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NASD VIEQUES, PR
SSIC 5000-33a

**FINAL REMEDIAL ACTION WORK PLAN ADDENDUM AREA OF CONCERN E
(AOC E) ATLANTIC FLEET WEAPONS TRAINING AREA FORMER NAVAL
AMMUNITION SUPPORT DETACHMENT VIEQUES PUERTO RICO**

07/01/2018
CH2M HILL

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Atlantic
Norfolk, Virginia

Final

**Remedial Action Work Plan Addendum
Area of Concern E**

Atlantic Fleet Weapons Training Area – Vieques
Former Naval Ammunition Support Detachment
Vieques, Puerto Rico

July 2018



Atlantic
Norfolk, Virginia

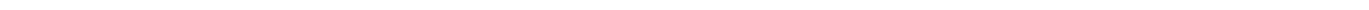
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**Remedial Action Work Plan Addendum
Area of Concern E**

Atlantic Fleet Weapons Training Area – Vieques
Former Naval Ammunition Support Detachment
Vieques, Puerto Rico

July 2018

Prepared for NAVFAC Atlantic
by CH2M HILL, Inc.
Virginia Beach, Virginia
Contract N62470-16-D-9000
CTO 0003



Executive Summary

In accordance with protocols dictated by the Area of Concern (AOC) E Record of Decision (ROD) (NAVFAC, 2015) and the *Remedial Action Work Plan, Groundwater Monitoring and Institutional Controls with Contingency Plans, Area of Concern E* (CH2M, 2015), this Remedial Action Work Plan (RAWP) Addendum presents the in situ chemical oxidation (ISCO) injection procedures for implementing hydrogen peroxide-activated sodium persulfate (Contingency Plan 2) to address persistent remedial goal (RG) exceedances in groundwater. AOC E, located at the former Naval Ammunition Support Detachment (NASD) in Vieques, Puerto Rico, is the site of a former 500-gallon underground storage tank (UST) and former 500-gallon aboveground storage tank (AST) that stored used oil from vehicle maintenance activities (**Figure ES-1**).

The Department of the Navy (Navy) and Environmental Protection Agency (EPA) Region 2 jointly selected the remedial action for AOC E, with the concurrence of the Commonwealth of Puerto Rico Environmental Quality Board (PREQB). Although the ISCO pilot study resulted in reductions of contaminants of concern (COCs) concentrations below regulatory standards, the remedial action involved annual groundwater monitoring of the COCs for 3 years to determine if and to what degree rebound above RGs would occur.

As dictated in the ROD and described in the RAWP, for any COC whose concentrations persist above its RG for three consecutive post-ROD monitoring events, a hydrogen peroxide-activated sodium persulfate solution will be applied in an effort to reduce its concentrations to the RG or below. The COCs originally identified at AOC E are benzene, 1,2-dichloroethane (1,2-DCA), 2-methylnaphthalene, methyl tert-butyl ether (MTBE), naphthalene, and xylenes. Three of the six COCs (i.e., naphthalene, 2-methylnaphthalene, and xylenes) have either not been detected (xylenes) or have been detected an order of magnitude or more below the RGs (naphthalene, 2-methylnaphthalene) during the three post-ROD events. Furthermore, none of these three was detected during the third event. However, benzene concentrations above the 5 micrograms per liter ($\mu\text{g/L}$) RG (i.e., between 8 and 10 $\mu\text{g/L}$) and MTBE concentrations above the 120 $\mu\text{g/L}$ RG (i.e., between 340 and 380 $\mu\text{g/L}$) were observed during each event in well MW-05, and 1,2-DCA concentrations above the 3.8 $\mu\text{g/L}$ RG (i.e., between 4 and 8 $\mu\text{g/L}$) were observed during each event in well MW-01 (**Figure ES-2**). Therefore, in accordance with the ROD, Contingency Plan 2 (application of hydrogen peroxide-activated sodium persulfate) will be implemented to stimulate degradation of the remaining three COCs, whose concentrations have persisted above the RGs. Following ISCO application, long-term monitoring of persulfate and the three remaining COCs (i.e., benzene, MTBE, and 1,2-DCA) will resume in accordance with the process shown in **Figure ES-3**.

NOTE: THIS SUMMARY IS PRESENTED IN ENGLISH AND SPANISH FOR THE CONVENIENCE OF THE READER. EVERY EFFORT HAS BEEN MADE FOR THE TRANSLATIONS TO BE AS ACCURATE AS REASONABLY POSSIBLE. HOWEVER, READERS SHOULD BE AWARE THAT THE ENGLISH VERSION OF THE TEXT IS THE OFFICIAL VERSION.

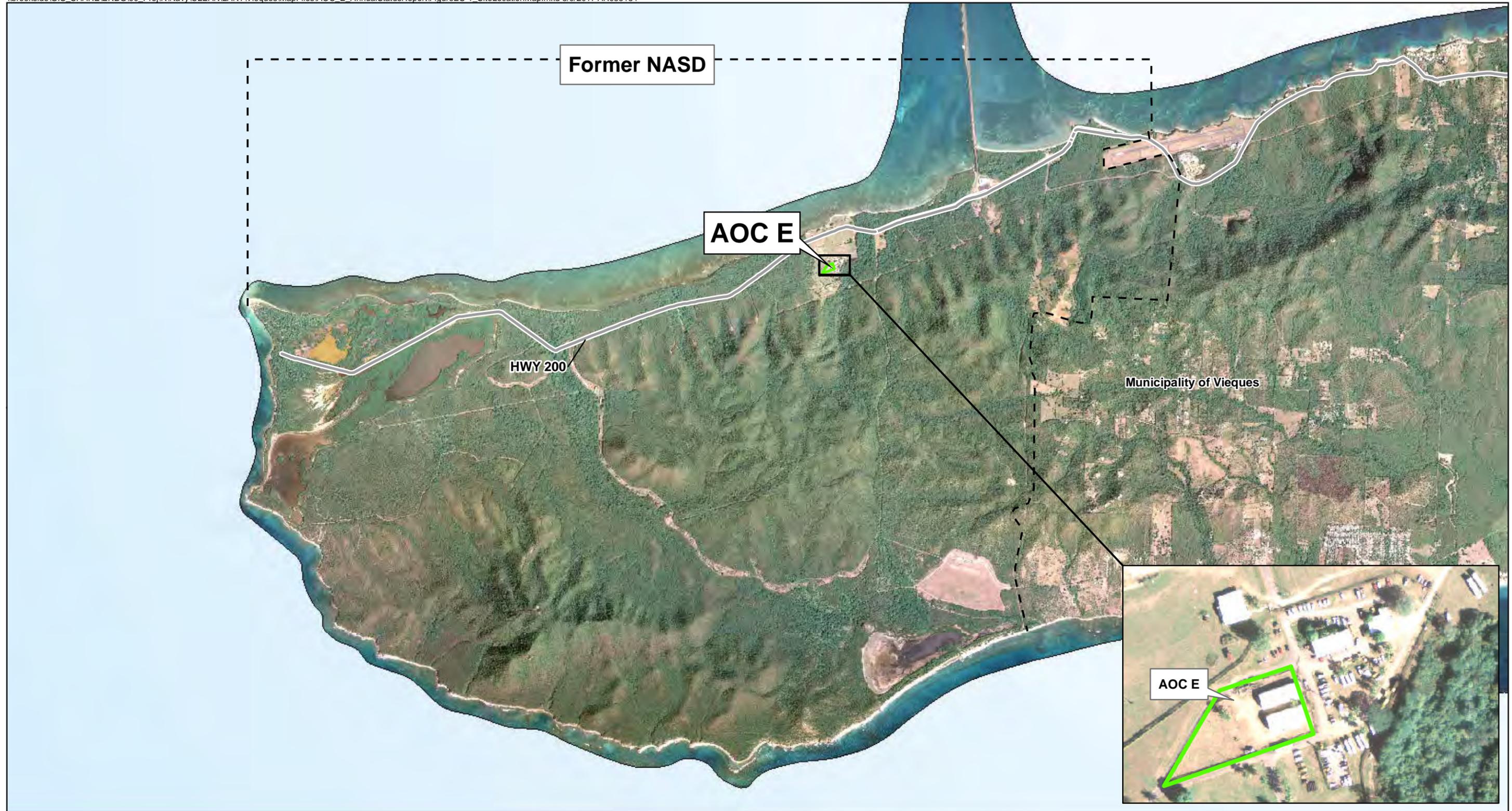
Resumen Ejecutivo

Este Anejo al Plan de Trabajo para la Acción de Remediación (RAWP, por sus siglas en inglés) presenta los procesos de inyección de oxidación química in-situ (ISCO, por sus siglas en inglés) para implementar persulfato de sodio activado por peróxido de hidrógeno (Plan de Contingencia 2) para atender los excedentes a las metas de remediación (RG, por sus siglas en inglés) que persisten en el agua subterránea según los protocolos dispuestos por el Récord de Decisión (ROD, por sus siglas en inglés) para el Área de Preocupación E (AOC E, por sus siglas en inglés), (NAVFAC, 2015), y el *Plan de Trabajo para la Acción de Remediación, Monitoreo de Agua Subterránea y Controles Institucionales con Planes de Contingencia, Área de Preocupación E* (CH2M, 2015). El AOC E, localizado en el Antiguo Destacamento de Apoyo de Municiones Navales (NASD, por sus siglas en inglés) en Vieques, Puerto Rico, albergaba un antiguo tanque de almacenamiento soterrado (UST, por sus siglas en inglés) y un antiguo tanque de almacenamiento sobre la superficie (AST, por sus siglas en inglés), ambos de 500 galones, los cuales almacenaban aceite usado proveniente de las actividades de mantenimiento de vehículos (**Figura ES-1**).

Las medidas correctivas para el AOC E fueron seleccionadas en conjunto por el Departamento de la Marina de los EE.UU. (Marina), y la Agencia de Protección Ambiental de los Estados Unidos (EPA, por sus siglas en inglés) Región 2, con el consentimiento de la Junta de Calidad Ambiental (JCA) de Puerto Rico. Aunque el plan piloto ISCO redujo las concentraciones de sustancias químicas de preocupación (COC, por sus siglas en inglés) por debajo de los estándares reglamentarios, la acción de remediación requería de un monitoreo anual de COCs en el agua subterránea durante 3 años, a fin de determinar si, y en qué medida, ocurriría un rebote sobre las RG.

De conformidad con lo dispuesto en el ROD y según descrito en el RAWP, por cada COC que mantenga una concentración sobre su RG por tres eventos consecutivos de monitoreo post-ROD, se aplicará una solución de persulfato de sodio activado por peróxido de hidrógeno en un esfuerzo para disminuir su concentración al nivel RG o menor. Los COC originalmente identificados en el AOC E son: benceno; 1,2 dicloroetano (1,2-DCA); 2-metilnaftaleno; metil-tert-butil éter (MTBE, por sus siglas en inglés); naftaleno y xilenos. Tres de los seis COCs (naftaleno, 2-metilnaftaleno y xilenos) no fueron detectados (xilenos) o se detectaron en una o más órdenes de magnitud por debajo del RG (naftaleno, 2-metilnaftaleno) en los tres eventos post-ROD. Además, no hubo detección de ninguna de los tres en el tercer evento. No obstante, concentraciones de benceno sobre el RG de 5 µg/L (es decir, entre 8 y 10 µg/L) y concentraciones de MTBE sobre el RG de 120 µg/L RG (entre 340 y 380 µg/L) fueron detectadas en el pozo MW-05 en cada evento, y concentraciones de 1,2-DCA sobre las RG de 3.8 µg/L (entre 4 y 8 µg/L) fueron detectadas en cada evento en el pozo MW-01 (**Figura ES-2**). Por consiguiente, según el ROD, el Plan de Contingencia 2 (aplicación de persulfato de sodio activado por peróxido de hidrógeno) será implementado para estimular la degradación de los tres COC restantes, cuyas concentraciones han persistido sobre los RGs. Luego de la aplicación de ISCO, el monitoreo a largo plazo de persulfato y los tres COCs restantes (i.e. benceno, MTBE y 1,2-DCA) continuará de acuerdo al proceso que se muestra en la **Figura ES-3**.

NOTA: ESTE RESUMEN SE PRESENTA EN INGLÉS Y EN ESPAÑOL PARA LA CONVENIENCIA DEL LECTOR. SE HAN HECHO TODOS LOS ESFUERZOS PARA QUE LA TRADUCCIÓN SEA PRECISA EN LO MÁS RAZONABLEMENTE POSIBLE. SIN EMBARGO, LOS LECTORES DEBEN ESTAR AL TANTO QUE EL TEXTO EN INGLÉS ES LA VERSIÓN OFICIAL.



Legend

- Road
- AOC E Land Use Control Boundary

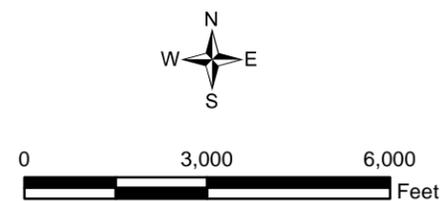


Figure ES-1
AOC E Site Location Map
AOC E Remedial Action Work Plan Addendum
Former Naval Ammunition Support Detachment
Vieques, Puerto Rico

Sample ID	MW-08	MW-08	MW-08	MW-08	MW-08	MW-08
Sample Date	09/08/03	08/26/04	07/27/08	04/01/15	03/31/15	01/10/17
Volatile Organic Compounds (UG/L)	1 st Round			2 nd Round		3 rd Round
	1,2-Dichloroethane	<0.5	<0.5	<0.5	<0.5	<0.5
Benzene	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Methyl-tert-butyl ether (MTBE)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Xylene, total (summation of m-, o-, and p-)	<2	<2	<0.5	<1.5	<1.5	<1.5
Semivolatile Organic Compounds (UG/L)						
2-Methylnaphthalene	<5.2	<5.2	<0.098	<0.095	<0.094	<0.094
Naphthalene	<5.2	<5.2	<0.098	<0.095	<0.094	<0.094

Sample ID	MW-07	MW-07	MW-07	MW-07	MW-07	MW-07
Sample Date	05/24/02	08/26/04	07/27/08	04/06/15	03/31/15	01/10/17
Volatile Organic Compounds (UG/L)	1 st Round			2 nd Round		3 rd Round
	1,2-Dichloroethane	<1	<0.5	<0.5	<0.5	<0.5
Benzene	<1	<0.5	<0.5	<0.5	<0.5	<0.5
Methyl-tert-butyl ether (MTBE)	NA	<0.5	<0.5	<0.5	<0.5	<0.5
Xylene, total (summation of m-, o-, and p-)	<1	<1	<2	<1.5	<1.5	<1.5
Semivolatile Organic Compounds (UG/L)						
2-Methylnaphthalene	<5.8	<5	<0.11	<0.095	<0.094	<0.097
Naphthalene	<5.8	<5	<0.11	<0.095	<0.094	<0.097

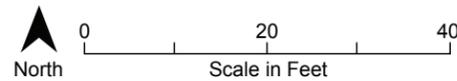
Sample ID	MW-04	MW-04	MW-04	MW-04	MW-04	MW-04	MW-04	MW-04
Sample Date	04/27/00	05/21/02	08/30/04	7/28/08	03/17/10	03/31/15	03/31/15	01/12/17
Volatile Organic Compounds (UG/L)	1 st Round			2 nd Round		3 rd Round		
	1,2-Dichloroethane	<1	4.6	0.59	<0.5	<5	<0.5	<0.5
Benzene	2	0.72 J	0.21 J	<0.5	<5	<0.5	0.53 J	0.51 J
Methyl-tert-butyl ether (MTBE)	NA	NA	234	110	130	14	26	12
Xylene, total (summation of m-, o-, and p-)	0.9 J	<1	<2	<0.5	<5	<1.5	<1.5	<1.5
Semivolatile Organic Compounds (UG/L)								
2-Methylnaphthalene	<5	<5.4	<5.1	0.05 J	<1	0.13 J	<0.095	<0.096
Naphthalene	<5	<5.4	<5.1	<0.093	<1	<0.094	<0.095	<0.096

COCs	RG (ug/L)
1,2-DCA	3.8
Benzene	5
MTBE	120
Xylene, total	10,000
2-Methylnaphthalene	27
Naphthalene	6.1

Notes:

← General Groundwater Flow Direction

- Initial two rounds of persulfate injections were performed in March and June 2010.
 - Post ROD performance monitoring was performed 2015 through 2017.
 - All concentrations are in ug/L.
 - Highlighted results exceed RGs.
- NA - Not analyzed
 < - Non-detected results (below detection limit)
 J - Estimated results
 1,2-Dichloroethane - 1,2-DCA
 Methyl-tert-butyl ether - MTBE
 RG - Remedial Goal
 ROD - Record of Decision
 UG/L - micrograms per liter



