The 2015 Salty Brine State Beach Incident

RHODE ISLAND DEPARTMENT OF ENVIRONMENTAL MANAGEMENT

June 2016

Authors: Eric G. Schneider[1] and Arthur J. Spivack[2]

[1] Rhode Island Department of Environmental Management, Division of Fish and Wildlife, Marine Fisheries, Jamestown, RI 02879, USA.

[2] Graduate School of Oceanography, University of Rhode Island, Narragansett, RI 02882, USA.

Suggested citation: Schneider, E. G. and A. J. Spivack. 2016. *The 2015 Salty Brine State Beach Incident*. Rhode Island Department of Environmental Management. 50 pp.

Cover photo credit: David Curran, RI Division of the State Fire Marshal, taken July 11, 2015 at Salty Brine State Beach, Narragansett, RI.

Purpose and Scope

This report, *The 2015 Salty Brine State Beach Incident*, presents the findings of the scientific investigation into the events that occurred at Salty Brine State Beach in Rhode Island on July 11, 2015. The purpose of the report is to provide a factual account of the incident, response, scientific investigation and findings, and to draw conclusions.

Acknowledgments

DEM wishes to recognize the professionalism and collaboration of all partners involved with the investigation, including the Rhode Island State Police, Rhode Island Division of the State Fire Marshal, United States Coast Guard, Rhode Island Governor's Office (including Governor Gina M. Raimondo and her communications staff Joy Fox and Marie Aberger), United States Army Corps of Engineers, National Grid (especially President Timothy F. Horan), Rhode Island Building Code Commission (including Robert Raimbeault, State Electric Inspector), United States Department of Agriculture Natural Resource Conservation Service (NRCS), and the University of Rhode Island (URI) Graduate School of Oceanography (GSO).

DEM extends special thanks for the dedication and scientific expertise offered by the DEM-GSO Scientific Team, including GSO team members Professors Dr. John King, Dr. Brian Heikes and Dr. Arthur Spivack; GSO graduate students Justine Sauvage and Kira Homola; GSO marine technician Dennis Graham; DEM Principal Marine Fisheries Biologist Eric Schneider; and NRCS Assistant State Soil Scientist Jim Turenne. DEM appreciates the leadership and can-do spirit of GSO Dean Dr. Bruce Corliss and the support from GSO Director of Administration Thomas Miller. Additional field and technical assistance was provided by Dr. Jimmie Oxley (URI), Dr. Mark Stolt (URI), Dr. Bryan Oakley (Eastern Connecticut State University), Katie Thow (NRCS), and Josh Sargent (NRCS).

DEM also wishes to acknowledge the professionalism and diligence of DEM staff who contributed to the response and investigation and preparation of this report, including: Director Janet Coit; Associate Director for Natural Resources Larry Mouradjian; Division of Law

Enforcement Deputy Chief Kurt Blanchard, Lieutenant Ed Cabral and Environmental Police Officer Michael Schipritt; Assistants to the Director Rayna Maguire and Gail Mastrati; Chief Public Affairs Officer Rose Jones; Division of Parks and Recreation Chief Robert Paquette, Regional Park Manager Roger Monfette, Assistant Regional Park Manager Paul Herbert, Park Managers Kyle Cahoon and John MacCoy, and Supervising Electrician Robert Ferland; Chief Distribution Officer Carmino Paliotta and Chief Construction Supervisor Paul Zolkos; Division of Marine Fisheries Supervising Environmental Scientist Dr. Chris Deacutis; the Emergency Response Team of Jim Ball, Coordinator, and Hazardous Material Specialists Thomas Campbell, John Leo and Raymond Meunier; Division of Planning and Development Engineers James McGinn and Lisa Lawless; and the Division of Park and Recreation and Natural Resources Bureau seasonal staff, especially Laborers Ryan Kania and Dan Timpson.

Table of Contents

	Page
Purpose and Scope	i
Acknowledgments	i
Table of Contents	iii
Executive Summary	1
Background	7
Description of Incident	7
Initial Response and Investigation	8
Investigation by Scientific Experts	10
Background - Hypotheses	10
Sample Collection	12
Sample Analyses - Hydrogen and Methane Determination	13
Results – Methane	13
Results – Hydrogen	13
Additional Field Sampling and Monitoring	14
Removal of remaining sub-marine four-conductor power cable	15
Analysis of Future Risk	16
Conclusions	16
Literature Cited	18
Figures	19
Appendix I - Detailed Methods and Results of Methane and Hydrogen Analyses	35
Appendix II – Letter from Rhode Island Governor Gina Raimondo to the United States Coast Guard regarding underground cables at Rhode Island State Beaches	43

This page is intentionally left blank

Executive Summary

At approximately 11:15 a.m. on July 11, 2015 officials began to receive reports of a small explosion at the waterline near the stone jetty at Salty Brine State Beach. State and local officials, including the Rhode Island (RI) Department of Environmental Management (DEM) Division of Law Enforcement (DLE), Rhode Island State Police (RISP), and Narragansett Police Department, responded immediately. The area around the incident was secured, and the beach and adjacent waters closed to the public. Witnesses reported that there was a "loud bang" and immediately following one beach patron's chair began to sink into the sand. The sand then "erupted" beneath her, and she was propelled forward approximately five to eight feet away from the jetty. The incident left an area of sand approximately six feet in diameter cracked and disturbed. Emergency medical workers assisted the beach patron who was later transported to South County Hospital with non-life-threatening injuries.

The DLE – in coordination with the RISP; Rhode Island Division of the State Fire Marshal (RI SFM); United States Federal Alcohol, Tobacco and Firearms (US ATF); DEM Emergency Response (ER); and other officials – conducted the initial investigation to determine what caused the incident. Members of the RI SFM Bomb Squad searched the site for evidence of explosive materials (e.g., explosive residues from a bomb, relict military ordnance, or other explosive device). All tests were negative, and there was no evidence to suggest explosives were involved in the incident. Given this lack of evidence and the conclusion by law enforcement of no present threat to public safety, DEM reopened the beach on July 12, 2015.

State officials continued to explore potential alternative causes of the incident. These included a shifting or movement of stones within the adjacent jetty, a seismic event, and an electrical explosion in an abandoned power cable. The latter had been used previously to power navigation aids in the Point Judith Harbor of Refuge. It remained buried under the sand in the general vicinity of the incident.

On Monday July 13, 2015, DLE, RI SFM, RISP, National Grid, the United States Coast Guard (USCG), and the United States Army Corps of Engineers (US ACOE) were at the site and

investigated these alternative potential causes. The US ACOE, owner of the jetty, examined the condition of the jetty and found no evidence that stones had recently moved or shifted. No damage to the jetty was observed. Also, there were no confirmed seismic events registered in Rhode Island on July 11, 2015. Collectively, these results suggested the stone jetty did not cause the incident. National Grid officials tested the four-conductor power cable (disconnected in the 1980s) that ran from the parking lot under the sand near the site of the incident and out towards the navigation aids in the Harbor of Refuge. No electrical power was detected, and the cable was left buried under the sand.

On Tuesday, July 14, 2015, the USCG worked onsite with DLE, RI DEM Division of Parks and Recreation (DPR), RI SFM, and the Rhode Island State Electric Inspector to remove the four-conductor power cable from under the beach area. Using heavy equipment, workers excavated the cable from the beach sand and cut it below the waterline. During the excavation, workers discovered an older piece of three-conductor cable in the immediate vicinity of the incident. RI SFM and DLE officials observed that one end of the cable, located within feet of the incident, had several shiny, bright copper and steel wires; these wires showed remarkably little sign of corrosion despite being buried in sand saturated with seawater from more than 30 years.

Based on USCG records, it appears the older three-conductor cable powered the navigation aids in the Harbor of Refuge from the 1950s until the early 1980s when it became unreliable. The USCG removed the submarine portion of the cable and laid the newer four-conductor cable in the former's path. Records indicate the USCG could not remove a section of the older three-conductor cable at the water line, as it was either stuck or entangled (USCG official, personal communication, July 23, 2016). As a result, the cable was cut and abandoned in place at the waterline.

The newer four-conductor cable powered the navigation aids from the early 1980s until they were transferred to solar power in 2007. At that time, USCG disconnected the four-conductor cable from the power source (a utility pole), capped it, and abandoned it in place. On July 14, 2015, the USCG, DEM, RI SFM, and RISP removed the two abandoned cables – the older three-conductor cable piece, and the entirety of a four-conductor cable. The State Electric Inspector

later confirmed that there was no power connection to the cables and thus no likelihood of an electrical explosion.

With all obvious potential causes (e.g., bomb, military ordnance, electrical explosion, movement of the breakwater, and earthquake) excluded, DEM Director Janet Coit contacted Dr. Bruce Corliss, Dean of the University of Rhode Island Graduate School of Oceanography (GSO), to request assistance with the investigation. A team of DEM and GSO scientists was assembled. GSO scientists hypothesized that the combustion of sub-surface methane or hydrogen gas was possible explanations for the event. The DEM-GSO team – assisted by scientists from the US Department of Agriculture, Natural Resources Conservation Service (NRCS), and others – collected beach sand core samples for hydrogen and methane analyses. GSO scientists then analyzed samples to test these hypotheses.

