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MEMORANDUM

SUBJECT:	General Electric Vieques Corrective Measures Memorandum
FROM:	Jesse Avilés
TO:	FILE
DATE:	2015-03-23
PROJECT ID:	CEPD-RCRA-07-0039
EPA ID:	PRD000692582
RECORD SCHEDULE:	206b
STATUS:	FINAL

As part of the Environmental Protection Agency (EPA) Lean initiative, EPA held a teleconference with General Electric (GE) on October 14, 2014 to recommend a remedy for the GE Vieques LLC Caribe General Electric Distribution Transformer Inc. (Caribe GE) (1). The recommended remedy will be subjected to public review and comment. During the meeting three remedial alternatives were considered: (1) monitored natural attenuation, (2) enhanced monitored natural attenuation and (3) no action. EPA and GE agreed that the first option, monitored natural attenuation, was the best corrective measure for the facility considering current conditions. However, GE agreed to review on a periodic basis whether an enhancement could be appropriate and if so, conduct research to determine what type of enhancement will work best due to the rock matrix where the contaminant is located. This MEMORANDUM will function as the GE Vieques Corrective Measures Report by summarizing the activities since 2005.

BACKGROUND

Caribe GE is an approximately 4-acre facility involved in the manufacture of power fuses, auxiliary relays, and switch gear accessories. The facility is located near the north coast of Vieques at the intersection of Road 200 and Road 201 in the Barrio Martino section of the Isabel Segunda Ward. Caribe GE started manufacturing in 1969. The property is owned by the Puerto Rico Industrial Development Corporation (PRIDCO) and leased by GE. GE performed a corrective study investigation to determine what corrective action to implement at the facility. The investigation and subsequent actions are performed under a voluntary program.

The Puerto Rico Environmental Board (EQB) prepared a RCRA Facility Assessment (RFA) report dated September 30, 1988, and submitted it to EPA for review. After review, EPA accepted the report on April 1, 1991. At the time of the RFA, the facility was generating degreasing solvents (F001), acids (D002) and rinse waters (D003). EQB identified four (4) solid waste management units (SWMUs) and three (3) areas of concern (AOC). The SWMUs and AOC are:

SWMUs	AOC
SWMU-1 – Hazardous waste container area	AOC-1 – Raw material storage area
SWMU-2 – Leach field	AOC-2 – Degreaser tank

SWMUs	AOC
SWMU-3 – Concrete treatment/settling sump	AOC-3 – Electroplating area
SWMU-4 – Septic tank system	

EQB recommended no further action at SWMU-1, AOC-1, AOC-2 and AOC-3. In January 13, 2000 EQB updated the RFA and did not identify additional areas.

All of the hazardous waste management units have been investigated, closure activities completed, and recommended to EPA for clean closure. In March 21, 2005, EPA issued a letter accepting the closure certification for the following units:

- Inactive subsurface leach field system (leach field – SWMU-2, closed April 1991)
- Sediment tank (associated with the leach field) (SWMU-3, closed April 1991)
- Septic tank system (SWMU-4, closed September 1993)
- Bright dip area (formerly located at the southwest of the main building, closed 1991)

EPA stated on a letter dated March 21, 2005 that "the Closure Certification was submitted in accordance with the amended Closure Plan which was approved on March 16, 1994; the approved Closure Report dated October 22, 2004; and in compliance with the requirements stipulated in 40 CFR § 265.115 and 265(h)."

During an investigation performed for the closure of the above-mentioned SWUs and AOCs, Caribe GE found chlorinated volatile organic compounds (cVOCs) in the groundwater to the south of the leach field. These cVOCs were trichloroethene (TCE), 1,1-dichloroethene (1-1 DCE) and cis 1,2-dichloroethene (cDCE). As part of the closure certification, EPA required the installation of additional wells and to continue with groundwater monitoring. During the fall of 2005, Caribe GE installed four (4) additional wells and collected groundwater samples. By the end of 2005, Caribe GE had installed ten (10) wells, identified C-1 to C-10. Currently, Caribe GE monitors these wells on a semiannual basis.

In March 2007, Caribe GE performed a soil gas survey alongside its groundwater monitoring program. The soil gas survey was used to evaluate any potential source zones of cVOCs in the unconsolidated sediments at the facility. The sampling area was located at the south of the facility. The results of the sampling showed that none of the contaminants were detected in the soil vapor.