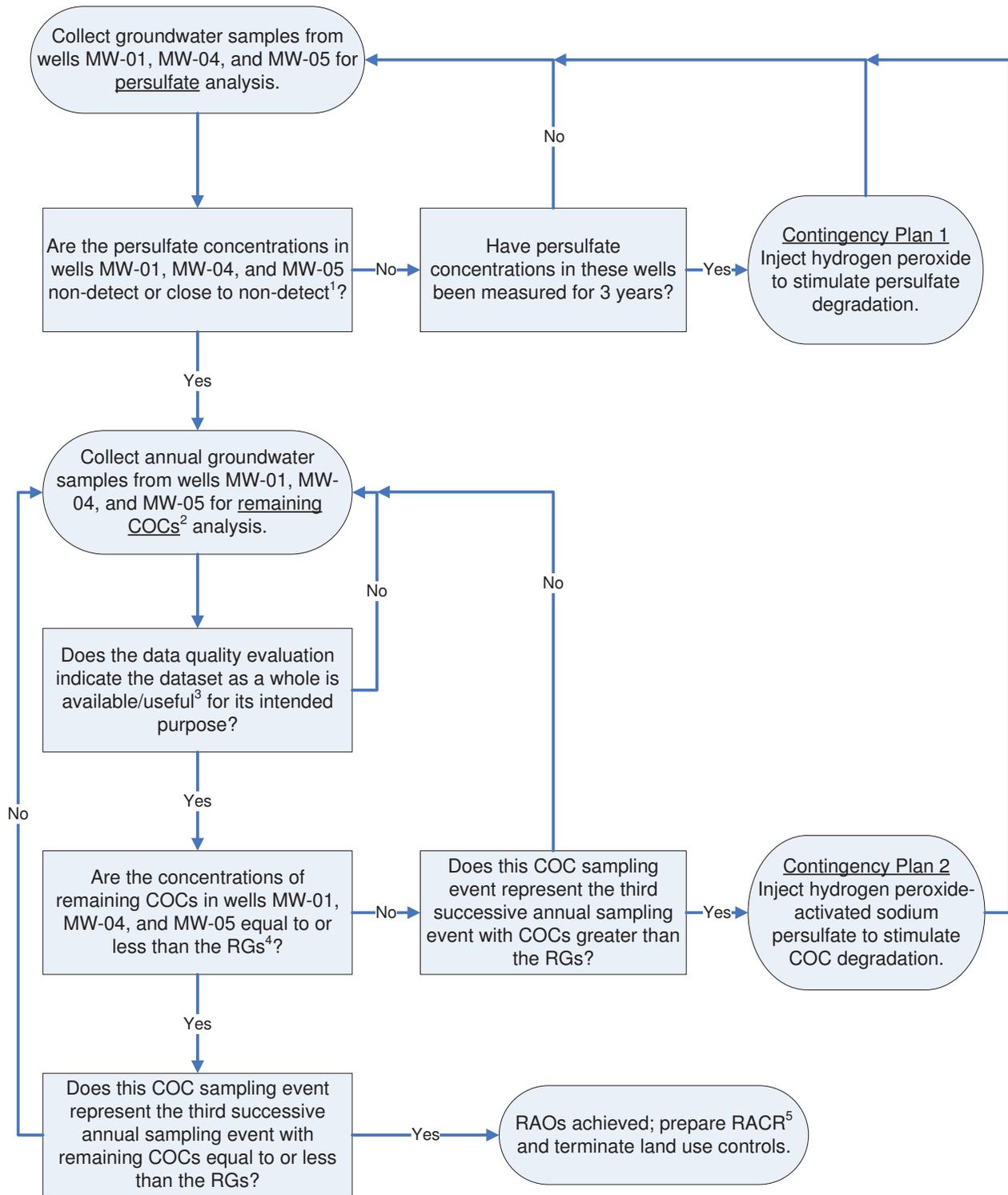
2004 Aerial Photograph

Sample ID	MW-05	MW-05	MW-05	MW-05	MW-05	MW-05	MW-05	MW-05	
Sample Date	05/01/00	08/30/04	08/30/04	7/29/08	03/17/10	04/01/15	01/06/16	01/13/17	
Volatile Organic Compounds (UG/L)	1 st Round						2 nd Round		3 rd Round
	1,2-Dichloroethane	32	7.2	6.2	<0.5	<0.5	0.85 J	0.85 J	<0.5
Benzene	6	0.81 J	1.2 J	16	4.5 J	9.8	7.8	7.9	
Methyl-tert-butyl ether (MTBE)	NA	1,180	1,220	560	520	350	380	340	
Xylene, total (summation of m-, o-, and p-)	20	1 J	1.8 J	2.5	<5	<1.5	<1.5	<1.5	
Semivolatile Organic Compounds (UG/L)									
2-Methylnaphthalene	14	<5.1	<5.2	16 J	5.8	0.2	0.084 J	<0.099	
Naphthalene	15	<5.1	<5.2	35 J	13	<0.096	0.1 J	<0.099	

Sample ID	MW-01	MW-01	MW-01	MW-01	MW-01	MW-01	MW-01	MW-01
Sample Date	09/11/98	09/01/04	07/29/08	03/17/10	03/31/15	01/06/16	01/13/17	
Volatile Organic Compounds (UG/L)	1 st Round			2 nd Round		3 rd Round		
	1,2-Dichloroethane	NA	<0.5	<0.5	<5	4.4	7.5	6.6
Benzene	17	4.1	3.8	6.4	2.1	3.2	6.6	
Methyl-tert-butyl ether (MTBE)	NA	260	150	120	23	18	21	
Xylene, total (summation of m-, o-, and p-)	<15	26.2	0.22 J	<5	<1.5	<1.5	<1.5	
Semivolatile Organic Compounds (UG/L)								
2-Methylnaphthalene	NA	12	4.3	8	0.2 J	0.1 J	<0.1	
Naphthalene	NA	9.5	4.3	6.6	<0.094	<0.096	<0.1	

Sample ID	MW-03	MW-03	MW-03	MW-03	MW-03	MW-03	MW-03	MW-03	MW-03
Sample Date	09/11/98	04/05/00	05/21/02	08/25/04	07/27/08	03/16/10	03/31/15	03/31/15	01/10/17
Volatile Organic Compounds (UG/L)	1 st Round						2 nd Round		3 rd Round
	1,2-Dichloroethane	NA	<1	<1	<0.5	<0.5	<5	<0.5	<0.5
Benzene	<5	<1	<1	<0.5	<0.5	<5	<0.5	<0.5	<0.5
Methyl-tert-butyl ether (MTBE)	NA	NA	NA	<0.5	<0.5	<5	<0.5	<0.5	<0.5
Xylene, total (summation of m-, o-, and p-)	<15	<1	<1	<2	<0.5	<5	<1.5	<1.5	<1.5
Semivolatile Organic Compounds (UG/L)									
2-Methylnaphthalene	NA	<5	<5.6	<5.3	<0.095	<1	<0.094	<0.094	<0.098
Naphthalene	NA	<5	<5.6	<5.3	<0.095	<1	<0.094	<0.094	<0.098

Figure ES-2
Groundwater COC Concentration Map
 AOC E Remedial Action Work Plan Addendum
 Former Naval Ammunition Support Detachment
 Vieques, Puerto Rico



Notes:

The decision makers associated with this decision tree are the Navy, EPA, and PREQB (Vieques Technical Subcommittee).

¹ "Close to non-detect" is a subjective concentration determination that will be based on concurrence by the Vieques Technical Subcommittee

² Remaining Contaminants of Concern (COCs): 1,2-dichloroethane (1,2-DCA); benzene; methyl tert-butyl ether (MTBE)

³ "Available" and "Useful" data are described in Worksheet #37 of the AOC E Remedial Action Work Plan (CH2M, 2015)

⁴ Remediation Goals (RGs): 1,2-DCA (3.8 µg/L); benzene (5 µg/L); MTBE (120 µg/L)

⁵ RACR = Remedial Action Completion Report

Figure ES-3
Long-term Monitoring Decision Tree
 AOC E Remedial Action Work Plan Addendum
 Atlantic Fleet Weapons Training Area – Vieques
 Former Naval Ammunition Support Detachment
 Vieques, Puerto Rico

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1-3	Groundwater COC Concentration Map
2-1	AOC E Injection and Long-Term Monitoring Network
2-2	Long-Term Monitoring Decision Tree

Acronyms and Abbreviations

µg/L	micrograms per liter
1,2-DCA	1,2-dichloroethane
AOC	Area of Concern
AST	aboveground storage tank
bls	below land surface
CLEAN	Comprehensive Long-term Environmental Action—Navy
cm/s	centimeters per second
COC	contaminant of concern
CP	contingency plan
CTO	Contract Task Order
DO	dissolved oxygen
EPA	Environmental Protection Agency
g/kg	grams per kilogram
gpm	gallons per minute
IC	Institutional Control
ISCO	in situ chemical oxidation
LTM	long-term monitoring
MTBE	methyl tert-butyl ether
MW	monitoring well
NASD	Naval Ammunition Support Detachment
NAVFAC	Naval Facilities Engineering Command
Navy	Department of the Navy
NOD	natural oxidant demand
ORP	oxidation-reduction potential
pH	potential of hydrogen
PPE	personal protective equipment
PREQB	Puerto Rico Environmental Quality Board
psi	pound per square inch
RAO	Remedial Action Objective
RAWP	Remedial Action Work Plan
RG	Remedial Goal
ROD	Record of Decision
UST	underground storage tank

Introduction

In accordance with protocols dictated by the Area of Concern (AOC) E Record of Decision (ROD) (NAVFAC, 2015) and the *Remedial Action Work Plan, Groundwater Monitoring and Institutional Controls with Contingency Plans, Area of Concern E* (CH2M, 2015), this Remedial Action Work Plan (RAWP) Addendum presents the in situ chemical oxidation (ISCO) injection procedures for implementing hydrogen peroxide-activated sodium persulfate (Contingency Plan 2) to address persistent remedial goal (RG) exceedances in groundwater. AOC E is located at the former Naval Ammunition Support Detachment (NASD) in Vieques, Puerto Rico (**Figures 1-1 and 1-2**). The RAWP Addendum was prepared under the Naval Facilities Engineering Command (NAVFAC), Atlantic Comprehensive Long-term Environmental Action – Navy (CLEAN) 9000 Contract N62470-16-D-9000, Contract Task Order (CTO) 0003, for submittal to NAVFAC, the Environmental Protection Agency (EPA) Region 2, and the Commonwealth of Puerto Rico Environmental Quality Board (PREQB).

The Department of the Navy (Navy) and EPA jointly selected the remedial action for AOC E, with the concurrence of PREQB. The remedial action selected for AOC E is Long-Term Monitoring (LTM) and Institutional Controls (ICs) with Contingency Plans (CPs), as documented in the ROD (NAVFAC, 2015). The components of the remedial action include implementing groundwater LTM, physical barriers and ICs, groundwater treatment contingency plans (as necessary), and statutory Five-Year Reviews and reporting.

As dictated in the ROD and described in the RAWP, for any contaminant of concern (COC) whose concentrations persist above its RG for three consecutive post-ROD monitoring events, a hydrogen peroxide-activated sodium persulfate solution will be applied in an effort to reduce its concentrations to the RG or below. The COCs originally identified at AOC E are benzene, 1,2-dichloroethane (1,2-DCA), 2-methylnaphthalene, methyl tert-butyl ether (MTBE), naphthalene, and xylenes. **Table 1-1** shows the original COCs, associated RGs, and maximum concentrations detected during the three post-ROD annual LTM events. As shown in the table, three of the six COCs (i.e., naphthalene, 2-methylnaphthalene, and xylenes) have either not been detected (xylenes) or have been detected an order of magnitude or more below the RGs (naphthalene, 2-methylnaphthalene) during the three post-ROD events. Furthermore, none of these three were detected during the third event. However, benzene concentrations above the 5 micrograms per liter ($\mu\text{g/L}$) RG (i.e., between 8 and 10 $\mu\text{g/L}$) and MTBE concentrations above the 120 $\mu\text{g/L}$ RG (i.e., between 340 and 380 $\mu\text{g/L}$) were observed during each event in well MW-05, and 1,2-DCA concentrations above the 3.8 $\mu\text{g/L}$ RG (i.e., between 4 and 8 $\mu\text{g/L}$) were observed during each event in well MW-01 (**Figure 1-3**). Therefore, the remainder of this RAWP Addendum provides the details of the ISCO application to address rebound of the three remaining COCs (i.e., benzene, MTBE, and 1,2-DCA), including solution(s) and quantities to be applied, application location(s), field parameters to be collected, performance monitoring to be conducted, an estimated schedule, and reporting. Because this document is an addendum to an existing work plan, historical and related background information regarding AOC E can be found in the Remedial Investigation Report (CH2M, 2008), Focused Feasibility Study Report (CH2M, 2012), Record of Decision (NAVFAC, 2015), and RAWP (CH2M, 2015).

This RAWP Addendum is organized as follows:

- Section 1 – Introduction
- Section 2 – ISCO Injection Plan
- Section 3 – Reporting
- Section 4 – Project Schedule
- Section 5 – References

Tables and figures are provided at the end of each section.

TABLE 1-1
Remedial Goals and Maximum COC Concentration (2015-2017)
AOC E Remedial Action Work Plan Addendum
Former Naval Ammunition Support Detachment
Vieques, Puerto Rico

COC	Retained for Long-term Monitoring? (Yes/No)	Maximum Concentration (2015-2017)	Remedial Goal	Basis
Benzene	Yes	9.8	5	MCL
1,2-Dichloroethane	Yes	7.5	3.8	PRWQS for Groundwater (SG); an ARAR that is lower than the MCL of 5 µg/L
MTBE	Yes	380	120	ELCR of 1X10 ⁻⁵ and HI of 0.02 (EPA, 2013)
2-Methylnaphthalene	No	0.2	27	HI of 1; not a potential carcinogen
Naphthalene	No	0.1 J	6.1	HI of 1 and ELCR of 4X10 ⁻⁵ (EPA, 2013)
Total xylenes	No	1.5 U	10,000	MCL

Notes:

1. All concentrations are in micrograms per liter (µg/L).
2. Maximum detected concentrations are based on last three events (2015 through 2017) for monitoring wells MW-01, MW-03, MW-04, MW-06, MW-07 and MW-08.
3. Bolded concentration exceeds RG.
4. Only remaining COCs with concentrations exceeding RGs are retained for long-term monitoring.

ARAR - Applicable or relevant and appropriate requirement

COC – chemical of concern

ELCR - excess lifetime cancer risk

HI - hazard index

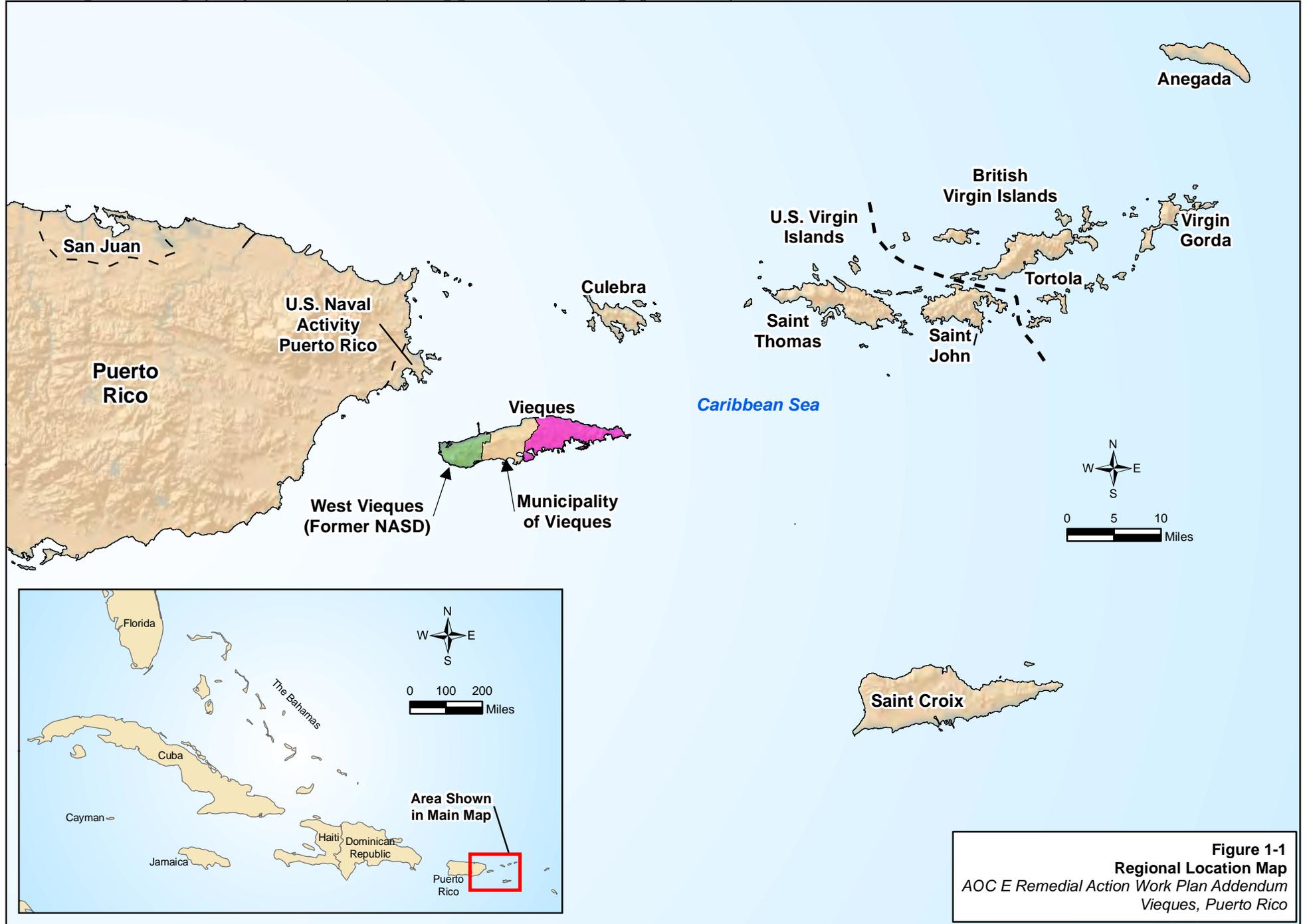
J- estimated result

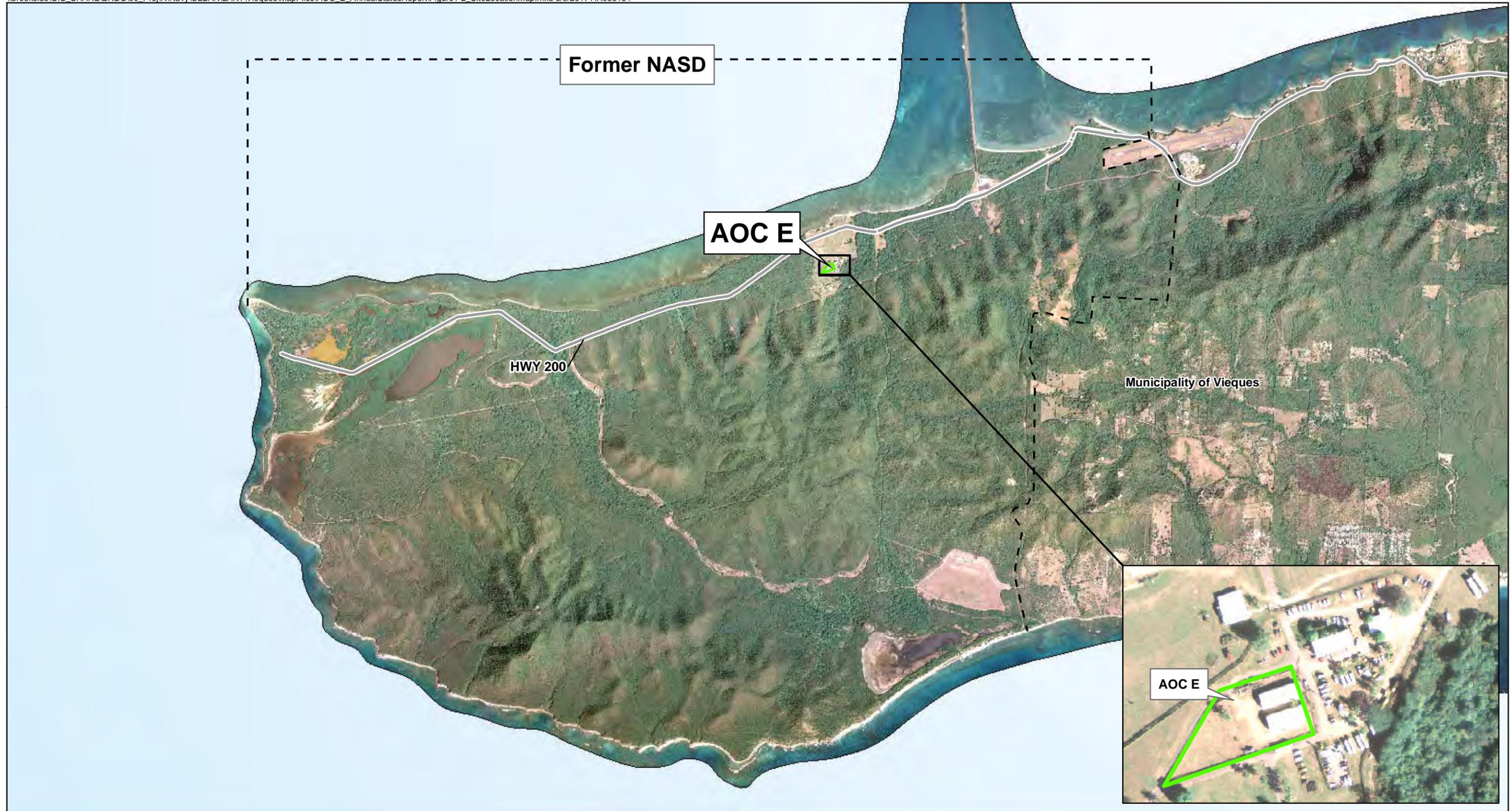
MCL – Federal Maximum Contaminant Level (EPA, 2009)

