot clearing zone along these roads suggesting the viewshed analysis result may present a conservative assessment of visibility that ignores roadside screening vegetation. Small areas of visibility were also indicated in the vicinity of Callahan Road, north of the Project site and along the immediate shoreline of Wickford Harbor and the Village of Wickford. In the western portion of the VSA, the viewshed analysis indicated no potential visibility beyond the limits of the Project site.

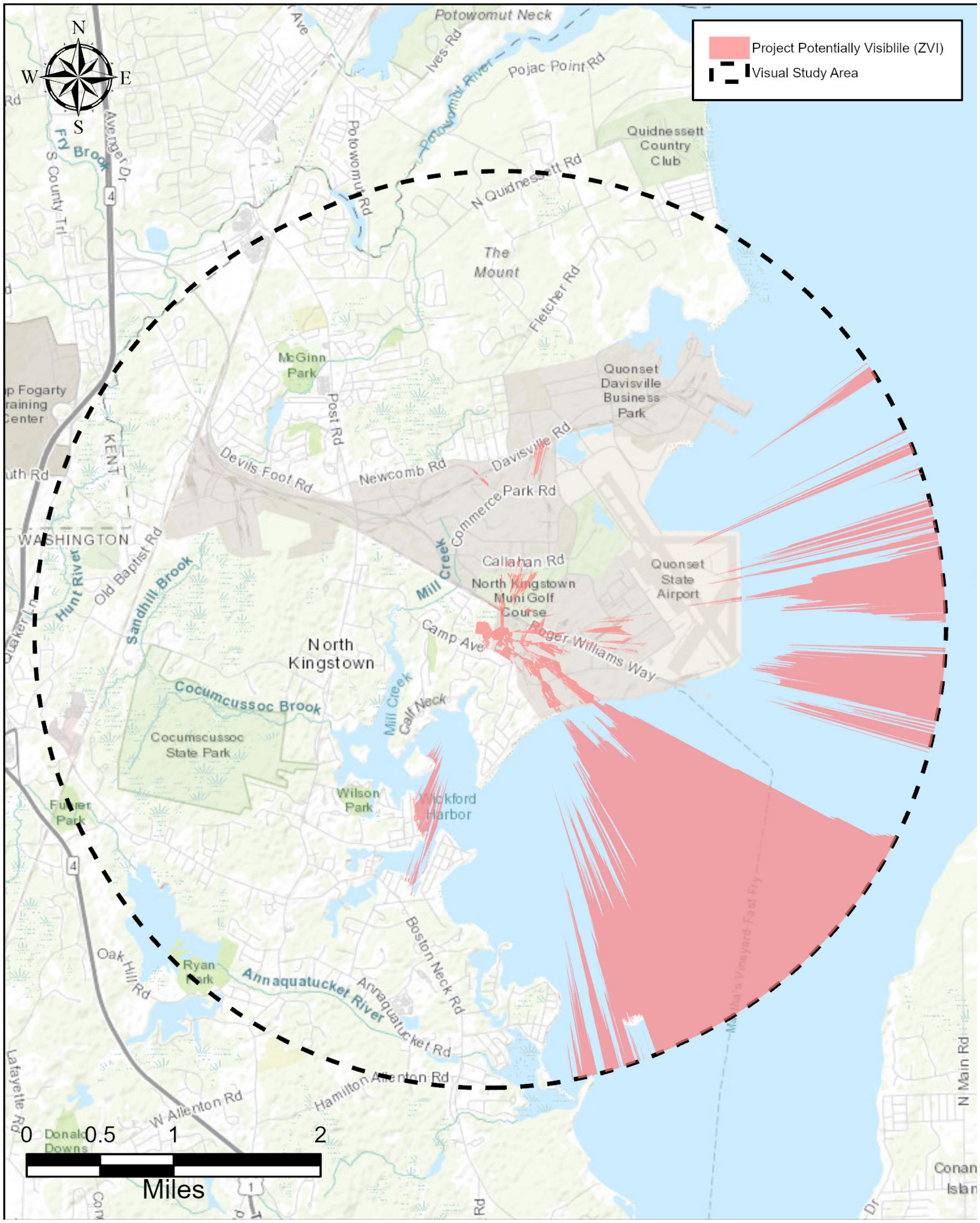

Figure 2.1-2. Viewshed Analysis Results

2.1.3 Visibility Results from Visually Sensitive Resources

Five of the 95 VSRs occurring within the 3-mile radius VSA were indicated as having potential visibility of the Project. A description of these resources, their distance from the Project, and the nature and degree of potential visibility as indicated by the viewshed analysis is provided in Table 2.1-1 and Figure 2.1-3, below. Appendix A contains a full list of VSRs keyed to Figure 2.1-3, their distance to the Project, and potential visibility.

Table 2.1-1 Visually Sensitive Resources with Project Visibility

Map ID	Resource Name	Distance from the Project (mi.)	Description of Resource	Description of Potential Visibility
11	Wickford Historic District	1.1	This historic district encompasses approximately 389.7 acres and is roughly bounded by Tower Hill Road, Wickford Cove, Mill Cove, and Fishing Cove.	An area of visibility occurs along the shoreline measuring approximately 0.3 miles long and includes residential properties along Pleasant Street as well as a small portion of the harbor. Generally, landscape vegetation limits outward views to the water and the immediate shoreline and inland visibility does not occur.
17	Quonset Point Naval Air Station	0.25	This NRHP-eligible site is an approximately 974-acre former US Navy training facility, built according to typical World War II-era design and construction concepts. The Quonset Point Naval Air Station was completed in 1941 in response to the new threats posed by military submarines and aircraft at the outbreak of World War II.	Visibility from within this VSR generally restricted to small discrete corridors occurring between existing buildings associated with the facility. Additionally, two large warehouse buildings were erected after the collection of lidar data. Based on the areas indicated as visible by the viewshed analysis, Project visibility could be significantly reduced with the addition of these buildings near the perimeter of the facility.
84	Wickford Harbor/Wickford Village State Scenic Area	1.0	The Rhode Island Landscape Inventory of State Scenic Areas lists this area as a “Historic Fishing Village with water views” and includes Mill Cove, Wickford Cove, the Village of Wickford, and portions of Main Street and Post Road.	See description for VSR 11
94	Quonset to Martha’s Vineyard Ferry	1.5	This ferry departs from Quonset Point and sails down Narragansett Bay to Vineyard Sound before arriving at Oak Bluffs on Martha’s Vineyard. The ferry service is only available during the summer season.	See description for VSR 95

Map ID	Resource Name	Distance from the Project (mi.)	Description of Resource	Description of Potential Visibility
95	Narragansett Bay	0.6	Narragansett Bay covers approximately 147 square miles. It is New England's largest estuary hosting a large number of ports, harbors, and marinas (some of which occur in the VSA).	Narragansett Bay has the largest areas of contiguous Project visibility within the VSA and is the only resource that could potentially have visibility out to the full extent of the VSA. However, the viewshed analysis considers the tallest portions of the Project which generally have a narrow profile. Visibility of the lightning mast and transmission structures is likely to be minimal given their narrow profile and the presence of buildings and vegetation between the Project and this resource.

In addition, to the VSR's described above, if construction of the Project requires vegetative clearing to the edge of Camp Avenue, a number of the residents on the south side of Camp Avenue could experience view of the Project. Vegetative clearing can result in changes to the lighting and shading of adjacent properties, and may reveal views of the Project, which can be characterized as a large, industrial installation.

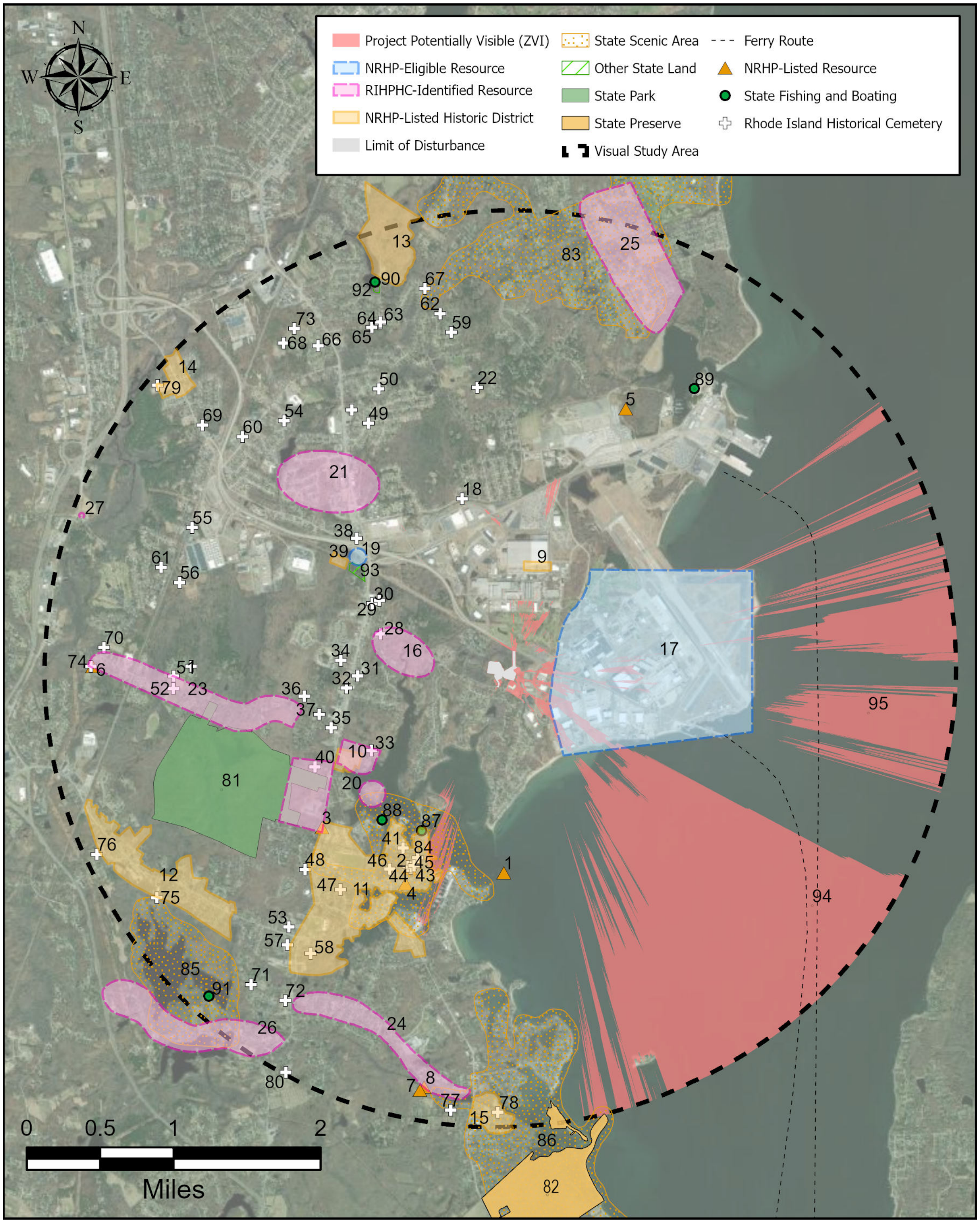

Figure 2.1-3. Visibility from Visually Sensitive Resources

2.1.4 Field Verification Methodology

EDR conducted site visits to the VSA on September 16, 2020 and October 16, 2020. The purpose of this field review was to verify potential visibility of the Project (as suggested by the viewshed analysis), to document the visual character within the VSA, and to identify the type and extent of existing visual screening.

During the site visit, EDR staff members drove public roads and visited public vantage points within the VSA, and obtained photographs from 21 individual viewpoints utilizing a digital SLR camera with a lens setting of 50 mm. Viewpoint locations were selected to document views from Camp Avenue, and within the Quonset Point Business Park. These locations were recorded using an in-camera global positioning system (GPS) unit, and all field notes, GPS points, focal length parameters, times, and dates were documented electronically. The viewpoint photographs are illustrated in Appendix B and the viewpoint locations are illustrated in Figure 2.1-4, below.

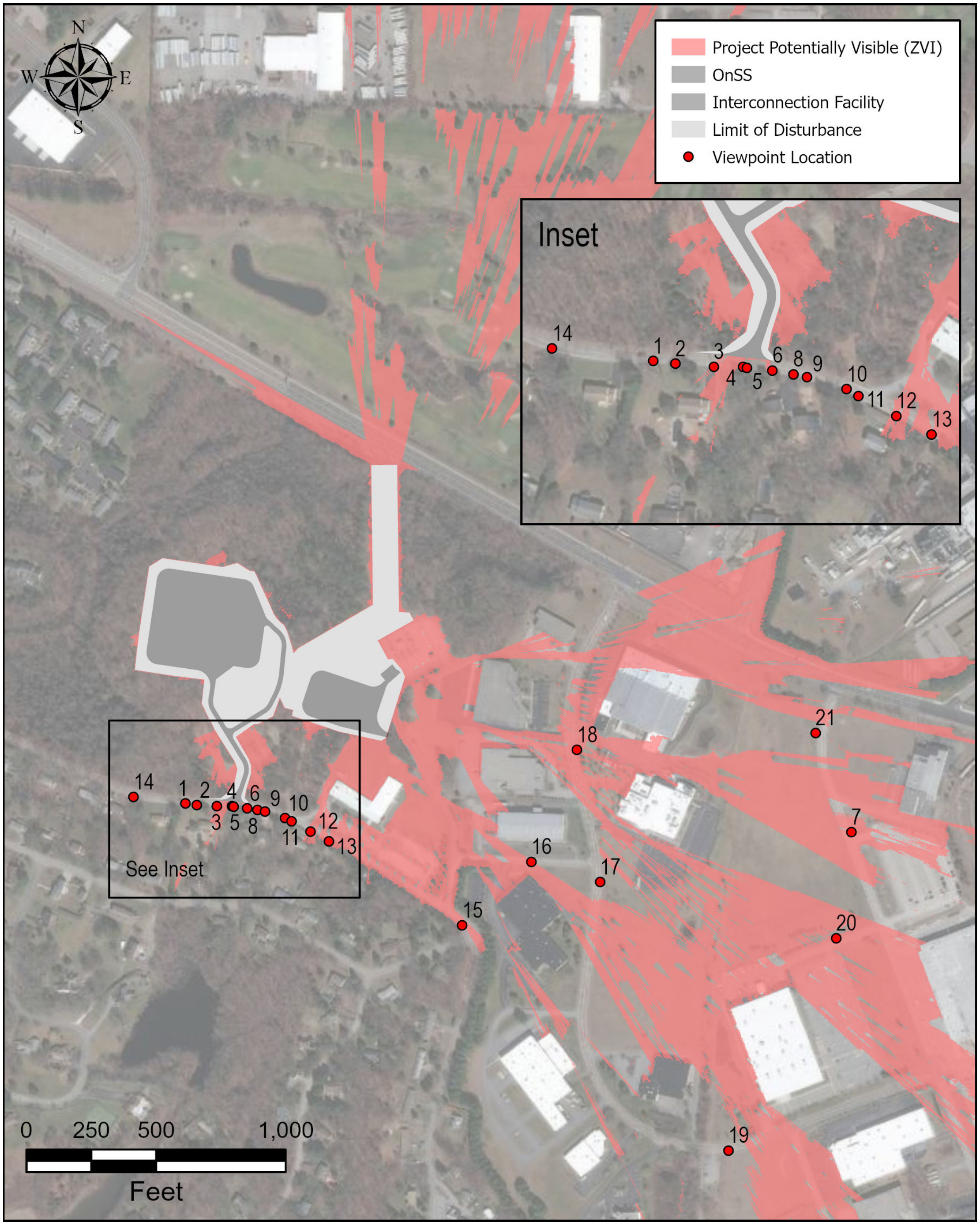

Figure 2.1-4. Viewpoint Locations

2.1.5 Field Verification Results

Field review suggests that visibility of the Project will be more limited than suggested by the viewshed analysis due to the presence of roadside vegetation. As mentioned previously, in order to avoid misinterpretation of overhead utility lines in the lidar data, the road corridors in the VSA were modeled with an assumption of no vegetation to a distance of 50 feet from the road centerline. This in effect eliminated the effect of any vegetative screening along public roads. Field photography was completed along Camp Avenue which runs adjacent to the Project site. In this location, the existing vegetative buffer completely screens views into the Project site. However, some changes to this buffer will be apparent to the adjacent residences due to a thinning of the buffer and changes in light quality. Visibility from within the adjacent Quonset Point Business Park will also be minimal and will likely only include the upper portions of the tallest components of the Project. In a number of locations (Camp Avenue, Circuit Drive, and Burlingham Avenue, visibility was limited by the presence of landscape vegetation combined with the presence of multiple structures.

2.1.6 Line of Sight Cross Section Methodology

The viewshed analysis identifies those locations where any portion of the OnSS or ICF facilities could potentially be seen from ground-level vantage points. This visibility may include only the top few feet of the tallest structures associated with the Project. In order to determine which facility components may be visible, EDR completed line of sight cross sections (LOS) from two visually sensitive resources indicated as having potential Project visibility by the viewshed analysis. In addition to illustrating the degree of Project visibility, the LOS also provide an opportunity to identify any additional screening features not included in the 2011 lidar data. To accomplish this, each LOS was overlaid on a recent (2018) aerial photograph of the VSA and the lidar data were used to create a specific cross sectional “cut” of the site topography, vegetation, and structures along a line specifically placed in the areas of the viewshed indicated as having Project visibility. Section A-A’ illustrates potential visibility from the Wickford Historic District and Wickford Harbor/Wickford Village State Scenic Area. Section B-B’ illustrates potential visibility from Narragansett Bay and Quonset Point Naval Air Station. The results of these analyses are provided in Section 2.1.7.

2.1.7 Line of Sight Cross Section Results

Line of Sight A-A’ (see Appendix C) begins near Main Street in Wickford Village and runs in a north-northeasterly direction across Wickford Harbor and Fishing Cove before making landfall near Fishing Cove Road in South Kingstown. The LOS crosses the residential neighborhoods along Windward Walk Road and Camp Avenue before entering the forested area leading up to the Project Site where it intersects the OnSS facility. As illustrated in the LOS, the OnSS is substantially screened from view and the only potentially visible Project component is the proposed interconnection transmission structures associated with the ICF. All of the lightning mast and lower level Project features are completely screened by existing structures and vegetation. It is likely that the visibility of the transmission structure will be imperceptible from the Village of Wickford at a distance of 1.5 miles do to the fact that the structures will have a relatively narrow profile and because only the upper 10 feet of the proposed structures are indicated as having potential visibility.