In 2008, Caribe GE submitted a Corrective Measures work plan. EPA approved the work plan, with some modifications on July 7, 2012. As part of the modifications, Caribe GE installed an additional well (C-11) at the west side of the main building to determine the extent of contaminants at this area. In addition, pressure transducers were installed in all the wells to continuously log groundwater elevation (2). The contaminants of concern for the facility are: (1) TCE, 1,1-dichloroethane (1,1-DCA), (2) 1-1 DCE, (3) cDCE and (4) vinyl chloride (VC). The last sampling event occurred on October 19 and 20, 2015 (3).

ENVIRONMENTAL SETTINGS

The following information was obtained from the Focused Corrective Measures Study Workplan of August 17, 2012 (4).

Vieques Regional Features

The island of Vieques covers an area of about 40 square miles and is approximately 18 miles long and 3 miles wide. It is located approximately 10 miles off the east coast of the main island of Puerto Rico. Vieques is dominated by a 250 to 500 foot high east-west trending ridge stretching the length of the island. Monte Pirata, at the west end of Isla de Vieques, is the highest point on the island with an elevation of 988 feet above mean sea level. With the exception of Monte Pirata, the topography is gentle, consisting of relatively broad valleys separated by rounded hills trending seaward from the central ridge.

The eastern half of Vieques was formerly used by the U.S. Marine Corps as a training facility and gunnery impact area. The western quarter of the island was also under military control. These areas are currently closed to further military use. Historical non-military land use is concentrated in the central portions of Vieques.

Topography

The topography has been graded relatively flat with a 14-ft high shelf along the south side of the facility, steeply sloping to an alley along the back of the main building. The majority of the area is occupied by the GE main plant building and paved parking lot. Two small auxiliary buildings are located on the steep slope at the south side of the alley. The ground surface around the main building slopes gently away from the perimeter walls in all directions. Stormwater runoff flows overland and through alley drainage to the north and east of the facility.

Surrounding Land Use

Land usage to the north (downgradient) is primarily residential with the exception of a commercial facility (Con-Agra) directly across Road 200 from the facility. Properties to the east and west of the facility are also primarily residential. The property directly southwest of the facility is occupied by the Puerto Rico Electric Authority and is used for equipment and vehicle storage along with several trailers used for field offices. To the south (upgradient) several facilities are involved in the manufacturing of electronic components and have been evaluated as potential upgradient sources for TCE. These facilities include two electronics assemblage facilities and a printing operation approximately 300-400 feet to south of GE Caribe, in two buildings located on PRIDCO property. Soil gas testing was conducted near these facilities and detected PCE and TCE.

In 1995, a well survey found no domestic wells within a one-half mile radius north (downgradient) of the plant. In addition, a 1995 USGS water well survey report (Open-File report 95-368) found no used wells within a radius of at least one mile of the facility. Public drinking water supplied to Vieques is piped from the Rio Blanco filtration plant located on the main island of Puerto Rico. A well field was operated on the south side of the island (in the Esperanza Valley alluvial deposits); however, operation of this well field ceased in 1978 due to saltwater intrusion. Groundwater on the island is no longer used for potable public water supply. There are no known shallow or deep bedrock wells in the vicinity of the facility.

Climate

Vieques climate is tropical-marine with temperatures that average about 79 degrees Fahrenheit. Annually, the temperature ranges from an average of 76 degrees Fahrenheit in February to 82 degrees Fahrenheit in August. Vieques lies in the path of the easterly trade winds, which regulate

the rainfall on the island. The average wind velocity is about 8 mph but can exceed 12 mph for as many as 30 days each year. The average amount of precipitation is about 45 inches a year. The western part of the island receives a higher amount of rainfall (about 50 inches a year) than the eastern section (about 25 inches a year), (NCDC, 1994). The rainy season is from August through November while the remainder of the year is drier. Tropical storms are common from June to November.