The GSO team measured methane in 21 individual samples from 13 sediment cores. Results from one sample (No. M-2.2) at only one depth, 51.5 cm from the surface, showed levels above background (partial pressure equivalent to 0.03% methane in air). A replicate sample from this depth had partial pressures of 0.31% methane in air. The low levels of methane observed did not support the hypothesis that the incident was the result of methane combustion.

The GSO team measured hydrogen in 101 individual samples from 13 sediment cores. Sixty-seven samples had no detectable hydrogen. Twenty-seven samples were between the detection limit (0.04% hydrogen in air) and 1% hydrogen in air, while seven samples were above 1%. The two highest values, 9.60% and 10.49%, were the deepest samples (No. H-3.5 and H-3.6), 207.5 cm below the surface, taken in close proximity to both the site of the incident and where the terminal end of the older three-conductor cable was located. These high values are in great excess − 20,000 times higher − of natural beach sediment levels (i.e., 0.0005%), and within the partial pressure range of both burning (4% hydrogen in air) and detonation (11% hydrogen in air).

Scientists from NRCS and DEM conducted additional field sampling on July 20, 2015 to determine if there were any other USCG cables or foreign objects remaining in the sand. Using

ground-penetrating radar (GPR) and heavy equipment, they found another portion of the older three-conductor power cable (approximately 80 feet in length) buried in the sand. USCG, DEM, RI SFM, and RISP removed the cable and transferred it to the RISP headquarters in Scituate, Rhode Island. In addition to the GPR work, DEM conducted air quality sampling for hydrogen gas at 10 locations near the jetty, extending approximately 60 feet up the beach away from the waterline. None of the samples registered hydrogen concentrations above detection. DEM continued air quality sampling for hydrogen and additional sampling for other volatile organic compounds (VOCs) for the remainder of the beach season. All results were negative.

After the incident Rhode Island Governor Gina Raimondo wrote to the USCG requesting that the "…USCG remove any remaining abandoned cables buried in the vicinity of our [RI] state beaches and in the Point Judith Harbor of Refuge". In response to the Governor's request and to avoid potential public safety concerns, the USCG removed the remaining portion of the abandoned four-conductor power cable during February and March of 2016. This cable extended from the waterline at Salty Brine State Beach along the sea bottom out to an USCG Navigation Aid at the end of the West Breakwater (Point Judith Harbor of Refuge West Entrance Light 3, LLNR 19505). This cable was cut below the water line on July 14, 2015 as part of the investigation into the Salty Brine State Beach incident. With this piece removed and based on records review, DEM believes no abandoned, buried cables remain at Salty Brine State Beach.

Ultimately, multiple lines of evidence are consistent with the conclusion that the Salty Brine State Beach incident was the result of hydrogen detonation. It is likely that the hydrogen was produced as a product of the anaerobic corrosion of an abandoned cable. The evidence supporting this conclusion includes: high levels of hydrogen in the water-saturated sand near the incident site; a shiny, uncorroded end of an old steel and copper cable found within feet of the incident indicating a cathodic hydrogen-producing metal surface; and observations consistent with a hydrogen detonation, including a loud report, no visible flames, and no observed radiated heat.

The scientists involved with this investigation believe the likelihood of another incident involving hydrogen is extremely low considering 1) the lack of other known hydrogen

combustion incidents at beaches or in other coastal environments, 2) hydrogen is not produced as ubiquitously as methane in shallow subsurface coastal environments, and 3) methane, itself, does not present a significant risk at beaches. Further, after careful review and consultation with USCG, DEM believes there are no similar abandoned cables present at any state beaches. As a result, the scientific experts conclude that the risk of a future event similar to what occurred at Salty Brine State Beach in July 2015 is extremely low.

This page is intentionally left blank

Background

Salty Brine State Beach is a state-owned and operated beach facility located at the western-most end of the contiguous beach within the Harbor of Refuge in Narragansett, Rhode Island (RI). This beach, formerly Galilee State Beach, was transferred from the RI Division of Harbors and Rivers to the RI Division of Parks and Recreation (DPR) in 1954 and renamed "Salty Brine State Beach" after a prominent radio and TV personality in 1990s (RI Division of Parks and Recreation 2015). In 2010, the RI Department of Environmental Management (DEM) DPR completed a major renovation that included a new beach pavilion, boardwalk along the jetty with fishing and overlook platforms, and a renovated parking lot. The upgraded facilities – along with the relatively protected and calm waters, adjacent stone jetty, and view of fishing boats and ferries entering and leaving the Port of Galilee – contribute to the beach's popularity.

Description of Incident

On July 11, 2015 at approximately 11:15 a.m., local and state officials began to receive reports of a small explosion at the waterline near the stone jetty at Salty Brine State Beach (Figure 1). The DEM Division of Law Enforcement (DLE), Rhode Island State Police (RISP), and Narragansett Police Department responded immediately to Salty Brine State Beach. These agencies secured the area around the incident, closed the beach-sand area to the public, and closed adjacent waters to swimming. The DLE requested that a Rhode Island Division of the State Fire Marshal (RI SFM) explosive technician with the State Bomb Squad assist with the initial response.

Based on witness statements contained in the RISP report (Montminy, 2015), it is believed that several beach patrons were in the general vicinity of the incident. They were sitting in chairs and playing in the sand near the water line adjacent to the jetty at the western-edge of the beach from approximately 9:15 a.m. until the incident occurred at approximately 11:15 a.m. Patrons stated that nothing out of the ordinary occurred prior to the incident. Around 11:15 a.m. patrons heard a loud bang, described as a noise like that of a "M-80" firework exploding or boat crashing into the jetty. A patron who was sitting in a chair close to the jetty reported that immediately after

hearing the "loud bang," she attempted to stand and move away from the jetty (to the east). Initially when attempting to stand, the patron reported she could not because the chair was sinking into the sand. Immediately after that, the patron reported that the sand "erupted" and she was propelled forward approximately five to eight feet to the east, away from the jetty. The incident left an area of sand approximately six feet in diameter (Groff, 2015) cracked and disturbed (Figures 2A-D). Emergency medical workers assisted the beach patron who was later transported to South County Hospital with non-life threatening injuries.

Initial Response and Investigation

The DLE – in coordination with the RISP; RI SFM; United States Federal Alcohol, Tobacco and Firearms (US ATF); DEM Emergency Response (ER); and other officials – conducted the initial investigation to determine what caused the incident. The focus of this investigation was to determine if there was an explosion and if so, what had caused it. Members of the RI SFM Bomb Squad searched the site for evidence of explosive materials (e.g., explosive residues from a bomb, relict military ordnance, or other explosive device) by screening the sand in the area, testing for explosive residue using chemical wipes, and using explosive detecting K-9s to search the area. RI SFM John Chartier stated, "All of this testing was negative. Based on the available evidence, there is no reason to believe that explosives were involved in the incident" (Montminy, 2015). Given this lack of evidence and the conclusion by law enforcement of no present threat to public safety, DEM reopened the beach on July 12, 2015.

State officials continued to compile and explore potential alternative causes of the incident. These included a potential shifting or movement of stones within the adjacent stone jetty or a possible electrical explosion in an abandoned power cable. United States Coast Guard (USCG) cables had formerly been used to power navigation aids in the Harbor of Refuge and remained buried under the sand in the general vicinity of the incident.

On Monday July 13, 2015 DLE, RI SFM, RISP, National Grid, USCG, and the United States Army Corps of Engineers (US ACOE) were at the site and investigated these alternative potential causes. The US ACOE, owner of the jetty, examined the condition of the jetty. They

found no evidence that stones had recently moved or shifted and no evidence of displacement or damage. In addition, there were no confirmed seismic events registered in Rhode Island on July 11, 2015 (IRIS, 2015). Collectively these results suggested that the stone jetty did not cause the incident. National Grid officials cut and tested the formerly mentioned underground four-conductor power cable that ran from the parking lot to the sand near the site of the incident. No electrical power was detected. An electrical contractor installed a cap on the cut cable adjacent to the beach pavilion. The remnant of the cable remained intact and buried under the sand.

On Tuesday July 14, 2015 the USCG worked onsite with DLE, DPR, RI SFM, and the State Electric Inspector to remove the underground four-conductor power cable from under the beach area. The DPR used heavy equipment to excavate the cable. The USCG cut this cable below the waterline. While digging to excavate this cable (Figure 3), an older piece of three-conductor cable was discovered in the immediate vicinity of the incident (Figure 4) (Groff, 2015). Based on USCG records, it appears this older three-conductor cable was used to power the navigation aids in the Harbor of Refuge from the 1950s until the early 1980s when its power became unreliable. At that time, the USCG removed the submarine portion of the cable and laid the newer four-conductor cable in the former's path. Records indicate the USCG could not remove a section of the older three-conductor cable at the waterline, as it was either stuck or entangled (USCG official, personal communication, July 23, 2016). As a result, the cable was cut and abandoned in place at the waterline. The newer four-conductor cable was used from the early 1980s until the navigation aids were transferred to solar power in 2007. At that time, the four-conductor cable was disconnected from the power source (a utility pole), capped, and abandoned in place.