Line of Sight B-B’ begins in Narragansett Bay and runs northwest to the Quonset Point Business Park. From there it runs across two sections of Circuit Drive, intersecting two large warehouse structures and a portion of the Quonset Point Naval Air Station before entering the Project site where the LOS intersects the ICF and OnSS. As was the case with LOS A-A’, only a small portion of the top of the proposed transmission structures are likely to have potential visibility from the VSRs included along this section line due to screening provided by the structures and vegetation adjacent to the Project site. As discussed previously, at a distance of approximately 1.5 miles, the potentially visible portions of the Project will likely be imperceptible due to their narrow profile.

3.0 CONCLUSIONS

Based on results of the viewshed analysis, it is anticipated that the Project may be potentially visible from approximately 15% of the entire VSA and five of the 95 (5%) identified VSRs within the VSA. However, field review suggested that Project visibility would likely be significantly less than suggested by the viewshed analysis due to the presence of landscape vegetation present along roadways, which was not considered in the viewshed analysis.

As illustrated in the line of sight cross sections, being within the Project viewshed does not necessarily indicate that the Project will result in visual impacts to the VSR present within the VSA. In fact, for the majority of these resources, Project Visibility will only include the upper portions of a few proposed transmission structures. As the LOSs indicate from Wickford Historic District and Wickford Harbor/Wickford Village State Scenic Area, Narragansett Bay and the Quonset Point Naval Air Station, the Project will be barely perceptible amongst the buildings and vegetation present in the Quonset Point Business Park. This is particularly the case for viewpoints and viewers located greater than 1 mile from the Project.

However, where visible at near foreground distances, the proposed Project would introduce new industrial/utility structures into the landscape. At a maximum height of 80 feet, the proposed Project will not be out of scale or character with the existing types of development currently present in the vicinity, such as the existing Davisville Substation, or the structures at nearby Quonset Point Business Park. As such, it is anticipated that the Project will result in negligible visual impacts to the public resources present in the VSA. As mentioned previously, some Camp Avenue residences are likely to experience limited visual impacts as a result of the vegetative clearing associated with the ICF, OnSS and the Project access road. While these impacts are expected to alter the existing views experienced by the residents directly adjacent to the Project, they are generally localized and can be minimized through the use of mitigation, such as visual screening (see Section 3.1).

3.1 Mitigation

Options for mitigating the visual impacts of the Project are limited, given the nature of the Project and its siting criteria. However, various mitigation measures that were considered to minimize the Project's potential visual impacts are listed below:

- Siting. The proposed Project has been located near an existing substation which will limit perceived changes in land use and scenic quality. Given the lack of interconnection options close to the proposed landfall, relocation of the Project to another site would likely only relocate the potential visual impacts to a different part of the state. Given that the Project has been proposed in an area intended for industrial development, the Project is generally in keeping with this intended use. Additionally, the Project layout has been designed to accommodate various set-backs from roads, residences, private properties, wetlands and cultural resources, thus limiting options for relocation of individual Project components.

- Screening. Screening could be an effective treatment for the mitigation of views toward the proposed OnSS and ICF along portions of Camp Road. Additionally, the Project access road could benefit from a landscape treatment that is consistent with residential landscape vegetation and materials. This type of treatment is recommended to make the facility entrance appear similar to existing residential driveways in the area.

- Camouflage. Given the nature of the technology, camouflage is not under consideration for the proposed ICF and OnSS.

- Low Profile. The height of the lightning masts and transmission structures associated with the OnSS and ICF substations cannot be reduced due to safety considerations.

- Downsizing. The Project design responds to the on-site environmental constraints and limited space available around an existing substation. As such, the design already includes technology with the specific purpose of reducing the facility footprint and limiting the horizontal and vertical extent of the proposed equipment.

- Alternate Technologies. Alternate technologies for interconnection to the electric power grid are not available.

- Non-specular Materials. The Project will likely utilize galvanized materials that, although shiny at the time of installation, become dull over time.

- Lighting at the OnSS and ICF will be kept to a minimum, and turned on only as needed, either by switch or timer. Where possible lights will be directed downward and will utilize full cut-off fixtures to minimize off-site light trespasses

- Maintenance. The Project components and site will be maintained to assure a clean and orderly appearance.

As indicated above, the most effective mitigation measure will include supplemental vegetative screening and landscape treatment in order to address very localized visual impacts to the adjacent residents along Camp Avenue. With these mitigation measures effectively applied to the Project, it is anticipated that the Project will result in minimal impacts to sensitive resources and viewers within the VSA.

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Appendix A - Visually Sensitive Resources

* Blue Text Indicates Resources with Potential Project Visibility

Map ID	Resource Name	Distance From Project (mi.)	Distance Zone	Visibility Indicated in Viewshed Analysis
NRHP-Listed Resource				
1	Poplar Point Lighthouse	1.3	Foreground	No
2	Old Narragansett Church	1.4	Foreground	No
3	Palmer-Northrup House	1.4	Foreground	No
4	Saint Paul's Church	1.5	Foreground	No
5	Allen-Madison House	1.9	Middle Ground	No
6	Six Principle Baptist Church	2.7	Middle Ground	No
7	Esbon Sanford House	2.8	Middle Ground	No
8	Steven Northrup House	2.8	Middle Ground	No
NRHP-Listed Historic District				
9	Camp Endicott Davisville	0.7	Foreground	No
10	Smith's Castle	1.1	Foreground	No
11	**Wickford Historic District**	**1.5**	**Foreground**	**Yes**
12	Lafayette Village Historic District	2.5	Middle Ground	No
13	Forge Road Historic District	2.9	Middle Ground	No
14	Davisville Historic District	2.9	Middle Ground	No
15	Hamilton Mill Historic District	2.9	Middle Ground	No
16	Tourgee "Tidemill" Cottage	0.6	Foreground	No
Rhode Island Historical Preservation & Heritage Commission Resource				
17	**Quonset Point Naval Air Station**	**1.1**	**Foreground**	**Yes**
19	Devil's Foot Rock	1.2	Foreground	No
20	Wickford Historic District Expansion	1.5	Foreground	No
21	Nike Housing	1.7	Middle Ground	No
22	Aylesworth	1.9	Middle Ground	No
23	D. Larston Farm/1633 Stony Lane House	2	Middle Ground	No
24	360 Annaquatuckett Road	2.4	Middle Ground	No
25	Quidnesset Agricultural District	2.7	Middle Ground	No
26	Old Bellevue School	2.9	Middle Ground	No
27	Silas Jones House	3	Middle Ground	No
Rhode Island Historical Cemetery				
18	Peleg Card Lot	1.2	Foreground	No
28	Chase and Wheeden Cemetery	0.8	Foreground	No
29	Pearce - Watson	0.9	Foreground	No
30	Pierce and Phillips	0.9	Foreground	No
31	Carpenter	0.9	Foreground	No
32	Brown and Briggs	0.9	Foreground	No
33	Ayrrault Condon Updike	0.9	Foreground	No
34	Reynolds	1	Foreground	No
35	Hall	1.1	Foreground	No
36	Sedgefield Road Lot	1.2	Foreground	No
37	Smith	1.2	Foreground	No
38	Vaughn and Arnold	1.3	Foreground	No
39	Devil's Foot Cemetery	1.3	Foreground	No
40	Hall and Carpenter	1.3	Foreground	No
41	Constantino Lot	1.3	Foreground	No
42	Quaker Graveyard	1.3	Foreground	No
43	Young	1.3	Foreground	No
44	St Paul - Updike	1.4	Foreground	No

* Blue Text Indicates Resources with Potential Project Visibility

Map ID	Resource Name	Distance From Project (mi.)	Distance Zone	Visibility Indicated in Viewshed Analysis
45	Wightman Lot	1.4	Foreground	No
46	Whitford Lot	1.4	Foreground	No
47	Kimath-Tennant	1.7	Middle Ground	No
48	Smith Cemetery	1.8	Middle Ground	No
49	Gardiner	1.9	Middle Ground	No
50	Reynolds lot	2.1	Middle Ground	No
51	Reynolds	2.1	Middle Ground	No
52	Jacoy	2.1	Middle Ground	No
53	Thomas Lot	2.1	Middle Ground	No
54	Capt Ebenezer Slocum	2.2	Middle Ground	No
55	Hunt Cemetery	2.2	Middle Ground	No
56	Burdick Farm Graveyards	2.2	Middle Ground	No
57	Peckham	2.2	Middle Ground	No
58	Boone Cemetery	2.2	Middle Ground	No
59	Old Tanner Cemetery	2.3	Middle Ground	No
60	Chadsey-Gardiner	2.3	Middle Ground	No
61	Hunt and Hall	2.3	Middle Ground	No
62	Old Tanner	2.4	Middle Ground	No
63	Warner Lot	2.5	Middle Ground	No
64	Very Lot	2.5	Middle Ground	No
65	Joseph Phillips	2.5	Middle Ground	No
66	Quidnesset Memorial Cemetery	2.5	Middle Ground	No
67	William Reynolds Lot	2.6	Middle Ground	No
68	H. Austin	2.6	Middle Ground	No
69	Tourgee	2.6	Middle Ground	No
70	Sweet	2.6	Middle Ground	No
71	Phillips-Gardiner Cemetery	2.6	Middle Ground	No
72	Lawton Lot	2.6	Middle Ground	No
73	Hall Cemetery	2.7	Middle Ground	No
74	Old Baptist Meeting House	2.7	Middle Ground	No
75	Carr Lot	2.7	Middle Ground	No
76	Phillips	2.9	Middle Ground	No
77	Hiscox	2.9	Middle Ground	No
78	Ayrault	2.9	Middle Ground	No
79	Davis	3	Middle Ground	No
80	Eldred	3	Middle Ground	No
State Park				
81	Cocumcussoc State Park	1.3	Foreground	No
State Forest Preserve				
82	John H. Chafee Rome Point Preserve, Rome Point	2.8	Middle Ground	No
Rhode Island State Scenic Area				
83	Quidnessett Farm Lands	2.5	Middle Ground	No
84	**Wickford Harbor/Wickford Village**	**1**	**Foreground**	**Yes**
85	Belleville Pond	2.5	Middle Ground	No
86	Bissel Cove/Rome Point	2	Middle Ground	No
Public Boating & Fishing Access				
87	Pleasant Street Boat Ramp	1.1	Foreground	No
88	North Kingstown Boat Ramp	1.2	Foreground	No

* Blue Text Indicates Resources with Potential Project Visibility

Map ID	Resource Name	Distance From Project (mi.)	Distance Zone	Visibility Indicated in Viewshed Analysis
89	Allen Harbor Fishing/Boating Access	2.3	Middle Ground	No
90	Potowomut Pond Fishing/Boating Access	2.8	Middle Ground	No
91	Belleville Pond Fishing/Boating Access	2.9	Middle Ground	No
92	Potowomut Pond Access Park	2.7	Middle Ground	No
Local Park				
93	Devils Foot Rock Park	1	Foreground	No
Ferry Terminal				
94	**Quonset - Martha's Vineyard Ferry**	**1.5**	**Foreground**	**Yes**
Major Body of Water				
95	**Narraganset Bay**	**0.6**	**Foreground**	**Yes**

Appendix B: Viewpoint Photolog

Viewpoint: 1

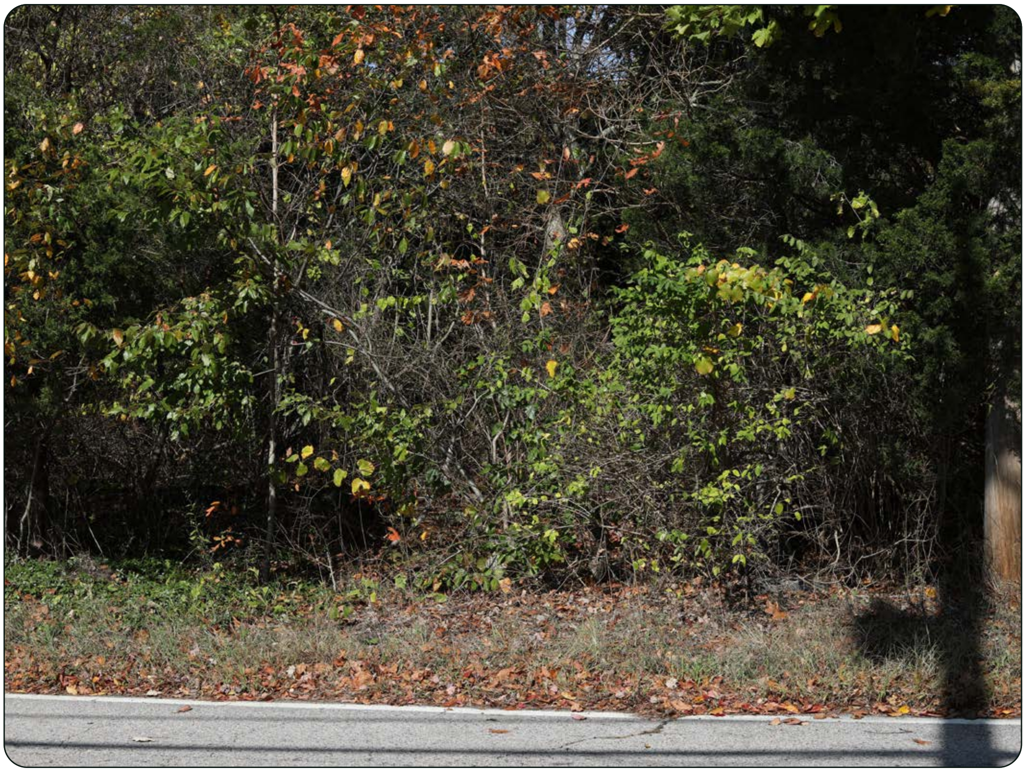
Location:
41.59092102° N,
71.43838761° W

View from Camp Ave, in the Town of North Kingstown, Washington County, looking North

Viewpoint: 2

Location:
41.59090652° N,
71.43822558° W

View from Camp Ave, in the Town of North Kingstown, Washington County, looking North



Viewpoint: 3

Location:
41.59089000° N,
71.43794833° W

View from Camp Ave, in the Town of North Kingstown, Washington County, looking North

Viewpoint: 4

Location:
41.59089000° N,
71.43773333° W

View from Camp Ave, in the Town of North Kingstown, Washington County, looking North

Viewpoint: 5

Location:
41.59088380° N,
71.43770656° W

View from Camp Ave, in the Town of North Kingstown, Washington County, looking North

Viewpoint: 6

Location:
41.59086980° N,
71.43752141° W

View from Camp Ave, in the Town of North Kingstown, Washington County, looking North-Northwest

Viewpoint: 7

Location:
41.59061161° N,
71.42900400° W

View from Burlingham Ave, in the Town of North Kingstown, Washington County, looking West

Viewpoint: 8

Location:
41.59084911° N,
71.43737048° W

View from Camp Ave, in the Town of North Kingstown, Washington County, looking North-Northwest

Viewpoint: 9

Location:
41.59083402° N,
71.43727003° W

View from Camp Ave, in the Town of North Kingstown, Washington County, looking Northwest

Viewpoint: 10

Location:
41.59076664° N,
71.43698285° W

View from Camp Ave, in the Town of North Kingstown, Washington County, looking Northwest

Viewpoint: 11

Location:
41.59073041° N,
71.43689662° W

View from Camp Ave, in the Town of North Kingstown, Washington County, looking Northwest

Viewpoint: 12

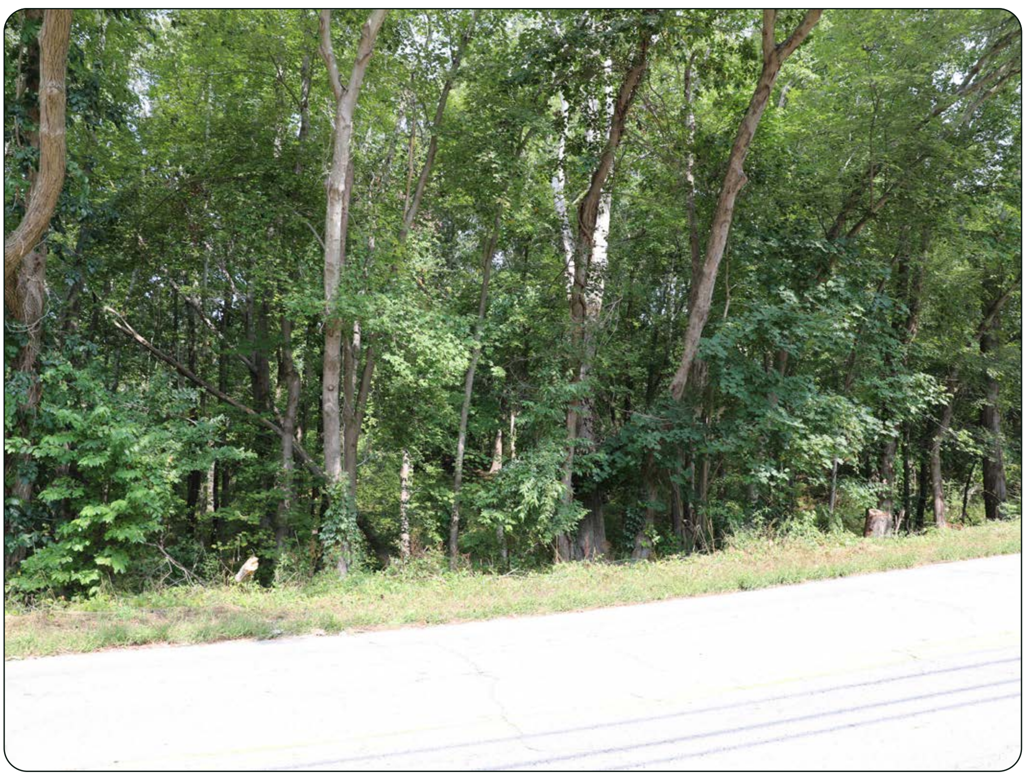
Location:
41.59062155° N,
71.43662434° W

View from Camp Ave, in the Town of North Kingstown, Washington County, looking Northwest

Viewpoint: 13

Location:
41.59052014° N,
71.43636785° W

View from Camp Ave, in the Town of North Kingstown, Washington County, looking Northwest



Viewpoint: 14

Location:
41.59098986° N,
71.43911872° W

View from Camp Ave, in the Town of North Kingstown, Washington County, looking North-Northeast

Viewpoint: 15

Location:
41.58963000° N,
71.43448833° W

View from Camp Ave, in the Town of North Kingstown, Washington County, looking West

Viewpoint: 16

Location:
41.59030167° N,
71.43351333° W

View from Camp Ave, in the Town of North Kingstown, Washington County, looking West

Viewpoint: 17

Location:
41.59008667° N,
71.43254440° W

View from Circuit Dr., in the Town of North Kingstown, Washington County, looking West