PRWQS – Puerto Rico Water Quality Standards (November 2016; for groundwater – Class SG)

RG – Remedial Goal

U – nondetect result





Legend

- Road
- AOC E Land Use Control Boundary

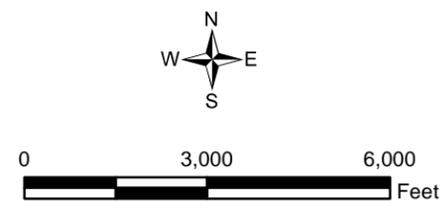


Figure 1-2
AOC E Site Location Map
AOC E Remedial Action Work Plan Addendum
Former Naval Ammunition Support Detachment
Vieques, Puerto Rico

Sample ID	MW-08	MW-08	MW-08	MW-08	MW-08	MW-08
Sample Date	09/08/03	08/26/04	07/27/08	04/01/15	03/31/15	01/10/17
Volatile Organic Compounds (UG/L)	1 st Round			2 nd Round		3 rd Round
	1,2-Dichloroethane	<0.5	<0.5	<0.5	<0.5	<0.5
Benzene	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Methyl-tert-butyl ether (MTBE)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Xylene, total (summation of m-, o-, and p-)	<2	<2	<0.5	<1.5	<1.5	<1.5
Semivolatile Organic Compounds (UG/L)						
2-Methylnaphthalene	<5.2	<5.2	<0.098	<0.095	<0.094	<0.094
Naphthalene	<5.2	<5.2	<0.098	<0.095	<0.094	<0.094

Sample ID	MW-07	MW-07	MW-07	MW-07	MW-07	MW-07
Sample Date	05/24/02	08/26/04	07/27/08	04/06/15	03/31/15	01/10/17
Volatile Organic Compounds (UG/L)	1 st Round			2 nd Round		3 rd Round
	1,2-Dichloroethane	<1	<0.5	<0.5	<0.5	<0.5
Benzene	<1	<0.5	<0.5	<0.5	<0.5	<0.5
Methyl-tert-butyl ether (MTBE)	NA	<0.5	<0.5	<0.5	<0.5	<0.5
Xylene, total (summation of m-, o-, and p-)	<1	<1	<2	<1.5	<1.5	<1.5
Semivolatile Organic Compounds (UG/L)						
2-Methylnaphthalene	<5.8	<5	<0.11	<0.095	<0.094	<0.097
Naphthalene	<5.8	<5	<0.11	<0.095	<0.094	<0.097

Sample ID	MW-04	MW-04	MW-04	MW-04	MW-04	MW-04	MW-04	MW-04
Sample Date	04/27/00	05/21/02	08/30/04	7/28/08	03/17/10	03/31/15	03/31/15	01/12/17
Volatile Organic Compounds (UG/L)	1 st Round			2 nd Round		3 rd Round		
	1,2-Dichloroethane	<1	4.6	0.59	<0.5	<5	<0.5	<0.5
Benzene	2	0.72 J	0.21 J	<0.5	<5	<0.5	0.53 J	
Methyl-tert-butyl ether (MTBE)	NA	NA	234	110	130	14	26	
Xylene, total (summation of m-, o-, and p-)	0.9 J	<1	<2	<0.5	<5	<1.5	<1.5	
Semivolatile Organic Compounds (UG/L)								
2-Methylnaphthalene	<5	<5.4	<5.1	0.05 J	<1	0.13 J	<0.095	<0.096
Naphthalene	<5	<5.4	<5.1	<0.093	<1	<0.094	<0.095	<0.096

COCs	RG (ug/L)
1,2-DCA	3.8
Benzene	5
MTBE	120
Xylene, total	10,000
2-Methylnaphthalene	27
Naphthalene	6.1

Sample ID	MW-05	MW-05	MW-05	MW-05	MW-05	MW-05	MW-05	MW-05
Sample Date	05/01/00	08/30/04	08/30/04	7/29/08	03/17/10	04/01/15	01/06/16	01/13/17
Volatile Organic Compounds (UG/L)	1 st Round			2 nd Round		3 rd Round		
	1,2-Dichloroethane	32	7.2	6.2	<0.5	<0.5	0.85 J	0.85 J
Benzene	6	0.81 J	1.2 J	16	4.5 J	9.8	7.8	
Methyl-tert-butyl ether (MTBE)	NA	1,180	1,220	560	520	350	340	
Xylene, total (summation of m-, o-, and p-)	20	1 J	1.8 J	2.5	<5	<1.5	<1.5	
Semivolatile Organic Compounds (UG/L)								
2-Methylnaphthalene	14	<5.1	<5.2	16 J	5.8	0.2	0.084 J	<0.099
Naphthalene	15	<5.1	<5.2	35 J	13	<0.096	0.1 J	<0.099

Sample ID	MW-01	MW-01	MW-01	MW-01	MW-01	MW-01	MW-01	MW-01
Sample Date	09/11/98	09/01/04	07/29/08	03/17/10	03/31/15	01/06/16	01/13/17	
Volatile Organic Compounds (UG/L)	1 st Round			2 nd Round		3 rd Round		
	1,2-Dichloroethane	NA	<0.5	<0.5	<5	4.4	7.5	6.6
Benzene	17	4.1	3.8	6.4	2.1	3.2	6.6	
Methyl-tert-butyl ether (MTBE)	NA	260	150	120	23	18	21	
Xylene, total (summation of m-, o-, and p-)	<15	26.2	0.22 J	<5	<1.5	<1.5	<1.5	
Semivolatile Organic Compounds (UG/L)								
2-Methylnaphthalene	NA	12	4.3	8	0.2 J	0.1 J	<0.1	
Naphthalene	NA	9.5	4.3	6.6	<0.094	<0.096	<0.1	

Sample ID	MW-03	MW-03	MW-03	MW-03	MW-03	MW-03	MW-03	MW-03	MW-03
Sample Date	09/11/98	04/05/00	05/21/02	08/25/04	07/27/08	03/16/10	03/31/15	03/31/15	01/10/17
Volatile Organic Compounds (UG/L)	1 st Round			2 nd Round		3 rd Round			
	1,2-Dichloroethane	NA	<1	<1	<0.5	<0.5	<5	<0.5	<0.5
Benzene	<5	<1	<1	<0.5	<0.5	<5	<0.5	<0.5	<0.5
Methyl-tert-butyl ether (MTBE)	NA	NA	NA	<0.5	<0.5	<5	<0.5	<0.5	<0.5
Xylene, total (summation of m-, o-, and p-)	<15	<1	<1	<2	<0.5	<5	<1.5	<1.5	<1.5
Semivolatile Organic Compounds (UG/L)									
2-Methylnaphthalene	NA	<5	<5.6	<5.3	<0.095	<1	<0.094	<0.094	<0.098
Naphthalene	NA	<5	<5.6	<5.3	<0.095	<1	<0.094	<0.094	<0.098

Notes:

- ← General Groundwater Flow Direction
- 1. Initial two rounds of persulfate injections were performed in March and June 2010.
- 2. Post ROD performance monitoring was performed 2015 through 2017.
- 3. All concentrations are in ug/L.
- 4. Highlighted results exceed RGs.

NA - Not analyzed
 < - Non-detected results (below detection limit)
 J - Estimated results
 1,2-Dichloroethane - 1,2-DCA
 Methyl-tert-butyl ether - MTBE
 RG - Remedial Goal
 ROD - Record of Decision
 UG/L - micrograms per liter

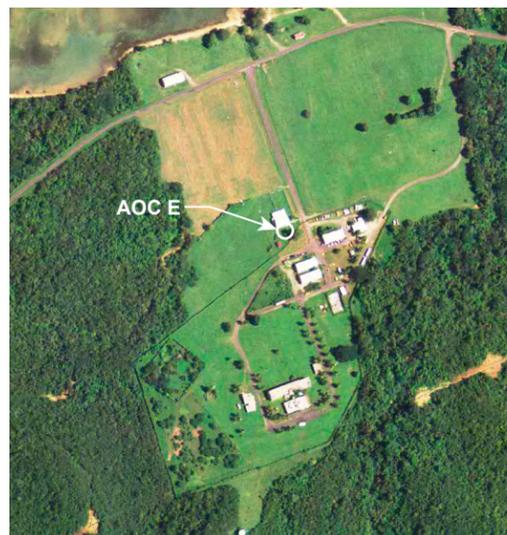


Figure 1-3
Groundwater COC Concentration Map
 AOC E Remedial Action Work Plan Addendum
 Former Naval Ammunition Support Detachment
 Vieques, Puerto Rico

ISCO Application and Monitoring

The section provides the details of the ISCO application process, including the basis for the specific chemical makeup of the solution. It also includes the post-application monitoring protocol.

2.1 ISCO Solution

Based on the results of the pilot study, Focused Feasibility Study, and observations made during the post-ROD monitoring, approximately 1,102 pounds of sodium persulfate (Klozur® SP or equivalent; twenty 55.1-pound bags), approximately 252 gallons of 17.5% by mass hydrogen peroxide, and 18 pounds of citric acid stabilizer, will be required for an approximately 25-foot-by-25-foot target treatment area. Based on a 10-foot impacted groundwater treatment thickness and persulfate natural oxidant demand (NOD) of 1.5 grams per kilogram (g/kg) of solid matrix. Considering the relatively small area of the Contingency Plan 2 ISCO application and 3 to 4 years of persulfate persistence observed during pilot study, the oxidant demand was reduced from 2.4 g/kg lab-determined tests to 1.5 g/kg. Although minimal, the calculated oxidant mass also takes into account the stoichiometric demand of the COC concentrations in the groundwater. Using an aggressive activator such as hydrogen peroxide reduces the persistence of persulfate in the subsurface compared to sodium hydroxide used during the pilot study. This more aggressive and shorter persulfate persistence should result in a shorter time before performance monitoring of the effect on the remaining COCs can be conducted.

The required quantity of hydrogen peroxide activator is based on the manufacturer's recommended dosage of a 2:1 molar ratio (hydrogen peroxide: sodium persulfate). The lateral and vertical extent of the treatment area is based on the concentrations of the three remaining COCs in monitoring wells MW-01 and MW-05.

Table 2-1 provides a summary of the planned injection configuration, including the rationale for each element and, as applicable, where it varies from the original injection configuration.

2.2 Application

2.2.1 Mobilization and Preparation

Mobilizations will include CH2M staff, subcontractor(s), and equipment traveling to Vieques, as well as procuring the materials necessary to perform the application activities. The primary equipment to be used includes: mixing tank, injection/transfer pump(s) and tank(s), secondary containment, generator, delivery hoses, manifolds, flow/totalizer meters, and pressure gauges. The injection pumps will have capacity of up to 100 pounds per square inch (psi) pressure. Equipment arriving onsite will be inspected for fluid leaks and general working condition. Secondary containment will be provided for oxidant storage area and oxidant mixing area to prevent potential spills. The specific secondary containment approach may vary depending on field conditions and equipment/materials availability, but may include Rain for-Rent-type L-bracket containment systems (or similar), which use a synthetic liner. Alternatively, a synthetic liner or plastic sheeting may be used in conjunction with sandbags or a soil berm. Further, prior to starting the pump for injection, equipment interlocks, tooling, and valves will be checked by the Subcontractor. A leak test will be performed using water to ensure there is no leakage of injection hose, pipe, valves, and connection to the wellhead assembly or manifold.

2.2.2 Chemical Delivery and Storage

Materials, including sodium persulfate (Klozur® SP or equivalent; twenty 55.1-pound bags), hydrogen peroxide (PeroxyChem or equivalent; 17.5% solution; five 55-gallon drums), and citric acid (Jacquard or equivalent; 18 pounds) will be handled in the bags, drums, and/or pails in which they are shipped. Materials that are sensitive to moisture will be kept sealed in their containers, covered with tarps/plastic sheeting, and/or stored indoors, as applicable, prior to use. Klozur® SP, hydrogen peroxide, and citric acid product technical literature is included in **Appendix A**.

2.2.3 Oxidant Solution Injection

As indicated in Section 1.4 of the ROD, the ISCO application involves injecting hydrogen peroxide-activated sodium persulfate solution into the two 2-inch-diameter monitoring wells where persistent COC rebound above the RGs was observed: MW-01 and MW-05. Application will be performed by injection with low pressure (up to 30 psi), assuming injection rates of 1 gallon per minute (gpm) per well. The target treatment interval is from approximately 40 to 50 feet below land surface (bls), corresponding to the well screen interval of MW-01 and MW-05. **Figure 2-1** shows the locations of ISCO treatment wells in addition to the surrounding wells at AOC E. **Table 2-2** includes the well construction details for the wells into which the ISCO solution will be applied and/or included in post-application performance monitoring. Because well MW-03 is upgradient of the area of contamination, wells MW-07 and MW-08 are downgradient of the area of contamination, none of these wells has shown any impact from the site contaminants, especially when the COC concentrations were significantly higher, and because the planned injection is essentially the same as the previous injection, these three wells are not necessary to include in further LTM.

Injection Protocol

- Based on previous pilot study findings and persistence of persulfate, the sodium persulfate mass per kilogram of soil within the treatment zone was decreased to a lower NOD of 1.5 g/kg. The volume of the injectate is 50% of the effective pore volume. This higher percentage of the pore volume will optimize contact between the oxidant and the contaminants, and increase the radius of influence of injected solution.
- 1,102 pounds of sodium persulfate will be mixed with approximately 2,800 gallons of potable water (obtained from the water supply at Camp Garcia) and prepared in a polytank in batches to create an approximately 4.7% sodium persulfate solution of approximately 2,800 gallons.
- Approximately 252 gallons of 17.5% hydrogen peroxide will be diluted with water in a polytank in batches to create an approximate 8% hydrogen peroxide solution of approximately 552 gallons. A total of about 18 pounds of Citric acid will be added to the solution to help stabilize the hydrogen peroxide.
- Prior to the injection event, field water quality parameters (potential of hydrogen [pH], temperature, specific conductivity, oxidation-reduction potential [ORP], and dissolved oxygen [DO]), persulfate, hydrogen peroxide, and depth to water will be monitored in MW-01 and MW-05 (ISCO application and performance monitoring wells) and MW-04 (downgradient performance monitoring well).
- The hydrogen peroxide solution stabilized with citric acid will be injected as activator into each of the two injection wells (MW-01 and MW-05) after completing the sodium persulfate injections, as described below. Although not anticipated, if visual observation suggests off-gassing or heat may be problematic (a subjective determination) during hydrogen peroxide injections, the hydrogen peroxide concentration will be lowered. The concentration of hydrogen peroxide can be decreased by adding water to lower concentration based on field observation.
- The injection amount and sequence is as follows:
 - Inject approximately 1,400 gallons of 4.7% sodium persulfate solution per well, into MW-01 and MW-05.
 - Following the application of persulfate, inject the hydrogen peroxide-citric acid solution into MW-01 and MW-05.
 - Inject approximately 20 gallons of water chaser per well to flush the well and the well-screen to ensure the oxidant solution is pushed into the formation.

The average hydraulic conductivity is 7.06×10^{-5} centimeters per second (cm/s), which represents a relatively tight formation; thus, slow injection rates are anticipated. The low-pressure injection will be completed using ancillary equipment (mixing tanks, pumps, etc.) under a low to moderate wellhead pressure of 5 to 30 psi. If flow rates of less than 0.5 gpm are encountered, then the injection pressure can be increased step-wise (up to 100 psi). Simultaneous injection into MW-01 and MW-05 will be conducted. The injection pump will be rated

at 5 to 100 psi with a flowrate capacity of up to 10 gpm. Flow rate gauges will be able to measure down to 0.5 gpm.