These two abandoned cables – the older three-conductor cable piece and the entirety of a four-conductor cable – were removed from the sand by DEM, USCG, RI SFM, and RISP. The USCG took custody and moved these cables to a USCG facility. These cables were later transferred to RISP Headquarters in Scituate, Rhode Island for further investigation. The State Electric Inspector later confirmed that there was no power connection to the cables and thus found no evidence of an electrical explosion (Montminy, 2015). Of particular note: RI SFM and DLE officials stated that one end of the older three-conductor cable, located within feet of the

incident, had several shiny, bright copper and steel wires. These wires showed remarkably little sign of corrosion (Groff, 2015; Figures 5A-B) despite being buried in sand saturated with seawater for more than 30 years. RI SFM officials noted that after removing the cables from the marine environment, the shiny copper and steel wires began to dull (T. Groff, personal communication, July 20, 2015).

Investigation by Scientific Experts

With all obvious potential causes (e.g., bomb, military ordnance, electrical explosion, movement of the breakwater, and earthquake) excluded, DEM Director Janet Coit contacted Dr. Bruce Corliss, Dean of the University of Rhode Island Graduate School of Oceanography (GSO), to request expert scientific assistance with the investigation. A team of DEM and GSO scientists was quickly assembled. (See the Acknowledgments Section for a list of team members and contributors.) GSO scientists hypothesized that the detonation of sub-surface methane or the detonation of hydrogen gas were possible explanations for the combustion event. They then collected and analyzed samples to test the hypotheses, as described below. Specific analytical methodologies and results are contained in Appendix I.

Background - Hypotheses

Methane is commonly produced by micro-organisms in soil and sediment in oxygen-free environments where there is sufficient organic matter (Jorgensen, 2003). In most beaches, the upper layer of sand is porous and contains air, while in deeper layers the pores are filled with water. Within the sub-surface water-saturated zone of beach sand, oxygen is often depleted and methane is produced. Some of this methane will diffuse or bubble out of the water-saturated zone and up through the pore spaces in the overlying sand. For example, bubble transport out of coastal marsh sediments is common (e.g., Flury, et al., 2015). Methane produced in the water-saturated zone and transported to the overlying unsaturated zone of the beach sand will mix with oxygen (approximately 20% in the ambient air), which has diffused down into the pore spaces in the beach sand (Flury, et al., 2015).

A gas mixture of methane and oxygen is not stable and has the potential to burn (reaction with a subsonic flame propagation velocity, also called deflagration) and detonate (reaction with supersonic propagation velocity). For example, combustion of biogenic methane, released from deeper levels following a small seismic event, is attributed to be the cause of a beach fire that burned at Kittery Maine for nearly one hour in 1905 (Dickson, 2000). The lower methane composition limit for burning (percent amount of methane needed for sustained burning) in free air is approximately 5.0 % while the detonation composition limit is approximately 6.3% (Crowl, 2003). The depth where a mixture of these compositions might occur in the shallow sub-surface depends on how much organic matter is present, how deeply it is buried, temperature, and the rate at which the gas disperses into and out of the water unsaturated zone (Flury, et al., 2015).

In oxygen free environments, hydrogen is also produced by microorganisms, as well as abiogenically due to metal corrosion (Jorgensen, 2003; McCafferty, 2010). Biogenic hydrogen concentrations in marine sediments are generally very low and have not previously been observed at combustible concentrations because hydrogen is readily consumed by microbes (Hoehler, 1998). Anaerobic (oxygen-free) hydrogen production associated with metal corrosion is a well-recognized process (McCafferty, 2010). Briefly, when a metal dissolves or corrodes, its electrons are left behind in the metal. If oxygen is not present, the electrons drive the metal to a low voltage at which hydrogen can form by reaction with water (Figure 6). Often, where metals are in environments in which there is a chemical gradient (variations in ionic strength or reduction potential) or the metal has experienced different levels of stress, one area of the metal will be anodic (corroding area of electron supply) and another area will be cathodic (hydrogen producing area of electron consumption) (McCafferty, 2010). Cathodic, hydrogen producing, regions typically are not corroded and maintain shiny metallic surfaces.

Additionally, a buried cable could be a source of hydrogen via an applied cathodic voltage (intentional or stray) (McCafferty, 2010). However, at Salty Brine State Beach, the cables were not powered and not near any likely sources of stray voltage. Thus, corrosion is the only likely source of hydrogen. As with methane, hydrogen produced in the water-saturated beach sand can diffuse or bubble up through the sand and contact oxygen in the water unsaturated zone (Figure 7).

Similar to methane, a mixture of hydrogen and air is not stable. The lower flammability (deflagration) limit of hydrogen in air is approximately 4% and its lower detonation limit is approximately 11% (Alcock, et al., 2001). However, unlike methane, hydrogen flames are nearly invisible and typically do not produce burns from radiated heat. A loud report is produced during hydrogen detonation. The Scandanavian and German word for explosive hydrogen "knallgas" means "boom-gas". Again, like methane, the depth at which a mixture of hydrogen and air might detonate in the shallow sub-surface will depend on the magnitude of the hydrogen source and the rate it disperses.

For combustion of either gas, an ignition source (e.g., spark, electrical discharge, flame, ember) is required as their auto-ignition temperatures (temperature at which they will spontaneously react) are very high (>500 °C). The ignition energy for hydrogen depends on the gas composition but is as low as approximately 1/15 of that for methane (Alcock, et al., 2001). This extremely low ignition energy for hydrogen often hampers the identification of specific ignition sources in industrial hydrogen accidents (Gummer and Hawksworth, 2008). Thus, determining the specific ignition source is often not possible, given that ignition sources can be as minor as static from someone's hair or clothes or an ember from a recently-lit match or cigarette.

Sample collection

The DEM-GSO team, assisted by personnel from Eastern Connecticut State University, URI College of Life Sciences, Department of Natural Resource Studies, and NRCS, utilized a vibracore to collect beach sand core samples at Salty Brine State Beach for hydrogen and methane determinations on two days, July 16 and July 20, 2015. Vibracoring is a technique used for collecting unconsolidated saturated sediments. A core tube is attached to a source of mechanical vibration and lowered into the sediment or beach sand. The vibrations provide energy for rearranging the particles within the sediment in such a way that the core tube penetrates under the static weight of the vibracoring apparatus (Figure 8A-B). In addition to vibracoring, a few cores were collected using a four inch poly-carbonate tube driven into the sand using a wooden hammer (sometimes referred to as a hammer core). During both the July

16 and July 20, 2015 sampling events, ER personnel were present and conducted air sampling for Volatile Organic Compounds (VOCs).

Sample Analyses - Hydrogen and Methane Determination

For the analysis of hydrogen and methane, the GSO team followed their standard laboratory practices for volatile gasses and physical properties in sediment (D'Hondt, et al., 2011). These are detailed in Appendix I. Briefly, the methods are used to determine the concentration of hydrogen and methane in the water contained within the water-saturated zone of beach sand. In this report, concentrations are converted to equilibrium partial pressures using the known solubility of these gasses. These partial pressures can be compared to known flammability (deflagration) and detonation limits.

Results - Methane

The GSO Team measured methane in 21 samples from 13 sediment cores (Appendix I, Table A2, Figure 9). Samples from only one depth were detectable above background (partial pressure equivalent to 0.03% methane in air), 51.5 cm in Sample No. M-2.2 (*Appendix I, Table A2*); replicate samples from this depth had partial pressures of 0.0031 atm. (0.31% methane in air). The low-levels of methane observed do not support the hypothesis that the incident was the result of methane combustion.

Results - Hydrogen

The GSO Team measured hydrogen in 101 individual samples from 13 sediment cores (Appendix I, Table A3, Figure 9). The detection limit for hydrogen above background is 0.0004 atm. (0.04 % hydrogen in air). Sixty-seven samples had no detectable hydrogen. Of these sixty-seven, thirteen had measured water loss values indicating that the sand in these particular samples was not water saturated. Twenty-seven samples were between the detection limit and 1% hydrogen in air, while seven samples were above 1%. The two highest values, 9.60% and 10.49%, were found in the deepest samples (207.5 cm below the surface) in Sample No. H-3.5

and H-3.6, respectively, (*Appendix I, Table A3*) collected in close proximity to the terminal end of the older three-conductor cable and the site of the incident (Figure 9). These high values are in great excess − 20,000 times higher − of natural beach sediment levels, and within the partial pressure range of both burning (4% hydrogen in air) and detonation (11% hydrogen in air). For example, nearshore sediment typically contains levels of hydrogen less than 0.0005% (Hoehler, et al, 1998).

Based on these unusually high hydrogen levels, in conjunction with other evidence, we conclude that it is very likely that the incident on July 11, 2015 was the result of hydrogen detonation. The additional evidence includes the close proximity of a likely potential source of hydrogen (abandoned uncorroded cable end), no evidence of any other explosives source (bomb, ordnance, methane), a loud report but no observed flames or radiated heat, and the low energy required to ignite a hydrogen/air mixture.

As described above, corroding metal in an oxygen-free environment will often have a cathodic area that produces hydrogen, identified by a shiny metallic surface. The steel and copper at the end of the abandoned three-conductor cable recovered in the immediate vicinity (i.e., within a few feet) of the incident was shiny metallic (Figures 5 A-B), while the remainder of the cable was corroded. This finding is consistent with the end of the cable near the location of the incident being a cathodic area of hydrogen production.