Viewpoint: 18

Location:
41.59148500° N,
71.43286833° W

View from Circuit Dr., in the Town of North Kingstown, Washington County, looking West

Viewpoint: 19

Location:
41.58724667° N,
71.43073833° W

View from Circuit Dr., in the Town of North Kingstown, Washington County, looking North-Northwest

Viewpoint: 20

Location:
41.58949000° N,
71.42921667° W

View from Burlingham Ave, in the Town of North Kingstown, Washington County, looking West

Viewpoint: 21

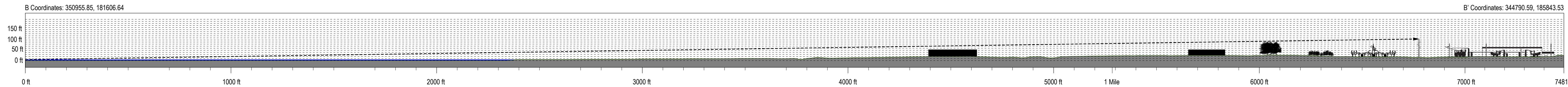
Location:
41.59166167° N,
71.42950667° W

View from Burlingham Ave, in the Town of North Kingstown, Washington County, looking West

Appendix C: Line of Sight Cross Sections

Revolution Wind Onshore Facilities
North Kingstown, Rhode Island

Appendix C - Line of Sight Cross Sections



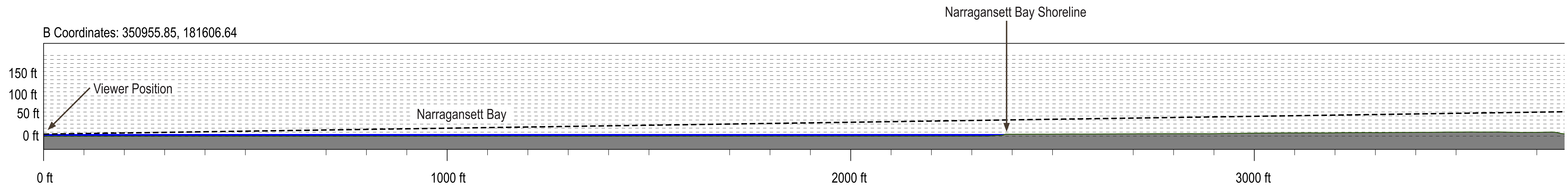
B

Section B - B'

B'

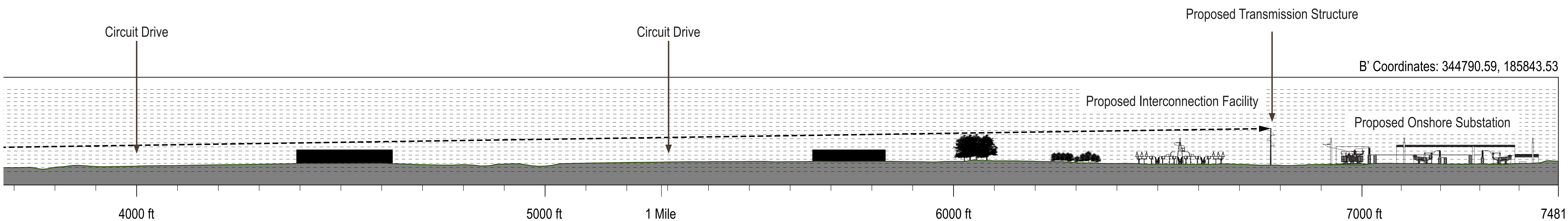
Detail 1

Detail 2



B

Detail 1

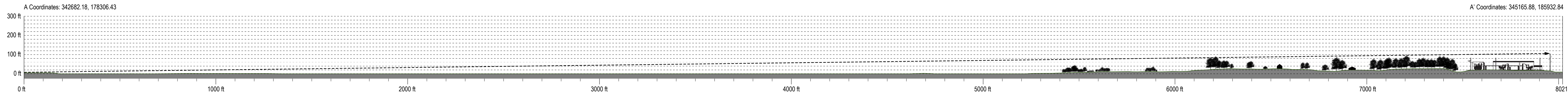


Detail 2

B'

Revolution Wind Onshore Facilities
North Kingstown, Rhode Island

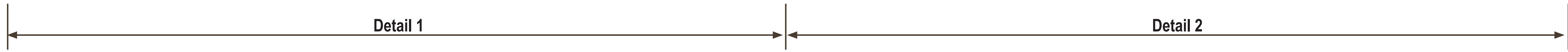
Appendix C - Line of Sight Cross Sections

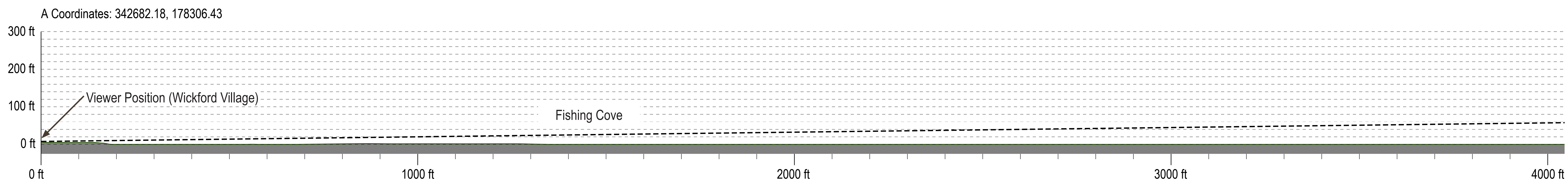


A

Section A - A'

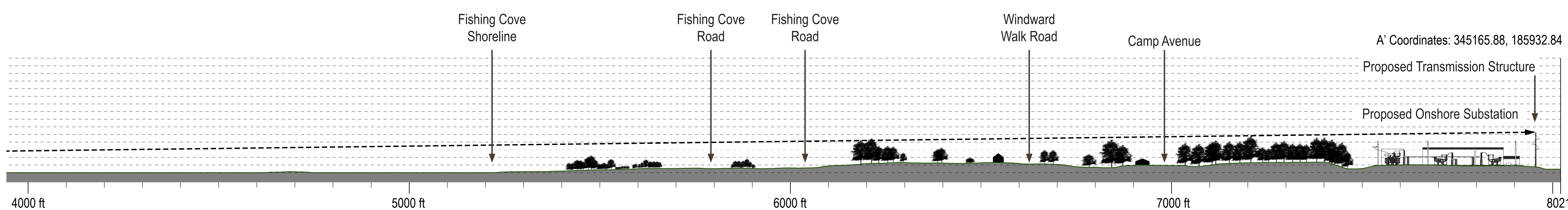
A'





A

Detail 1



Detail 2

A'

RevWind Exhibit 1(A)(vii)

Extremely Low Frequency Electric and Magnetic Fields and Health—Review and Update of the Current Status 2018-2020

RevWind Exhibit 1(A)(vii)

Appendix F:
Extremely Low Frequency Electric and Magnetic Fields and Health- Review and Update of the Current Status 2018-2

Health Sciences Practice

Exponent®

Extremely Low Frequency Electric and Magnetic Fields and Health – Review and Update of the Current Status

2018 – 2020

Extremely Low Frequency Electric and Magnetic Fields and Health – Review and Update of the Current Status

2018 – 2020

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For submittal to:

Rhode Island Energy Facilities Siting Board
Public Utilities Commission
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December 28, 2020

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Acronyms and Abbreviations

AC	Alternating current
ADHD	Attention-deficit/hyperactivity disorder
ALL	Acute lymphoblastic leukemia
ALS	Amyotrophic lateral sclerosis
ARPANSA	Australian Radiation Protection and Nuclear Safety Agency
B-ALL	B-lineage acute lymphoblastic leukemia
CgA	Chromogranin A
CHD	Congenital heart disease
CI	Confidence interval
CNS	Central nervous system
EFHRAN	European Health Risk Assessment Network
EFSB	Energy Facilities Siting Board
ELF	Extremely low frequency
EMF	Electric and magnetic fields
G	Gauss
HHS	Health and Human Services
Hz	Hertz
IARC	International Agency for Research on Cancer
ICES	International Committee for Electromagnetic Safety
ICNIRP	International Commission on Non-Ionizing Radiation Protection
kV	Kilovolt
kV/m	Kilovolts per meter
mG	Milligauss
NIEHS	National Institute for Environmental and Health Sciences
NRPB	National Radiation Protection Board of Great Britain
NZMH	New Zealand Ministry of Health
OR	Odds ratio
ROW	Right of way
RR	Relative risk
SCENIHR	Scientific Committee on Emerging and Newly Identified Health Risks
SSM	Swedish Radiation Safety Authority
TWA	Time weighted average
V/m	Volts per meter
WHO	World Health Organization

Limitations

At the request of Vanasse Hangen Brustlin, on behalf of Revolution Wind, LLC, Exponent prepared this summary report on the status of research related to extremely low-frequency electric and magnetic fields and health. The findings presented herein are made to a reasonable degree of scientific certainty. Exponent reserves the right to supplement this report and to expand or modify opinions based on review of additional material as it becomes available, through any additional work, or review of additional work performed by others.

The scope of services performed during this investigation may not adequately address the needs of other users of this report, and any re-use of this report or its findings, conclusions, or recommendations presented herein is at the sole risk of the user. The opinions and comments formulated during this assessment are based on observations and information available at the time of the investigation. No guarantee or warranty as to future life or performance of any reviewed condition is expressed or implied.

Executive Summary

This report was prepared to update the Rhode Island Energy Facility Siting Board (EFSB) on current human health research relating to extremely low frequency (ELF) electric and magnetic fields (EMF) at the request of Revolution Wind, LLC (Revolution Wind). This will assist the EFSB and the public consider evidence from scientific research addressing these fields and public health and the scientific consensus of health and scientific agencies on this topic. This report fulfills the EFSB requirement that applications for transmission facilities "shall include a review of the current independent scientific research pertaining to electromagnetic fields (EMF)."[1] The focus of this report is on the scientific literature published during the period from October 1, 2018, to October 1, 2020, and serves to update the Exponent report titled "*Research on Extremely Low Frequency Electric and Magnetic Fields and Health – A Status Report, September 1, 2016 – October 1, 2018*," dated February 20, 2019 (Exponent, 2019).[2]

Questions about ELF EMF and health are commonly raised during the permitting of electric transmission lines. ELF EMF are invisible fields surrounding all objects that generate, use, or transmit electricity. People living in developed countries are almost constantly exposed to ELF EMF in their environments because the electricity network is an essential infrastructure of technologically-advanced societies. Sources of manmade ELF EMF include household electrical appliances (e.g., hair dryers, vacuum cleaners), electric motors, wiring in homes and offices, and distribution and transmission lines. Section 1 of this report provides information on the nature and sources of ELF EMF and typical exposure levels.

Since the late 1970s, researchers have examined whether ELF EMF from manmade sources can cause short- or long-term health effects in humans using a variety of research studies, including epidemiologic (observational studies of humans), *in vivo* (experimental studies of whole animals), and *in vitro* (experimental studies of cells and tissues). In a health risk assessment of any exposure, it is essential to consider the type and strength of research studies available for evaluation. Scientists use systematic methods (often referred to as weight-of-evidence reviews) to evaluate observations and assess the potential impact of a specific agent on human health. This process is designed to ensure that more weight is given to those studies of better quality, and to ensure that studies with a given result are not selectively chosen from available studies to advocate or suppress a preconceived idea of an adverse effect. The methods used by scientists and scientific organizations to assess whether the evidence points to a causal link between an exposure (such as ELF EMF) and adverse human health effects are described in Section 2 of this report.

The existing body of scientific literature on ELF EMF and health is extensive and has been

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1 http://www.ripuc.ri.gov/efsb/EFSB2/SB2018_05_Rule_Practice.pdf

2 Exponent's 2019 report was developed at the request of Eversource Energy for the Massachusetts Energy Facilities Siting Board.

thoroughly and repeatedly evaluated by multidisciplinary expert panels convened by numerous national and international health, scientific, and governmental agencies, including the International Agency for Research on Cancer (IARC), the Scientific Committee of Emerging and Newly Identified Health Risks (SCENIHR)[3] of the European Union, and the World Health Organization (WHO). The most comprehensive of these reviews was published by the WHO in 2007, in which the WHO's Task Group critically reviewed the cumulative epidemiologic and laboratory research through 2005, taking into account the strength and quality of the individual research studies. Section 3 provides a summary of the reviews conducted by the WHO and, more recently, by SCENIHR. Overall, none of these agencies and expert panels have concluded that long-term exposure to ELF EMF is known to cause any adverse health effect, including cancer and other illnesses.

Section 4 of this report contains a review of recent research results published between October 1, 2018, and October 1, 2020. The particular health outcomes reviewed include childhood cancers (leukemia and brain cancer), adult cancer (brain cancer, breast cancer, and leukemia), reproductive and developmental effects, neurodegenerative diseases, and cardiovascular disease. A brief overview of recent *in vivo* studies relevant to carcinogenesis also is included. These recent studies do not provide sufficient evidence to alter the basic conclusions expressed by the WHO and other organizations that conducted comprehensive reviews of the scientific evidence—that the research does not confirm that electric fields or magnetic fields are a cause of cancer or any other disease at the levels we encounter in our everyday environment. The current guidance from the WHO on its website states,*"[b]ased on a recent in-depth review of the scientific literature, the WHO concluded that current evidence does not confirm the existence of any health consequences from exposure to low level electromagnetic fields."*[4] While the large body of existing research does not confirm any likely harm associated with ELF EMF exposure at low levels, research on this topic will continue to reduce remaining scientific uncertainty.

The scientifically-established standards and guidelines for EMF exposure are discussed in Section 5. Recommended exposure limits for the general public have been established by the International Commission on Non-Ionizing Radiation Protection and the International Committee for Electromagnetic Safety. The WHO recommends adherence to these limits for the prevention of established acute health effects at high exposure levels. Finally, an overall summary of the report is provided in Section 6.

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[3] SCENIHR was succeeded in 2016 by the Scientific Committee on Health, Environmental and Emerging Health Risks (i.e., SCHEER). Since the reports on EMF were published while the committee was known as SCENIHR, we refer to SCENIHR rather than SCHEER throughout this report.

[4] https://www.who.int/peh-emf/about/WhatisEMF/en/index1.html

1 Nature and Characteristics of Electric and Magnetic Fields

Electricity is transmitted as current from generating sources to high-voltage transmission lines, substations, distribution lines, and then finally to our homes and workplaces for consumption. The vast majority of electricity in North America is transmitted as alternating current (AC), changing direction in full cycles 60 times per second (i.e., a frequency of 60 Hertz [Hz]). Extremely low frequency (ELF) electric and magnetic fields (EMF) from these AC sources are often referred to as power-frequency EMF.

Everything that is connected to our electrical system (i.e., power lines, appliances, and wiring) produces ELF EMF. Electric fields and magnetic fields are both properties of the space near these electrical sources. Forces are experienced by objects capable of interacting with these fields; electric charges are subject to a force in an electric field, and moving charges experience a force in a magnetic field.

- **Electric fields** are the result of voltages applied to electrical conductors and equipment. The electric field is expressed in units of volts per meter (V/m) or kilovolts per meter (kV/m), where 1 kV/m is equal to 1,000 V/m. Conducting objects including fences, buildings, and our own skin and muscle easily block electric fields. Therefore, certain appliances within homes and workplaces are the major source of electric fields indoors, while power lines are the major source of electric fields outdoors.

- **Magnetic fields** are produced by the flow of electric currents. Unlike electric fields, however, most materials (including the earth) do not readily block magnetic fields. The strength of a magnetic field is expressed as magnetic flux density in units of gauss (G) or milligauss (mG), where 1 G is equal to 1,000 mG.[5] The strength of the magnetic field at any point depends on characteristics of the source, including (in the case of power lines) the arrangement of conductors, the amount of current flow, and distance from the conductors.

Sources and exposure

The intensity of both electric fields and magnetic fields diminishes with increasing distance from the source. For example, higher EMF levels are measured close to the conductors of distribution and transmission lines and decrease rapidly with increasing distance from the conductors, generally at a rate in proportion to the square of the distance.

Since electricity is such an integral part of our infrastructure (e.g., transportation systems) and our homes and businesses, people living in modern communities are surrounded by these fields

[5] Scientists also refer to magnetic flux density at these levels in units of microtesla. Magnetic flux density in mG units can be converted to microtesla by dividing by 10 (i.e., 1 mG is equal to 0.1 microtesla).

(Figure 1). While EMF levels decrease with distance from the source, any home, school, office, or other work environment tends to have a background EMF level as a result of the combined effect of the numerous EMF sources present in these locations.

Figure 1. Common sources of ELF EMF in the home (appliances, wiring, currents running on water pipes, and nearby distribution and transmission lines).

Figure 2 outlines typical EMF levels measured in residential settings and occupational environments (all of which contribute to a person's background EMF level) compared to typical EMF levels measured at a typical transmission line's right-of-way (ROW).[6] In general, the background magnetic-field level as estimated from the average of measurements throughout a house away from appliances may range up to approximately 5 mG, while levels can be hundreds of mG in close proximity to appliances. Background levels of electric fields range from 10 to 20 V/m, while appliances produce levels up to several tens of V/m (WHO, 1984).

Experiments have yet to show which aspect of long-term ELF EMF exposure, if any, may be relevant to biological systems. The most commonly used metric of EMF exposure for health research is long-term, average personal exposure, which is the average of all exposures to the varied electrical sources encountered in the many places we spend our days and nights. As expected, this exposure is different for every person and is difficult to approximate. Exposure assessment is a source of uncertainty in epidemiologic studies of ELF EMF and health (WHO,

[6] Underground transmission lines are not included in this figure because they are an uncommon source of magnetic-field exposure except in urban areas. The magnetic-field level over buried conductors can be as high as, or even higher than, an overhead line, but the magnetic field will diminish more quickly with distance. No electric field is produced above ground by underground cables.