If the designed 1,400 gallons per injection well is too high for the formation to accept during low pressure injection, the amount of water mixed with persulfate will be decreased, resulting in an increase in persulfate concentration being applied. However, the resulting persulfate solution concentration will not be allowed to exceed 25% by weight (as the persulfate can precipitate out of solution at concentrations greater than this). If the formation cannot accept injectate after adjusting persulfate concentrations, the field crew will allow the water-bearing unit to re-equilibrate for a period of time (up to several days), and then inject the remaining oxidant and activator.

2.2.4 Process Monitoring During Injections

During the injection event, injection rates and pressures, injectate volume and concentrations, oxidant and activator inventory, and the start and end times for delivering the designated amount of solution to each of the wells will be monitored and recorded. During injection, a dedicated disposable bailer for each monitoring well will be used to collect samples for field parameters. Injection field parameters (pH, temperature, specific conductivity, and ORP), persulfate, hydrogen peroxide, and depth to groundwater will be monitored in MW-01, MW-04, and MW-05, approximately three times a day during injection, as warranted based on ongoing observations. Persulfate and hydrogen peroxide will be measured using with a CHEMetrics test kit, in accordance with procedures detailed in **Appendix B**, to monitor oxidant and activator consumption and decomposition rates. In addition, water level measurements will be made to determine if mounding is occurring in observation wells. If more than several feet (a subjective determination) of mounding is observed, the injection pressure (and, as a result, the flowrate) will be decreased or injection will be temporarily suspended to avoid daylighting and allow the mounding to subside.

2.2.5 Demobilization

Decontamination of equipment will be performed by the injection subcontractor in the injection area. Several types of potentially contaminated wastes may be generated during the fieldwork: (1) used personal protective equipment (PPE); (2) fluids from the decontamination of sampling tools, other equipment; and (3) purge water from groundwater sampling. The used PPE will be decontaminated and disposed of with normal trash. The small volume of purge water produced will be allowed to evaporate per the Master Standard Operating Procedures, Protocols, and Plans (CH2M, 2018).

2.2.6 Post-injection Persulfate Persistence Monitoring

Following ISCO application, residual persulfate monitoring will take place in accordance with Section 3.1 and Worksheet #11 (Appendix C) of the RAWP (CH2M, 2015) with the following modifications:

- Residual persulfate monitoring will be conducted only in wells MW-01, MW-04, and MW-05. As noted in Section 2.2.3, historical information collected from wells MW-03, MW-07, and MW-08 (when COC concentrations were significantly higher) and during the original injection indicate (under similar injection protocol) further monitoring of these wells is not warranted.

The residual persulfate monitoring process is displayed in **Figure 2-2**.

2.2.7 Groundwater Performance Monitoring

Groundwater performance monitoring will be initiated and performed in accordance with Section 3.1 and Worksheet #11 (Appendix C) of the RAWP (CH2M, 2015) with the following modifications:

- Groundwater performance monitoring will be conducted using three monitoring wells (MW-01, MW-04, and MW-05). These wells are either located within the area of COC RG exceedances (i.e., wells MW-01 and MW-05) or are immediately downgradient of these wells (i.e., well MW-04). As noted previously, historical information collected from wells MW-03, MW-07, and MW-08 (when COC concentrations were significantly

higher) and during the original injection (under similar injection protocol) indicate further monitoring of these wells is not warranted.

- Sampling parameters will comprise the three remaining COCs (benzene, MTBE, and 1,2-DCA). Because the Remedial Action Objective (RAO) for naphthalene, 2-methylnaphthalene, and xylenes has been achieved (i.e., non-detect or concentrations below RGs for three consecutive annual performance monitoring events), analysis of these former COCs is not warranted.

The performance monitoring process is displayed in **Figure 2-2**.

TABLE 2-1

ISCO Injection Configuration Summary

AOC E Remedial Action Work Plan Addendum

Former Naval Ammunition Support Detachment

Vieques, Puerto Rico

Description	Value	Unit	Contingency Plan 2 Configuration Notes
TTZ Area	625	square feet	Based on past performance and current COC concentrations, a TTZ area of 25 feet x 25 feet around wells MW-01 and MW-05 will address the existing area of COCs above RGs
Vertical Thickness of TTZ	10	feet	40 to 50 feet below ground surface (well screen interval of MW-01 and MW-05); same as previous treatment interval
Total Volume of TTZ	231	cubic yard	
Effective TTZ Pore Volume	5,610	gallons	Assumed effective porosity = 0.12 for saprolite
Chemical Dose			
Klozur® SP (Sodium Persulfate)	1,102	pounds	Based on pilot study results (i.e., undesirably long persulfate persistence), a lower NOD likely exists. Therefore, 1.5 grams sodium persulfate (vs 2.4 grams used in previous application) per kilogram of soil mass (20 bags; 55.1 pounds per bag).
Hydrogen Peroxide Activator (17.5%)	252	gallons	17.5% of standard grade hydrogen peroxide solution (5 drums; 50.4 gallon per drum); a more aggressive activator that replaces the sodium hydroxide activator used in the previous application
Citric Acid (Stabilizer)	18	pounds	Used to extend hydrogen peroxide activator persistence
ISCO Injection Parameters			
Sodium Persulfate Injectate Volume	2,800 (1,400/well)	gallons	Due to undesirable persulfate persistence during initial application and because COC concentrations are significantly lower, will inject a 4.7% solution prepared from dry Klozur® SP (reduced from approximately 20% solution used during initial application to reduce persulfate persistence)
Hydrogen Peroxide Injectate Volume	550 (275/well)	gallons	Inject up to 8% solution; diluted from standard grade 17.5% solution and stabilized with citric acid
Targeted Percent of Treatment Zone Pore Volume	50	percent	The total oxidant solution targets a higher percent of the pore volume for the Contingency Plan 2 design versus the target percent during the initial application to enhance contact between the oxidant and residual COCs
Number of Wells Injected	2	well	MW-01 and MW-05 (per the ROD, inject in the wells with COC concentrations above RGs)
Water Chase per Well	20	gallons	After hydrogen peroxide injection, to ensure sodium persulfate is pushed into formation
Injection Pressure	< 100	psi	Targeted low-pressure injection pressure is 30 psi. If injection flowrate is less than 0.5 gpm, injection pressure can be gradually increased to maximum 100 psi.
Estimated Injection Rate	1 to 2	gpm	Assume 1 gpm per well; can inject simultaneously into MW-01 and MW-05 if injection flowrate is less than about 0.5 gpm per well and/or no deleterious effects observed (see text)

Notes:

gpm - gallons per minute

NOD - natural oxidant demand

psi - pounds per square inch

TTZ - target treatment zone

TABLE 2-2

Well Construction Details

AOC E Remedial Action Work Plan Addendum
 Former Naval Ammunition Support Detachment
 Vieques, Puerto Rico

Well ID	Top of Casing Elevation (ft amsl)	Well Depth (ft bls)	Screen Interval Depth (ft bls)	Well Diameter (inch)	Northing UTM NAD 83 (Meter)	Easting UTM NAD 83 (Meter)	Depth to Groundwater below TOC 1/9/2017 (ft BTOC)	Groundwater Elevation on 01/09/2017 (ft amsl)	Date	pH	Conductivity (uS/cm)	redox (ORP) (mV)	DO (mg/L)	Persulfate (mg/L)
MW-01	43.93	50	40-50	2	232797.520	2005684.767	41.26	2.67	1/12/17	7.18	24,209	76.0	1.80	0
MW-04	43.60	50	40-50	2	232793.297	2005687.006	41.16	2.44	1/11/17	10.86	16,723	-9.0	1.64	0.7
MW-05	44.32	50	40-50	2	232798.483	2005687.310	41.72	2.60	1/12/17	7.18	21,607	67.2	0.52	0

Notes:

BTOC - below top of casing

ft amsl - feet above mean sea level (NGVD)

ft bls - feet below land surface

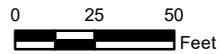
mg/L - milligram per liter

ORP - oxidation reduction potential



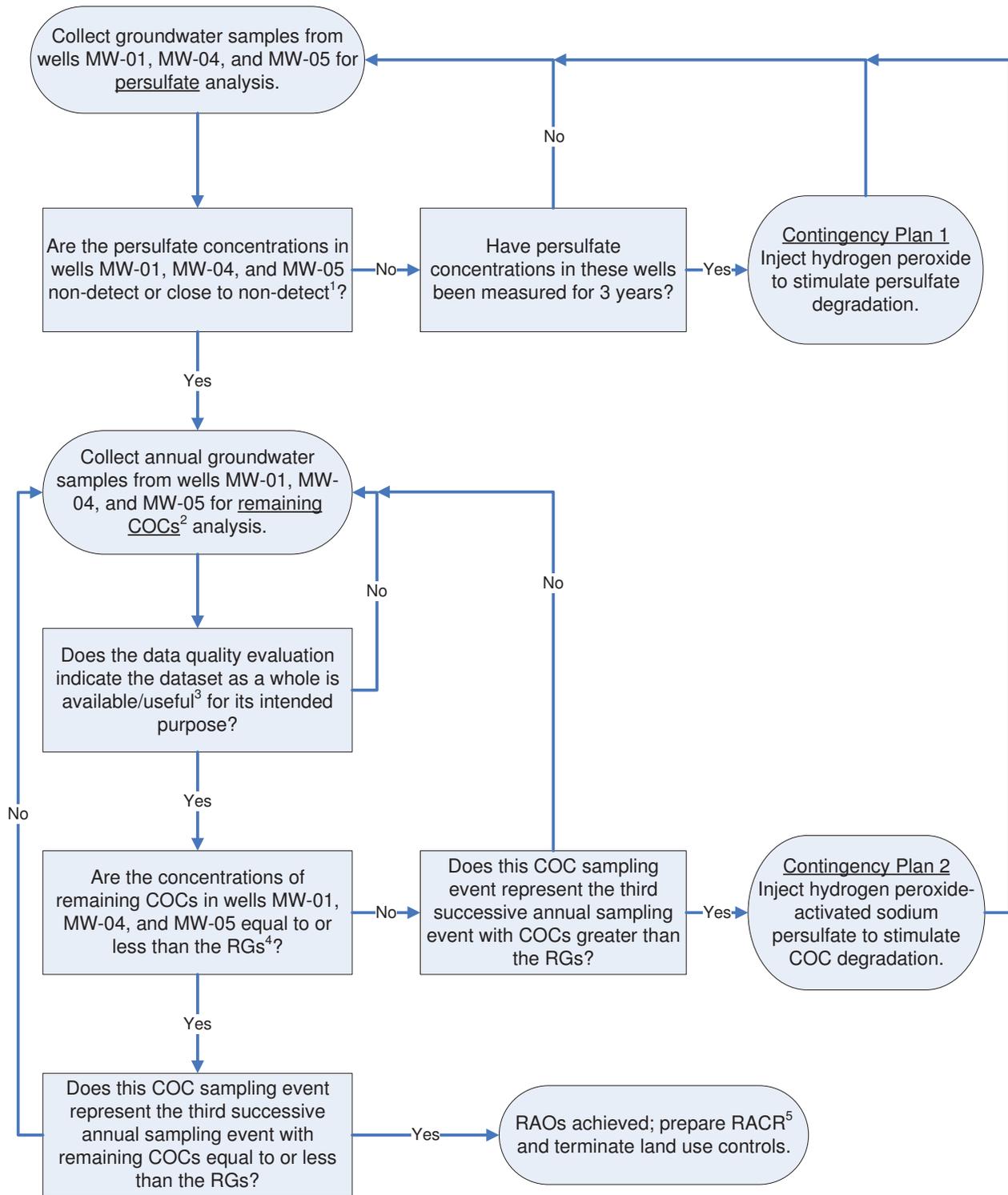
Legend

-  Performance Monitoring Well
-  ISCO Injection and Performance Monitoring Well
-  Existing Monitoring Well
-  Fence
-  AOC E Land Use Control Boundary



2007 Aerial Imagery

Figure 2-1
AOC E Injection and Long-Term Monitoring Network
AOC E Remedial Action Work Plan Addendum
Vieques, Puerto Rico



Notes:

The decision makers associated with this decision tree are the Navy, EPA, and PREQB (Vieques Technical Subcommittee).

¹ "Close to non-detect" is a subjective concentration determination that will be based on concurrence by the Vieques Technical Subcommittee

² Remaining Contaminants of Concern (COCs): 1,2-dichloroethane (1,2-DCA); benzene; methyl tert-butyl ether (MTBE)

³ "Available" and "Useful" data are described in Worksheet #37 of the AOC E Remedial Action Work Plan (CH2M, 2015)

⁴ Remediation Goals (RGs): 1,2-DCA (3.8 µg/L); benzene (5 µg/L); MTBE (120 µg/L)

⁵ RACR = Remedial Action Completion Report

Figure 2-2
Long-term Monitoring Decision Tree
 AOC E Remedial Action Work Plan Addendum
 Atlantic Fleet Weapons Training Area – Vieques
 Former Naval Ammunition Support Detachment
 Vieques, Puerto Rico

SECTION 3

Reporting

Reporting will be performed as described in Section 4 of the RAWP (CH2M, 2015). The first annual status report issued following implementation of Contingency Plan 2 will include the details of its implementation in addition to a summary of inspection/monitoring activities and results.

SECTION 4

Project Schedule

The tentative schedule for implementing Contingency Plan 2 outlined in this RAWP Addendum is provided below. Each year, the schedule will be adjusted, as necessary, and documented in the fiscal year Site Management Plan schedule update, which will provide the specific month(s) of the year when the actual activities below are planned.

- Work Plan Addendum preparation and project planning: August 2017 - March 2018
- Contingency Plan 2 implementation: April 2018
- Initial (post Contingency Plan 2 implementation) persulfate monitoring: Within 3 months
- Subsequent persulfate monitoring: No less frequently than annually following initial persulfate monitoring unless and until persulfate concentrations in the three wells are non-detect or, by concurrence among the Navy, EPA, and PREQB, close to non-detect
- Initial COC monitoring: During the monitoring event when persulfate levels in all three wells are non-detect or, by concurrence among the Navy, EPA, and PREQB, close to non-detect
- Subsequent COC monitoring: Annually until the three remaining COC concentrations in the three wells being monitored are less than or equal to the RGs for three successive annual events

SECTION 5

References

CH2M HILL, Inc. (CH2M). 2008. *Remedial Investigation Report, Area of Concern (AOC) E, Former Naval Ammunition Support Detachment, Vieques, Puerto Rico*. July

CH2M. 2012. *Focused Feasibility Study Report, Area of Concern (AOC) E Former Naval Ammunition Support Detachment, Vieques, Puerto Rico*. November.

CH2M. 2015. *Remedial Action Work Plan, Groundwater Monitoring and Institutional Controls with Contingency Plans, Area of Concern E, Atlantic Fleet Weapons Training Area – Vieques, Former Naval Ammunition Support Detachment, Vieques, Puerto Rico*. January.

CH2M. 2018. *Master Standard Operating Procedures, Protocols, and Plans, Revision 2018. Environmental Restoration Program, Vieques, Puerto Rico*. April.

Naval Facilities Engineering Command (NAVFAC) Atlantic. 2015. *Record of Decision, Area of Concern (AOC) E, Atlantic Fleet Weapons Training Area – Vieques, Former Naval Ammunition Support Detachment, Vieques, Puerto Rico*. January.

Appendix A
Chemical Safety Data Sheets and
Application Notes

SAFETY DATA SHEET

Klozur® SP

SDS #: 7775-27-1-12
Revision date: 2016-08-01
Format: NA
Version 1.03



1. PRODUCT AND COMPANY IDENTIFICATION

Product Identifier

Product Name Klozur® SP

Other means of identification

CAS-No 7775-27-1
Synonyms Sodium Persulfate; Sodium Peroxydisulfate; Disodium Peroxydisulfate; Peroxydisulfuric acid, disodium salt; Peroxydisulfuric acid, sodium salt

Alternate Commercial Name Klozur® Persulfate

Recommended use of the chemical and restrictions on use

Recommended Use: In situ and ex situ chemical oxidation of contaminants and compounds of concern for environmental remediation applications

Restrictions on Use: No uses to be advised against were identified.

Manufacturer/Supplier

PeroxyChem LLC
2005 Market Street
Suite 3200
Philadelphia, PA 19103
Phone: +1 267/ 422-2400 (General Information)
E-Mail: sdsinfo@peroxychem.com

Emergency telephone numbers

For leak, fire, spill or accident emergencies, call:
1 800 / 424 9300 (CHEMTREC - U.S.A.)
1 703 / 527 3887 (CHEMTREC - Collect - All Other Countries)
1 303/ 389-1409 (Medical - U.S. - Call Collect)

2. HAZARDS IDENTIFICATION

Classification

OSHA Regulatory Status

This material is considered hazardous by the OSHA Hazard Communication Standard (29 CFR 1910.1200).

Acute toxicity - Oral	Category 4
Skin corrosion/irritation	Category 2
Serious eye damage/eye irritation	Category 2B
Respiratory sensitization	Category 1
Skin sensitization	Category 1
Specific target organ toxicity (single exposure)	Category 3
Oxidizing Solids	Category 3

GHS Label elements, including precautionary statements**EMERGENCY OVERVIEW****Danger****Hazard Statements**

H334 - May cause allergy or asthma symptoms or breathing difficulties if inhaled
H335 - May cause respiratory irritation
H320 - Causes eye irritation
H315 - Causes skin irritation
H317 - May cause an allergic skin reaction
H302 - Harmful if swallowed
H272 - May intensify fire; oxidizer

**Precautionary Statements - Prevention**

P261 - Avoid breathing dust.
P285 - In case of inadequate ventilation wear respiratory protection
P271 - Use only outdoors or in a well-ventilated area
P280 - Wear protective gloves/ protective clothing
P264 - Wash face, hands and any exposed skin thoroughly after handling
P210 - Keep away from heat/sparks/open flames/hot surfaces. - No smoking
P220 - Keep/Store away from clothing/combustible materials
P221 - Take any precaution to avoid mixing with combustibles

Precautionary Statements - Response

P305 + P351 + P338 - IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing
P337 + P313 - If eye irritation persists: Get medical advice/ attention
P302 + P352 - IF ON SKIN: Wash with plenty of water.
P333 + P313 - If skin irritation or rash occurs: Get medical advice/ attention
P304 + P341 - IF INHALED: If breathing is difficult, remove to fresh air and keep at rest in a position comfortable for breathing
P342 + P311 - If experiencing respiratory symptoms: Call a POISON CENTER or doctor
P301 + P312 - IF SWALLOWED: Call a POISON CENTER or doctor if you feel unwell
P330 - Rinse mouth
P370 + P378 - In case of fire: Use water spray for extinction

Precautionary Statements - Storage

P403 + P233 - Store in a well-ventilated place. Keep container tightly closed

Hazards not otherwise classified (HNOC)

No hazards not otherwise classified were identified.