Additional Field Sampling and Monitoring

On July 20, 2015 scientists from NRCS in cooperation with DEM conducted a survey of the beach adjacent to the jetty using ground penetrating radar (GPR). The goal was to determine if there were any other USCG cables or foreign objects remaining in the sand. Based on real-time interpretations of GPR results several locations were identified for further investigation. RI SFM, and DLE investigated these locations by digging in the sand and found another portion of the older three-conductor power cable (approximately 80 feet in length) buried in the sand extending south from the concrete slab at the base of the pavilion (See Figure 10 for overview of

cable locations). USCG, DEM, RI SFM, and RISP removed this cable and transferred it to the RISP headquarters in Scituate, Rhode Island.

Results from a desktop review of the GPR imagery suggested a few locations contained a signature that could not be identified and warranted further investigation to ensure that nothing of consequence was located under the sand. On July 24, 2015 NRCS and DEM returned to the beach to investigate these few areas again using GPR. A DEM excavator was brought in and sites of interest were excavated to the water table. Only a short piece of metal pipe was located.

In addition to the GPR work, air quality sampling for hydrogen gas was conducted at 10 locations. At each location samples were taken within cores approximately 12-36" deep, made using a four inch bucket auger, along transects 25-30 feet in length running perpendicular to the jetty extending from the waterline to approximately 60 feet up the beach away from the waterline. Tests were conducted using Draeger Tubes, which have a detection limit for hydrogen of 0.2% or 2,000 ppm. None of the samples registered hydrogen concentrations above detection (not detected). Air quality sampling for hydrogen, and additional sampling for other VOCs was continued at this site for the remainder of the beach season. Tests were conducted with Draeger Tubes using a multiRAE Lite to measure for oxygen levels, hydrogen sulfide (H_2S), CO, VOC. All of these results were negative.

Removal of remaining sub-marine four-conductor power cable

After the incident, Rhode Island Governor Gina Raimondo wrote to the USCG requesting that the ". . . USCG remove any remaining abandoned cables buried in the vicinity of our [RI] state beaches and in the Point Judith Harbor of Refuge." (see Appendix II.) In response to the Governor's request and to avoid potential public safety concerns, the USCG removed the remaining portion of the abandoned four-conductor power cable during February and March of 2016. It extended approximately 4,557 feet from the waterline at Salty Brine State Beach along the sea bottom out to an USCG Navigation Aid at the end of the West Breakwater (Point Judith Harbor of Refuge West Entrance Light 3, LLNR 19505). This cable was cut below the water line on July 14, 2015 as part of the investigation into the Salty Brine State Beach incident. With

this piece removed and based on records review, DEM believes no abandoned, buried cables remained at Salty Brine State Beach.

Analysis of Future Risk

Methane and hydrogen are commonly produced in many shallow, oxygen-free sub-surface environments (e.g., marshes, beaches, near-shore sediment) either biologically or by metal corrosion and impressed corrosion control in the case of hydrogen (McCafferty, 2010; Jorgensen, 2006). It is not possible to develop a meaningful quantitative risk model for incidents similar to that which occurred at Salty Brine State Beach due to the broad range of unconstrained physical factors that influence hydrogen production and dispersion rates, as well as the common inability to determine the cause of ignition. Instead, an empirical approach, based on the consideration of similar past incidences, is instructive. An extensive search of the scientific literature and news sources revealed no other incidences of hydrogen detonations at a beach or other coastal environments and only the one incident of methane burning, in Kittery, Maine (Dickson, 2000). Therefore, the scientists involved with this investigation believe the likelihood of another incident involving hydrogen is extremely low, considering, 1) the lack of other known hydrogen combustion incidents at beaches or in other coastal environments, 2) hydrogen is not produced as ubiquitously as methane in shallow subsurface coastal environments, 3) methane, itself, does not present a significant risk at beaches. Further, after careful review and consultation with USCG, DEM believes there are no similar cables present at any state beaches. As a result, the scientific experts conclude that the risk of an event similar to that at Salty Brine State Beach is extremely low.

Conclusions

Ultimately, multiple lines of evidence are consistent with the conclusion that the 2015 Salty Brine State Beach incident was the result of hydrogen detonation. It is likely that the hydrogen was produced as a product of the anaerobic corrosion of an abandoned cable. The evidence supporting this conclusion includes: high levels of hydrogen in the water-saturated sand near the incident site; a shiny, uncorroded end of an old steel and copper cable found within feet of the

incident indicating a cathodic hydrogen-producing metal surface; and observations consistent with a hydrogen detonation, including a loud report, no visible flames, and no observed radiated heat. In sum, the scientific experts engaged in this investigation conclude that the risk of a future event similar to what occurred at Salty Brine State Beach in July 2015 is extremely low.

Literature Cited

Alcock, J. L., Shirvill, L.C., and R.F. Cracknell. 2001. Compilation of Existing Safety Data on Hydrogen and Comparative Fuels. The European Integrated Hydrogen Project - Phase II. Retrieved from: http://www.eihp.org/public/documents/CompilationExistingSafetyData_on_H2_and_ComparativeFuels_S..pdf

Crowl, D. A. 2003. *Understanding Explosions*. New York, NY, USA, Center for Chemical Process Safety of the American Institute of Chemical Engineers.

Dickson, Stephen M. 2000. A Natural Beach Bonfire in Kittery, Maine. Geologic Site of the Month February, Maine Geological Survey. Retrieved from http://www.maine.gov/dacf/mgs/explore/marine/sites/feb00.pdf.

D'Hondt, S., Inagaki, F., Alvarez Zarikian, C.A., and the Expedition 329 Scientists. 2011. Proceedings of the Integrated Ocean Drilling Program, Volume 329.

Flury, S., Glud, R. N., Premke, K. and D. F. McGinnis. 2015. Effect of Sediment Gas Voids and Ebullition on Benthic Solute Exchange. Environ. Sci. Technol. 49: 10413-10420.

Groff, Thomas. 2015. *Incident Report*. Agency Incident ID: 15-235. Rhode Island Division of the State Fire Marshal: Technical Services Unit. Print. September 2015.

Gummer, J. and S. Hawksworth. 2008. Spontaneous Ignition of Hydrogen. HSE Books, Research Report RR615.

Hoehler, T.M., Alperin, M.J., Albert, D.B. and Martens, C.S. 1998. Thermodynamic control on H_2 concentrations in an anoxic marine sediment. Geochimica et Cosmochimica Acta 62: 1745-1756.

Incorporated Research Institutions for Semiology (IRIS). 2015. "SeismiQuery". Retrieved from http://ds.iris.edu/SeismiQuery/.

Jørgensen, Bo Barker. 2006. Bacteria and Marine Biogeochemistry In *Marine Geochemistry*. Schulz, Horst D., and Zabel, Matthias (Eds.) (pp. 169-206). New York, NY, USA, Springer Berlin Heidelberg.

McCafferty, E. 2010. Introduction to Corrosion Science. New York, NY, USA, Springer Science & Business Media.

Montminy, Brian. 2015. *Wickford Incident Report*. Incident No. 15RIK2-345-OF. Rhode Island State Police: Wickford Barracks. Print. September 2015.

RI Division of Parks and Recreation 2015: "Salty Brine State Beach (1954)". Retrieved from http://www.riparks.com/History/HistorySaltyBrine.html.

Figure 1. Overview of Salty Brine State Beach, Narragansett, Rhode Island (Google Earth Image captured December 15, 2015). Red arrow illustrates the general location of where the incident occurred on July 11, 2015**.**