2007). The following are some basic conclusions drawn from surveys of the general public's exposure to magnetic fields:

- **Residential sources of magnetic-field exposure**:
  - Residential magnetic-field levels are caused by currents carried by nearby transmission and distribution systems, pipes or other conductive paths, and electrical appliances (Zaffanella, 1993).
  - The highest magnetic-field levels are typically found directly next to appliances (Zaffanella, 1993). The National Institute of Environmental Health Sciences identified field levels at various distances from a number of common appliances in the home—the highest reported measured values at 6-inches from selected appliances were as follows: can opener, 1,500 mG; vacuum cleaner, 700 mG; electric range, 200 mG; dishwasher, 100 mG; and washing machine, 100 mG; to name a few (NIEHS, 2002).
  - Several parameters affect personal magnetic-field exposures at home: residence type, residence size, type of water line, and proximity to overhead power lines. Persons living in small homes, apartments, homes with metallic piping, and homes close to three-phase electric power distribution and transmission lines tended to have higher at-home magnetic-field levels (Zaffanella and Kalton, 1998).
- **Personal magnetic-field exposure**:
  - A survey of approximately 1,000 randomly selected persons in the United States who wore a magnetic-field meter that recorded the magnetic field twice each second reported that the average of all measurements taken over 24-hours (i.e., their time-weighted average [TWA] exposure), is less than 2 mG for the vast majority of persons (Zaffanella and Kalton, 1998).[7]
  - In general, personal magnetic-field exposure is greatest at work and when traveling (Zaffanella and Kalton, 1998).

[7] TWA exposure is the average exposure over a given specified time period (i.e., an 8-hour workday or a 24-hour day) of a person's exposure to a chemical or physical agent. The average is determined by sampling the exposure of interest throughout the time period.

- **Workplace magnetic-field exposure:**
  - Some occupations (e.g., electric utility workers, sewing machine operators, telecommunications workers, industrial welders) have higher exposures due to work near equipment with high ELF EMF levels (NIEHS, 2002).

- **Power-line magnetic-field exposure:**
  - The EMF levels associated with power lines vary substantially depending on their configuration, amount of current flow (load), and distance from conductors, among other parameters. While increased magnetic-fields levels may be measured immediately under overhead distribution and transmission lines or immediately above underground lines, the distance of most buildings and homes from a power line's ROW reduces the effect of these sources on magnetic-field levels measured inside a home or office, since the intensity of magnetic fields diminishes quickly with distance from the source. At a distance of 300 feet and during average electricity demand, the magnetic-field levels from many overhead transmission lines are often similar to the background levels found in most homes, as shown in Figure 2. Magnetic-field levels from underground cables diminish more quickly with distance from the lines compared to overhead transmission lines.

Known health effects

Like virtually any exposure, adverse effects can be expected from exposure to very high levels of ELF EMF. If the current density or electric field induced by an extremely strong magnetic field exceeds a certain threshold, excitation of muscles and nerves is possible. Also, strong electric fields can induce charges on the surface of the body or ungrounded objects that can lead to small shocks (i.e., micro shocks) when discharged. These effects have no long-term damage or health consequences. Limits for the general public and workplace have been set to prevent these effects (*see* Section 5), but there are no real-life situations where these levels are exceeded on a regular basis.

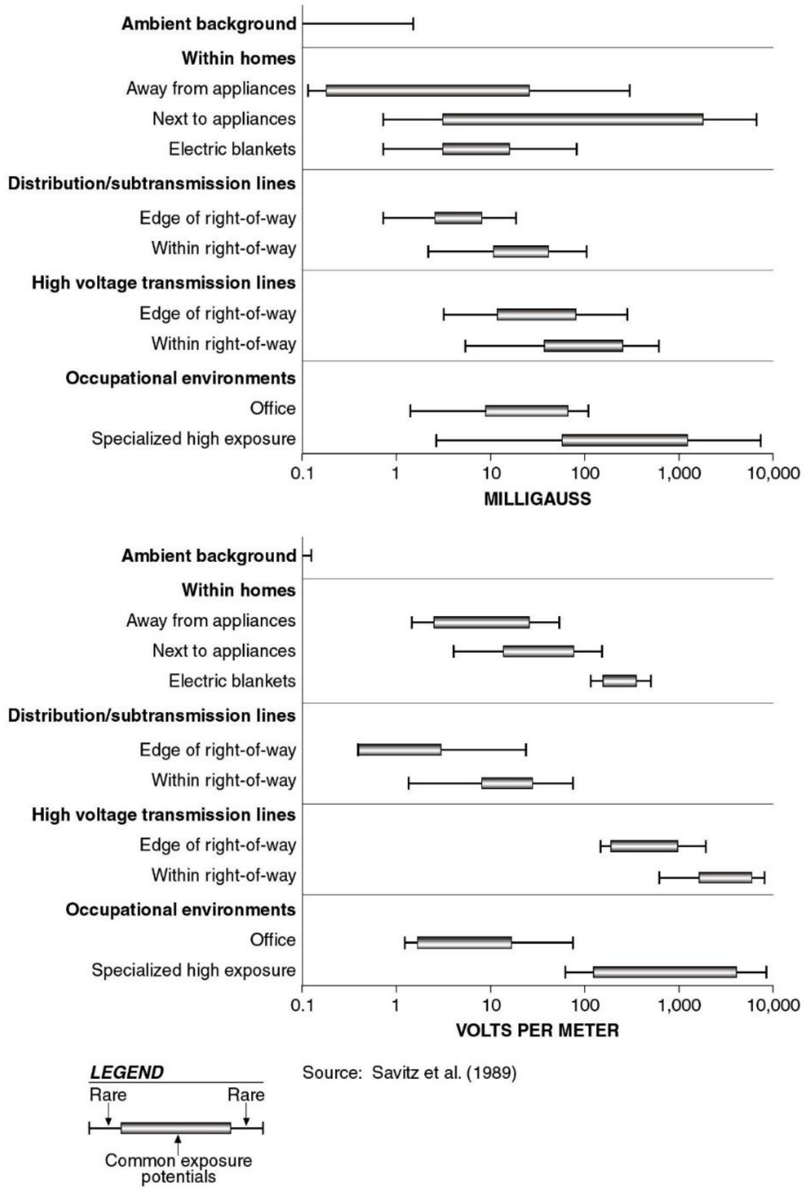

Figure 2. ELF magnetic-field levels (upper panel) and electric-field levels (lower panel) in various environments.

2 Methods for Evaluating Scientific Research

Science is more than a collection of facts. It is a method of obtaining information and of reasoning to ensure that the information and conclusions are accurate and correctly describe physical and biological phenomena. Many misconceptions in human reasoning occur when people casually interpret their observations and experience. Therefore, scientists use systematic methods to conduct and evaluate scientific research and assess the potential impact of a specific agent on human health. This process is designed to ensure that more weight is given to those studies of better quality and studies with a given result are not selected out from all of the studies available to advocate or suppress a preconceived idea of an adverse effect. Scientists and scientific agencies and organizations use these standard methods to draw conclusions about the many exposures in our environment.

Weight-of-evidence reviews

The scientific process entails looking at *all* the evidence on a particular issue in a systematic and thorough manner to evaluate if the overall data present a logically coherent and consistent picture. This is often referred to as a weight-of-evidence review, in which all relevant studies are considered together, giving more weight to studies of higher quality and using an established analytic framework to arrive at a conclusion about a possible causal relationship. Weight-of-evidence reviews are typically conducted within the larger framework of health risk assessments or evaluations of particular exposures or exposure circumstances that qualitatively and quantitatively define health risks. Weight-of-evidence and health risk assessment methods have been described by several agencies, including the International Agency for Research on Cancer (IARC), which routinely evaluates substances such as drugs, chemicals, and physical agents for their ability to cause cancer; the World Health Organization (WHO) International Programme for Chemical Safety; and the U.S. Environmental Protection Agency, which sets guidance for public exposures (USEPA, 1993, 1996; WHO, 1994; Rooney et al., 2014; OHAT, 2015). Two steps precede a weight-of-evidence evaluation: a systematic review to identify the relevant literature and an evaluation of each study to determine its strengths and weaknesses.

The following sub-sections discuss important considerations in the evaluation of human health studies of ELF EMF in a weight-of-evidence review, including exposure considerations, study design, methods for estimating risk, bias, and the process of causal inference. The purpose of discussing these considerations here is to provide context for the later weight-of-evidence evaluations in Section 4.

EMF exposure considerations

Exposure assessment methods range widely in studies of ELF EMF. These methods include the classification of residences based on the relative capacity of nearby power lines to produce magnetic fields (i.e., wire code categories); occupational titles; calculated magnetic-field levels based on job histories (e.g., a job-exposure matrix); residential distance from nearby power lines; spot measurements of magnetic-field levels inside or outside residences; 24-hour and 48-hour measurements of magnetic fields in a particular location in the house (e.g., a child's bedroom); calculated magnetic-field levels based on the characteristics of nearby power installations; and personal 24-hour and 48-hour magnetic-field measurements.

Each of these methods has strengths and limitations (Kheifets and Oksuzyan, 2008). Since magnetic-field exposures are ubiquitous and vary over a lifetime as the places one frequents and the sources of EMF in those places change, determining valid estimates of personal magnetic-field exposure is challenging. Furthermore, without a biological basis to define a relevant exposure metric (e.g., average or peak exposure) and a defined critical period for exposure (e.g., *in utero* or shortly before diagnosis), relevant and valid assessments of exposure are problematic. Exposure misclassification is one of the most significant concerns in epidemiologic studies of ELF EMF.

In general, long-term personal exposure measurements are the metric recommended by most epidemiologists to estimate exposure in their studies. Changes in the study subjects' behavior or environment that may be related to the disease under investigation, however, could potentially result in misclassification of the exposure when personal measurements are conducted following disease development. Other methods are also subject to exposure misclassification because they may not be strong predictors of long-term exposure and do not take into account all magnetic-field sources.

EMF can be estimated indirectly by assigning an estimated amount of EMF exposure to an individual based on calculations considering nearby power installations or a person's job title. For example, a relative estimate of exposure could be assigned to all machine operators based on historical information on the magnitude of the magnetic field produced by the machine. Indirect measurements are not as accurate as direct measurements because they do not contain information specific to that person or the exposure situation. In the example of machine operators, the indirect measurement may not account for how much time any one individual spends working at that machine or any potential variability in magnetic fields produced by the machines over time, and occupational measurements do not take into account the worker's residential magnetic-field exposures.

While an advance over earlier methods, job-exposure matrices still have some important limitations, as highlighted in a review by Kheifets et al. (2009) summarizing an expert panel's findings.[8] A person's occupation provides some relative indication of the overall magnitude of his or her occupational magnetic-field exposure, but it does not take into account the possible variation in exposure due to different job tasks within occupational titles, the frequency and intensity of contact to relevant exposure sources, or variation by calendar time. This was highlighted in a study of 48-hour magnetic-field measurements of 543 workers in Italy in a variety of occupational settings, including: ceramics, mechanical engineering, textiles, graphics, retail, food, wood, and biomedical industries (Gobba et al., 2011). There was significant variation in this study among the measured TWA magnetic-field levels for workers in many of the International Standard Classification of Occupations' job categories, which the authors attributed to variation in industry within the task-defined categories.

Types of health research studies

Research studies can be broadly classified into two groups: 1) epidemiologic observations of people and 2) experimental studies conducted on humans, animals (*in vivo*), and cells and tissues (*in vitro*) in laboratory settings.

Epidemiologic studies investigate how disease is distributed in populations and what factors influence or determine this disease distribution (Gordis, 2000). Epidemiologic studies attempt to establish causes for human disease while observing people as they go about their normal, daily lives. Such studies are designed to quantify and evaluate the associations between disease and reported exposures to environmental factors.

The most common types of epidemiologic studies in the EMF literature are case-control and cohort studies. In case-control studies, the exposures of people with and without the disease of interest are compared. Often, people are interviewed or their personal records (e.g., medical records or employment records) are reviewed in order to establish the exposure history for each individual. The exposure histories of the diseased (case) and non-diseased (control) populations are compared to determine whether any statistically significant differences in exposure histories exist. A difference in the exposure of the case and control populations may suggest an association between the exposure and the disease. In cohort studies, on the other hand, individuals within a defined cohort of people (e.g., all persons working at a utility company) are classified as exposed or non-exposed and followed over time for the incidence of disease. Researchers then compare disease incidence in the exposed and non-exposed groups and so can directly estimate exposure related risks.

Experimental studies are designed to test specific hypotheses under controlled conditions and are vital to assess cause-and-effect relationships. An example of a human experimental study

[8] Kheifets et al. (2009) reports on the conclusions of an independent panel organized by the Energy Networks Association in the United Kingdom in 2006 to review the current status of the science on occupational EMF exposure and identify the highest priority research needs.

relevant to this area of research would be a study that measures the impact of magnetic-field exposure on acute biological responses in humans, such as hormone levels. These studies are conducted in laboratories under controlled conditions.

In vivo and *in vitro* experimental studies are also conducted under controlled conditions in laboratories. *In vivo* studies expose laboratory animals to very high levels of a chemical or physical agent to determine whether exposed animals develop cancer or other diseases at higher rates than unexposed animals, while attempting to control other factors that could possibly affect disease rates (e.g., diet and genetics). *In vitro* studies of isolated cells and tissues are also important because they can help scientists understand biological mechanisms as they relate to the same exposure in intact humans and animals.

The results of experimental studies of animals, and particularly those of isolated tissues or cells, however, may not always be directly extrapolated to human populations. In the case of *in vitro* studies, the responses of cells and tissues outside the body may not reflect the response of those same cells if maintained in a living system, so their relevance cannot be assumed. Therefore, it is both necessary and desirable to conduct epidemiologic studies to explore agents that could present a potential health threat.

Both of these approaches—epidemiologic and experimental laboratory studies—have been used to evaluate whether exposure to EMF has any adverse effects on human health. Epidemiologic studies are valuable because they are conducted in human populations, but they are limited by their non-experimental design and typical retrospective nature. In epidemiologic studies of EMF, for example, researchers cannot control the amount of individual exposure to EMF, the contribution from different field sources, how exposure occurs over time, or individual behavior that could affect disease risk, such as diet or smoking. In valid risk assessments of EMF, epidemiologic studies are considered alongside experimental studies of laboratory animals, while studies of isolated cells and tissues are generally acknowledged as being supplementary.

Estimating risk

Epidemiologists measure the statistical association between exposures and disease in order to estimate risk. In this context, risk simply refers to an exposure that is associated with a health event and does not imply that a causal relationship has been established.[9] This brief summary of risk is included to provide a foundation for understanding and interpreting statistical associations in epidemiologic studies as risk estimates.

Two common types of risk estimates are absolute risk and relative risk (RR). Absolute risk, also known as incidence, is the amount of new disease that occurs in a given period. For example,

[9] An epidemiology dictionary defines risk factor as "…an aspect of personal behavior or lifestyle, an environmental exposure, or an inborn or inherited characteristic, that, on the basis of epidemiological evidence, is known to be associated with health-related condition(s) considered important to prevent" (Last, 2001, p. 160).

the absolute risk of invasive childhood cancer in children ages 0 to 19 years for 2004 was 14.8 per 100,000 children (Ries et al., 2007). RR estimates are calculated to evaluate whether a particular exposure or inherent quality (e.g., EMF, diet, genetics, race) is associated with a disease outcome. This is calculated by looking at the absolute risk in one group relative to that in a comparison group. For example, white children in the 0 to 19 age range had an estimated absolute risk of childhood cancer of 15.4 per 100,000 in 2004, and African American children had an estimated absolute risk of 13.3 per 100,000 in the same year. By dividing the absolute risk of white children by the absolute risk of African American children, we obtain a RR estimate of 1.16. This RR estimate can be interpreted to mean that white children have a risk of childhood cancer that is 16% greater than the risk of African American children. Additional statistical analysis is needed to evaluate whether this association is statistically significant, as defined in the following sub-section.

It is important to understand that risk is estimated differently in cohort and case-control studies because of the way the studies are designed. Traditional cohort studies can provide a direct estimate of RR, while case-control studies can only provide indirect estimates of RR, called odds ratios (OR). For this reason, among others, cohort studies usually provide more reliable estimates of the risk associated with particular exposures. Case-control studies are more common than cohort studies, however, because they are less costly and more time efficient.

Thus, the association between a particular disease and exposure is measured quantitatively in an epidemiologic study as either the RR estimate (cohort studies) or the OR (case-control studies). The general interpretation of an RR estimate equal to 1.0 is that the exposure is not associated with the occurrence of the disease. If the RR estimate is greater than 1.0, the inference is that the exposure is associated with an increased incidence of the disease. On the other hand, if the RR estimate is less than 1.0, the inference is that the exposure is associated with a reduced incidence of the disease. The magnitude of the RR estimate is often referred to as its strength (i.e., strong vs. weak). Stronger associations are given more weight because they are less susceptible to the effects of bias.

Statistical significance

Statistical significance testing provides an idea of whether or not a statistical association is caused by chance alone (i.e., whether the association is likely to be observed upon repeated testing or whether it is simply a chance occurrence). The terms statistically significant and statistically significant association are used in epidemiologic studies to describe the tendency of the level of exposure and the occurrence of disease to be linked, with chance alone as an unlikely explanation. Statistically significant associations, however, are not automatically an indication of cause-and-effect, because the interpretation of statistically significant associations depends on many other factors associated with the design and conduct of the study, including, how the data were collected and the size of the study. Statistical significance testing in itself does not provide any information on potential sources of systematic error or bias in the study.

Confidence intervals (CI) are typically reported along with RR and OR values. A CI is a range of values for an estimate of effect that has a specified probability (e.g., 95%) of including the true estimate of effect; CIs evaluate statistical significance, but do not address the role of bias, as described further below. A 95% CI indicates that if the study were conducted a very large number of times, 95% of the measured estimates would be within the upper and lower confidence limits.

The range of the CI is also important for interpreting estimated associations, including the precision and statistical significance of the association. A very wide CI indicates great uncertainty in the value of the true risk estimate. This is usually due to a small number of observations. A narrow CI provides more certainty about where the true estimate of RR lies (assuming no bias in the study). Another way to interpret the CI is if the 95% CI does not include 1.0, the probability of an association being due to chance alone is 5% or lower and the result is considered statistically significant, as discussed above. Statistical variation, however, while easily estimated, is just one of the sources of uncertainty in the characterization of epidemiological associations. Additional uncertainties may result from bias (e.g., participation, selection, or recall bias) and confounding by alternative exposures. These additional uncertainties are not quantified by statistical testing and the assessment of their influence on the overall interpretation requires expert evaluation of information from outside the studies themselves.

Meta-analyses and pooled analyses

In epidemiologic research, the results of studies with a smaller number of participants may be difficult to distinguish from normal, random variation. This is also the case for sub-group analyses where few cases are estimated to have high exposure levels (e.g., in case-control studies of childhood leukemia and TWA magnetic-field exposure greater than 3 to 4 mG). Meta-analysis is an analytic technique that combines the published results from a group of studies into one summary result. A pooled analysis, on the other hand, combines the raw, individual-level data from the original studies and analyzes all of the data from the studies together. These methods are valuable because they increase the number of individuals in the analysis, which allows for a more robust and stable estimate of association. Meta-analyses and pooled analyses also are an important tool for quantitatively synthesizing the results of a large group of studies.