Other Information Risk of decomposition by heat or by contact with incompatible materials

Unknown acute toxicity

0% of the mixture consists of ingredient(s) of unknown toxicity

3. COMPOSITION/INFORMATION ON INGREDIENTSFormula Na₂O₈S₂

Chemical name	CAS-No	Weight %
Sodium Persulfate	7775-27-1	> 99

4. FIRST AID MEASURES

General Advice	Remove from exposure, lie down. Show this material safety data sheet to the doctor in attendance.
Eye Contact	Rinse thoroughly with plenty of water for at least 15 minutes, lifting lower and upper eyelids intermittently. Consult a physician. If symptoms persist, call a physician.
Skin Contact	Wash off immediately with soap and plenty of water while removing all contaminated clothes and shoes. Get medical attention if irritation develops and persists.
Inhalation	Remove from exposure, lie down. If breathing is irregular or stopped, administer artificial respiration. Call a physician immediately.
Ingestion	Do NOT induce vomiting. Call a physician or poison control center immediately. Rinse mouth. Drink 1 or 2 glasses of water.
Most important symptoms and effects, both acute and delayed	Itching; Redness; Coughing and/ or wheezing.
Indication of immediate medical attention and special treatment needed, if necessary	Treat symptomatically

5. FIRE-FIGHTING MEASURES

Suitable Extinguishing Media	Water. Cool containers with flooding quantities of water until well after fire is out.
Unsuitable extinguishing media	Do not use carbon dioxide or other gas filled fire extinguishers; they will have little effect on decomposing persulfate.
Specific Hazards Arising from the Chemical	Decomposes under fire conditions to release oxygen that intensifies the fire.
Explosion data	
Sensitivity to Mechanical Impact	Not sensitive.
Sensitivity to Static Discharge	Not sensitive.
Protective equipment and precautions for firefighters	As in any fire, wear self-contained breathing apparatus pressure-demand, MSHA/NIOSH (approved or equivalent) and full protective gear.

6. ACCIDENTAL RELEASE MEASURES

Personal Precautions	Keep off any unprotected persons. Avoid contact with the skin and the eyes. Avoid breathing dust. Wear personal protective equipment.
Other	Never add other substances or combustible waste to product residues.
Environmental Precautions	Prevent material from entering into soil, ditches, sewers, waterways, and/or groundwater. See Section 12, Ecological Information for more detailed information.
Methods for Containment	Vacuum, shovel or pump waste into a drum and label contents for disposal. Avoid dust formation. Store in closed container.

Methods for cleaning up Clean up spill area and treat as special waste. Dispose of waste as indicated in Section 13.

7. HANDLING AND STORAGE

Handling Wear personal protective equipment. Use only in area provided with appropriate exhaust ventilation. Avoid dust formation. Handle product only in closed system or provide appropriate exhaust ventilation at machinery. Avoid contact with skin and eyes. Avoid breathing dust. Remove and wash contaminated clothing before re-use. Reference to other sections.

Storage Keep containers tightly closed in a dry, cool and well-ventilated place. Keep away from heat. Do not store near combustible materials. Avoid contamination of opened product. Keep away from food, drink and animal feedingstuffs. Avoid formation and deposition of dust.

Incompatible products . Acids, alkalis, halides (fluorides, chlorides, bromides), combustible materials, reducing agents and organic compounds.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Control parameters

Exposure Guidelines

Chemical name	ACGIH TLV	OSHA PEL	NIOSH	Mexico
Sodium Persulfate 7775-27-1	TWA: 0.1 mg/m ³	-	-	-
Chemical name	British Columbia	Quebec	Ontario TWAEV	Alberta
Sodium Persulfate 7775-27-1	TWA: 0.1 mg/m ³	-	TWA: 0.1 mg/m ³	TWA: 0.1 mg/m ³

Appropriate engineering controls

Engineering measures Provide local exhaust or general ventilation adequate to maintain exposures below permissible exposure limits.

Individual protection measures, such as personal protective equipment

Eye/Face Protection Eye protection recommended. Chemical goggles consistent with EN 166 or equivalent.

Skin and Body Protection Wear long-sleeved shirt, long pants, socks, and shoes.

Hand Protection Protective gloves: Neoprene gloves, Polyvinylchloride, Natural Rubber.

Respiratory Protection If exposure limits are exceeded or irritation is experienced, NIOSH/MSHA approved respiratory protection should be worn: particulate filtering facepiece respirators.

Hygiene measures Keep away from food, drink and animal feeding stuffs. Do not eat, drink or smoke when using this product. Wash hands before breaks and after shifts. Keep work clothes separate, remove contaminated clothing - launder after open handling of product.

General information Protective engineering solutions should be implemented and in use before personal protective equipment is considered.

9. PHYSICAL AND CHEMICAL PROPERTIES

Information on basic physical and chemical properties

Appearance Crystalline solid
Physical State Solid
Color White

Odor	odorless
Odor threshold	Not applicable
pH	6.0 (1% solution)
Melting point/freezing point	180 °C (Decomposes)
Boiling Point/Range	Decomposes upon heating
Flash point	Not flammable
Evaporation Rate	No information available
Flammability (solid, gas)	Not flammable
Flammability Limit in Air	Not applicable
Upper flammability limit:	No information available
Lower flammability limit:	No information available
Vapor pressure	6.07E-30 mm Hg at 25°C
Vapor density	No information available
Density	2.59 g/cm ³ (crystal density)
Specific gravity	No information available
Water solubility	575 g/l @ 25 °C
Solubility in other solvents	No information available
Partition coefficient	No information available (inorganic)
Autoignition temperature	No evidence of combustion up to 600°C
Decomposition temperature	> 100 °C (assume)
Viscosity, kinematic	No information available (Solid)
Viscosity, dynamic	No information available
Explosive properties	Not explosive
Oxidizing properties	oxidizer
Molecular weight	238.1
VOC content (%)	Not applicable
Bulk density	1.12 g/cm ³ (loose)

10. STABILITY AND REACTIVITY

Reactivity	Oxidizer. Contact with other material may cause fire
Chemical Stability	Stable.
Possibility of Hazardous Reactions	None under normal processing.
Hazardous polymerization	Hazardous polymerization does not occur.
Conditions to avoid	Heat. Moisture.
Incompatible materials	Acids, alkalis, halides (fluorides, chlorides, bromides), combustible materials, reducing agents and organic compounds. .
Hazardous Decomposition Products	Oxygen which supports combustion.

11. TOXICOLOGICAL INFORMATION

Product Information

Unknown acute toxicity	0% of the mixture consists of ingredient(s) of unknown toxicity
LD50 Oral	Sodium Persulfate: 895 mg/kg (rat)
LD50 Dermal	Sodium Persulfate: > 10 g/kg
LC50 Inhalation	Sodium Persulfate: >5.10 mg/L (4h) (rat)
Serious eye damage/eye irritation	Irritating to eyes.
Skin corrosion/irritation	Minimally irritating.
Sensitization	Sodium Persulfate: May cause sensitization by inhalation and skin contact.

Information on toxicological effects

Symptoms	Symptoms of allergic reaction may include rash, itching, swelling and trouble breathing.
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Delayed and immediate effects as well as chronic effects from short and long-term exposure

Irritation corrosivity	Irritating to eyes, respiratory system and skin. None.
Carcinogenicity	Contains no ingredient listed as a carcinogen.
Mutagenicity	Did not show mutagenic effects in animal experiments
Neurological effects	Not neurotoxic
Reproductive toxicity Developmental toxicity Teratogenicity	This product is not recognized as reprotox by Research Agencies. None known. Not teratogenic in animal studies.
STOT - single exposure STOT - repeated exposure	May cause respiratory irritation. Not classified.
Target organ effects	Eyes, Lungs.
Aspiration hazard	No information available.

12. ECOLOGICAL INFORMATION**Ecotoxicity****Ecotoxicity effects**

Sodium Persulfate (7775-27-1)				
Active Ingredient(s)	Duration	Species	Value	Units
Sodium Persulfate	96 h LC50	Rainbow trout	163	mg/L
Sodium Persulfate	48 h LC50	Daphnia magna	133	mg/L
Sodium Persulfate	96 h LC50	Grass shrimp	519	mg/L
Sodium Persulfate	72 h EC50	Algae Selenastrum capricornutum	116	mg/L

Persistence and degradability	Biodegradability does not pertain to inorganic substances.
Bioaccumulation	Does not bioaccumulate.
Mobility	Dissociates into ions.
Other Adverse Effects	None known.

13. DISPOSAL CONSIDERATIONS

Waste disposal methods	This material, as supplied, is a hazardous waste according to federal regulations (40 CFR 261). It must undergo special treatment, e.g. at suitable disposal site, to comply with local regulations.
Contaminated Packaging	Empty remaining contents. Dispose of in accordance with local regulations.

14. TRANSPORT INFORMATION**DOT**

UN/ID no UN 1505
 Proper Shipping Name SODIUM PERSULFATE
 Hazard class 5.1
 Packing Group III

TDG

UN/ID no UN 1505
 Proper Shipping Name SODIUM PERSULFATE
 Hazard class 5.1
 Packing Group III

MEX

UN/ID no UN 1505
 Proper Shipping Name SODIUM PERSULFATE
 Hazard class 5.1
 Packing Group III

ICAO/IATA

UN/ID no UN 1505
 Proper Shipping Name SODIUM PERSULFATE
 Hazard class 5.1
 Packing Group III

IMDG/IMO

UN/ID no UN 1505
 Proper Shipping Name SODIUM PERSULFATE
 Hazard class 5.1
 Packing Group III

ADR/RID

UN/ID no UN 1505
 Proper Shipping Name SODIUM PERSULFATE
 Hazard class 5.1
 Packing Group III

ADN

Proper Shipping Name SODIUM PERSULFATE
 Hazard class 5.1
 Packing Group III

15. REGULATORY INFORMATION

U.S. Federal Regulations

SARA 313

Section 313 of Title III of the Superfund Amendments and Reauthorization Act of 1986 (SARA). This product does not contain any chemicals which are subject to the reporting requirements of the Act and Title 40 of the Code of Federal Regulations, Part 372

SARA 311/312 Hazard Categories

Acute health hazard	Yes
Chronic health hazard	No
Fire hazard	Yes
Sudden release of pressure hazard	No
Reactive Hazard	No

Clean Water Act

This product does not contain any substances regulated as pollutants pursuant to the Clean Water Act (40 CFR 122.21 and 40 CFR 122.42)

CERCLA/EPCRA

This material, as supplied, does not contain any substances regulated as hazardous substances under the Comprehensive Environmental Response Compensation and Liability Act (CERCLA) (40 CFR 302) or the Superfund Amendments and Reauthorization Act (SARA) (40 CFR 355). There may be specific reporting requirements at the local, regional, or state level pertaining to releases of this material

US State Regulations

U.S. State Right-to-Know Regulations

This product contains the following substances regulated under state Right-to-Know laws:

Chemical name	Massachusetts	New Jersey	Pennsylvania	Illinois	Rhode Island
Sodium Persulfate		X			

California Proposition 65

This product does not contain any Proposition 65 chemicals

International Inventories

Component	TSCA (United States)	DSL (Canada)	EINECS/EL INCS (Europe)	ENCS (Japan)	China (IECSC)	KECL (Korea)	PICCS (Philippines)	AICS (Australia)	NZIoC (New Zealand)
Sodium Persulfate 7775-27-1 (> 99)	X	X	X	X	X	X	X	X	X

Mexico

Mexico - Grade Slight risk, Grade 1

16. OTHER INFORMATION

NFPA	Health Hazards 1	Flammability 0	Stability 1	Special Hazards OX
HMIS	Health Hazards 1	Flammability 0	Physical hazard 1	Special precautions J

NFPA/HMIS Ratings Legend Special Hazards: OX = Oxidizer
 Protection=J (Safety goggles, gloves, apron, combination dust and vapor respirator)

Revision date: 2016-08-01
 Revision note (M)SDS sections updated: 15

Disclaimer

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Prepared By:

PeroxyChem

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End of Safety Data Sheet

SAFETY DATA SHEET

Hydrogen Peroxide 17.5% Standard

SDS # : 7722-84-1-17.5-10
Revision date: 2015-10-23
Format: NA
Version 1.01



1. PRODUCT AND COMPANY IDENTIFICATION

Product Identifier

Product Name Hydrogen Peroxide 17.5% Standard

Other means of identification

CAS-No 7722-84-1

Recommended use of the chemical and restrictions on use

Recommended Use: Industrial bleaching, processing, pollution abatement and general oxidation reactions

Restrictions on Use: Use as recommended by the label.

Manufacturer/Supplier

PeroxyChem LLC
2005 Market Street
Suite 3200
Philadelphia, PA 19103
Phone: +1 267/ 422-2400 (General Information)
E-Mail: sdsinfo@peroxychem.com
PeroxyChem Canada
PG Pulp Mill Road
Prince George, BC V2N2S6
1+ 250/ 561-4200 (General Information)

Emergency telephone number

For leak, fire, spill or accident emergencies, call:
1 800 / 424 9300 (CHEMTREC - U.S.A.)
1 703 / 527 3887 (CHEMTREC - Collect - All Other Countries)
1 613/ 996-6666 (CANUTEC - Canada)
1 303/ 389-1409 (Medical - U.S. - Call Collect)

1 281 / 474-8750 (Bayport, Texas Plant)
1 250 / 561-4221 (Prince George, BC, Canada Plant)

2. HAZARDS IDENTIFICATION

Classification

OSHA Regulatory Status

This material is considered hazardous by the OSHA Hazard Communication Standard (29 CFR 1910.1200).

Acute toxicity - Oral	Category 4
Serious eye damage/eye irritation	Category 1
Oxidizing Liquids	Category 3

GHS Label elements, including precautionary statements

EMERGENCY OVERVIEW

Danger

Hazard Statements

H318 - Causes serious eye damage

H302 - Harmful if swallowed

H272 - May intensify fire; oxidizer



Precautionary Statements - Prevention

P264 - Wash face, hands and any exposed skin thoroughly after handling

P280 - Wear protective gloves/ protective clothing/ eye protection/ face protection

P210 - Keep away from heat/sparks/open flames/hot surfaces. - No smoking

P220 - Keep/Store away from clothing/ flammable materials /combustible materials

P221 - Take any precaution to avoid mixing with combustibles - flammables

Precautionary Statements - Response

P305 + P351 + P338 - IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing

P310 - Immediately call a POISON CENTER or doctor

P301 + P312 - IF SWALLOWED: Call a POISON CENTER or doctor if you feel unwell

P330 - Rinse mouth

P370 + P378 - In case of fire: Use water for extinction

Hazards not otherwise classified (HNOC)

No hazards not otherwise classified were identified.

Other Information

Keep container in a cool place out of direct sunlight. Store only in vented containers. Do not store on wooden pallets. Do not return unused material to its original container. Avoid contamination - Contamination could cause decomposition and generation of oxygen which may result in high pressure and possible container rupture. Empty drums should be triple rinsed with water before discarding.

3. COMPOSITION/INFORMATION ON INGREDIENTS

Formula

HO-OH

Chemical name	CAS-No	Weight %
Hydrogen peroxide	7722-84-1	17.5
Water	7732-18-5	82.5

Occupational exposure limits, if available, are listed in section 8

4. FIRST AID MEASURES

Eye Contact

Rinse immediately with plenty of water, also under the eyelids, for at least 15 minutes. Remove contact lenses, if present, after the first 5 minutes, then continue rinsing. Seek immediate medical attention/advice.

Skin Contact	Take off contaminated clothing. Rinse skin immediately with plenty of water for 15-20 minutes. Call a poison control center or doctor for further treatment advice.
Inhalation	Move to fresh air. If person is not breathing, contact emergency medical services, then give artificial respiration, preferably mouth-to-mouth if possible. Call a poison control center or doctor for further treatment advice.
Ingestion	Rinse mouth. Do not induce vomiting. If conscious, give 2 glasses of water. Get immediate medical attention. Never give anything by mouth to an unconscious person.
Most important symptoms and effects, both acute and delayed	Hydrogen Peroxide irritates respiratory system and, if inhaled, may cause inflammation and pulmonary edema. The effects may not be immediate. Overexposure symptoms are coughing, giddiness and sore throat. In case of accidental ingestion, necrosis may result from mucous membrane burns (mouth, esophagus and stomach). Oxygen rapid release may cause stomach swelling and hemorrhaging, which may product major, or even fatal, injury to organs if a large amount has been ingested. In case of skin contact, may cause burns, erythema, blisters or even necrosis.
Indication of immediate medical attention and special treatment needed, if necessary	Hydrogen peroxide at these concentrations is a strong oxidant. Direct contact with the eye is likely to cause corneal damage especially if not washed immediately. Careful ophthalmologic evaluation is recommended and the possibility of local corticosteroid therapy should be considered. Because of the likelihood of corrosive effects on the gastrointestinal tract after ingestion, and the unlikelihood of systemic effects, attempts at evacuating the stomach via emesis induction or gastric lavage should be avoided. There is a remote possibility, however, that a nasogastric or orogastric tube may be required for the reduction of severe distension due to gas formation.

5. FIRE-FIGHTING MEASURES

Suitable Extinguishing Media	Water. Do not use any other substance.
Specific Hazards Arising from the Chemical	In closed unventilated containers, risk of rupture due to the increased pressure from decomposition. Contact with combustible material may cause fire
Hazardous Combustion Products	On decomposition product releases oxygen which may intensify fire.
Explosion data	
Sensitivity to Mechanical Impact	Not sensitive.
Sensitivity to Static Discharge	Not sensitive.
Protective equipment and precautions for firefighters	Use water spray to cool fire exposed surfaces and protect personnel. As in any fire, wear self-contained breathing apparatus pressure-demand, MSHA/NIOSH (approved or equivalent) and full protective gear.