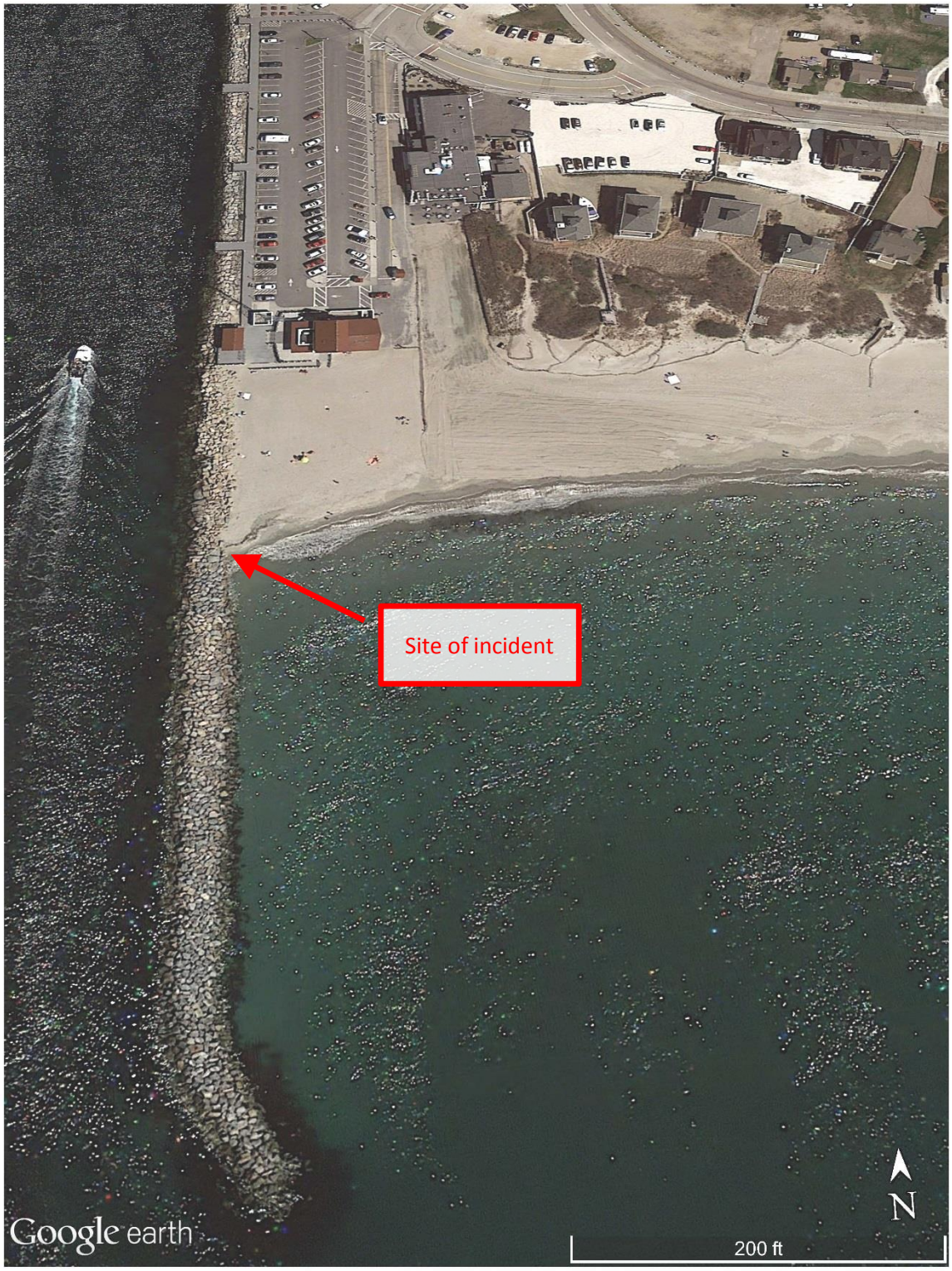


Figure 2A. Photograph of incident site taken after patrons were assisted and removed from the site (photo credit: D. Curran, RI Div. of the State Fire Marshal).

Figure 2B. Photograph of incident site taken after patrons were assisted and removed from the site (photo credit: D. Curran, RI Div. of the State Fire Marshal).

Figure 2C. Photograph of incident site taken after patrons were assisted and removed from the site (photo credit: D. Curran, RI Div. of the State Fire Marshal).

Figure 2D. Photograph of incident site taken after patrons were assisted and removed from the site (photo credit: D. Curran, RI Div. of the State Fire Marshal).

Figure 3. Photograph showing the US Coast Guard four-conductor power cable after being cut at the landward end of the beach (photo credit: RI State Police).

Figure 4. An approximate 6 ft long segment of the 29 ft long three-conductor power cable unearthed near the incident site (photo credit: T. Groff, RI Div. of the State Fire Marshal). The end of the cable (shown in the lower-right portion of the photograph) was located within feet of the incident. Note the shiny, bright copper and steel wires with remarkably little sign of corrosion despite being buried in sand saturated with seawater from more than 30 years.

Figure 5A. Photograph of the "shiny" end of the US Coast Guard three-conductor power cable laid in the 1950s and unearthed near the incident site (photo credit: T. Groff, RI Div. of State Fire Marshal). Note the non-corroded steel sheathing and copper wires, despite being located in sand saturated with seawater for more than 30 years.

Figure 5B. Photograph of one of three uncorroded copper conductors located on the "shiny" end of the US Coast Guard three-conductor power cable laid in the 1950s and unearthed near the incident site (photo credit: T. Groff, RI Div. of the State Fire Marshal).

Figure 6. Schematic of hydrogen production via corrosion. In short, when a metal corrodes its electrons are left behind in the metal. If oxygen is not present, the electrons drive the metal to a low voltage at which hydrogen can form from reaction with water (figure credit: Professor A. Spivack, URI GSO).

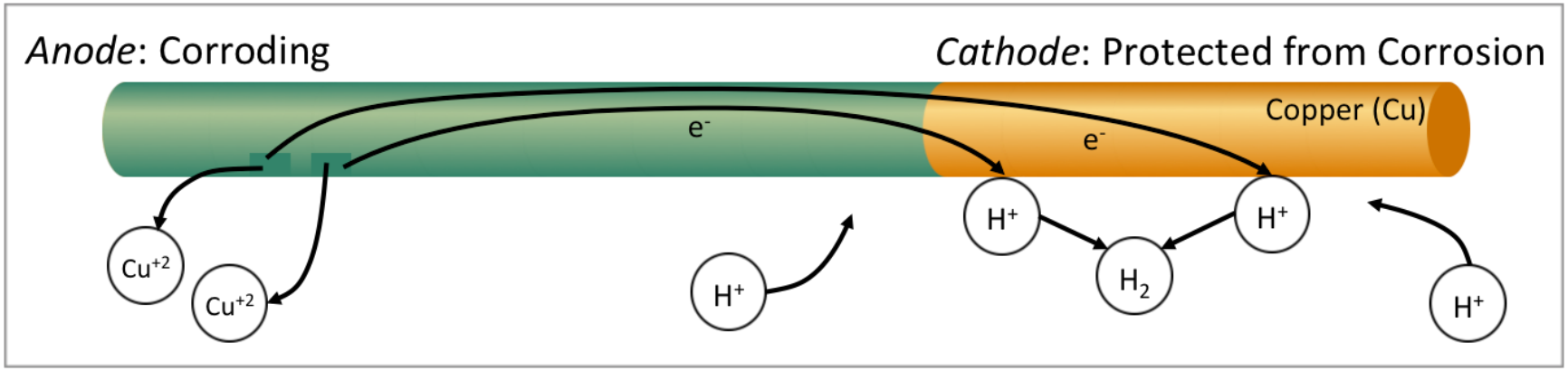


Figure 7. A diagram showing a potential scenario for hydrogen generation and reaction at the location of the incident (figure credit: Professor A. Spivack, URI GSO). Note that as with methane, hydrogen produced in water-saturated beach sand can diffuse or bubble up through the sand and contact oxygen in the water unsaturated zone. Similar to methane, a mixture of hydrogen and air is not stable. The flammability limit of hydrogen in air is approximately 4% and its lower detonation limit is approximately 11% (Alcock, et al., 2001*)*.

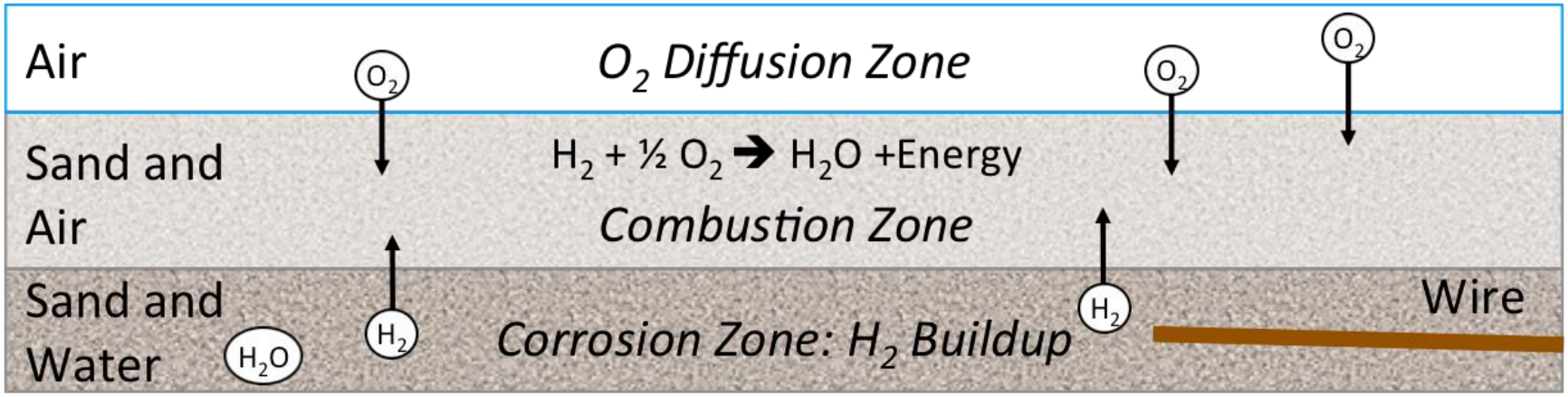


Figure 8A. Photograph of vibracore operation showing beach sand core sample being collected.

Figure 8B. Photograph of vibracore operation showing beach sand core tube being recovered.