The disadvantage of meta-analyses and pooled analyses is that they can convey a false sense of consistency across studies if *only* the combined estimate of effect is considered (Rothman and Greenland, 1998). These analyses typically combine data from studies with different study populations, methods for measuring and defining exposure, and disease definitions. This is particularly true for analyses that combine data from case-control studies, which often use very different methods for the selection of cases and controls and exposure assessment. Therefore, in addition to the synthesis or combining of data, meta-analyses and pooled analyses should be used to understand what factors cause the results of the studies to vary (e.g., publication date, study design, possibility of selection bias), and how these factors affect the associations calculated from the data of all the studies combined (Rothman and Greenland, 1998).

Meta-analyses and pooled analyses are a valuable technique in epidemiology; however, in addition to calculating a summary RR, they should follow standard techniques (Stroup et al., 2001) and analyze the factors that contribute to any heterogeneity between the studies. It is also important to note that potential biases present in the original individual studies will also impact the results of the meta-analyses and pooled analyses.

Bias in epidemiologic studies

One key reason that results of non-experimental epidemiologic studies cannot directly provide evidence for cause-and-effect is the potential presence of bias. Bias is defined as “any systematic error in the design, conduct or analysis of a study that results in a mistaken estimate of an exposure’s effect on the risk of disease” (Gordis, 2000, p. 204). In other words, sources of bias are factors or research situations that can mask a true association or cause an apparent association in the study that does not truly exist. As a result, the extent of bias, as well as its types and sources, is one of the most important considerations in the interpretation of epidemiologic studies. Since it is not possible to fully control human populations, perfectly measure their exposures, or control for the effects of all other risk factors, bias will exist in some form in all epidemiologic studies of human health. Experimental studies, on the other hand, more effectively manage bias because of the tight control the researchers have over most study variables.

One important source of bias occurs when a third variable confuses the relationship between the exposure and disease of interest because of its relationship to both. Consider an example of a researcher whose study finds that people who exercise have a lower risk of diabetes compared to people who do not exercise. It is known that people who exercise more also tend to consume healthier diets and healthier diets may lower the risk of diabetes. If the researcher does not control for the impact of diet, it is not possible to say with certainty that the lower risk of diabetes is due to exercise and not to a healthier diet. In this example, diet is the confounding variable.

Cause vs. association and evaluating evidence regarding causal associations

Epidemiologic studies can help suggest factors that may contribute to the risk of disease, but they are not used as the sole basis for drawing inferences about cause-and-effect relationships. Since epidemiologists do not have control over the many other factors to which people are exposed in their studies (e.g., chemicals, pollution, infections) and diseases can be caused by a complex interaction of many factors, the results of epidemiologic studies must be interpreted with caution. A single epidemiologic study is rarely unequivocally supportive or non-supportive of causation; rather, a weight is assigned to the study based on the validity of its methods and all studies (epidemiologic, *in vivo*, and *in vitro*) must be considered together in a weight-of-evidence review to arrive at a conclusion about possible causality between an exposure and disease.

Scientific guidance for assessing the overall epidemiologic evidence for causality was formally proposed by Sir Austin Bradford Hill (Hill, 1965). Hill put forth nine criteria for use in an evaluation of causality for associations observed in epidemiologic studies. These criteria included strength of association, consistency, specificity, temporality, biological gradient, plausibility, coherence, experiment, and analogy. Hill cautioned that while none of these criteria are *sine qua non* (i.e., absolutely necessary) to establish causality, the more the epidemiologic evidence meets these guidelines, the more convincing the evidence is for a potential causal interpretation. The use of these guidelines is recommended after chance is ruled out with reasonable certainty as a potential explanation for the observed epidemiologic association.

In 1964, the Surgeon General of the United States published a landmark report on smoking-related diseases (HEW, 1964). The report outlined nine criteria, similar to those proposed by Hill for evaluating epidemiologic studies (along with experimental data) for causality. In a more recent version of this report, prepared by the United States Department of Health and Human Services (HHS), these criteria have been reorganized into seven criteria. In the earlier version, coherence, plausibility, and analogy were considered as distinct items, but are now summarized together because they have been treated in practice as essentially reflecting one concept (HHS, 2004). Table 1 provides a list of the criteria developed by HHS and a brief description of each.

The criteria were meant to be applied to statistically significant associations that have been observed in the cumulative epidemiologic literature (i.e., if no statistically significant association has been observed for an exposure then the criteria are not relevant). It is important to note that these criteria were not intended to serve as a checklist; rather, they were intended to serve as a guide in evaluating associations for causal inference. Theoretically, it is possible for an exposure to meet all seven criteria, but still not be deemed a causal factor. Also, no one criterion can provide indisputable evidence for causation, nor can any single criterion, aside from temporality, rule out causation.

Table 1. Criteria developed by HHS for evaluating whether an association is causal

Criteria	Description
Consistency	Repeated observation of an association between exposure and disease in multiple studies of adequate statistical power, in different populations, and at different times.

Criteria	Description
Strength of the association	The larger (stronger) the magnitude and statistical strength of an association between exposure and disease, the less likely such an effect is the result of chance or unmeasured confounding.
Specificity	The exposure is the single cause or one of a few causes of disease.
Temporality	The exposure occurs prior to the onset of disease.
Coherence, plausibility, and analogy	The association cannot violate known scientific principles and the association must be consistent with experimentally demonstrated biologic mechanisms.
Biologic gradient	This is also known as a dose-response relationship (i.e., the observation that the stronger or greater the exposure, the stronger or greater the effect).
Experiment	Observations that result from situations in which natural conditions imitate experimental conditions. Also stated as a change in disease outcome in response to a non-experimental change in exposure patterns in populations.

In summary, the judicious consideration of these criteria is useful in evaluating epidemiologic studies, but they cannot be used as the sole basis for drawing inferences about cause-and-effect relationships. In line with the criteria of "coherence, plausibility, and analogy," epidemiologic studies are considered along with *in vivo* and *in vitro* studies in a comprehensive weight-of-evidence review. Epidemiologic support for causality is usually based on high-quality studies reporting consistent results across many different populations and study designs that are supported by the experimental data collected from *in vivo* and *in vitro* studies.

Biological response vs. disease in human health

When interpreting research studies, it is important to distinguish between a reported biological response and an indicator of disease. This is relevant because exposure to EMF may elicit a biological response that is simply a normal response to environmental conditions. This response, however, might not be a disease, cause a disease, or be otherwise harmful. There are many exposures or factors encountered in day-to-day life that elicit a biological response, but the response is neither harmful nor does it cause disease. For example, when a person walks from a dark room indoors to a sunny day outdoors, the pupils of the eye naturally constrict to limit the amount of light passing into the eye. This constriction of the pupil is a biological response to the change in light conditions. Pupil constriction, however, is neither a disease itself, nor is it known to cause disease.

3 Reviews of Research by Scientific Organizations

Scientific research on the possible health effects of ELF EMF is reviewed regularly by independent scientific and governmental organizations worldwide. These organizations assemble expert panels with the relevant expertise to conduct weight-of-evidence reviews of the scientific literature. The members of these expert panels have the knowledge and mandate to review relevant research and provide scientifically-grounded public health recommendations.

Over the past twenty years, numerous national and international scientific and health agencies have reviewed the research and evaluated potential health risks of exposure to ELF EMF. These organizations include the National Institute for Environmental and Health Sciences (NIEHS), the IARC, the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA), the National Radiological Protection Board of Great Britain (NRPB), the WHO, International Commission on Non-Ionizing Radiation Protection (ICNIRP), the European Commission's European Health Risk Assessment Network on Electromagnetic Fields Exposure (EFHRAN), Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR), the New Zealand Ministry of Health (NZMH), and the Swedish Radiation Safety Authority (SSM) (NRPB, 2001; IARC, 2002; NIEHS, 2002; WHO, 2007; ICNIRP, 2010; EFHRAN, 2012; SCENIHR, 2015; NZHM, 2015; SSM, 2016, 2018, 2019, 2020).

Overall, the published conclusions of the scientific review panels and health agencies have been consistent. None have concluded that either electric fields or magnetic fields are a known or likely cause of any adverse health effect, including cancer or other chronic diseases, at the low exposure levels found in the environment.

The conclusions of several of the scientific review panels, including those convened for the WHO and SCENIHR (both of which conducted comprehensive reviews of the research), are described in more detail below and in the relevant sub-sections of Section 4.

International Agency for Research on Cancer

As an agency of the WHO, IARC routinely assembles international working groups of experts to critically and systematically review and evaluate human, animal, mechanistic, and exposure-related evidence on the carcinogenicity of various human exposures as the first step (hazard identification) in a carcinogen risk assessment. These evaluations are published as IARC Monographs. Monograph 80 reviewed non-ionizing ELF EMF (IARC, 2002).

IARC uses specific terms to describe the strength of the evidence in support of causality between an agent and cancer in humans: *sufficient evidence of carcinogenicity, limited evidence of carcinogenicity,* and *inadequate evidence of carcinogenicity. Sufficient evidence of carcinogenicity* is assigned to a body of epidemiologic research if a positive association has been observed in studies in which chance, bias, and confounding can be ruled out with reasonable confidence. *Limited evidence of carcinogenicity* describes a body of epidemiologic research where chance, bias, or confounding cannot be ruled out as an explanation for the observed epidemiologic association; the findings are inconsistent or there are outstanding questions about study design or other methodological issues that preclude making a conclusion. *Inadequate evidence of carcinogenicity* describes a body of epidemiologic research where it is unclear whether the data are supportive or unsupportive of causation because there is a lack of data or there are major quantitative or qualitative issues. A similar classification system is used for evaluating *in vivo* studies and mechanistic data for carcinogenicity.

Summary categories are then assigned by considering the conclusions of epidemiologic and *in vivo* evidence together. Categories include (from highest to lowest risk): known carcinogen (Group 1); probable carcinogen (Group 2A); possible carcinogen (Group 2B); and not classifiable (Group 3). These categories are intentionally meant to err on the side of caution, giving more weight to the possibility that the exposure is truly carcinogenic and less weight to the possibility that the exposure is not carcinogenic. As of June 2020, IARC has reviewed more than 1,000 substances and exposure circumstances to evaluate their potential carcinogenicity. Eighty percent of substances and exposures fall in the categories of possible carcinogen (31%) or not classifiable (49%).[10] This occurs because it is nearly impossible to prove that something is completely 'safe' and few exposures show a clear-cut or probable risk, so most agents will end up in either of these two categories. Throughout the history of the IARC, only one agent has been classified as probably not a carcinogen, which illustrates the conservatism of the evaluations and the difficulty in proving the absence of an effect beyond all doubt.

After reviewing the scientific literature on ELF magnetic fields, IARC classified ELF magnetic fields as "*possibly carcinogenic to humans (Group 2B)"* (IARC, 2002, p. 338). In the IARC classification system, a possible carcinogen denotes exposures for which there is limited evidence of carcinogenicity in epidemiologic studies and less than sufficient evidence of carcinogenicity in studies of experimental animals. For ELF magnetic fields, IARC concluded that there *was "limited evidence in humans for the carcinogenicity of extremely low frequency magnetic fields in relation to childhood leukaemia"* (IARC, 2002, p. 338). This classification was largely based on an association between childhood leukemia and a TWA magnetic-field exposure greater than 3 to 4 mG reported in two pooled analyses of epidemiologic studies (Ahlbom et al., 2000; Greenland et al., 2000). IARC further concluded that there was *"inadequate evidence in humans for the carcinogenicity of extremely low frequency magnetic fields in relation to all other cancers"* and *"inadequate evidence in experimental animals for the carcinogenicity of extremely low-frequency magnetic fields"* (IARC, 2002, p. 338). After

[10] https://monographs.iarc.fr/agents-classified-by-the-iarc/. Last updated June 26, 2020. Accessed October 3, 2020.

reviewing the scientific literature on ELF electric fields, IARC classified ELF electric fields as "*not classifiable as to their carcinogenicity to humans (Group 3)"* (IARC, 2002, p. 338).

World Health Organization

The WHO is a scientific organization within the United Nations system with the mandate to provide leadership on global health matters, shape health research agendas, and set norms and standards. A comprehensive review of ELF EMF research was published by the WHO in 2007 as their *Environmental Health Criteria (EHC) Monograph 238* (WHO, 2007). The WHO's Task Group critically reviewed the cumulative epidemiologic and laboratory research through 2005, taking into account the strength and quality of the individual research studies. The WHO used the same terminology as IARC to describe the strength of evidence in support of causality between specific agents and cancer.

The WHO 2007 report provided the following overall conclusions:

> *New human, animal, and in vitro studies published since the 2002 IARC Monograph, 2002 [sic] do not change the overall classification of ELF as a possible human carcinogen* (WHO, 2007, p. 347).
>
> *Acute biological effects [i.e., short-term, transient health effects such as a small shock] have been established for exposure to ELF electric and magnetic fields in the frequency range up to 100 kHz that may have adverse consequences on health. Therefore, exposure limits are needed. International guidelines exist that have addressed this issue. Compliance with these guidelines provides adequate protection. Consistent epidemiological evidence suggests that chronic low-intensity ELF magnetic field exposure is associated with an increased risk of childhood leukaemia. However, the evidence for a causal relationship is limited, therefore exposure limits based upon epidemiological evidence are not recommended, but some precautionary measures are warranted* (WHO, 2007, p. 355).

The current guidance from the WHO on its website states:[11]

> *Despite the feeling of some people that more research needs to be done, scientific knowledge in this area is now more extensive than for most chemicals. Based on a recent in-depth review of the scientific literature, the WHO concluded that current evidence does not confirm the existence of any health consequences from exposure to low level electromagnetic fields. However, some gaps in knowledge*

[11] https://www.who.int/peh-emf/about/WhatisEMF/en/index1.html

> *about biological effects exist and need further research … Science cannot provide a guarantee of absolute safety yet but the development of research is reassuring overall.*

Scientific Committee on Emerging and Newly Identified Health Risks

The most recent weight-of-evidence review of EMF and health was released in 2015 by SCENIHR. The Committee consists of independent scientific experts assembled to provide advice on public health and risk assessments to the Department of Health and Consumer Protection of the European Commission. The Committee addresses questions related to emerging or newly identified health and environmental risks and on broad, complex, or multidisciplinary issues requiring a comprehensive assessment of risks to consumer safety or public health. The 2015 report on the potential health effects of exposure to electromagnetic fields serves as an update to the previous review published in 2009 (SCENIHR, 2009). In performing its assessment of the literature, the Committee followed the scientific guidelines it had developed for the assessment of the quality of the evidence of human health risks (SCENIHR, 2012).

The conclusions of the 2015 SCENIHR review are consistent with earlier comprehensive reviews, most notably the WHO review discussed above. SCENIHR (2015) did not conclude that the available scientific evidence confirms a causal link between any adverse health effects (including both cancer and non-cancer health outcomes) and EMF exposure. Conclusions related to specific health outcomes, including child and adult cancers, are summarized in the relevant sub-sections of Section 4.

4 Summary of Recently Published Research

The following section identifies and describes peer-reviewed epidemiologic studies and *in vivo* studies of carcinogenesis related to ELF EMF exposure published from October 1, 2018 through October 1, 2020.[12] The purpose of this section is to evaluate whether the findings of these recent studies alter the conclusions of the reviews published by scientific and health agencies. To provide background and context, some of the relevant studies summarized in Exponent (2019) report, which was submitted to the Massachusetts EFSB, also are discussed.

As epidemiologic studies conducted in human populations and *in vivo* studies of experimental whole animals provide the primary basis for a human health risk assessment, these studies will be the focus of this review and evaluation. Epidemiologic studies are evaluated below by outcome (childhood cancer; adult cancer; reproductive or developmental effects; neurodegenerative diseases; and cardiovascular effects), followed by an evaluation of *in vivo* research in the field of cancer. Systematic review articles of relevant topics are also noted, where appropriate. Studies published prior to the scope of this update are noted in certain circumstances to provide context. There is a greater opportunity for long-term exposure to magnetic fields since electric fields are effectively blocked by common conductive objects. For this reason, among others, research on long-term health effects has focused on exposure to magnetic fields rather than electric fields. No recent epidemiologic studies have assessed exposure to electric fields, thus, all EMF epidemiologic studies discussed below are magnetic-field studies.

Childhood leukemia

Since the late 1970s, numerous epidemiologic studies have evaluated the relationship between exposure to ELF EMF and childhood leukemia. As noted in Section 3, in their 2002 review of research related to ELF EMF, the IARC classified EMF as *possibly carcinogenic* (Group 2B) largely based on two combined analyses of epidemiologic studies that reported an association between childhood leukemia and exposure to high magnetic-field levels (i.e., levels greater than 3 to 4 mG) (Ahlbom et al., 2000; Greenland et al., 2000). The classification of *possibly*

[12] A structured literature search for this time period was conducted using PubMed, a search engine provided by the National Library of Medicine and the National Institutes of Health that includes over 26 million up-to-date citations from MEDLINE and other life science journals for biomedical articles (http://www.pubmed.gov). All fields (title, abstract, keywords, among others) were searched with various search strings that referenced the exposure (EMF, magnetic fields, electric fields, or electromagnetic) and diseases of interest (i.e., cancer [cancer, leukemia, lymphoma, carcinogenesis], neurodegenerative disease [neurodegenerative disease, Alzheimer's disease, amyotrophic lateral sclerosis, or Lou Gehrig's disease], cardiovascular effects [cardiovascular or heart rate], or reproductive outcomes [miscarriage, reproduction, or development]). Only peer-reviewed, epidemiologic studies and pooled- or meta-analyses of 50-Hz or 60-Hz ELF EMF and recognized disease entities are included. *In vivo* animal and human studies of 50-Hz or 60-Hz ELF EMF are also included, but only on the topic of cancer. Since there is sometimes a delay between the availability of a study and the date it is indexed in PubMed, it is possible that some studies available prior to October 1, 2020, but not yet indexed by PubMed, are not included in this update.

carcinogenic was confirmed by the WHO in their 2007 review, in which the WHO concluded that the *"evidence for a causal relationship [between ELF magnetic-field exposure and childhood leukemia] is limited"* (WHO, 2007, p. 355). Given that few children are expected to have average magnetic-field exposures greater than 3 to 4 mG, however, the WHO noted that, even if the association was determined to be causal, *"in a global context, the impact on public health, if any, would be limited and uncertain"* (WHO, 2007, p. 12).