Regional Hydrogeology

Vieques was formed from igneous and volcanic rock, mostly granodiorite, quartz diorite, and some lava which created the bedrock of the island. Igneous quartz-diorite and granodiorite underlie most of the western half of the island, including bedrock under GE Caribe. These plutonic rocks are part of the San Lorenzo-Humacao Batholith that also outcrops in southeastern Puerto Rico. Igneous and volcanic bedrock is exposed and weathered near the facility on the central portion of the eastern half of the island. Over the millennia, this material has gathered in valleys by the ocean, forming alluvial deposits (sediment deposited by flowing water) where the valley meets the sea. The alluvial sedimentary deposits generally consist of a mixture of gravel, sand, silt, and clay. Other portions of Vieques have ancient marine deposits from a time when the island was submerged, revealing areas with some limestone, sandstone, siltstone, and other sedimentary rocks at the surface.

All the groundwater on Vieques is derived from rain that falls on the island. This water runs downhill as intermittent stream runoff or it seeps into the soil and underlying deposits. Water in pore space, cracks, and fractures in the weathered bedrock eventually flows to the ocean or into alluvial deposits.

There are two main types of potential water bearing zones on Vieques. The first type is within the upper portion of the bedrock and sedimentary rocks. The weathering, fracturing, and faulting of this rock has created pore space, joints, or fractures where water can seep underground. The flow of groundwater in these unnamed aquifer systems is controlled by the influence of gravity and flows in a downgradient direction through the pore space and along fracture or joint surfaces. Groundwater flow may be locally obstructed in areas where dense, nonporous rock or fault surfaces restrict flow.

The second type of water bearing zone is within the alluvial deposits where water seeps into the sand and gravel areas, filling up the pore space between these materials. These alluvial water bearing zones are found below the hills in the low flat valleys, predominantly along the north and south coasts. Water flow within these water bearing zones is also toward lower topographic areas and the Atlantic Ocean. The alluvial water bearing zones are generally self-contained with limited communication from one alluvial water bearing zone to another on the island.

Facility Hydrogeology

Eleven (11) on-site monitor well borings have been drilled/cored to approximately 110 ft bgs (approximately 104 ft of bedrock coring at well C-7) during three different remedial investigations at GE Caribe since 1990. The following hydrogeologic information was determined from these drilling programs, subsequent monitor well testing and sampling, and closure activities.

The facility is underlain by late-Cretaceous/early-Tertiary granodiorite bedrock overlain by unconsolidated residual silty sand and gravels that are 0 ft to 28 feet thick. In the vicinity of GE

Caribe, the unconsolidated overburden material is predominantly unsaturated, and consists of soil and saprolite. The soil is poorly sorted, very fine to medium grained sand with little silt and clay, highly organic, coarsening down to predominantly sandy gravel from weathered granodiorite bedrock grains. This gravel saprolite is highly decomposed bedrock that retains the structure of the parent bedrock while remaining in its original place. The soil horizon is thickest in the northeast portion of the site (Monitor Wells C-2 and C-3), the only area where monitoring well groundwater levels have been historically noted at elevations within unconsolidated material, up to eight feet above the bedrock surface at Monitor Well C-3 measured during the December 6, 2006 quarterly sampling event. The soil horizon is thinnest along the southwest portions of the facility (Monitor Well C-6) where bedrock outcrops are noted.

Bedrock under GE Caribe is composed of fractured igneous granodiorite. Common vertical and horizontal fracture sets have been identified in rock cores. Bedrock coring and drilling notes indicate that the degree of fracturing decreases with depth and that the top and bottom elevation of the uppermost water bearing zone is variable. The first occurrence of a water bearing zone ranges from approximately 50 ft bgs near C-3 to 65 ft bgs at C-10. This uppermost water bearing zone extends to a depth of approximately 110 ft bgs at C-7 based on packer test data and to a depth of 80 ft bgs at C-10 based on observed water bearing zones in its screened interval. At C-10, no water bearing zones were encountered from a depth of 80 ft to 110 ft bgs as evidenced by the absence of groundwater inflow in this zone while the borehole was open.