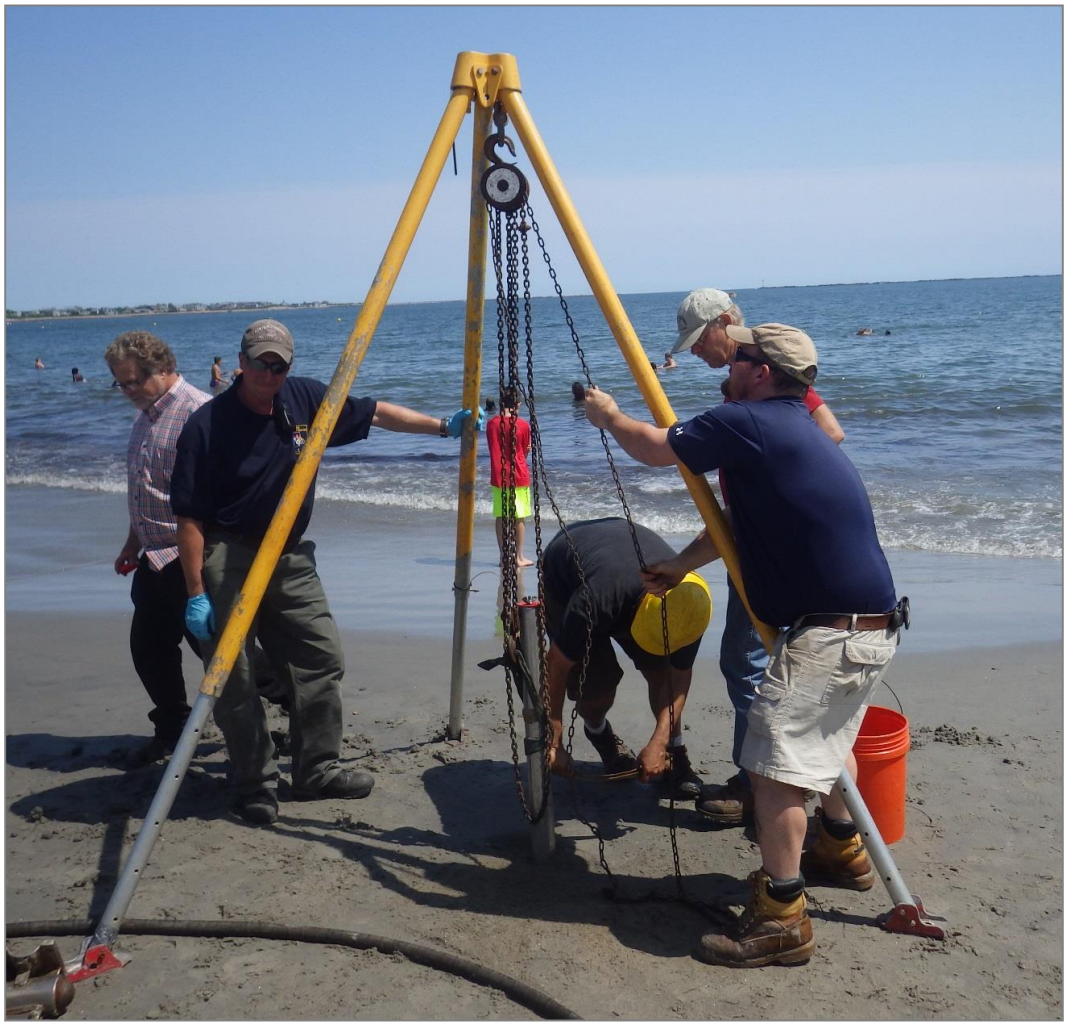


Figure 9. Overview of the Salty Brine State Beach core sampling, including the location of the July 11, 2015 incident, three- and four-conductor power cables unearthed at Salty Brine State Beach during July 2015, and the sediment core sampling conducted July 16, 2015 and July 20, 2015 (Overlaid on 2014 Pictometry Aerial Oblique Imagery).

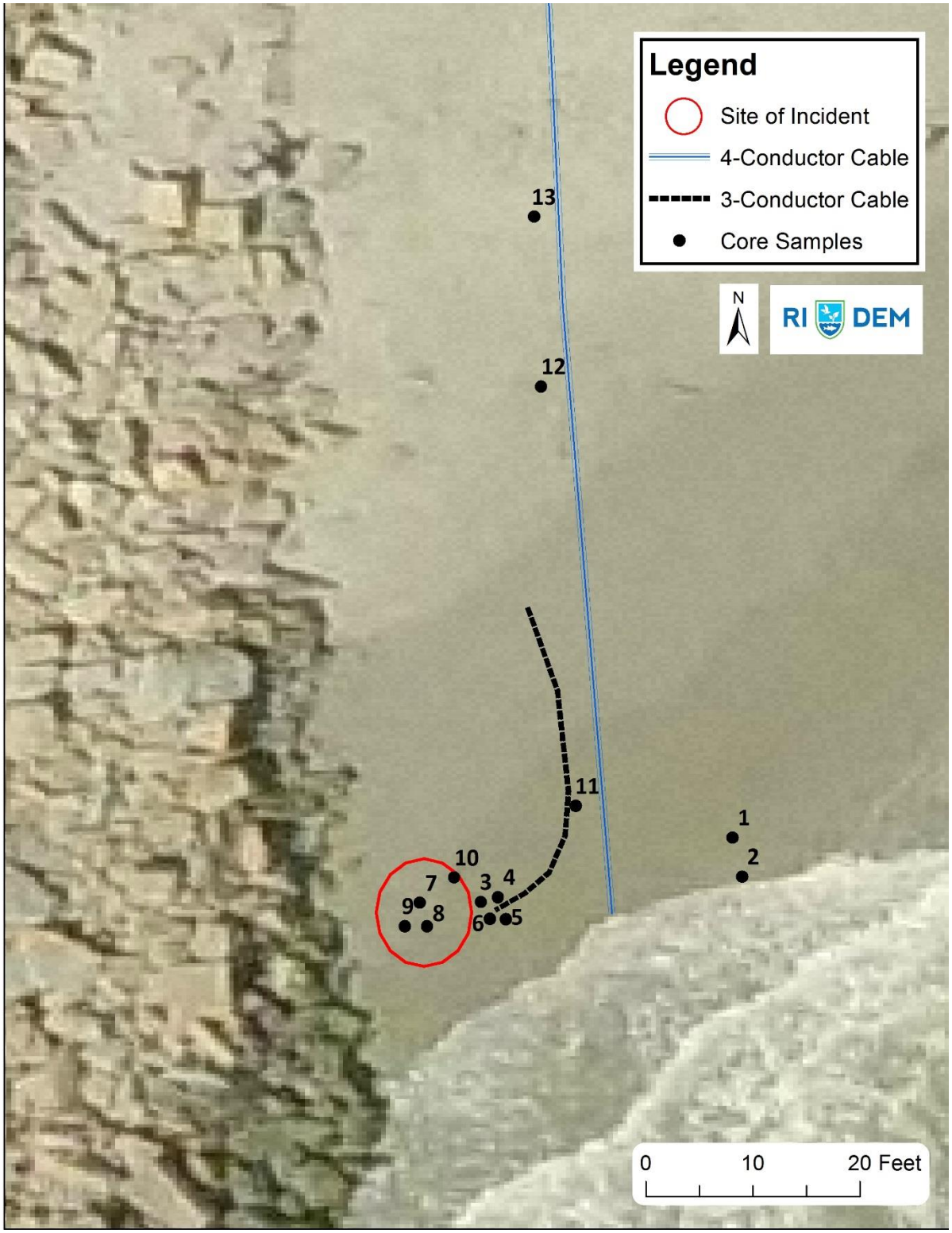
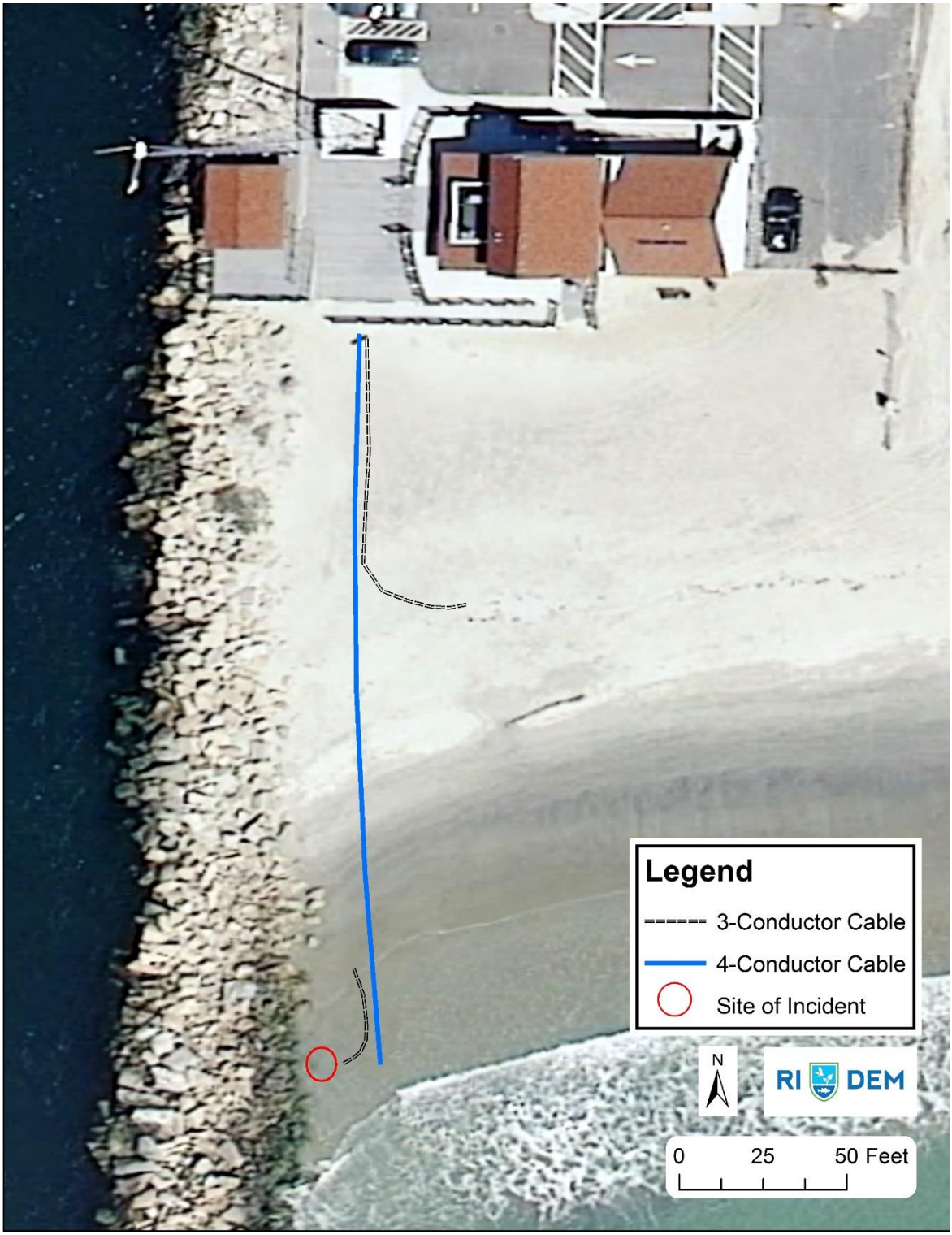