6. ACCIDENTAL RELEASE MEASURES

Personal Precautions	Avoid contact with skin, eyes and clothing. Wear personal protective equipment. Isolate and post spill area. Keep people away from and upwind of spill/leak. Eliminate all sources of ignition and remove combustible materials.
Other	Combustible materials exposed to hydrogen peroxide should be immediately submerged in or rinsed with large amounts of water to ensure that all hydrogen peroxide is removed. Residual hydrogen peroxide that is allowed to dry (upon evaporation hydrogen peroxide can concentrate) on organic materials such as paper, fabrics, cotton, leather, wood or other combustibles can cause the material to ignite and result in fire.
Environmental Precautions	Prevent material from entering into soil, ditches, sewers, waterways, and/or groundwater. See Section 12, Ecological Information for more detailed information.
Methods for Containment	Dike to collect large liquid spills. Stop leak and contain spill if this can be done safely. Small spillage: Dilute with large quantities of water.
Methods for cleaning up	Flush area with flooding quantities of water. Hydrogen peroxide may be decomposed by

Hand Protection	For hand protection, wear approved gloves made of nitrile, PVC, or neoprene. DO NOT use cotton, wool or leather for these materials react RAPIDLY with higher concentrations of hydrogen peroxide. Thoroughly rinse the outside of gloves with water prior to removal. Inspect regularly for leaks.
Respiratory Protection	If concentrations in excess of 10 ppm are expected, use NIOSH/DHHS approved self-contained breathing apparatus (SCBA) or other approved air-supplied respirator (ASR) equipment (e.g., a full-face airline respirator (ALR)). DO NOT use any form of air-purifying respirator (APR) or filtering facepiece (dust mask), especially those containing oxidizable sorbants such as activated carbon.
Hygiene measures	Avoid breathing vapors, mist or gas. Clean water should be available for washing in case of eye or skin contamination. .
General information	Protective engineering solutions should be implemented and in use before personal protective equipment is considered.

9. PHYSICAL AND CHEMICAL PROPERTIES

Information on basic physical and chemical properties

Appearance	Clear, colorless liquid
Physical State	Liquid
Color	Colorless
Odor	odorless
Odor threshold	Not applicable
pH	No information available
Melting point/freezing point	Not applicable
Boiling Point/Range	103 °C
Flash point	Not applicable
Evaporation Rate	> 1 (n-butyl acetate=1)
Flammability (solid, gas)	Not flammable
Flammability Limit in Air	Not applicable
Upper flammability limit:	No information available
Lower flammability limit:	No information available
Vapor pressure	28 mmHg @ 30°C
Vapor density	No information available
Density	1.06 g/cm ³ @ 20°C
Specific gravity	1.06
Water solubility	completely soluble
Solubility in other solvents	No information available
Partition coefficient	log Kow = -1.5 @ 20 °C
Autoignition temperature	Not combustible
Decomposition temperature	No information available
Viscosity, kinematic	1.04 cP @ 20 °C
Viscosity, dynamic	No information available
Explosive properties	No information available
Oxidizing properties	Strong oxidizer
Molecular weight	34
Bulk density	Not applicable

10. STABILITY AND REACTIVITY

Reactivity

Chemical Stability	Stable under normal conditions. Decomposes on heating. Stable under recommended storage conditions.
Possibility of Hazardous Reactions	Contact with organic substances may cause fire or explosion. Contact with metals, metallic ions, alkalis, reducing agents and organic matter (such as alcohols or terpenes) may produce self-accelerated thermal decomposition.

Hydrogen Peroxide 17.5% Standard

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Revision date: 2015-10-23

Version 1.01

Hazardous polymerization	Hazardous polymerization does not occur.
Conditions to avoid	Excessive heat; Contamination; Exposure to UV-rays; pH variations.
Incompatible materials	Combustible materials. Copper alloys, galvanized iron. Strong reducing agents. Heavy metals. Iron. Copper alloys. Contact with metals, metallic ions, alkalis, reducing agents and organic matter (such as alcohols or terpenes) may produce self-accelerated thermal decomposition.
Hazardous Decomposition Products	Oxygen which supports combustion. Liable to produce overpressure in container.

11. TOXICOLOGICAL INFORMATION

Product Information

LD50 Oral	50% solution: LD50 > 225 mg/kg bw (rat) 35 % solution: LD50 1193 mg/kg bw (rat) 70 % solution: LD50 1026 mg/kg bw (rat)
LD50 Dermal	35% solution: LD50 > 2000 mg/kg bw (rabbit) 70 % solution: LD50 9200 mg/kg bw (rabbit)
LC50 Inhalation	50% solution: LC50 > 170 mg/m ³ (rat) (4-hr) Hydrogen Peroxide vapors: LC0 9400 mg/m ³ (mouse) (5 - 15 minutes) Hydrogen Peroxide vapors: LC50 > 2160 mg/m ³ (mouse)
Serious eye damage/eye irritation Skin corrosion/irritation	Corrosive. Risk of serious damage to eyes. Moderately irritating.
Sensitization	Did not cause sensitization on laboratory animals.

Information on toxicological effects

Symptoms	Vapors, mists, or aerosols of hydrogen peroxide can cause upper airway irritation, inflammation of the nose, hoarseness, shortness of breath, and a sensation of burning or tightness in the chest. Prolonged exposure to concentrated vapor or to dilute solutions can cause irritation and temporary bleaching of skin and hair. Exposure to vapor, mist, or aerosol can cause stinging pain and tearing of eyes.
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Delayed and immediate effects as well as chronic effects from short and long-term exposure

Carcinogenicity	This product contains hydrogen peroxide. The International Agency for Research on Cancer (IARC) has concluded that there is inadequate evidence for carcinogenicity of hydrogen peroxide in humans, but limited evidence in experimental animals (Group 3 - not classifiable as to its carcinogenicity to humans). The American Conference of Governmental Industrial Hygienists (ACGIH) has concluded that hydrogen peroxide is a 'Confirmed Animal Carcinogen with Unknown Relevance to Humans' (A3).
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Chemical name	ACGIH	IARC	NTP	OSHA
Hydrogen peroxide 7722-84-1	A3	3		

Mutagenicity	This product is not recognized as mutagenic by Research Agencies In vivo tests did not show mutagenic effects
Reproductive toxicity	This product is not recognized as reprotox by Research Agencies. No toxicity to reproduction in animal studies.
STOT - single exposure STOT - repeated exposure	Not classified. Not classified.
Target organ effects	Eyes, Respiratory System, Skin.

Aspiration hazard No information available.

12. ECOLOGICAL INFORMATION

Ecotoxicity

Ecotoxicity effects Hydrogen peroxide is naturally produced by sunlight (between 0.1 and 4 ppb in air and 0.001 to 0.1 mg/L in water). Not expected to have significant environmental effects

Hydrogen peroxide (7722-84-1)				
Active Ingredient(s)	Duration	Species	Value	Units
Hydrogen peroxide	96 h LC50	Fish Pimephales promelas	16.4	mg/L
Hydrogen peroxide	72 h LC50	Fish Leuciscus idus	35	mg/L
Hydrogen peroxide	48 h EC50	Daphnia pulex	2.4	mg/L
Hydrogen peroxide	24 h EC50	Daphnia magna	7.7	mg/L
Hydrogen peroxide	72 h EC50	Algae Skeletonema costatum	1.38	mg/L
Hydrogen peroxide	21 d NOEC	Daphnia magna	0.63	mg/L

Persistence and degradability Hydrogen peroxide in the aquatic environment is subject to various reduction or oxidation processes and decomposes into water and oxygen. Hydrogen peroxide half-life in freshwater ranged from 8 hours to 20 days, in air from 10 - 20 hours, and in soils from minutes to hours depending upon microbiological activity and metal contamination.

Bioaccumulation Material may have some potential to bioaccumulate but will likely degrade in most environments before accumulation can occur.

Mobility Will likely be mobile in the environment due to its water solubility.

Other Adverse Effects Decomposes into oxygen and water. No adverse effects.

13. DISPOSAL CONSIDERATIONS

Waste disposal methods Dispose of in accordance with local regulations. Can be disposed as waste water, when in compliance with local regulations.

US EPA Waste Number D001

Contaminated Packaging Dispose of in accordance with local regulations. Drums - Empty as thoroughly as possible. Triple rinse drums before disposal. Avoid contamination; impurities accelerate decomposition. Never return product to original container.

14. TRANSPORT INFORMATION

DOT

UN/ID no 2984
Proper Shipping Name HYDROGEN PEROXIDE, AQUEOUS SOLUTION
Hazard class 5.1
Packing Group III

TDG

UN/ID no 2984
Proper Shipping Name HYDROGEN PEROXIDE, AQUEOUS SOLUTION
Hazard class 5.1
Packing Group III

Hydrogen Peroxide 17.5% Standard

SDS # : 7722-84-1-17.5-10

Revision date: 2015-10-23

Version 1.01

ICAO/IATA

Air regulation permit shipment of Hydrogen Peroxide (<=40%) in non-vented containers for Air Cargo Only aircraft, as well as for Passenger and Cargo aircraft. HOWEVER, all PeroxyChem Hydrogen Peroxide containers are vented and therefore, air shipments of PeroxyChem H2O2 are not permitted. IATA air regulations state that venting of packages containing oxidizing substances is not permitted for air transport.

IMDG/IMO

UN/ID no	2984
Proper Shipping Name	HYDROGEN PEROXIDE, AQUEOUS SOLUTION
Hazard class	5.1
Packing Group	III

OTHER INFORMATION

Protect from physical damage. Keep drums in upright position. Drums should not be stacked in transit. Do not store drums on wooden pallets.

15. REGULATORY INFORMATION

U.S. Federal Regulations

SARA 313

Section 313 of Title III of the Superfund Amendments and Reauthorization Act of 1986 (SARA). This product does not contain any chemicals which are subject to the reporting requirements of the Act and Title 40 of the Code of Federal Regulations, Part 372

SARA 311/312 Hazard Categories

Acute health hazard	Yes
Chronic health hazard	No
Fire hazard	Yes
Sudden release of pressure hazard	No
Reactive Hazard	No

Clean Water Act

This product does not contain any substances regulated as pollutants pursuant to the Clean Water Act (40 CFR 122.21 and 40 CFR 122.42)

CERCLA/EPCRA

Chemical name	CERCLA Hazardous Substances RQs (40 CFR 302.4)	SARA Sec 304 Extremely Hazardous Substance RQ (40 CFR 355 Appendix A)	SARA Section 302 EHS Threshold Planning Quantity (40 CFR 355)
Hydrogen peroxide 7722-84-1		1000 lb	1000 lb

Hydrogen Peroxide RQ is for concentrations of > 52% only

International Inventories

Component	TSCA (United States)	DSL (Canada)	EINECS/EL INCS (Europe)	ENCS (Japan)	China (IECSC)	KECL (Korea)	PICCS (Philippines)	AICS (Australia)	NZIoC (New Zealand)
Hydrogen peroxide 7722-84-1 (17.5)	X	X	X	X	X	X	X	X	X

Mexico - Grade

Serious risk, Grade 3

CANADA

Hydrogen Peroxide 17.5% Standard

SDS # : 7722-84-1-17.5-10

Revision date: 2015-10-23

Version 1.01

WHMIS Statement

This product has been classified in accordance with the hazard criteria of the Controlled Products Regulations (CPR) and the MSDS contains all the information required by the CPR.

WHMIS Hazard Class

C - Oxidizing materials

D2B - Toxic materials



16. OTHER INFORMATION

NFPA	Health Hazards 3	Flammability 0	Stability 1	Special Hazards OX
HMIS	Health Hazards 3	Flammability 0	Physical hazard 1	Special precautions H

NFPA/HMIS Ratings Legend

Severe = 4; Serious = 3; Moderate = 2; Slight = 1; Minimal = 0

Special Hazards: OX = Oxidizer

Protection = H (Safety goggles, gloves, apron, the use of supplied air or SCBA respirator is required in lieu of a vapor cartridge respirator)

Uniform Fire Code

Oxidizer: Class 1--Liquid

Revision date:

2015-10-23

Revision note

(M)SDS sections updated: 15

Disclaimer

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Prepared By:

PeroxyChem

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End of Safety Data Sheet

Safety Data Sheet



Rupert, Gibbon, & Spider, Inc.

1147 Healdsburg Avenue

Healdsburg, CA 95448

PHONE: 707-433-9577

SDS for Citrus/Sugar solution:

- Citric Acid SDS – see pages 1-10
- Sugar SDS – see pages 11-16

1. IdentificationProduct identifier **Citric Acid** AnhydrousProduct Code Number **CHM1022, CHM2022**

Date June 6, 2015

Manufacturer/Importer/Supplier/Distributor information

Contact Information:**Rupert Gibbon & Spider, Inc.**1147 Healdsburg Ave.
Healdsburg, CA 95448
800-442-0455**Emergency phone number****CHEMTREC (24HR Emergency Telephone), call:**

1-800-424-9300

International CHEMTREC, call: 1-703-527-3887**For non-emergency assistance, call:** 800-442-0455**2. Hazard(s) identification**

Physical hazards Not classified.

Health hazards	Skin corrosion/irritation	Category 2
	Serious eye damage/eye irritation	Category 2A
	Specific target organ toxicity, single exposure	Category 3 respiratory tract irritation

OSHA defined hazards Combustible dust

Label elements

Signal word Warning

Hazard statement Causes skin irritation. Causes serious eye irritation. May cause respiratory irritation. May form combustible dust concentrations in air.

Precautionary statement

Prevention Observe good industrial hygiene practices. Keep away from heat/sparks/open flames/hot surfaces. - No smoking. Use only outdoors or in a well-ventilated area. Keep container tightly closed. Ground/bond container and receiving equipment. Avoid breathing dust. Wash thoroughly after handling. Wear protective gloves. Wear eye/face protection. Prevent dust accumulation to minimize explosion hazard.

Response Specific treatment (see this label). If skin irritation occurs: Get medical advice/attention. If eye irritation persists: Get medical advice/attention. Take off contaminated clothing and wash before reuse. In case of fire: Use appropriate media to extinguish.

Storage Store in a well-ventilated place. Keep container tightly closed. Store locked up.

Disposal Dispose of contents/container in accordance with local/regional/national/international regulations.

Hazard(s) not otherwise classified (HNOC) **Supplemental information**
Not applicable.

None known.

3. Composition/information on ingredients

Mixtures

Chemical name	CAS number	%
Citric acid	77-92-9	100

4. First-aid measures

Inhalation	If dust from the material is inhaled, remove the affected person immediately to fresh air. Call a POISON CENTER or doctor/physician if you feel unwell.
Skin contact	Wash with plenty of soap and water. If skin irritation occurs: Get medical advice/attention. Take off contaminated clothing and wash before reuse.
Eye contact	Do not rub eyes. Immediately flush eyes with plenty of water for at least 15 minutes. Remove contact lenses, if present and easy to do. Continue rinsing. If eye irritation persists: Get medical advice/attention.
Ingestion	Get medical attention if symptoms occur.
Most important symptoms/effects, acute and delayed	Dusts may irritate the respiratory tract, skin and eyes. Symptoms may include stinging, tearing, redness, swelling, and blurred vision. Skin irritation. May cause redness and pain.
Indication of immediate medical attention and special treatment needed	Provide general supportive measures and treat symptomatically. Keep victim under observation. Symptoms may be delayed.
General information	Ensure that medical personnel are aware of the material(s) involved, and take precautions to protect themselves.

5. Fire-fighting measures

Suitable extinguishing media	Water fog. Foam. Dry chemical powder. Carbon dioxide (CO ₂). Apply extinguishing media carefully to avoid creating airborne dust.
Unsuitable extinguishing media	Do not use water jet as an extinguisher, as this will spread the fire.
Specific hazards arising from the chemical	Explosion hazard: Avoid generating dust; fine dust dispersed in air in sufficient concentrations and in the presence of an ignition source is a potential dust explosion hazard.
Special protective equipment and precautions for firefighters	Self-contained breathing apparatus and full protective clothing must be worn in case of fire.
Fire-fighting equipment/instructions	In case of fire and/or explosion do not breathe fumes. Move containers from fire area if you can do so without risk. Use water spray to cool unopened containers.
Specific methods	Use standard firefighting procedures and consider the hazards of other involved materials.
General fire hazards	May form combustible dust concentrations in air.

6. Accidental release measures

Personal precautions, protective equipment and emergency procedures	Keep unnecessary personnel away. Keep people away from and upwind of spill/leak. Keep out of low areas. Dust deposits should not be allowed to accumulate on surfaces, as these may form an explosive mixture if they are released into the atmosphere in sufficient concentration. Use only non-sparking tools. Wear appropriate protective equipment and clothing during clean-up. Avoid inhalation of dust. Use a NIOSH/MSHA approved respirator if there is a risk of exposure to dust/fume at levels exceeding the exposure limits. Do not touch damaged containers or spilled material unless wearing appropriate protective clothing. Ensure adequate ventilation. Local authorities should be advised if significant spillages cannot be contained. For personal protection, see section 8 of the SDS.
Methods and materials for containment and cleaning up	Eliminate all ignition sources (no smoking, flares, sparks, or flames in immediate area). Take precautionary measures against static discharge. Use only non-sparking tools. Avoid dispersal of dust in the air (i.e., clearing dust surfaces with compressed air). This product is miscible in water. Stop the flow of material, if this is without risk. Large Spills: Wet down with water and dike for later disposal. If sweeping of a contaminated area is necessary use a dust suppressant agent which does not react with the product. Collect dust using a vacuum cleaner equipped with HEPA filter. Minimize dust generation and accumulation. Prevent entry into waterways, sewer, basements or confined areas. Following product recovery, flush area with water. Small Spills: Sweep up or vacuum up spillage and collect in suitable container for disposal. Never return spills to original containers for re-use. For waste disposal, see section 13 of the SDS.
Environmental precautions	Avoid discharge into drains, water courses or onto the ground.