Over the eight quarterly groundwater sampling events from February 2006 through December 2007, the highest elevation of groundwater was measured in December 2006 at the four wells in the SE corner of the facility, approximately 55.5 ft MSL (approximately 25 to 40 ft bgs). Over this same time frame, the lowest elevation of groundwater was measured in March 2007 at well C-9, approximately 39.6 ft MSL (approximately 40.9 ft bgs). These elevations are significantly higher than the first occurrence of groundwater noted during drilling, indicating semi-confined upper aquifer conditions. There was no evidence of perched water in the drilling through unconsolidated sediments across the facility. Based on the above and analyses of contaminant data, the uppermost aquifer is semi-confined and occurs within an interconnected zone of fractures located approximately 50 ft to 110 ft bgs in the granodiorite bedrock. The results of the aquifer testing investigation (see reference (4)) indicate that the hydraulic conductivity of the granodiorite is relatively low. The hydraulic conductivity was highest (3.5×10^{-5} cm/s) in the 90-110 ft bgs packer pumping test at C-7. A pumping and recovery test was performed in C-7 after the well was installed. The pumping test in this well indicated a lower value (1.1×10^{-6} cm/s), which suggests that fewer fractures were influenced during the shorter time period of this test. The remaining data are from slug tests, which indicate a geometric mean for hydraulic conductivity of 1.2×10^{-6} cm/s based on data collected in the monitoring wells.

Both aquifer pumping test data and rapid water level declines during well development indicate that the hydraulic conductivity of the granodiorite is low. Using estimated values of 1.1×10^{-6} cm/s (0.0031 ft/day based on pump test at C-7) to 1.0×10^{-4} cm/s (0.28 ft/day, which is a factor of 3 higher than maximum observed value) for the horizontal hydraulic conductivity, a horizontal hydraulic gradient of 0.0094 ft/ft between C-4 and C-10, and an estimated effective porosity of 0.1, the average linear groundwater velocity is estimated to range from 0.11 ft/yr to 9.6 ft/yr at the facility. These values indicate that groundwater moves relatively slowly, which is consistent with the limited observed plume migration distance at the facility.

Water level elevations have been measured since 1992. A typical potentiometric surface map of the water level data for December 19, 2007 is shown as Figure 5 (see reference (4)). The data indicate that the uppermost aquifer is locally semi-confined. A comparison of horizontal (0.0208 ft/ft between C-4 and C-10) and vertically upward (0.0008 ft/ft between C-7 and C-4) hydraulic gradients on this date indicates that groundwater flow is primarily horizontal in the uppermost aquifer. The minor upward hydraulic gradient is consistent with the proximity of the Atlantic Ocean, which is a groundwater discharge zone. Note that an upward hydraulic gradient was observed between C-7 and C-4 in 7 of the 8 quarterly sampling events in 2006 and 2007, ranging from 0.03 to 0.18 ft. Based on previous reports submitted to EPA, historical water level data indicate that the water levels in the monitoring wells rise and fall in a pattern consistent with precipitation events. Given the low permeability of the granodiorite, lower precipitation rate in Vieques, and the high evapotranspiration rate, local rainfall may not reach the uppermost aquifer at the facility, which is consistent with the absence of a water table. Recharge likely occurs in upland areas located to the south where aquifer conditions are unconfined.

The groundwater monitoring report from the October 2014 sampling event (3) shows that the groundwater elevations and flow direction observed during this monitoring event are consistent with previous monitoring events and historical records. The report's hydrographs indicate long-term groundwater elevation trends which generally correlate with higher elevations during the rainy season (August to November) and lower elevations during the dry season (February to March).

Surface Water

The closest surface-water body to the Site is the Atlantic Ocean, approximately 2,500 ft north of the facility. There are no perennial streams on the island.

CONCEPTUAL SITE MODEL

The conceptual model was presented in 2005 and then in the 2012 CMS Workplan (4). The 2010 conceptual model was a refinement of the 2005 model. The conceptual model of 2012 remains unchanged except for additional data collected since 2012.

Groundwater

Groundwater is located within the granodiorite below the facility. The granodiorite is fractured and the fractures decrease with depth. In 2005 groundwater velocity was estimated to range from 0.11 ft/yr to 9.6 ft/yr at the facility. The contaminant appears located at the south portion of the facility.

The primary contaminant of concern is TCE and its degradation products. The source of the contamination has not been found. The highest concentrations of TCE are located at wells C-4, C-7 and C-8. Wells C-1, C-2, C-3, C-9 and C-10 are north and downgradient of the contamination zone. The concentration of contaminants at this last group of wells has been non-detectable or below the MCL since 2005. Chart 1 shows the concentrations over time, since 2005, of trichloroethene. Appendix E of the October 2015 Groundwater Monitoring Report shows historical charts of the concentrations of the chlorinated compounds (3).