In their 2015 report, SCENIHR concluded that the epidemiologic data on childhood leukemia and EMF exposure reviewed for the report *"are consistent with earlier findings of an increased risk of childhood leukaemia with estimated daily average exposures above 0.3 to 0.4 µT [3 to 4 mG]"* and noted that *"no mechanisms have been identified and no support is existing [sic] from experimental studies that could explain these findings, which, together with shortcomings of the epidemiological studies prevent a causal interpretation"* (SCENIHR, 2015, p. 164).

Subsequent research reviewed by Exponent has not provided consistent or compelling evidence to alter the conclusions of the WHO or SCENIHR. While most of the large and methodologically advanced epidemiologic studies published during this timeframe showed no statistically significant associations (e.g., Pedersen et al., 2015; Crespi et al., 2016; Kheifets et al., 2017), and a pooled analysis indicated statistically non-significant associations (Amoon et al., 2018), the association between childhood leukemia and magnetic fields observed in some earlier studies remains unexplained.

Summary of research published between 2018 and 2020

Crespi et al. (2019) investigated the separate and combined relationship between distance from high-voltage power lines and calculated magnetic-field exposure and childhood leukemia risk within the same epidemiologic study of childhood cancers in California that was analyzed in several previous studies (Kheifets et al., 2015; Vergara et al., 2015; Crespi et al., 2016). In Crespi et al. (2019), the authors reported that neither close proximity to high-voltage power lines (< 50 meters, ≥ 200 kilovolts [kV]) nor exposure to calculated magnetic fields (≥ 0.4 microtesla [µT] [≥ 4 mG]) alone were associated with childhood leukemia, and that an association was observed only for those participants who were both close to high-voltage power lines and had high calculated magnetic fields. No associations were observed with low-voltage power lines. The authors noted that their study was *"hypothesis generating"* and that the observed associations could be spurious findings due to small sample sizes or confounding. The authors concluded that their findings *"argue against magnetic fields as a sole explanation"* for an association between distance and childhood leukemia and *"in favor of some other explanation"* linked to the power lines (Crespi et al., 2019, p. 535).

Using the same overall study population as Crespi et al. (2019), Amoon et al. (2019, 2020) assessed the potential impact of residential mobility and dwelling type as confounders in the associations observed between childhood leukemia and magnetic-field exposure. Amoon et al.

(2019) reported that uncontrolled confounding by residential mobility had some impact on the association between magnetic-field exposure and childhood leukemia, with greater potential bias observed when the relationship between mobility, magnetic-field exposure, and disease was stronger. The authors concluded, however, that confounding by residential mobility is *"unlikely to be the primary driving force behind previously observed largely consistent, but unexplained associations"* (Amoon et al., 2019, p. 7). Amoon et al. (2020) reported that while the type of dwelling at which a child resides (e.g., single-family home, apartment, duplex, mobile home) was associated with socioeconomic status and race or ethnicity, it was not associated with childhood leukemia and did not appear to be a potential confounder in the relationship between childhood leukemia and magnetic-field exposure in this study. The authors noted potential differences in the strength of the association between childhood leukemia and magnetic-field exposure by type of dwelling and recommended additional research in this area.

Recent epidemiologic studies on magnetic fields and childhood cancer also have been published by Kyriakopoulou et al. (2018), Auger et al. (2019a), and Núñez-Enríquez et al. (2020). Kyriakopoulou et al. (2018) examined the association between parental occupational exposures and childhood acute leukemia in a case-control study conducted at a major pediatric hospital in Greece. No statistically significant associations were observed between *"electromagnetic-field"*[13] exposure (based on parents' job title, literature review, and the authors' professional judgment) and childhood acute leukemia for any of the parental exposure periods examined (1 year before conception, during pregnancy, during breastfeeding, and from birth until diagnosis). No associations were observed between childhood acute leukemia and the remaining exposure categories. The size of the group exposed to electromagnetic fields was very small (6% of workers) compared to the other three exposure groups, which limits the statistical precision and interpretations of the data. An additional limitation is the assignment of exposure based on job title, which does not account for differences in exposure across individuals with the same occupation.

Auger et al. (2019a) examined the relationship between exposure to EMF during pregnancy (based on distance to the nearest high-voltage transmission line or transformer station) and risk of childhood cancer in a cohort of 784,000 children born in Québec and followed for one decade after birth. Exposure to EMF was assessed by calculating distance to the nearest high-voltage transmission line or transformer station using geocoded postal codes. The authors reported *"borderline"* associations that were not statistically significant between residential distance to transformer stations and any cancer, hematopoietic cancer, and solid tumors (Auger et al., 2019a, p. 1). No associations were reported with distance to transmission lines. The authors concluded that *"[t]hese contradictory findings suggest an absence of a causal link between [EMF] from high voltage power sources and the risk of cancer in children"* (Auger et al., 2019a, p. 6).

[13] In this context, the authors used the term electromagnetic fields to refer to ELF magnetic fields.

Núñez-Enríquez et al. (2020) assessed the relationship between residential magnetic-field exposure and B-lineage acute lymphoblastic leukemia (B-ALL) in children less than 16 years of age in Mexico City, Mexico. The study included 290 cases and 407 controls; magnetic-field exposure was assessed through the collection of 24-hour measurements in the participants' bedrooms, which were then categorized into ranges of exposure levels. The authors reported statistically significant associations between B-ALL and 24-hour magnetic-field exposures ≥ 0.4 μT [4 mG] and ≥ 0.6 μT [6 mG]; however, non-statistically significant associations were reported for 24-hour magnetic field exposures ≥ 0.2 μT [2 mG], ≥ 0.3 μT [3 mG], and ≥ 0.5 μT [5 mG]. The authors concluded that *"...to date, a clear mechanism through which exposure to ELF-MFs [magnetic fields] may be associated with leukemia has not been established. Therefore, it is possible that other factors related to ELF-MF exposure, which we could not identify in the present study, may be relatively more relevant as risk factors for childhood leukemia development"* (Núñez-Enríquez et al., 2020, p. 9). Strengths of the study include the use of 24-hour measurements, the large proportion of participants with higher magnetic-field exposures (14% of cases and 11% of controls had 24-hour exposures ≥ 0.3 μT [3 mG]), and ability to analyze results for the most common childhood leukemia subtype (B-ALL) separately. One limitation of the study is the observed difference between the cases and controls related to infections during the first year of life; compared the control group, cases were more likely to have an infection during the first year of life, which may be a potential risk factor for the development of B-ALL. An additional limitation of the study is the hospital-based selection of controls, which may result in selection bias, if the catchment areas of the hospitals used to recruit controls were different than those of the hospitals where the leukemia cases were treated and recruited. Participation rate was also lower among cases than among controls, representing another potential source of selection bias.

More recent pooled analyses of epidemiologic studies of childhood leukemia and magnetic-field exposure indicated weaker and statistically non-significant associations. Swanson et al. (2019) examined 41 studies to observe the trends in childhood leukemia risk over time. The authors reported a statistically non-significant decline in risk from the mid-1990s until the present, which they stated was *"unlikely to be solely explained by improving study quality but may be due to chance"* (Swanson et al., 2019, p. 470). The authors concluded, however, that the current body of literature on EMF *"argue against health effects of MFs [magnetic fields] at these exposure levels"* (Swanson et al., 2019, p. 485). Talibov et al. (2019) conducted a pooled analysis of 11 case-control studies examining the relationship between parental occupational exposure to ELF magnetic fields and childhood leukemia. No statistically significant association was found for paternal or maternal exposure by leukemia sub-type or overall, and no association was observed when additional exposure categories were used. The authors concluded that their study "*suggests that parental ELF-EMF exposure plays no relevant role in the aetiology of childhood leukemia*" (Talibov et al., 2019, p. 7).

Assessment

The results of epidemiologic studies published between 2018 and 2020 do not change the classification of the epidemiologic data as limited, as determined by IARC and WHO. In their most recent review of the research, SSM concluded that,

> *[r]egarding the exposure to ELF magnetic fields and the development of childhood leukaemia, the latest studies did not consistently observe an association. However, these studies did not use new approaches and the same limitations apply as in previous research. Thus, the conclusion from previous Council reports still holds: epidemiologically, associations have been observed, but a causal relationship has not been established* (SSM, 2020, p. 6).

Childhood brain cancer

Compared to the research on magnetic fields and childhood leukemia, there have been fewer studies of childhood brain cancer, and the epidemiologic evidence reviewed by IARC and WHO was classified as inadequate. The WHO 2007 review concluded, *"the evidence for other childhood cancers [besides childhood leukaemia] remains inadequate"* (WHO, 2007, p. 307). In their 2015 report, SCENIHR concluded that *"[n]o association has been observed for the risk of childhood brain tumours"* and that *"[s]tudies on other childhood cancers [besides childhood leukemia] or adult cancers show no consistent associations"* (WHO, 2007, pp. 157-158).

As summarized in Exponent (2019), Su et al. (2018) published a meta-analysis of 22 epidemiologic studies that investigated the association between parental exposure to ELF magnetic fields and nervous system tumors in their offspring. The authors reported no consistent associations between maternal or paternal exposure to ELF magnetic fields and neuroblastoma or central nervous system (CNS) tumors.

Summary of research published between 2018 and 2020

The previously described study on childhood leukemia by Auger et al. (2019a) also examined the association between exposure to EMF during pregnancy and CNS tumors. The authors reported a statistically non-significant association between a residential distance of 80 meters from a transformer station and CNS tumors. When the authors stratified their analysis by gender, an association was observed for males only. No associations were observed with distance to transmission lines. The authors concluded that *"[r]esidential proximity to transformer stations is associated with a borderline risk of childhood cancer, but the absence of an association with transmission lines suggests no causal link"* (Auger et al., 2019a).

Assessment

The limited additional research published during the time period of this review contributes to the overall weight-of-evidence that an association between magnetic-field exposures and childhood brain cancer development is not supported. The results of studies conducted in recent years do not report any consistent or convincing evidence for an association, nor do they alter the classification of the epidemiologic data in this field as "*inadequate*" (IARC, 2002; WHO, 2007; EFHRAN, 2012; SCENIHR, 2015).

Adult brain cancer

Regarding adult brain cancer and adult leukemia, the WHO concluded, *"the new studies published after the IARC monograph do not change the conclusion that the overall evidence for an association between ELF [EMF] and the risk of these diseases remains inadequate"* (WHO, 2007, p. 307). As noted above, the 2015 SCENIHR report concluded that studies on adult cancers *"show no consistent associations"* (SCENIHR, 2015, p. 158).

Subsequent research reviewed by Exponent did not provide evidence to alter the conclusions of the WHO or SCENIHR. Two Swedish case-control studies investigated the relationship between occupational exposure to ELF EMF and glioma (Carlberg et al., 2017) and meningioma (Carlberg et al., 2018). In Carlberg et al. (2017), the authors reported no overall association between glioma and cumulative exposure to ELF EMF and a marginally significant association with the highest average exposure category. Sub-analyses examining the association by tumor grade and exposure period did not show consistent associations. In Carlberg et al. (2018), no trend or association was reported between meningioma development and exposure to ELF EMF using any of the exposure metrics or exposure periods. In a study investigating the potential interaction between ELF magnetic fields and occupational exposure to various chemicals (e.g., metals, solvents, polycyclic aromatic hydrocarbons), Turner et al. (2017) reported that there was no clear evidence for an interaction between occupational exposure to ELF magnetic fields and exposure to any of the included chemicals for either glioma or meningioma (Turner et al., 2017).

Summary of research published between 2018 and 2020

Carlberg et al. (2020) examined the association between occupational exposure to magnetic fields and acoustic neuroma within the same study population that was used in several previously published case-control studies on brain and head tumors (Hardell et al., 2006, 2013). The study was conducted during the periods of 1997 to 2003 and 2007 to 2009 and included 310 cases and 3,485 controls; average and cumulative magnetic field exposure was assessed using the participants' questionnaire responses and a previously developed job-exposure matrix (Turner et al., 2014). The authors reported no statistically significant associations between acoustic neuroma and either average or cumulative magnetic-field exposure, regardless of the exposure period examined (1 to 14 years or 15+ years). The authors concluded that *"occupational ELF-EMF was not associated with an increased risk for acoustic neuroma"* (Carlberg et al., 2020, p. 1).

Carles et al. (2020) investigated the association between residential proximity to power lines and brain tumor development among adults in France. The study included 490 cases (gliomas and meningiomas combined) and 980 controls; exposure was assessed for the period from 1965 to 2006 using the distance from the residence to the nearest power line and the voltage of the power lines as surrogate indicators of magnetic-field exposure. Several statistically significant associations were reported, although the associations were not consistent across brain tumor types or exposure metrics, and no clear exposure-response trend was observed. The authors reported statistically significant associations between living < 50 meters from power lines of any voltage for more than 15 years and all brain tumors, as well as meningiomas; statistically significant associations also were observed between ever living < 50 meters from a power line of any voltage and glioma and between ever living < 50 meters from a high-voltage power line (< 200 kV) and both glioma and all brain tumors. No statistically significant associations were observed between any tumor type and living < 50 meters from very high voltage power lines (≥ 200 kV) or living near power lines of any voltage for more than 5 years and more than 10 years. In addition, no statistically significant associations were observed when exposures were defined based on a threshold approach (using an exposure cut-off of ≥ 0.3 μT [3 mG]).

Assessment

The two recent studies continue to show no consistent associations between EMF exposure and development of adult brain cancers. Overall the data remain inadequate to support a causal association for adult brain cancer with magnetic-field exposure (WHO, 2007, EFHRAN, 2012; SCENIHR, 2015).

Breast cancer

In their 2007 report, the WHO noted that studies on adult breast cancer published around or after 2000 were higher in quality compared with earlier studies, and that there was strong support for consensus statements that magnetic-field exposure does not influence the risk of breast cancer. The 2007 WHO report concluded, *"[s]ubsequent to the IARC monograph a number of reports have been published concerning the risk of female breast cancer in adults associated with ELF magnetic field exposure. These studies are larger than the previous ones and less susceptible to bias, and overall are negative. With these studies, the evidence for an association between ELF exposure and the risk of breast cancer is weakened considerably and does not support an association of this kind"* (WHO 2007, p. 307). The recent review by SCENIHR (2015) concluded that overall, studies on adult cancers *"show no consistent associations"* (p. 158).

Subsequent research reviewed by Exponent did not provide evidence to alter the conclusions of the WHO or SCENIHR. A case-control study of male breast cancer and occupational exposure to magnetic fields was published by Grundy et al. (2016). The authors reported no statistically significant associations, thus adding to the growing body of null evidence for a role for magnetic-field exposure in the development of breast cancer in either residential or occupational settings.

Summary of research published between 2018 and 2020

No published epidemiologic studies examining the potential relationship between ELF EMF and breast cancer development were identified within the time period of this report.

Assessment

As no new published studies were identified during the time period of this report, the conclusion that there is no association between ELF EMF and breast cancer has not changed. In two of the recent annual reports published by the SSM, the Council concluded that, with respect to female breast cancer, *"now it is fairly certain that there is no causal relation with exposure to ELF magnetic fields"* (SSM, 2016; p. 7), and with respect to male breast cancer, *"[t]o date, there is no established link between ELF-MF [magnetic field] exposure and breast cancer in men"* (SSM, 2018; p. 49).

Adult leukemia and lymphoma

Most of the scientific literature on EMF and adult leukemia is related to occupational exposures. Overall, the findings of these studies are inconsistent—some studies report a positive association between estimates of EMF exposure and leukemia, yet other studies show no association. No pattern has been identified whereby studies of higher quality or design are more likely to produce positive or negative associations. In their 2007 review, the WHO classified the epidemiologic evidence for adult leukemia as inadequate and concluded,

> *the new studies published after the IARC monograph do not change the conclusion that the overall evidence for an association between ELF [EMF] and the risk of these diseases remains inadequate* (WHO, 2007, p. 307).

As summarized previously, the 2015 SCENIHR report concluded that studies on *"adult cancers show no consistent associations"* (SCENIHR, 2015, p. 158).

Subsequent research reviewed by Exponent did not provide evidence to alter the conclusions of the WHO or SCENIHR. Huss et al. (2018) conducted a census-based cohort study of occupational ELF magnetic fields and hematopoietic malignancies (i.e., various types of acute and chronic leukemias and lymphomas) using data on 3.1 million Swedes obtained from the Swiss National Cohort study. None of the hematopoietic cancer types included in the main analyses were statistically significantly associated with ELF magnetic-field exposure. Some statistically significant findings were reported in sub-analyses by cancer subtype; however, the potential for residual confounding by smoking may explain the association observed in some of the sub-analyses. In the same study, Huss et al. (2018) also conducted a meta-analysis of epidemiologic studies of ELF magnetic fields and acute myeloid leukemia and reported a weak overall association.

Summary of research published between 2018 and 2020

No epidemiologic studies examining the potential relationship between ELF EMF and adult leukemia or lymphoma development were identified within the time period of this report.

Assessment

As no new published studies were identified during the time period of this report, the classification of the epidemiologic data in this field as inadequate by the WHO has not changed (WHO, 2007).

Reproductive/developmental effects

In their 2007 review, the WHO concluded that, overall, the body of research does not suggest that maternal or paternal exposures to ELF EMF cause adverse reproductive or developmental outcomes. The WHO concluded, *"[t]here is some evidence for increased risk of miscarriage associated with measured maternal magnetic-field exposure, but this evidence is inadequate"* and recommended further epidemiologic research, although it was designated as low priority (WHO, 2007, p. 254). Studies on ELF EMF exposure and reproductive or development effects published subsequent to the WHO 2007 report provided little new insight on pregnancy and reproductive outcomes and did not change the classification of the data from earlier assessments as inadequate. The review by SCENIHR concluded that *"[r]ecent results do not show an effect of the ELF fields on the reproductive function in humans"* (SCENIHR, 2015, p. 187). An assessment of the scientific literature on ELF EMF exposure and measures of infertility and adverse pregnancy outcomes concluded that design limitations in most studies may explain their inconsistent findings (Lewis et al., 2016).

Subsequent research reviewed by Exponent included epidemiologic studies investigating the relationship between ELF EMF intrauterine exposure and miscarriage (Li et al., 2017), preterm birth (Sadeghi et al., 2017), and childhood asthma (Sudan et al., 2017). Li et al. (2017) reported an increased risk of miscarriage in women with high magnetic-field exposure (i.e., the 99th percentile value during a 24-hour EMF measurement ≥ 2.5 mG) compared to women with low magnetic-field exposure (< 2.5 mG) when measurements were collected on a typical day (defined as a day reflecting participants' typical pattern of work and leisure activities during pregnancy). No association was reported among those women whose magnetic-field exposure was measured on a non-typical day, and no trend was observed for miscarriage risk with increasing magnetic-field exposures above 2.5 mG. The study included several limitations, including failure to measure the women's mobility during the day of measurement. This represents a potential major source of confounding in the study, as the level of mobility between women with healthy pregnancies that went to term and women who miscarried is likely to differ (e.g., Savitz, 2002; Mezei et al., 2006; Savitz et al., 2006; Lewis et al., 2016); thus, this remains an alternative explanation for the findings in the study. In addition, no information was provided in the paper on the exact timing of the EMF measurement (i.e., whether the measurement day preceded the occurrence of miscarriage among cases); this is a substantial limitation as measurements taken following miscarriage in a substantial fraction of cases was a major criticism of the previous study by the same research team (Li et al., 2002). No statistically significant associations were observed between exposure and preterm birth or childhood asthma (Sadeghi et al., 2017; Sudan et al., 2017).