Figure 10. General locations of the July 11, 2015 incident and the three- and four-conductor power cables unearthed at Salty Brine State Beach during July 2015 (Overlaid on 2011 Aerial Imagery).



This page is intentionally left blank

Appendix I - *Detailed Methods and Results of Methane and Hydrogen Analyses*

Hydrogen and Methane Determination

For the determination of dissolved hydrogen and methane, the GSO team followed their standard laboratory practices for volatile gasses and physical properties in sediment (D'Hondt et al, 2011). We describe these practices briefly below.

Sampling and Instrumentation

Whole sections, 5 cm long, were cut from the core tube. A nominal, 5-cm^3 sediment sample was collected from the freshly exposed end of the cut core section using an open-ended plastic syringe. This sample was transferred into a headspace vial and immediately crimp-sealed. The samples were allowed to degas into the headspace for at least 24 hours. Hydrogen and methane in the headspace gas was then quantified.

For quantification of methane, 5-cm^3 of headspace gas was extracted from the sealed sample vial using a standard gas syringe and directly injected into a gas chromatograph (GC, Shimadzu). The GC was equipped with a 2.4 m Å~ 3.2 mm stainless steel column packed with 100/120 mesh HayeSep R and a flame ionization detector (FID) set at 250°C. The GC oven temperature was programmed to hold for 0.5 min at 80°C, then to ramp at 30°C/min to 100°C, then to ramp at 15°C/min to 110°C, remain at 110°C for 4.5 min, before ramping at 50°C/min to 150°C with a final holding time of 1.8 minutes. Helium was used as the carrier gas. A series of certified gas standards was used for calibration.

A reduced gas analyzer GC (hyRGA, Trace Analytical, Inc) was used for hydrogen quantification. This is an instrument specifically designed for the high sensitivity analysis of hydrogen. It utilizes a series of columns to isolate hydrogen and a mercury bed reactor with spectrophotometric detection. Samples of the headspace sample are directly injected into this GC. A certified gas standard was used for calibration mixed to various concentrations.

Beach sand sample volume and porosity are calculated based on water loss on drying assuming a seawater density of 1.029 g/cm^3 and a beach sand density of 2.70 g/cm^3.

Hydrogen and Methane Partial Pressure and Gas Abundance Calculations

Two methods are used to calculate methane and hydrogen gas abundance (percent in air) in the beach sand, depending on whether the sample was water-saturated or not. For samples that were not water-saturated, the reported gas abundances are the values directly determined by GC analysis. For water-saturated samples, for both gasses we use similar equations to convert measured headspace abundances into equilibrium partial pressures of the beach sand water. In detail, measured headspace abundances are first converted to dissolved gas concentrations, then the equilbrium partial pressures of the dissolved gas is calculated using the appropriate Henry's Law coefficient for 35 g/kg salinity at 20 °C (Pilson, 2012; Crozier and Yamamoto, 1974),

$$P_i = \left(\frac{X_{i,sub} P_{atm.} V_{HS}}{RT\phi V_T}\right)\left(\frac{1}{K_{H,i}}\right) \qquad (1)$$

where

$$X_{i,sub} = X_{i,meas} - X_{i,back} \qquad (2)$$

and the symbols used are defined in the Table A1 below and the subscript, *i*, refers to either methane or hydrogen. At one atmosphere, the gas composition, in percent, is equal to the partial pressure (P_i) times 100.

Table A1. Description of symbols used in equations and calculations.

Term	Description	Value	Units
X_i	measured abundance of gas i, in headspace	measured	$\text{ppm} \equiv \frac{\text{moles } H_2}{\text{moles air x } 10^{-6}}$
$X_{i,back}$	Background abundance of gas i	measured	$\text{ppm} \equiv \frac{\text{moles } H_2}{\text{moles air x } 10^{-6}}$
$X_{i,sub}$	Background subtracted measured abundance of gas i, in headspace	measured	$\text{ppm} \equiv \frac{\text{moles } H_2}{\text{moles air x } 10^{-6}}$
V_{HS}	Head space volume	measured	cm^3
V_T	Sample volume	measured	cm^3
ϕ	porosity	measured	unitless ratio
P_i	Equilibrium partial pressure of gas i	calculated	atm.
$P_{atm.}$	Atmospheric pressure	1.00	atm.
R	Gas constant	0.0821	$\frac{L * atm}{mole * K}$
K_i	Henry's law constants for hydrogen and methane gas in seawater at 20 °C	$6.82x10^{-4}(H_2)$* $1.20x10^{-3}(CH_4)$**	$\frac{moles}{L * atm}$
T	Temperature	293.2	K

**Pilson (2012); *Crozier and Yamamoto (1974)

Results

Methane

We measured methane in 21 samples from 13 sediment cores (Table A2). We take the detection limit above background as three times the standard deviation above the average value of our laboratory and beach air, 0.0003 atm. (0.03% methane in air) for water-saturated samples and 0.0000005 atm. (0.0005% methane in air) for water unsaturated-samples. Samples from only one depth were above background, 51.5 cm in Sample No. M-2.2, replicate samples from this depth had partial pressures of 0.0031 atms. (0.31 % methane) (Table A2).

Hydrogen

We measured hydrogen in 101 samples from 13 sediment cores (Table A3). The detection limit for hydrogen, calculated as three times the standard deviation above the average value of our laboratory and beach air is 0.0006 atm. (0.06 % hydrogen in air) for the water saturated samples and 0.000001 atm. (0.0001% hydrogen in air) for the water unsaturated-samples. Sixty-seven samples had no detectable hydrogen. Of these sixty-seven, thirteen had measured water loss values

indicating that the sand was not water saturated. Twenty-seven samples were between the detection limit and 1% while seven samples were above 1%. The two highest values, 9.60 and 10.49% were the deepest samples (207.5 cm below the surface) in Samples H-3.5 and H-3.6, respectively (Table A3).

References

Crozier, T.E. and S. Yamamoto. 1974. Solubility of Hydrogen in Water, Seawater, and NaCl Solutions, Journal of Chemical and Engineering Data. Vol. 19, No. 3.

D'Hondt S., Inagaki F., Alvarez Zarikian C. A. and Expedition 329 Scientists. 2011. Expedition 329 Reports, Proceedings of the Integrated Ocean Drilling Program.

Pilson, M.E.Q. 2012. “An Introduction to the Chemistry of the Sea”, Cambridge University Press.

Table A2. Results of methane analyses of sediment core samples taken on July 16, 2015 and July 20, 2015 at Salty Brine State Beach. Methane results shown as percent methane at equilibrium in air; "bdl" are results below detection limit.

Sediment Core Number	Sample Number	Core Number Identifier	Depth (cm)	percent methane at equilibrium (20° C)
1	M-1.1	SB15-v1	53	bdl
1	M-1.2	SB15-v1	93	bdl
1	M-1.3	SB15-v1	133	bdl
1	M-1.4	SB15-v1	173	bdl
1	M-1.5	SB15-v1	193	bdl
2	M-2.1	SB15-p3	12	bdl
2	M-2.2	SB15-p3	51.5	0.31
3	M-3.1	SB15-v3	187.5	bdl
3	M-3.2	SB15-v3	207.5	bdl
4	M-4.1	SB20-v1	129.5	bdl
5	M-5.1	SB20-v2	96.5	bdl
6	M-6.1	SB20-v3	90.5	bdl
7	M-7.1	SB20-v4	129.5	bdl
8	M-8.1	SB20-v5	127.5	bdl
8	M-8.2	SB20-v5	167.5	bdl
8	M-8.3	SB20-v5	207.5	bdl
9	M-9.1	SB20-v6	111.5	bdl
10	M-10.1	SB20-v7	198.5	bdl
11	M-11.1	SB20-v8	104	bdl
12	M-12.1	SB20-v9	69.5	bdl
13	M-13.1	SB20-v10	85.5	bdl

Table A3. Results of hydrogen analyses of sediment core samples taken on July 16, 2015 and July 20, 2015 at Salty Brine Beach. Hydrogen results shown as percent hydrogen at equilibrium in air; "bdl" are results below detection.