The data collected for methane and chloride show levels at C-4, C-7 and C-8 that are higher than the other wells at the site. Additionally, the presence of high concentration of *cis* 1,1-DCE at well

C-7 and degradation products at wells C-4, C-6, C-8 and C-11 suggest that reductive dechlorination is occurring (5). Physical reduction mechanisms such as dissolution and adsorption to the rock matrix may also be occurring. These mechanisms may explain the reduction in TCE without the observation of degradation products.

Receptors

Closest human receptors are the workers of the facility. Since at least 2005 the contaminant remains contained in the current area. In 2007, GE performed a soil gas sampling to determine if vapor-phase contaminants were present. The results of the sampling showed that none of the contaminants were detected in the soil vapor (6).

A residential area is located north of the facility, across road PR-200. No exposure is expected for the community. The migration of contaminated groundwater is stabilized within the existing area of contamination. The groundwater contamination (cVOCs) were detected above MCL at wells C-4, C-6, C-7, C-8 and C-11. Those wells (C-4, C-6, C-7, C-8 and C-11) are located at the southeast end of the Facility. The samples collected in the remaining wells C-1, C-2, C-3, C-5, C-9 and C-10 did not indicate any exceedance of the MCLs. These remaining wells are located at the north and northwest end of the facility. Bedrock under GE Caribe is composed of fractured igneous granodiorite. Common vertical and horizontal fracture sets have been identified in rock cores. Bedrock coring and drilling notes indicate that the degree of fracturing decreases with depth and that the top and bottom elevation of the uppermost water bearing zone is variable. Additionally, the migration rate of these compounds is relatively low due to the low hydraulic conductivity of the granodiorite bedrock layer in which the monitoring wells are screened. Groundwater flow is from the southeast to northwest of the facility. The results and location of the wells show that the cVOCs have remained within their area of contamination and have not moved beyond the facility (7).

PROPOSED REMEDY

The contaminants have stayed within their current area since at least 2005. No completed pathway exist for workers at the facility and residences north of the facility. Data collected since at least 2005 show that natural attenuation has occurred.

The proposed remedy for this Site is monitored natural attenuation. GE will continue monitoring the groundwater on a semi-annual basis for a period of 10 years. Semi-annual monitoring reports will be submitted to the EPA following the completion of each event and held at the facility for public review. A paper copy will also be placed at the local library. The electronic documents will be available at the EPA website for the facility located at http://www3.epa.gov/region02/waste/fsgeviequ.htm.

During the course of the semi-annual monitoring period, EPA and GE will evaluate available technology to determine if it would be suitable to supplement the MNA program at the Site through bioaugmentation or other means of enhancing contaminant degradation. If EPA and GE determine that an enhancement is suitable for the facility, a pilot may be implemented to determine its suitability and a public notice will be issued.

Every five years GE will prepare a corrective measures assessment summary report. If contaminants continue attenuating and are determined not to pose a risk to receptors outside the boundaries of the Site, as determined by sampling wells C-2, C-3, C-9 and C-10, remediation will be

considered achieved after ten (10) years. A public notice will be issued at the time. The public will have at least 45 days to comment on all public notices issued during the corrective measures phase unless regulations require more time.

REFERENCES

1. **U.S. Environmental Protection Agency.** October 14, 2014 Meeting Summary. Guaynabo, PR, United States : s.n., October 14, 2014.

2. —. Documentation of Environmental Indicator Determination RCRIS Code (CA725). Guaynabo, Puerto Rico, United States : U.S. Environmental Protection Agency, September 24, 2014.

3. **MWH Americas, Inc.** Groundwater Monitoring Report - October 2015. Vieques, Puerto Rico, United States : s.n., June 7, 2016.

4. **Tetra Tech GEO, Inc.** Focused Corrective Measures Study Work Plan. Sterling, Virginia, United States : s.n., August 17, 2012.

5. **U.S. Environmental Protection Agency.** Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Ground Water. Washington, D.C. : U.S. Environmental Protection Agency, September 1998. EPA-600-R-98-128.

6. **GeoTrans, Inc.** Results of First Quarter (Q1) 2007 Groundwater Sampling Event and Soil Gas Survey. Sterling, Virginia : s.n., June 12, 2007.

7. **U.S. Environmental Protection Agency.** Documentation of Environmental Indicator Determination RCRIS Code (CA750) Migration of Contaminated Groundwater Under Control. Guaynabo, PR : U.S. Environmental Protection Agency, August 18, 2015.