Summary of research published between 2018 and 2020

Migault et al. (2018) studied the relationship between two pregnancy outcomes (moderate prematurity and being small for gestational age) and maternal occupational and residential ELF EMF exposure. The study included 18,329 infants born at 33 weeks of gestation or more in France during 2011. Cumulative exposure to both occupational and residential ELF EMF during pregnancy was assessed using the mothers' self-reported occupation and a job-exposure matrix, which included exposure estimates for five non-professional categories (e.g., housewife, student, parental leave, retired, and unemployed) that were used to estimate residential exposure. No statistically significant associations between maternal cumulative exposure and either birth outcome were observed. The authors noted that the ability to consider both occupational and residential exposure in their cumulative estimates is a strength of the study, but suggested that the small sample size in the high exposure categories limited the study's power to detect a potential association. Other limitations include the use of a job exposure matrix to characterize EMF exposure and the lack of information on co-exposures to other occupational agents.

Auger et al. (2019b) assessed the relationship between residential proximity to ELF EMF and risk of birth defects in a Canadian study that included more than 2 million infants. The authors calculated distance to the nearest high-voltage transmission line or transformer station using geocoded postal codes of the mother's residence at birth. No strong or consistent associations were reported. Weak, positive associations were observed between a distance of 50 meters from transmission lines and genital, clubfoot, or sense organ defects; however, reduced risks were observed for noncritical heart defects and congenital hip dislocation. Limitations of the study include the lack of information on exposure to other agents and on risk factors that are known to potentially cause birth defects (e.g., mothers' smoking habits).

Esmailzadeh et al. (2019) studied the relationship between residential proximity to high-voltage power lines and female infertility in Iran in a cross-sectional analysis. The study included 462 cases and 471 controls with no history of infertility; the nearest linear distance to high-voltage power lines was measured using geographic information systems and aerial evaluations. The authors reported an association between infertility and living within 500 meters of the power lines compared to living more than 1,000 meters away. One of the main limitations of the study was the use of residential address within 500 meters of power lines as a surrogate for EMF exposure. No elevation of ELF EMF levels can be expected for distances beyond approximately 100 meters; thus, no valid conclusions can be drawn from the study with respect to exposure to EMF. The study design is also a limitation, as the researchers were unable to establish whether exposure to the magnetic fields occurred before or after the outcome of interest (i.e., infertility).

Ren et al. (2019) examined the association between fetal growth and magnetic-field exposure using 24-hour personal magnetic-field measurements collected from 128 pregnant women in China during the third trimester of pregnancy. The authors observed associations between prenatal magnetic-field exposure and fetal growth indicators (lower birth weight, thinner skinfold, and smaller head, arm, and abdominal circumference) for newborn girls, but not for newborn boys. While the use of personal exposure measurements is an improvement in exposure assessment methods compared to many earlier studies, the collection of only one measurement over a single 24-hour period during pregnancy is a limitation of Ren et al. (2019), as day-to-day changes in exposure cannot be captured.

Li et al. (2020) analyzed data from previously conducted cohort studies in California to assess whether maternal exposure to magnetic fields is associated with the development of attention-deficit/hyperactivity disorder (ADHD) in their offspring. The study included 1,482 mother-child pairs who had participated in two previous studies conducted from 1996 to 1998 and 2006 to 2012 (e.g., Li et al., 2011; Li et al., 2017). Exposure was assessed using the 24-hour personal magnetic-field measurements that were collected on a single day of pregnancy during the first or second trimester in the two previous studies; in the current study, the authors selected the 90th percentile value observed during the 24-hour measurement period as the exposure of interest. Cohort members with ADHD diagnoses were identified through medical records. The authors reported a statistically significant association between mothers exposed to high levels of magnetic fields (defined as ≥ 1.3 mG) and a diagnosis of ADHD in their offspring; a stronger association was observed for children with a diagnosis persisting into adolescence. As noted above, the collection of only one measurement over a single 24-hour period during pregnancy is a limitation of this exposure assessment approach. The specific exposure metric and cut-point used in the study are unconventional and have not typically been used in previous epidemiologic studies investigating potential health effects of EMF.

Zarei et al. (2020) examined the relationship between maternal exposure to electromagnetic fields, including power lines and various radiofrequency field sources (e.g., mobile phones, Wi-Fi, cordless phones), and speech problems in offspring. The study was conducted in 2016 and included 110 mothers of children 3 to 7 years of age with speech problems who had been referred to a speech treatment center and 75 mothers of children defined as "healthy" by the authors (no additional details provided). Exposure was assessed using participants' responses to an interview questionnaire, in which participants "were asked to verify [Yes or No] whether they had been exposed to different sources of electromagnetic fields" (Zarei et al., 2020, p. 62). No additional information was provided in the paper on how exposure was defined or assessed.

Statistically significant associations were reported between offspring with speech problems and maternal "history of exposure to high tension power lines" before and during pregnancy (Zarei et al., 2020, p. 63). The authors also reported statistically significant associations with history of cordless phone use before and during pregnancy; no associations were observed with mobile phone use. Limitations of the study include the small overall size of the study population and the small number of participants who were defined as exposed to power lines; the use of self-reporting questionnaires to define exposure; incomplete information on how exposure (to power lines or other sources) was defined; and the potential for sampling bias, as mothers were enrolled in the study based on "convenience sampling," which is a sampling method in which study participants are selected from a group of people simply because they are easy to contact or reach.

Zhao et al. (2020) investigated the relationship between exposure to electrical appliances and electronic equipment in early pregnancy and congenital heart disease (CHD) in offspring in China. The study was conducted between 2014 to 2016 and included 585 cases and 1,754 controls. Exposure was ascertained through personal interviews with the mothers during their hospital stay for childbirth; occupational and residential exposure to the selected electrical appliances and electronic equipment (mobile phone, television, computer, induction cooker, microwave oven) three months before pregnancy and during the first trimester of pregnancy, and the participants were then divided into categories of exposed or unexposed based on the mothers' reported daily use. The authors reported statistically significant associations between offspring with CHD and maternal exposure to computers, induction cookers, and microwave ovens before and during pregnancy; a decrease in offspring with CHD was observed for mothers who reported wearing a radiation protection suit during the time periods under study. Limitations of the study include a high potential for recall bias; mothers who have given birth to infants with CHD may be more likely to attempt to accurately and completely recall the events leading up the diagnosis compared to mothers who gave birth to healthy children and thus have less reason to recall such memories. In addition, statistically significant differences were reported between the case and control participants that make it difficult to accurately compare the populations and may result in confounding in the study. For instance, mothers who gave birth to children with CHD were less likely to take folic acid, more likely to have a lower education and income level, more likely to be exposed to passive smoke, and more likely to drink compared to women who gave birth to healthy children.

Migault et al. (2020) conducted a pooled analysis of two French studies (Vandentorren et al., 2009; Ancel et al., 2014) to examine the relationship between maternal cumulative exposure to magnetic fields during pregnancy and the risk of prematurity or small for gestational age. Occupational maternal exposure to magnetic fields during three separate periods of gestational age (≤ 15 weeks of gestation, ≤ 28 weeks, and ≤ 32 weeks) was assessed using a job-exposure matrix; mothers who were not currently working were assigned exposure values based on the estimated exposures for students, housemakers, and the unemployed. The authors reported no association between cumulative magnetic-field exposure and prematurity among the two highest exposure categories; conversely, an increased risk of prematurity was observed for the lower exposure category. No consistent associations were observed between cumulative magnetic-field exposure and small for gestational age. The authors concluded that "*due to the heterogeneity of the results regarding exposure levels, the associations observed cannot be definitely explained by ELF-EMF exposure*" (Migault et al., 2020, p. 27). Limitations of the study include heterogeneity in study populations between the two included studies, low portion of mothers with high magnetic-field exposure (3% to 4%), and missing information on other occupational exposures that could explain the observed associations (e.g., chemical agents).

Assessment

The recent epidemiologic research on reproductive or developmental effects provided little, if any, new evidence for any potential associations. The classification of the overall evidence in support of any causal inference as inadequate remains appropriate, as studies in this research area still suffer from limitations in study design, sample size, and exposure assessment method.

Neurodegenerative diseases

The WHO reported that the majority of epidemiologic studies examining exposure to magnetic fields and neurodegenerative diseases have reported associations between occupational magnetic-field exposure and mortality from Alzheimer's disease and amyotrophic lateral sclerosis (ALS), although the design and methods of these studies were relatively weak (e.g., disease status was based on death certificate data; exposure was based on incomplete occupational information from census data; and there was no control for confounding factors). The WHO concluded that there is inadequate data in support of an association between magnetic fields and Alzheimer's disease or ALS. Specifically, the WHO concluded, *"When evaluated across all the studies, there is only very limited evidence of an association between estimated ELF [EMF] exposure and [Alzheimer's] disease risk"* (WHO, 2007, p. 194) and *"overall, the evidence for an association between ELF [EMF] exposure and ALS is considered inadequate"* (WHO, 2007, p. 206). The panel highly recommended that further studies be conducted in this area, particularly studies where the association between magnetic fields and ALS is estimated while controlling for the possible confounding effect of electric shocks.

The most recent SCENIHR report (2015) concluded that newly published studies *"do not provide convincing evidence of an increased risk of neurodegenerative diseases, including dementia, related to ELF MF [magnetic field] exposure"* (SCENIHR, 2015, p. 186).

Research published between the release of the 2015 SCENIHR report and the beginning of this review (October 1, 2018) did not provide consistent or convincing evidence to alter the conclusions of the WHO, SCENIHR, and other agency reviews; this includes studies of ALS (Koeman et al., 2017; Vicenti et al., 2017; Röösli and Jalilian, 2018; Huss et al., 2018) and Parkinson's disease (Pedersen et al., 2017). Many of these studies represented methodological improvements (e.g., increased sample size, improved exposure assessment, inclusion of incidence cases) compared to previous studies.

Summary of research published between 2018 and 2020

Amyotrophic lateral sclerosis

Peters et al. (2019) examined the relationship between occupational exposure to both ELF magnetic fields and electric shock with ALS within a multi-country European study. The overall study included 2,704 cases and 1,323 controls; occupational exposures were assessed using a job-exposure matrix. Statistically significant associations were observed between ALS and ever having been exposed above background levels to either magnetic fields or electric shocks. No clear exposure-response trends were observed, however, with exposure duration or cumulative exposure.

Filippinni et al. (2020) investigated the association between ALS and various environmental and occupational factors, including electromagnetic fields, within a case-control study in Italy. The study included 95 cases and 135 controls; exposures were assessed using the participants' responses to a questionnaire and included questions on occupational use of electric and electronic equipment, occupational EMF exposure, and residential distance to overhead power lines. The authors reported a statistically significant association between ALS and proximity to overhead power lines. The association between ALS and occupational exposure to EMF was not statistically significant; occupational use of electric and electronic equipment was associated with a statistically non-significant decreased risk of ALS development. The authors also reported an association between ALS and history of occupation in the agricultural sector and with exposure to solvents (e.g., thinners, paint removers) and metals. Limitations of the study include the possibility of selection bias due to the low overall response rate (< 20%) in the study population and the use of a self-reported questionnaire to assess exposures.

The relationship between exposure to magnetic fields and ALS was also examined in several recent meta-analyses (Gunnarsson and Bodin, 2018; Jalilian et al., 2020). Gunnarsson and Bodin (2018) conducted a meta-analysis of occupational risk factors for ALS. The authors reported statistically significant associations between ALS and occupational exposure to EMF and ALS and jobs that involve working with electricity among the 16 relevant publications included in their analysis. The authors noted a *"slight"* publication bias and some study heterogeneity (Gunnarsson and Bodin, 2018, p. 10). Significant associations were also reported between ALS and heavy physical work, exposure to metals (including lead) and chemicals (including pesticides), and working as a nurse or physician. Jalilian et al. (2020) conducted a meta-analysis of ALS and occupational exposure to ELF magnetic fields and electric shocks within 27 studies from Europe, the United States, and New Zealand. A weak statistically significant association was reported between magnetic-field exposure and ALS; no association was observed between ALS and electric shocks. For the studies examining ALS and magnetic-field exposure, the authors reported "*moderate to high*" heterogeneity and indications of publication bias and noted that *"the results should be interpreted with caution"* (Jalilian et al., 2020, p. 1).

Alzheimer's Disease and Parkinson's Disease

Checkoway et al. (2018) investigated the association between Parkinsonism[14] and occupational exposure to magnetic fields and other agents (e.g., endotoxins, solvents, shift work) among female textile workers in China. The study included 537 retired cotton factory workers and 286 age-matched controls who were retired cotton factory workers not exposed to cotton dust (which was used to define endotoxin exposure). Exposure to magnetic fields was assessed using a job exposure matrix. The authors reported no statistically significant associations between Parkinsonism and occupational exposure to magnetic fields, endotoxins, shift work, or solvents. The authors reported no statistically significant associations between Parkinsonism and exposure to magnetic fields based on the participants' occupation. Strengths of this study include the expanded definition of the health outcome (to reduce underreporting), as determined by neurologists, and the availability of information on relevant covariates, including smoking and medical histories. The low statistical power of the study, due to the low prevalence of disease among the population, is a limitation.

Gervasi et al. (2019) investigated the relationship between residential proximity to overhead power lines and risk of Alzheimer's disease and Parkinson's disease in Italy. The authors included 9,835 cases of Alzheimer's dementia and 6,810 cases of Parkinson's disease; controls were matched by sex, year of birth, and municipality of residence. Exposure was characterized using residential distance from the nearest overhead power line (> 30 kV). The authors reported a weak, but statistically not significant, association between residences within 50 meters of overhead power lines and both Alzheimer's disease and Parkinson's disease. Strengths of the study include the large study population and the inclusion of potential confounders. The characterization of exposure using residential distance to power lines, however, is a primary limitation of the study.

Jalilian et al. (2018) conducted a meta-analysis of 20 epidemiologic studies of occupational exposure to ELF magnetic fields and Alzheimer's disease. A moderate, but statistically significant, overall association was reported; however, the authors noted substantial heterogeneity among studies, as well as evidence for publication bias. Pooling results from studies with a higher risk of bias, as assessed by the authors, resulted in stronger associations, suggesting that bias in the studies likely contributed to the reported associations.

Gunnarsson and Bodin (2019) updated their previous meta-analysis (Gunnarsson and Bodin, 2018) to also include Parkinson's disease and Alzheimer's disease. A slight, yet statistically

[14] Checkoway et al. (2018) defined Parkinsonism as *"a syndrome whose cardinal clinical features bradykinesia, rest tremor, muscle rigidity, and postural instability. Parkinson disease is the most common neurodegenerative form of parkinsonism"* (p. 887).

significant, association was reported between exposure to EMF and Alzheimer's disease; no association was observed for Parkinson's disease. When the authors combined the studies of ALS and Alzheimer's disease, a stronger association with EMF was observed in those studies published prior to 2005 compared to studies published more recently; however, the authors also noted "*an evident publication bias*" in the studies published before 2005.

Assessment

The overall evidence from recent studies fail to alter the WHO's and SCENIHR's assessment that there is no consistent or convincing support for a causal association between EMF exposure and neurodegenerative diseases. Recent meta-analyses also do not provide compelling evidence of a relationship between ELF magnetic fields and neurodegenerative disease.

Cardiovascular disease

It has been hypothesized that magnetic-field exposure reduces heart rate variability, which in turn is a marker of increased susceptibility for acute myocardial infarction. In a large cohort of utility workers, Savitz et al. (1999) reported an increased risk of arrhythmia-related deaths and deaths due to acute myocardial infarction. Previous and subsequent studies, however, did not report a statistically significant increase in cardiovascular disease mortality or incidence related to occupational magnetic-field exposure (WHO, 2007). The WHO concluded, *"[o]verall, the evidence does not support an association between ELF [magnetic-field] exposure and cardiovascular disease"* (WHO, 2007, p. 220).

As discussed in Exponent (2019), Elmas (2016) summarized some of the literature examining the effects of EMF exposure on the heart. The review included studies that assessed the relationship between long-term occupational exposure and heart rate, as well as several studies examining short-term exposure and various health impacts. The author concluded that "*despite these studies, the effects of EMFs on the heart remain unclear*" and that there is "*not yet any consensus in these works about possible mechanisms by which effects of EMF exposure may occur*" (Elmas, 2016, pp. 80).

Summary of research published between 2018 and 2020

No epidemiologic studies examining the potential relationship between ELF EMF and cardiovascular disease were identified within the time period of this report.

Assessment

No original research studies have been identified on EMF and cardiovascular disease since the previous report. Thus, earlier conclusions on the lack of an association between magnetic fields and cardiovascular disease remain relevant.

In vivo studies of carcinogenesis

In the field of ELF EMF research, a number of research laboratories have exposed rodents, including those with a particular genetic susceptibility to cancer, to high levels of magnetic fields over the lifetime of the animals and performed tissue evaluations to assess the incidence of cancer in many organs. In these studies, magnetic-field exposure has been administered alone (to test for the ability of magnetic fields to act as a complete carcinogen), in combination with a known carcinogen (to test for a promotional or co-carcinogenetic effect), or in combination with a known carcinogen and a known promoter (to test for a co-promotional effect).

The WHO review described four large-scale, long-term studies of rodents exposed to magnetic fields over the course of their lifetime that did not report increases in any type of cancer related to the intensity of exposure (Mandeville et al., 1997; Yasui et al., 1997; McCormick et al., 1999; Boorman et al., 1999a, 1999b). The highest intensity studied was 50,000 mG (Yasui et al., 1997). At the time of the WHO report, there was no directly relevant animal model for childhood acute lymphoblastic leukemia (ALL). Some animals, however, develop a type of lymphoma similar to childhood ALL and studies exposing these predisposed transgenic mice to ELF magnetic fields did not report an increased incidence of this lymphoma type (Harris et al., 1998; McCormick et al., 1999; Sommer and Lerchl, 2004).