7. Handling and storage

Precautions for safe handling

Explosion-proof general and local exhaust ventilation. Keep away from heat/sparks/open flames/hot surfaces. - No smoking. Minimize dust generation and accumulation. Avoid significant deposits of material, especially on horizontal surfaces, which may become airborne and form combustible dust clouds and may contribute to secondary explosions. Dry powders can build static electricity charges when subjected to the friction of transfer and mixing operations. Provide adequate precautions, such as electrical grounding and bonding, or inert atmospheres. Routine housekeeping should be instituted to ensure that dusts do not accumulate on surfaces. Avoid breathing dust. Avoid contact with skin and eyes. Avoid prolonged exposure. Avoid contact with clothing. In case of insufficient ventilation, wear suitable respiratory equipment. Wear appropriate personal protective equipment. Observe good industrial hygiene practices.

Conditions for safe storage, including any incompatibilities

Store locked up. Keep away from heat, sparks and open flame. Keep containers tightly closed in a dry, cool and well-ventilated place. Store away from incompatible materials (see Section 10 of the SDS).

8. Exposure controls/personal protection

Occupational exposure limits

No exposure limits noted for ingredient(s).

Biological limit values

No biological exposure limits noted for the ingredient(s).

Appropriate engineering controls

Explosion-proof general and local exhaust ventilation. Good general ventilation (typically 10 air changes per hour) should be used. Ventilation rates should be matched to conditions. If applicable, use process enclosures, local exhaust ventilation, or other engineering controls to maintain airborne levels below recommended exposure limits. If exposure limits have not been established, maintain airborne levels to an acceptable level. Ventilation should be sufficient to effectively remove and prevent buildup of any dusts or fumes that may be generated during handling or thermal processing. If engineering measures are not sufficient to maintain concentrations of dust particulates below the Occupational Exposure Limit (OEL), suitable respiratory protection must be worn. Eye wash facilities and emergency shower must be available when handling this product.

Individual protection measures, such as personal protective equipment

Eye/face protection

Wear safety glasses with side shields (or goggles).

Skin protection

Hand protection

Wear appropriate chemical resistant gloves.

Other

Wear appropriate chemical resistant clothing.

Respiratory protection

If engineering controls do not maintain airborne concentrations below recommended exposure limits (where applicable) or to an acceptable level (in countries where exposure limits have not been established), an approved respirator must be worn. Use a NIOSH/MSHA approved respirator if there is a risk of exposure to dust/fume at levels exceeding the exposure limits.

Thermal hazards

Wear appropriate thermal protective clothing, when necessary.

General hygiene considerations

When using, do not eat, drink or smoke. Always observe good personal hygiene measures, such as washing after handling the material and before eating, drinking, and/or smoking. Routinely wash work clothing and protective equipment to remove contaminants.

9. Physical and chemical properties

Appearance

White granules

Physical state

Solid.

Form

Powder. Granules.

Color

White.

Odor

Not available.

Odor threshold

Not available.

pH

Not available.

Melting point/freezing point

307.4 °F (153 °C)

Initial boiling point and boiling range

Not available.

Flash point

Not available.

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Evaporation rate Not available.

Flammability (solid, gas) Not available.

Upper/lower flammability or explosive limits

Flammability limit - lower (%) Not available.

Flammability limit – upper (%)	Not available.
Explosive limit - lower (%)	Not available.
Explosive limit - upper (%)	Not available.
Vapor pressure	Not available.
Vapor density	Not available.
Relative density	Not available.
Solubility(ies)	
Solubility (water)	Soluble
Partition coefficient (n-octanol/water)	Not available.
Auto-ignition temperature	214 °F (101.11 °C)
Decomposition temperature	Not available.
Viscosity	Not available.
Other information	
Molecular formula	C6-H8-O7
Molecular weight	192.12 g/mol

10. Stability and reactivity

Reactivity	The product is stable and non-reactive under normal conditions of use, storage and transport.
Chemical stability	Material is stable under normal conditions.
Possibility of hazardous reactions	No dangerous reaction known under conditions of normal use.
Conditions to avoid	Keep away from heat, sparks and open flame. Contact with incompatible materials. Avoid dispersal of dust in the air (i.e., clearing dust surfaces with compressed air). Minimize dust generation and accumulation.
Incompatible materials	Strong oxidizing agents.
Hazardous decomposition products	No hazardous decomposition products are known.

11. Toxicological information

Information on likely routes of exposure

Ingestion	Expected to be a low ingestion hazard.
Inhalation	Inhalation of dusts may cause respiratory irritation.
Skin contact	Causes skin irritation.
Eye contact	Causes serious eye irritation. Dust in the eyes will cause irritation.

Symptoms related to the physical, chemical and toxicological characteristics
Dusts may irritate the respiratory tract, skin and eyes. Symptoms may include stinging, tearing, redness, swelling, and blurred vision. Skin irritation. May cause redness and pain.

Information on toxicological effects

Acute toxicity May cause respiratory irritation.

Components	Species	Test Results
Citric acid (CAS 77-92-9)		
Acute		
<i>Oral</i>		
LD50	Mouse	5040 mg/kg
	Rat	6730 mg/kg
<i>Other</i>		
LD50	Mouse	42 mg/kg
	Rabbit	330 mg/kg

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Rat

883 mg/kg

* Estimates for product may be based on additional component data not shown.

Skin corrosion/irritation	Causes skin irritation.
Serious eye damage/eye irritation	Causes serious eye irritation. Dust in the eyes will cause irritation.
Respiratory or skin sensitization	
Respiratory sensitization	Not available.
Skin sensitization	This product is not expected to cause skin sensitization.
Germ cell mutagenicity	No data available to indicate product or any components present at greater than 0.1% are mutagenic or genotoxic.
Carcinogenicity	This product is not considered to be a carcinogen by IARC, ACGIH, NTP, or OSHA.
Reproductive toxicity	This product is not expected to cause reproductive or developmental effects.
Specific target organ toxicity - single exposure	Respiratory tract irritation.
Specific target organ toxicity - repeated exposure	Not classified.
Aspiration hazard	Not available.
Chronic effects	Prolonged inhalation may be harmful.

12. Ecological information

Ecotoxicity	The product is not classified as environmentally hazardous. However, this does not exclude the possibility that large or frequent spills can have a harmful or damaging effect on the environment.
Persistence and degradability	No data is available on the degradability of this product.
Bioaccumulative potential	No data available.
Mobility in soil	No data available.
Other adverse effects	No other adverse environmental effects (e.g. ozone depletion, photochemical ozone creation potential, endocrine disruption, global warming potential) are expected from this component.

13. Disposal considerations

Disposal instructions	Collect and reclaim or dispose in sealed containers at licensed waste disposal site. This material and its container must be disposed of as hazardous waste. Do not allow this material to drain into sewers/water supplies. Do not contaminate ponds, waterways or ditches with chemical or used container. Dispose of contents/container in accordance with local/regional/national/international regulations.
Local disposal regulations	Dispose in accordance with all applicable regulations.
Hazardous waste code	The waste code should be assigned in discussion between the user, the producer and the waste disposal company.
Waste from residues / unused products	Dispose of in accordance with local regulations. Empty containers or liners may retain some product residues. This material and its container must be disposed of in a safe manner (see: Disposal instructions).
Contaminated packaging	Empty containers should be taken to an approved waste handling site for recycling or disposal. Since emptied containers may retain product residue, follow label warnings even after container is emptied.

14. Transport information

DOT

Not regulated as dangerous goods.

IATA

Not regulated as dangerous goods.

IMDG

Not regulated as dangerous goods.

Transport in bulk according to Annex II of MARPOL 73/78 and the IBC Code Not applicable.

15. Regulatory information

US federal regulations This product is a "Hazardous Chemical" as defined by the OSHA Hazard Communication Standard, 29 CFR 1910.1200.
One or more components are not listed on TSCA.

TSCA Section 12(b) Export Notification (40 CFR 707, Subpt. D)

Not regulated.

US. OSHA Specifically Regulated Substances (29 CFR 1910.1001-1050)

Not listed.

CERCLA Hazardous Substance List (40 CFR 302.4)

Not listed.

Superfund Amendments and Reauthorization Act of 1986 (SARA)

Hazard categories Immediate Hazard - Yes
Delayed Hazard - No
Fire Hazard - Yes
Pressure Hazard - No
Reactivity Hazard - No

SARA 302 Extremely hazardous substance

Not listed.

SARA 311/312 Hazardous chemical No

SARA 313 (TRI reporting)

Not regulated.

Other federal regulations**Clean Air Act (CAA) Section 112 Hazardous Air Pollutants (HAPs) List**

Not regulated.

Clean Air Act (CAA) Section 112(r) Accidental Release Prevention (40 CFR 68.130)

Not regulated.

Safe Drinking Water Act (SDWA) Not regulated.

Food and Drug Administration (FDA) Total food additive
Direct food additive
GRAS food additive

US state regulations

California Safe Drinking Water and Toxic Enforcement Act of 1986 (Proposition 65): This material is NOT known to contain any chemicals currently listed as carcinogens or reproductive toxins.

US. Massachusetts RTK - Substance List

Not regulated.

US. New Jersey Worker and Community Right-to-Know Act

Not listed.

US. Pennsylvania Worker and Community Right-to-Know Law

Not listed.

US. Rhode Island RTK

Not regulated.

US. California Proposition 65

California Safe Drinking Water and Toxic Enforcement Act of 1986 (Proposition 65): This material is NOT known to contain any chemicals currently listed as carcinogens or reproductive toxins.

US - California Proposition 65 - Carcinogens & Reproductive Toxicity (CRT): Listed substance

Not listed.

International Inventories

Country(s) or region	Inventory name	On inventory (yes/no)*
Australia	Australian Inventory of Chemical Substances (AICS)	No
Canada	Domestic Substances List (DSL)	No
Canada	Non-Domestic Substances List (NDSL)	No
China	Inventory of Existing Chemical Substances in China (IECSC)	No
Europe	European Inventory of Existing Commercial Chemical Substances (EINECS)	No
Europe	European List of Notified Chemical Substances (ELINCS)	No
Japan	Inventory of Existing and New Chemical Substances (ENCS)	No
Korea	Existing Chemicals List (ECL)	No
New Zealand	New Zealand Inventory	No

Country(s) or region	Inventory name	On inventory (yes/no)*
Philippines	Philippine Inventory of Chemicals and Chemical Substances (PICCS)	No
United States & Puerto Rico	Toxic Substances Control Act (TSCA) Inventory	No

*A "Yes" indicates this product complies with the inventory requirements administered by the governing country(s).

A "No" indicates that one or more components of the product are not listed or exempt from listing on the inventory administered by the governing

16. Other information, including date of preparation or last revision

Issue date	19-June-2014
Revision date	-
Version #	01
Further information	Refer to NFPA 654, Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids, for safe handling.
Disclaimer	The information in the sheet was written based on the best knowledge and experience currently available.

The information contained in this SDS is based on data from sources considered to be reliable but Rupert, Gibbon & Spider, Inc. does not guarantee the accuracy or completeness thereof. Rupert, Gibbon & Spider, Inc. urges each customer or recipient of this SDS to study it carefully to become aware of and understand the hazards associated with this product. The reader should consider consulting reference works or individuals who are experts in ventilation, toxicology or fire and understand the data in this SDS.

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SAFETY DATA SHEET

RUPERT, GIBBON & SPIDER PO BOX 425, HEALDSBURG CA, 95448 TEL: (707) 433-9577 FAX: (707) 433-4906

SECTION 1: IDENTIFICATION OF THE MATERIAL AND SUPPLIER

Product name: White Sugar (Crystalline)
Other Names: Sucrose, Sugar, Refined Sugar, Caster Sugar
Date: June 6, 2015
Recommended use: Natural color enhancer
Company: Rupert, Gibbon and Spider, Inc.
 1147 Healdsburg Ave.
 Healdsburg, CA 95448
 800-442-0455

Emergency Phone Number: CHEMTREC (24HR Emergency Telephone),
 call: 1-800-424-9300
 International CHEMTREC, call: 1-703-527-3887
 For non-emergency assistance, call: 800-442-0455

SECTION 2: HAZARDS IDENTIFICATION

Physical hazards Not classified.
Health hazards Not classified.

OSHA defined hazards Not classified.

Label elements

Hazard symbol None.
Signal word None.
Hazard statement The mixture does not meet the criteria for classification.

Precautionary statement

Prevention Observe good industrial hygiene practices.
Response Wash hands after handling.
Storage Store away from incompatible materials.
Disposal Dispose of waste and residues in accordance with local authority requirements.

Hazard(s) not otherwise classified (HNOC) None known.

Note: This product is a well known ingredient in food and beverages and this Safety Data Sheet is concerned only with occupational exposures.

SECTION 3: COMPOSITION / INFORMATION ON INGREDIENTS

Chemical Name:	Proportion:	CAS Number:
Sucrose	100%	57-50-1

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SECTION 4: FIRST AID MEASURES

Swallowed: Give water to drink.
Eye: Flush thoroughly with copious amounts of running water. If symptoms persist, seek medical attention.
Skin: Wash thoroughly with soap and water.
Inhaled: Remove to fresh air.
Advice to Doctor: Treat symptomatically. People with diabetes may need stabilization.

SECTION 5: FIRE FIGHTING MEASURES

Specific Hazards: Airborne sugar dust can explode where under certain conditions of temperature, humidity and where suspended in air exceeds 20 grams per cubic meter. Dust extraction systems, cleaning procedures, electrical earthing and other safety measures must be used to avoid the risk of explosion. Incompatible with strong oxidising agents.
Flammability: Low, product will burn in surrounding fire situation.
Extinguishing Media: Water, dry chemical, carbon dioxide, BCF and foam.
Hazards from combustion products: With heat, product burns/oxidises to form carbon, carbon monoxide and or carbon dioxide, and smoke.
Special protective precautions and equipment for fire fighters: Standard fire-fighting precautions applicable.
Hazchem code: None allocated

SECTION 6: ACCIDENTAL RELEASE MEASURES

Spills: Wet sweep, vacuum or shovel into containers. Wash area with water. Notify any relevant waste or environmental authority.

SECTION 7: HANDLING AND STORAGE

Handling: Material can ferment if excessive moisture contamination is allowed. Fermentation can yield carbon dioxide with possible traces of ethanol or volatile fatty acids (e.g. acetic, propionic, lactic, or butyric) and if exposed to a spark or flame may result in an explosion. These conditions should be avoided. If maintenance of tank requires entry by personnel, confined space precautions should be complied with. Insufficient oxygen may be present in vessels containing the product due to the generation of carbon monoxide during fermentation.
Storage: This product should be stored in its factory packaging in a dry area.

SECTION 8: EXPOSURE CONTROLS / PERSONAL PROTECTION

Occupational exposure limits No exposure limits noted for ingredient(s).
Biological limit values No biological exposure limits noted for the ingredient(s).
Appropriate engineering controls Ventilation should be sufficient to effectively remove and prevent buildup of any dusts or fumes that may be generated during handling or thermal processing.

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Individual protection measures, such as personal protective equipment**Eye/face protection** Unvented, tight fitting goggles should be worn in dusty areas.**Skin protection****Hand protection** Wear appropriate chemical resistant gloves.**Other** Wear suitable protective clothing.

Respiratory protection Use a NIOSH/MSHA approved respirator if there is a risk of exposure to dust/fume at levels exceeding the exposure limits. If engineering controls do not maintain airborne concentrations below recommended exposure limits (where applicable) or to an acceptable level (in countries where exposure limits have not been established), an approved respirator must be worn.

Thermal hazards Wear appropriate thermal protective clothing, when necessary.

General hygiene considerations

Always observe good personal hygiene measures, such as washing after handling the material and before eating, drinking, and/or smoking. Routinely wash work clothing and protective equipment to remove contaminants.

SECTION 9: PHYSICAL AND CHEMICAL PROPERTIES

Appearance:	White crystalline solid
Odor:	Sweet odor
pH, at stated concentration:	Not available
Vapour pressure:	Not determined
Vapour Density:	Not determined
Boiling Point/range: (°C)	170-186°C
Freezing/Melting Point: (°C)	Decomposes with heat
Solubility in water:	2 kg per liter
Solubility (Other):	Not applicable
Specific gravity: (H₂O = 1)	1.59
Molecular weight:	342
Flammability Limits:	Combustible
Flash Point:	Not applicable
Autoignition temperature:	500°C
Relative density:	Not available
Evaporation rate:	Not available
Partition coefficient n-octanol/water:	Not available
Decomposition temperature:	Not available
Viscosity:	No data available

SECTION 10: STABILITY AND REACTIVITY

Chemical Stability:	Stable
Incompatible Materials:	Incompatible with oxidizing agents (eg. peroxides).
Conditions to avoid:	None
Hazardous Decomposition products:	None
Hazardous Polymerisation:	None

SECTION 11: TOXICOLOGICAL INFORMATION

Toxicity Data: Non-toxic – a foodstuff
 Sucrose: LD50 (Ingestion) : 29,700 mg/kg (rat)

Health Effects

Acute (short term).

- Swallowed:** No health effects under normal conditions of industrial use, but ingestion may destabilize people with diabetes.
- Eye:** Irritating to the eyes and may cause watering and redness.
- Skin:** Skin contact may result in mild skin irritation.
- Inhaled:** Sugar dust may irritate the nose and throat.
- Chronic:** Repeated exposure to the powder and dust may result in increased nasal and respiratory secretions and coughing, but not irreversible health effects. Repeated skin contact may cause dermatitis.

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SECTION 12: ECOLOGICAL INFORMATION**Ecotoxicity:** Non-toxic to aquatic and terrestrial organisms.**Persistence and Degradability:** Product is persistent and would have a low degradability.**Mobility:** A low mobility would be expected in a landfill situation.**SECTION 13: DISPOSAL CONSIDERATIONS**

White Sugar can be treated as a common waste for disposal or dumped into a landfill site in accordance with relevant authority guidelines. Note BOD load of sugar solutions in waste water streams.

Personal precautions should be observed (see Section 8 above).