Sediment Core Number	Sample Number	Core Number Identifier	Depth (cm)	percent hydrogen at equilibrium (20° C)
1	H-1.1	SB15_V1	53	0.18
1	H-1.2	SB15_V1	73	bdl
1	H-1.3	SB15_V1	93	bdl
1	H-1.4	SB15_V1	113	0.08
1	H-1.5	SB15_V1	113	bdl
1	H-1.6	SB15_V1	133	bdl
1	H-1.7	SB15_V1	153	0.16
1	H-1.8	SB15_V1	153	bdl
1	H-1.9	SB15_V1	173	bdl
1	H-1.10	SB15_V1	173	bdl
1	H-1.11	SB15_V1	193	bdl
1	H-1.12	SB15_V1	193	0.22
2	H-2.1	SB15_P3	12	bdl
2	H-2.2	SB15_P3	31.5	bdl
2	H-2.3	SB15_P3	52.5	0.13
2	H-2.4	SB15_P3	71.5	bdl
3	H-3.1	SB15_V3	167.5	0.05
3	H-3.2	SB15_V3	167.5	0.10
3	H-3.3	SB15_V3	187.5	0.07
3	H-3.4	SB15_V3	207.5	0.49
3	H-3.5	SB15_V3	207.5	9.60
3	H-3.6	SB15_V3	207.5	10.49
4	H-4.1	SB20_V1	99.5	bdl
4	H-4.2	SB20_V1	99.5	0.11
4	H-4.3	SB20_V1	119.5	bdl
4	H-4.4	SB20_V1	119.5	3.45
4	H-4.5	SB20_V1	129.5	bdl
4	H-4.6	SB20_V1	129.5	bdl
4	H-4.7	SB20_V1	139.5	bdl

Table A3. Continued . . .

5	H-5.1	SB20_V2	76.5	bdl
5	H-5.2	SB20_V2	76.5	bdl
5	H-5.3	SB20_V2	86.5	bdl
5	H-5.4	SB20_V2	86.5	1.97
5	H-5.5	SB20_V2	86.5	2.14
5	H-5.6	SB20_V2	106.5	0.09
5	H-5.7	SB20_V2	106.5	bdl
5	H-5.8	SB20_V2	116.5	0.18
5	H-5.9	SB20_V2	116.5	bdl
5	H-5.10	SB20_V2	126.5	0.10
5	H-5.11	SB20_V2	126.5	0.09
6	H-6.1	SB20_V3	70.5	bdl
6	H-6.2	SB20_V3	70.5	bdl
6	H-6.3	SB20_V3	90.5	bdl
6	H-6.4	SB20_V3	90.5	bdl
6	H-6.5	SB20_V3	100.4	bdl
6	H-6.6	SB20_V3	100.5	bdl
7	H-7.1	SB20_V4	129.5	bdl
7	H-7.2	SB20_V4	129.5	bdl
7	H-7.3	SB20_V4	129.5	bdl
8	H-8.1	SB20_V5	127.5	bdl
8	H-8.2	SB20_V5	127.5	bdl
8	H-8.3	SB20_V5	147.5	0.09
8	H-8.4	SB20_V5	147.5	0.07
8	H-8.5	SB20_V5	187.5	bdl
8	H-8.6	SB20_V5	187.5	0.11
8	H-8.7	SB20_V5	207.5	0.18
8	H-8.8	SB20_V5	207.5	0.05
8	H-8.9	SB20_V5	227.5	0.06
8	H-8.10	SB20_V5	227.5	0.10
9	H-9.1	SB20_V6	91.5	bdl
9	H-9.2	SB20_V6	91.5	bdl
9	H-9.3	SB20_V6	101.5	bdl
9	H-9.4	SB20_V6	101.5	bdl
9	H-9.5	SB20_V6	131.5	0.12
9	H-9.6	SB20_V6	131.5	bdl

Table A3. Continued . . .

10	H-10.1	SB20_V7	118.5	0.14
10	H-10.2	SB20_V7	118.5	bdl
10	H-10.3	SB20_V7	138.5	bdl
10	H-10.4	SB20_V7	138.5	bdl
10	H-10.5	SB20_V7	158.5	bdl
10	H-10.6	SB20_V7	158.5	bdl
10	H-10.7	SB20_V7	178.5	0.06
10	H-10.8	SB20_V7	178.5	bdl
10	H-10.9	SB20_V7	198.5	bdl
10	H-10.10	SB20_V7	198.5	bdl
10	H-10.11	SB20_V7	218.5	0.14
10	H-10.12	SB20_V7	218.5	0.11
10	H-10.13	SB20_V7	238.5	bdl
10	H-10.14	SB20_V7	238.5	0.21
11	H-11.1	SB20_V8	64.5	bdl
11	H-11.2	SB20_V8	64.5	1.38
11	H-11.3	SB20_V8	84.5	bdl
11	H-11.4	SB20_V8	84.5	bdl
11	H-11.5	SB20_V8	104.5	bdl
11	H-11.6	SB20_V8	104.5	bdl
11	H-11.7	SB20_V8	123.5	bdl
11	H-11.8	SB20_V8	123.5	bdl
11	H-11.9	SB20_V8	143.5	3.45
11	H-11.10	SB20_V8	143.5	bdl
12	H-12.1	SB20_V9	29.5	bdl
12	H-12.2	SB20_V9	29.5	bdl
12	H-12.3	SB20_V9	69.5	bdl
12	H-12.4	SB20_V9	69.5	bdl
12	H-12.5	SB20_V9	114.5	bdl
12	H-12.6	SB20_V9	114.5	bdl
13	H-13.1	SB20_V10	65.5	bdl
13	H-13.2	SB20_V10	65.5	bdl
13	H-13.3	SB20_V10	105.5	bdl
13	H-13.4	SB20_V10	105.5	bdl
13	H-13.5	SB20_V10	145.5	bdl
13	H-13.6	SB20_V10	145.5	bdl

End of Appendix I

Appendix II – *Letter from Rhode Island Governor Gina Raimondo to the United States Coast Guard regarding underground cables at Rhode Island State Beaches*

State of Rhode Island and Providence Plantations
State House
Providence, Rhode Island 02903-1196
401-222-2080

Gina M. Raimondo
Governor

August 13, 2015

Rear Admiral Linda L. Fagan, Commander
First Coast Guard District
408 Atlantic Avenue
Boston, MA 02110

Dear Admiral Fagan,

I write to ask your assistance in removing remaining U.S. Coast Guard cables buried below the surface in the vicinity of Salty Brine State Beach in Narragansett, Rhode Island.

As you know, on July 11, 2015, there was a sub-surface ground disturbance near the East Jetty at Salty Brine State Beach. The incident injured one person and required evacuation and temporary closure of this popular beach.

Immediately following this incident, the Rhode Island State Police and Department of Environmental Management (DEM) led a coordinated investigation to determine what happened. I appreciate the cooperation of the Coast Guard staff who joined our state officials on the site multiple times in the days following the incident. Coast Guard personnel were on site on July 14, when DEM dug up a piece of abandoned Coast Guard cable in the vicinity of the incident site, and removed and cut other abandoned cable buried beneath Salty Brine State Beach. In coordination with the Coast Guard, DEM used round penetrating radar to subsequently locate additional abandoned cable.

As the investigation continued, and with assistance from the federal Natural Resource Conservation Service and scientists from the University of Rhode Island's Graduate School of Oceanography, DEM acquired core samples of beach sand from the site that were analyzed by the science team. This team, led by Dr. Arthur Spivack, an oceanographer with expertise in geo-chemistry, determined that the incident was caused by the ignition and combustion of a build-up of hydrogen gas in the beach sand created by the corrosion of an abandoned copper cable owned and previously used by the Coast Guard. LCDR Brian Maggi from your Civil Engineering Unit was able to participate in a briefing in my office where Dr. Spivack reviewed the evidence and his conclusions.

August 13, 2015
Page 2

I have been informed that the cable remnant in the vicinity of the incident was installed in the 1950s and used by the Coast Guard to power navigational lights for the Port of Galilee and Point Judith Harbor of Refuge. This cable was de-energized and abandoned in place, and an additional cable was installed in the 1980s. Several years ago the Coast Guard converted its navigational aides to solar power, resulting in the deactivation and abandonment of the second buried power cable. To avoid any further public safety concerns with abandoned power cables in the area of our state beaches, I respectfully request that the Coast Guard remove any remaining abandoned cables buried in the vicinity of our state beaches and in the Point Judith Harbor of Refuge.

Thank you for your attention to this matter. Please contact DEM Director Janet Coit at (401) 222-2771 if you would like to discuss this matter further.

Sincerely,

Gina M. Raimondo
Governor

End of Appendix II