Studies investigating whether exposure to magnetic fields can promote cancer or act as a co-carcinogen used known cancer-causing agents, such as ionizing radiation, ultraviolet radiation, or certain chemicals. No effects were observed for studies on chemically-induced preneoplastic liver lesions, leukemia or lymphoma, skin tumors, or brain tumors; however, the incidence of 7,12-dimethylbenz[a]anthracene-induced mammary tumors was increased with magnetic-field exposure in a series of experiments in Germany (Löscher et al., 1993, 1994, 1997; Mevissen et al., 1993a, 1993b, 1996a, 1996b, 1998; Baum et al., 1995; Löscher and Mevissen, 1995; Mandeville et al., 1997), suggesting that magnetic-field exposure increased the proliferation of mammary tumor cells. These results were not replicated in a subsequent series of experiments in a laboratory in the United States (Anderson et al., 1999; Boorman et al., 1999a, 1999b), possibly due to differences in experimental protocol and the species strain. In Fedrowitz et al. (2004), exposure enhanced mammary tumor development in one sub-strain (Fischer 344 rats), but not in another sub-strain of rats that was obtained from the same breeder, which argues against a promotional effect of magnetic fields.[15]

The WHO reviewed results from two laboratories that had reported an increase in genotoxic effects among exposed animals (e.g., DNA strand breaks in the brains of mice at magnetic-field

[15] The WHO concluded with respect to the German studies of mammary carcinogenesis, "*Inconsistent results were obtained that may be due in whole or in part to differences in experimental protocols, such as the use of specific substrains*" (WHO, 2007, p. 321).

levels between 100 and 5,000 mG [e.g., Lai and Singh, 2004]). Other investigators have reported no effect of magnetic-field exposure and thus did not replicate these results.

In summary, the WHO concluded the following with respect to *in vivo* research on carcinogenesis: "*There is no evidence that ELF [EMF] exposure alone causes tumours. The evidence that ELF field exposure can enhance tumour development in combination with carcinogens is inadequate*" (WHO, 2007, p. 322). Recommendations for future research included the development of a rodent model for childhood ALL and the continued investigation of whether magnetic fields can act as a promoter or co-carcinogen.

As summarized in Exponent (2019), the *in vivo* studies conducted up to 2018 do not alter the previous conclusion that there is inadequate evidence of carcinogenicity due to ELF EMF exposure. The research on whether magnetic-field exposure could enhance tumor development in combination with known carcinogens also remains inadequate. Several studies of long-term exposure reported some positive findings, but substantial methodological and reporting flaws affect their weight in the overall assessment (Qi et al., 2015; Soffritti et al., 2016a, 2016b). For example, at least some of the reported findings from Soffritti et al. (2016a, 2016b) are based on a limited number of affected animals and the occurrence of tumors that typically occur only at the extreme end of life. In addition to these studies, various shorter-term studies have been conducted to investigate the potential genotoxicity of magnetic-field exposure and its possible effects on gene expression in cells associated with cancer in humans. Many of these studies suffer from various methodological deficiencies, including small sample sizes, the absence of sham-exposure treatment groups, and analyses that were not conducted in a blinded manner. Further, consistency across the body of studies is commonly lacking in terms of the exposures applied, the cell types assessed, and the specific parameters evaluated.

In 2018, some of the data from these experiments were republished in a paper by Bua et al. (2018). This new paper included the complete results on the effects of magnetic fields alone (Experiment BT 1CEM). Bua et al. (2018) reported no effect of magnetic-field exposure on food and water consumption, body weight, or survival. The histopathological analysis of the rats at death revealed no statistically significant increase in the incidence of total tumors in any group exposed to magnetic fields at levels of 20, 200, and 1,000 mG. A statistically significant 24% decrease in the number of male rats bearing malignant tumors was observed in those continuously exposed to 10,000 mG.

Magnetic-field exposure at any level did not affect the incidence of the specific types of malignancies reported (mammary gland tumors, Schwannomas of the heart, thyroid C-cell carcinomas, and hemolymphoreticular neoplasia). The authors concluded that the study "*provided no evidence of any carcinogenic effect related to the exposure of ELF EMF alone*" (Bua et al., 2018, p. 274). This conclusion is consistent with the data reported for animals exposed to magnetic fields alone in previous publications by the Ramazzini Institute (Soffritti, 2010; Soffritti et al., 2016a, 2016b).

The strengths of the study include the large number of rats (250 to 502) in each group and exposures over their lifespan. These strengths, however, are outweighed by gross limitations in the design of the experiment and data analyses. The rats were not randomly allocated to exposure groups and no data were presented to confirm the absence of potentially confounding effects of noise and vibration. The lighting of the cages within the exposure room was not uniform and no measures to control this confounder were described. More important, the statistical analysis incorrectly treated each rat as the unit of analysis; whereas because the rats were exposed in groups, each cage should have been the unit of analysis (Festing and Altman, 2002). In addition, the large number of statistical tests performed could be expected to lead to false positive results by chance alone and the statistical criteria were not adjusted to correct for this. Finally, the major concerns that have been raised about the quality of the histopathological analyses of the autopsy samples by the Ramazzini Institute in other studies (EFSA, 2011; FDA, 2007; Gift et al., 2013; USEPA, 2013) undermine the credibility of histopathology findings (Wolf and Maack, 2017). Although Bua et al. (2018) reported in their paper that the "*histopathology evaluation was performed in [sic] blind by at least two pathologists,*" this was the first study from the Ramazzini Institute to state this claim (Bua et al., 2018, p. 273).

To prevent experimenter bias in the analysis of a study's results, it is essential for the experimenters to perform the analysis of data from the exposed and control subjects blind (i.e., without knowledge of the exposure status of the subjects). None of the studies from the Ramazzini Institute, however, stated that the experiments were performed in a blinded fashion except in the last publication that included the statement "*pathological diagnosis of the RI [Ramazzini Institute] were performed in blind [sic]*" (Bua et al., 2018, p. 277).

Three studies investigated of cytokines and indicators of oxidative processes that may function differently in some types of cancer (Li et al., 2015; Luo et al., 2016; Li et al., 2018).[16] The investigators exposed mice and rats to a 50-Hz magnetic field and reported change in some indicators at levels of 5,000 mG (Li et al., 2018), 60,000 mG (Luo et al., 2016), and 100,000 mG (Li et al., 2015). The three studies reported effects at magnetic-field levels far above the highest magnetic-field levels encountered by electric utility workers. The significance of these studies is further limited by inadequacies in procedures including failure to randomly allocate subjects, absence of blinded analyses, assumptions used for statistical analysis, and lack of control of other conditions that might confound the results.

[16] Note that the study authors of Li et al. (2015) are not the same scientists as Li et al. (2018).

Summary of research published between 2018 and 2020

Animal Studies

Campos-Sanchez et al. (2019) conducted a subsequent pilot study to Rodriguez-Hernandez et al. (2017). Rodriquez-Hernandez et al. (2017) had designed a model for childhood leukemia by inserting the gene ETV6-RUNX1, found in about 25% of children with ALL, into fertilized mouse embryos. They observed that about 11% of the mice born with this gene developed leukemia if raised under ordinary laboratory conditions in which bacterial and viral infections were common. In the subsequent pilot study by Campos-Sanchez et al. (2019), of mice treated in the same manner and exposed to 50-Hz magnetic fields at 15,000 mG, the authors were unable to assess an effect because of the small number of mice studied, the low frequency of disease development, and the lack of sham controls. No further research on this animal model has been published.

Occupational Biomarker Studies

Three cross-sectional studies of workers at coal-fired power plants explored the possibility that exposures to magnetic and electric fields were related to differences in blood samples from groups of workers with lower exposures. Such studies cannot determine whether measured or reported biological or health outcome occurred before, during, or after exposure to EMF (NRC, 2011, pp. 560-561), so these studies and any cross-sectional studies of other exposures, cannot establish a cause-and-effect relationship. Although cross-sectional studies cannot establish causation, such studies are initiated to test preliminary hypotheses and can be performed at reasonably low cost.

The focus of three biomarker studies of male thermal power plant workers was to determine if one-time samples of human cells analyzed for single strand breaks in DNA as detected by the alkaline comet assay, were related to EMF exposure. The DNA of every cell of the human body is damaged 10,000 times per day by ongoing cellular processes (Ames et al., 1993). In most cases, multiple other cell processes work to effectively repair this damage, or if severe, remove the damaged cell by programmed cell death (apoptosis). If not repaired properly, a mutation may result that, dependent upon other conditions, could lead to cancer. Hence, in the evaluation of biological processes that might lead to cancer, scientists have used a variety of tests to quantify levels of damage to DNA.

Zendehdel et al. (2019) reported a statistically significant difference in DNA strand breaks in blood cells between 29 power plant workers and a support group of 28 members as measured by the comet assay. Although the two groups of workers were similar with respect to age, length of work experience, and smoking status, the investigators made no effort to compare the workers with regard to exposure to the many chemicals within in a coal-fired power plant that have been associated with indicators of DNA damage (Celik et al., 2007). In addition, Zendehdel et al. (2019) reported no attempt to prevent bias in the collection and analysis of the samples by investigators by standard procedures for blinding. The time separating the measurement of the magnetic field and blood drawing was not reported.

A similar cross-sectional study of 102 thermal power plant workers and 136 office workers in Shahroud, Iran, measured aspects of DNA damage in blood lymphocytes in these groups by the comet assay as well as indicators of programmed cell destruction by flow cytometry (Hosseinabadi et al., 2019). Measured electric and magnetic fields and self-estimated time spent at workstations were used to compute TWA exposures. The analyses ranked the power plant workers by exposure into three groups and 50 cells from each subject were classified for DNA characteristics for 5 inter-related indices from the alkaline comet assay. The EMF measurements and comet assays were performed by separate persons and the comet assays were analyzed in a blinded fashion (i.e., without knowledge of the subjects' exposure history).

Differences between power plant workers for four of five of these indices from the comet assay by level of magnetic-field exposure were reported, but not on the most commonly reported measure of damage—length of the comet tail. Data from flow cytometry also indicated significant differences between plant worker groups on cellular apoptosis but not measured DNA damage. Comparisons of power plant and office workers on these comet assay measures showed small numerical differences between these groups with great variability. Statistical differences between these exposed groups were reported for three of the five indices. No explanation was given as to the authors' failure to report the results of flow cytometry analyses of the comparison group of office workers.

In a second study, Hosseinabadi et al. (2020a) reported that workers at a thermal power plant differed in some measures of indicators of oxidative stress in blood according to the categories of magnetic-field exposure but the overall total antioxidant capacity did not differ between the control and exposed groups (Hosseinabadi et al., 2020a). In a third study, Hosseinabadi et al. (2020b) randomly allocated thermal power plant workers to four groups: three groups received 1,000 milligrams of vitamin C, 400 units of vitamin E, both vitamins C+E, and one group received no vitamins. Each subject received 120 cubic centimeters of cocoa milk each day for 3 months with the indicated ingredient. EMF measurements and sample collection were similar to those used in the previous study (Hosseinabadi et al., 2019). The study did not report when the EMF measurements were taken or the times when blood sample collections were made before and after the treatment period.

The authors reported no differences in the EMF levels for these treatment groups (~160 mG and 23 kV/m). Neither were any differences in pre-treatment levels of any DNA measure reported for the groups. After the treatment period, post-measurements of apoptosis did not differ from pre-treatment levels following any treatments. In contrast, several post-treatment comet assay indicators in the vitamin C, vitamin E, and vitamins C+E were significantly lower than in the post-treatment control group. While Hosseinabadi et al. (2020a) provides more detailed information than the 2019 paper, it provided little insight as to a role of EMF in cell DNA attributes.

The measurement of DNA characteristics of single cells is a specialized and highly technical process that requires considerable experience. None of the laboratories that performed the sample analyses appeared to have demonstrated expertise, nor the historical database necessary, to carry out these complex tests, and none of the data reported in these studies met the criteria required to confirm a clear positive response (OECD, 2015).

A fourth cross-sectional study examined 15 male workers who maintain 225-kV and 400-kV transmission lines and who also live near these lines and substations, and 25 male controls (Touitou et al., 2020). No details on the controls were provided. The exposed worker had 1 to 20 years of experience in this type of work. The workers' magnetic-field exposures were measured at 30 second intervals for 1 week; the average magnetic-field levels of the exposed workers was 9 mG and the exposure of controls averaged 0.9 mG. From 10 PM to 8 AM, 13 blood samples were drawn from each participant, and chromogranin A (CgA), a general, non-specific marker that is elevated by neuroendocrine tumors and by stimulation of the adrenal gland by stress was measured in each sample. The CgA levels were observed to decrease steadily at the same rate from a nighttime peak in both the exposed and control groups. The results did not indicate that elevated exposure to magnetic fields had any significant effect on this indicator.

Assessment

The cross-sectional observational studies in which characteristics of volunteer subjects were categorized by estimated or measured EMF exposure and measured biomarkers of putative relevant covariates of cancer were of poor quality overall with regard to exposure assessment, sample size, methods to minimize potential biases and confounding by other factors, and standards for the detection of these markers of damage to DNA. In order to add to the weight of the scientific literature, such studies need to develop exemplary experimental control over potentially confounding exposures and apply rigorous study procedures to convince the scientific community that EMF was a contributing factor to the outcome of the studies and that those outcomes are directly relevant to the development of cancer. In addition, such studies by their design are not suitable for assessing causal hypotheses. Hence, the recent *in vivo* studies reviewed above do not alter the conclusions of the WHO and SCENIHR that there is inadequate evidence of carcinogenicity due to ELF EMF exposure. In their 2015 report, SCENIHR supported these conclusions, stating that:

> *Previously SCENIHR (2009) concluded that animal studies did not provide evidence that exposure to magnetic fields alone caused tumours or enhanced the growth of implanted tumours. The inclusion of more recent studies does not alter that assessment. In addition, these studies do not provide further insight into how*

magnetic fields could contribute to an increased risk of childhood leukaemia (SCENIHR, 2015, p. 161).

5 EMF Standards and Guidelines

There are no federal guidelines or standards limiting exposure to 60-Hz electric and magnetic fields in the United States, and no state guidelines or standards in the state of Rhode Island. Two states, Florida and New York, have enacted standards to limit EMF from transmission lines at the edge of the ROW to maintain the status quo such that fields from new transmission lines would be no higher than fields produced by existing lines.[17]

Two international scientific organizations—ICNIRP and the International Committee for Electromagnetic Safety (ICES)—published guidelines for limiting public and occupational exposure to ELF EMF (ICES, 2002; ICNIRP, 1998, 2010). These guidelines were developed following the organizations' reviews of the literature, including epidemiologic and experimental evidence related to both short-term and long-term exposure, and are set to prevent the known and established effects discussed in Section 1 (i.e., short-term, direct, acute effects that can occur at high levels of exposure, such as perception, annoyance, and the stimulation of nerves and muscles). Since no long-term health effects have been established by any of the scientific of health organizations discussed in previous sections, no exposure limits have been recommended based on long-term health effects. The ICNIRP guideline states that *"[t]he epidemiological and biological data concerning chronic conditions were carefully reviewed and it was concluded that there is no compelling evidence that they are causally related to low-frequency EMF exposure"* (ICNIRP, 2010, p. 818).

ICNIRP has set exposure guidelines (Reference Levels) for the general public of 4.2 kV/m and 2,000 mG for 60-Hz electric fields and magnetic fields, respectively (ICNIRP, 2010). ICES has set exposure guidelines (Exposure Reference Levels) for the general public of 5 kV/m and 9,040 mG for 60-Hz electric fields and magnetic fields, respectively (ICES, 2019).[18] For reference, in a survey by Zaffanella and Kalton (1998), only about 1.6% of the general public experienced exposure to magnetic fields of at least 1,000 mG during a 24-hour period. The guidelines from both organizations incorporate large safety factors to account for potential sources of uncertainty and to be protective of susceptible sub-populations in the general public. The ICNIRP exposure guidelines are formally recognized by the WHO and are recommended for adoption by governments (WHO, 2006).

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[17] These limits at the edges of new transmission line rights-of-ways, which are not based on any established health effects, are 200 mG (for 500-kV transmission lines) and 150 mG (for ≤ 230-kV transmission lines) for magnetic fields, and 2 kV/m (≤500-kV lines) for electric fields in Florida (FDEP, 1993) . In New York, the limit for magnetic fields is 200 mG and for electric fields is 1.6 kV/m (NYPSC, 1978; NYPSC, 1990).

[18] ICES also set a 10 kV/m limit on a transmission line ROW. This is an exception within transmission line ROWs – "[w]ithin areas designated as power line rights-of-way (or similarly designated areas, e.g., easement or corridor), the ERL [exposure reference level] for persons in unrestricted environments is 10 kV/m" – because people do not spend a substantial amount of time at these locations and very specific conditions are needed before a response is likely to occur (i.e., a person must be well insulated from ground and must contact a grounded conductor) (ICES, 2019, p. 47).

6 Summary

Since the late 1970s, a large number of scientific studies have been conducted and published that investigated potential effects of ELF EMF on human health. These studies included epidemiologic studies of humans and experimental laboratory studies of human, animals, and cells and tissues. This research focused on many aspects of physiology and disease, including cancers in children and adults, neurodegenerative diseases, reproductive effects, and cardiovascular disease.

The large body of scientific literature on potential long-term effects of ELF EMF exposure has been regularly and repeatedly reviewed and evaluated by a number of national and international health and scientific agencies. These agencies, through the expert panels they assembled, used generally accepted weight-of-evidence scientific methods to evaluate if the evidence points to the existence of any adverse health effects in association with exposure to ELF EMF (e.g., IARC, WHO, SCENIHR). None of these scientific evaluations concluded that the evidence confirms the existence of any adverse, long-term health effects in association with environmental exposure to ELF EMF below scientifically-established exposure guidelines (e.g., ICNIRP, ICES). More recent scientific literature, as reviewed in this report, does not provide evidence to change this overall conclusion.

There are no national recommendations, guidelines, or standards in the United States to regulate EMF or to reduce public exposures. Scientifically-established exposure guidelines (e.g., ICNIRP, ICES) were developed to protect the general public and workers from all known and established effects of EMF exposure, which are short-term, acute effects that can occur at high levels of exposure. The ICNIRP exposure guidelines are formally recognized by the WHO and are recommended for adoption by governments.

In summary, when recent studies are considered in the context of previous research, they support the previous conclusion that ELF EMF exposure at the levels encountered in everyday environments is not a cause of cancer or any other disease process. The current guidance from the WHO on its website states that *"[b]ased on a recent in-depth review of the scientific literature, the WHO concluded that current evidence does not confirm the existence of any health consequences from exposure to low level electromagnetic fields."*[19]

[19] https://www.who.int/peh-emf/about/WhatisEMF/en/index1.html

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