SECTION 14: TRANSPORT INFORMATION**Transport Requirements:** No special transport requirements are necessary.**UN number:** None allocated **Class:** Noneallocated **Subsidiary Risk 1:** None allocated **Packaging****Group:** None allocated **Hazchem code:**None allocated **DG Class:**None allocated **EPG:** None**Incompatibilities:** None**Proper Shipping Name:** None allocated**Marine Pollutant:** No**SECTION 15: REGULATORY INFORMATION**

US federal regulations All components are on the U.S. EPA TSCA Inventory List. This product is NOT known to be a "Hazardous Chemical" as defined by the OSHA Hazard Communication Standard, 29 CFR 1910.1200.

TSCA Section 12(b) Export Notification (40 CFR 707, Subpt. D) Not regulated.

OSHA Specifically Regulated Substances (29 CFR 1910.1001-1050) Not listed.

CERCLA Hazardous Substance List (40 CFR 302.4) Not listed.

Superfund Amendments and Reauthorization Act of 1986 (SARA)

Hazard categories

- Immediate Hazard - No
- Delayed Hazard - No
- Fire Hazard - No
- Pressure Hazard - No
- Reactivity Hazard - No

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SARA 302 Extremely hazardous substance Not listed.

SARA 311/312 Hazardous chemical No

SARA 313 (TRI reporting) Not regulated.

Other federal regulations

Clean Air Act (CAA) Section 112 Hazardous Air Pollutants (HAPs) List Not regulated.

Clean Air Act (CAA) Section 112(r) Accidental Release Prevention (40 CFR 68.130) Not regulated.

Safe Drinking Water Act (SDWA) Not regulated.

US state regulations

US. Massachusetts RTK - Substance List Not regulated.

US. New Jersey Worker and Community Right-to-Know Act Not listed.

US. Pennsylvania Worker and Community Right-to-Know Law Not listed.

US. Rhode Island RTK Not regulated.

US. California Proposition 65

California Safe Drinking Water and Toxic Enforcement Act of 1986 (Proposition 65): This material is NOT known to contain any chemicals currently listed as carcinogens or reproductive toxins.

SECTION 16: OTHER INFORMATION

Date: June 6, 2015

The information contained in this SDS is based on data from sources considered to be reliable but Rupert, Gibbon & Spider, Inc. does not guarantee the accuracy or completeness thereof. Rupert, Gibbon & Spider, Inc. urges each customer or recipient of this SDS to study it carefully to become aware of and understand the hazards associated with this product. The reader should consider consulting reference works or individuals who are experts in ventilation, toxicology or fire and understand the data in this SDS.



Activating Klozur® SP with an 8% Hydrogen Peroxide Solution

BACKGROUND

Klozur® SP can be activated with hydrogen peroxide to generate sulfate radicals, which are capable of destroying a wide range of organic contaminants. In general, hydrogen peroxide is dosed in conjunction with Klozur SP in a ratio of 1 mole hydrogen peroxide to 1 mole persulfate up to 10 moles hydrogen peroxide to 1 mole persulfate. Typically, a molar ratio of 5:1 hydrogen peroxide to persulfate is sufficient to treat most contaminants under a wide range of site conditions.

SAFETY AND HANDLING

Hydrogen peroxide is a strong oxidant, capable of generating significant heat and gasses when applied in the subsurface.

Review the appropriate Safety Data Sheet (SDS) with all workers prior to use. Follow guidance contained within the appropriate SDS when handling Klozur SP or hydrogen peroxide.

Hydrogen peroxide is sold commercially in a variety of concentrations. Common concentrations include 50%*, 35%*, 27%, 17.5%, and 8% by weight. Highly concentrated forms of hydrogen peroxide may generate extreme exothermic reactions and gas evolution upon injection into the subsurface or when contacting high levels of contamination, potentially liberating significant quantities of gas. Care must be taken to avoid excessive heat and gas evolution as this may cause damage to utilities, buildings and represents a safety hazard if not properly controlled.

*As of 2014, hydrogen peroxide with a concentrations of 35% by weight and greater are classified as chemicals of interest by the Department of Homeland Security and subject to the CFATS regulations. Please see <http://www.dhs.gov/chemical-facility-anti-terrorism-standards> for further information.

PeroxyChem recommends hydrogen peroxide solutions of no more than 8% by weight be used to activate Klozur SP.

This will help to minimize the generation of heat and gas upon injection of hydrogen peroxide into the subsurface.

Use of hydrogen peroxide solutions in excess of 8% by weight may increase the risk of injury, loss of product containment, and equipment damage.



DETERMINING THE AMOUNT ACTIVATOR NEEDED

PeroxyChem recommends using a bench scale study to determine the optimum hydrogen peroxide to sodium persulfate molar ratio.

An example calculation for a 5:1 hydrogen peroxide to persulfate molar calculation is as follows:

1. Determine the quantity of Klozur SP in lbs to be injected into the treatment area

2. Determine the number of moles of Klozur SP:

$$\text{moles sodium persulfate} = \text{lbs of sodium persulfate} / 238$$

3. Determine the number of moles of hydrogen peroxide needed;

$$\text{moles of hydrogen peroxide} = \text{moles of sodium persulfate} \times 5$$

4. Determine the lbs of hydrogen peroxide needed:

$$\text{lbs of hydrogen peroxide} = \text{moles hydrogen peroxide} \times 34$$

5. Determine the gallons of 8% hydrogen peroxide needed:

$$\text{Gallons of hydrogen peroxide} = \text{lbs of hydrogen peroxide} / 0.684$$

APPLICATION GUIDELINES

Hydrogen peroxide can be injected after injecting Klozur SP.

It is recommended that if the Klozur SP and 8 wt% hydrogen peroxide solution are added simultaneously:

- No more than 5 gallons of 8% hydrogen peroxide should be added per gallon of 30% Klozur SP solution
- No more than 3 gallons of 8% hydrogen peroxide should be added per gallon of 20% Klozur SP solution
- No more than 2 gallons of 8% hydrogen peroxide should be added per gallon of 10% Klozur SP solution

It is always safer to inject the materials sequentially. If mixing hydrogen peroxide and Klozur SP above ground, PeroxyChem recommends inline mixing to ensure safe conditions. Use clean water and clean mixing and handling equipment. Transition metals in the supply water, such as iron, can result in rapid decomposition of the hydrogen peroxide. It is recommended that oxidant solutions be injected promptly into the subsurface and avoid delays resulting in the solutions remaining in mix tanks for extended periods of time. Also use vented tanks and piping when using oxidizing solutions. Always drain lines to empty and avoid trapping solution between valves for extended periods of time. Do not “dead head” pumps. When injecting hydrogen peroxide solutions, it is recommended that temperature and back-pressure be monitored and controlled to prevent highly exothermic, subsurface reactions.

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Delivery and Storage of Hydrogen Peroxide

When designing and constructing Hydrogen Peroxide storage and handling equipment, four rules govern the use of H₂O₂:

1. **Never contaminate** - Hydrogen Peroxide can be contaminated by heat or energy, by contact with incorrect materials of construction or by externally introduced materials. Indications of contamination are activation of relief devices, peroxide is rapidly bubbling, temperatures are increasing or steam is evolving from the peroxide solution.

Hydrogen Peroxide is extremely stable at ambient temperatures with losses of less than 1% per year at 72° Fahrenheit, but assay loss increases with temperature rise. For example, losses are 1% per week at 150° Fahrenheit and are 2% per day at 218° Fahrenheit.

Hydrogen Peroxide is compatible with a select list of materials. High purity aluminum and low carbon stainless steel as well as polyethylene, is acceptable for storage tanks. Piping is made from low carbon stainless steel or high purity aluminum and gaskets from teflon or teflon related products. Materials to avoid are copper, brass carbon steel, lead and lubricating oils. All wetted surfaces must be thoroughly cleaned and passivated.

Historically, severe accidents involving Hydrogen Peroxide result from gross contaminations. Examples are wrong materials delivered to a storage tank, process backfeeds into peroxide storage tanks or used peroxide is returned to original container.

2. **Never confine** - Hydrogen Peroxide always decomposes only the rate varies. Any peroxide storage and handling system must be designed with relief devices where peroxide may be trapped. For example, relief devices are required between isolation valves or between a pump and a valve. All ball valves must be specially designed with vented cavities.

3. **Never contact** - personal contact and contact with flammable or combustible materials must be avoided. Personal Protective Equipment is required and varies by the task to be performed. Chemical safety goggles and rubber gloves are required for typical daily work involving peroxide. If exposure potential is increased due to spillage, maintenance or sampling, additional items are required (vinyl acid suit, neoprene boots, full-face shield). Failure to wear the proper PPE could lead to injuries to personnel or ignition of cotton clothes or leather boots.

Any storage or handling area must be clear of combustible materials, such as wood, leaves, paper, etc.

Always have water available whenever Hydrogen Peroxide is used, a reliable water source must be readily available to address spills or contact issues. Safety showers and eyewashes with potable water sources are recommended to address personnel exposure emergencies. A water hose is required to address spills, to put out fires or to cool the tank exterior in the event of decomposition.

PeroxyChem Engineering Services has provided solutions to Hydrogen Peroxide storage and handling challenges for nearly 50 years by using these basic principles.

This information contained herein is, to our knowledge, true and accurate. Because conditions of use are beyond our control, we make no warranty or representation, expressed or implied, except that the products discussed herein conform to the chemical descriptions shown on their labels. Nothing contained herein should be construed as permission or recommendation to infringe any patent. No agent, representative or employee of this company is authorized to vary any of the terms of this notice.

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PeroxyChem Recommended Storage and Handling Practices for Hydrogen Peroxide Drums

Hydrogen Peroxide is frequently transported and stored in drums. PeroxyChem recommends the following practices for storage and handling of Hydrogen Peroxide drums. Adherence to these guidelines is necessary to prevent personnel injury or property damage resulting from incidents with Hydrogen Peroxide. Refer to MSDS for additional information.



PeroxyChem Recommended Storage and Handling Practices for Hydrogen Peroxide Drums

Storage:

- A source of water and a safety shower/ eye wash station must be located within 7.62 M (25 ft) of where Hydrogen Peroxide drums are stored or handled. Access to water and safety devices must be unobstructed.
- H₂O₂ containers shall be properly labeled and hazards identified. The NFPA diamond should be readily visible in the event of a fire.
- Smoking is prohibited in all Hydrogen Peroxide drum storage areas.
- Store H₂O₂ containers away from heat sources, combustibles and incompatible chemicals such as other oxidizing agents, reducing agents, caustic etc. H₂O₂ drums should not be stored in direct sunlight.
- H₂O₂ drums must be equipped with at least one breather vent in its bung openings.
- H₂O₂ drums must be stored in upright positions at all times. Never block the drum breather vent (s).
- Drums of 27.5% H₂O₂ or greater must not be stored on wooden pallets (ref. Paragraph 2-4.2 of NFPA 430).
- Storage temperature should be maintained at or below 40°C (104°F). Higher temperatures will accelerate decomposition and reduce product assay.
- Proper container spacing (ref. NFPA 430) and adequate ventilation must be provided for H₂O₂ drum storage areas.
- H₂O₂ drum storage areas shall be provided with adequate secondary containment. This containment should be designed to prevent spilled Peroxide from coming in contact with incompatible materials.

Use:

- Wear personal protective equipment if exposure to H₂O₂ is possible. (e.g. slash proof chemical goggles and face shield, rubber boots, rubber gloves, and chemical resistant raingear or apron)
- H₂O₂ drums must not be contaminated.
- Unused Peroxide must never be returned to the original drum.
- Equipment used for dispensing/ transferring H₂O₂ from the drums must be compatible with H₂O₂; must be dedicated for H₂O₂ use only; and must be thoroughly rinsed with good quality water before and after each use. **Note:** Any stainless steel or aluminum “wetted” components must be properly passivated for H₂O₂ service.
- After usage, the bung caps (i.e. those provided with the H₂O₂ drums) must be returned to the drum openings if any peroxide remains in the H₂O₂ drum.

PeroxyChem Recommended Storage and Handling Practices for Hydrogen Peroxide Drums

- All H₂O₂ drum transfer systems must be designed to avoid areas where peroxide can be trapped. Design must ensure that any pressure/gas generated can be safely released.
- Systems must be designed to prevent back flow of process of water streams into the H₂O₂ drum. Empty drums must be thoroughly rinsed with water, and disposed of in accordance with all Federal, State and local regulations.
- Use water to respond to all incidents, (e.g. fires, spills, leaks) involving Hydrogen Peroxide.

Drum Filling/Refilling:

1. Initial Inspection
 - a. Only DOT drums approved for H₂O₂ service may be used.
 - b. Inspect the drum bottom for marking that indicates the month and year of manufacture. Reject any drum that is more than 24 months old. Industry experience is that, beyond 24 months, external UV exposure and/or internal chemical exposure may adversely impact drum integrity.
 - c. Reject any drum that has been used for product other than H₂O₂.
 - d. Inspect the exterior of each drum completely and carefully. Reject any drum that exhibits any damage that would affect drum integrity.
 - e. Inspect the interior of each drum with a light probe or drop light, and reject any drum with interior damage.
2. Drum Preparation
 - a. Remove all plus, gaskets, and vents. Discard, if a reused drum; these fittings must be replaced after each use.
 - b. Inspect the threads on each drum opening. If damaged, reject the drum.
 - c. Apply the appropriate labels for H₂O₂ grade and concentration to be filled.
3. Washing of Drums prior to Reuse (not required for "New" drums)
 - a. Ascertain that the drum has only been used in H₂O₂ service. Discard any drums, which have or are suspected to have contained any other material.
 - b. Using an acceptable water source, thoroughly wash the interior of the drum three times; then, completely drain to remove any residual water.
Note: Acceptable water is defined as water that meets the water quality standards or the specific grade of Hydrogen Peroxide. Reference H₂O₂ Initial Delivery protocol document, Dilution Water Criteria.
 - c. After the triple wash, inspect the interior of the drum using an appropriate light probe to ensure that there are no foreign materials present. Use care not to introduce any contaminants during this washing/inspection process. If there are any contaminants that cannot be removed by water rinse alone (e.g. grease, oil), then discard the drum. The use of solvents, detergents, etc., is prohibited, since they will only increase the potential for contamination.
 - d. Re- inspect the exterior of the drum to ensure that there is no physical damage.

PeroxyChem Recommended Storage and Handling Practices for Hydrogen Peroxide Drums

4. Filling/Refilling of Drums
 - a. New and reused drums should be filled in the same manner, taking every precaution to avoid spilling.
 - b. Install new plugs, gaskets and approved breather vent (s).
 - c. After filling, operator should be especially alert for any reaction inside the drum. If there is any indication of decomposition, the filling operation should be discontinued and all personnel should evacuate the area. As soon as a safe plan is developed to remediate the problem and it is safe to reenter the area, dispose of the product in the drum, triple wash the drum, and then discard the drum.
 - d. Analyze each drum for product stability. The peroxide stability in the drum should be at least 90% when tested at 100°C (212°F) for 24 hours. For stability test methods, please refer to H₂O₂ Technical Bulletin #59 located on this website.
 - e. Filled drums should be set- aside for 24 hours prior to placement in inventory or shipment. After 24 hours, they should be checked for leakage or accelerated decomposition (e.g. bulging drum). Drums, which are leaking or bulging should be emptied (i.e. with contents properly disposed of), and then rejected.
5. Reject Drum Disposal
 - a. Drums rejected for any of the reasons indicated above should be triple rinsed and disposed of in accordance with Federal, State, and local regulations.

PeroxyChem Recommended Storage and Handling Practices for Hydrogen Peroxide Drums

NFPA Requirements:

Compliance with the applicable National Fire Protection Association's (NFPA) Code is mandatory. NFPA 430 "Code for the Storage of Liquid and Solid Oxidizers" has primary applicability to the storage and handling of Hydrogen Peroxide. 8% to 27.5% H₂O₂ is a Class 3 Oxidizer; and greater than 91% H₂O₂ is a Class 4 Oxidizer. Other NFPA codes may also apply.

Storage & Handling Checklist for Concentrated (<52%) H₂O₂ Less- Than- Bulk Quantities

Customer _____ Location _____
 Customer Contact _____ Phone Number _____
 Application _____ Approved Application (Y/N) _____
 H₂O₂ Grade and % _____ FMC Rep. _____ Approved for Delivery (Y/N) _____

System Requirement	Yes/ No
1. Any new or significantly modified hydrogen peroxide (H ₂ O ₂) storage facility has been reviewed and approved by the local authority having jurisdiction (e.g. Fire Marshal, Building Inspector, etc.)	
2. The LEPC, SERC and fire department has/will be provided a MSDS if storing > 10,000 pounds of H ₂ O ₂ per 40 CFR 370. Note: Must also include on next annual report.	
3. The H ₂ O ₂ storage facility has appropriate security measures are in place.	
4. The H ₂ O ₂ storage facility has a suitable emergency plan in place.	
5. Personnel involved in the handling of H ₂ O ₂ drums have received appropriate H ₂ O ₂ safety training.	
6. A clean water source is readily available where H ₂ O ₂ drums are stored; additionally, a safety shower/ eye wash station is available wherever H ₂ O ₂ is used.	
7. H ₂ O ₂ drum storage areas are conspicuously identified by the words "Class_Oxidizers." (Insert "2" for 27.5% to 52%)	
8. Smoking is prohibited in al H ₂ O ₂ storage areas; "No Smoking" signs are conspicuously posted.	
9. H ₂ O ₂ drums are stored away from heat sources, combustibles and incompatible chemicals such as other oxidizing agents, reducing agents, caustic etc.; and are stored out of direct sunlight. Note: Storage of H₂O₂ drums on wooden pallets is prohibited.	
10. H ₂ O ₂ drums are stored in an upright position at all times, and drum breather vent (s) are not blocked.	
11. Temperature of H ₂ O ₂ drum storage area is maintained at or below 52°C (125°F).	
12. H ₂ O ₂ drum storage areas are well ventilated.	
13. H ₂ O ₂ drum storage area is provided with adequate secondary containment.	
14. All H ₂ O ₂ "wetted" equipment is compatible with H ₂ O ₂ and is dedicated for H ₂ O ₂ use only.	
15. Any stainless steel aluminum wetted H ₂ O ₂ components have been properly passivated for H ₂ O ₂ service.	
16. Equipment used for dispensing/transferring H ₂ O ₂ from the drums is thoroughly flushed with clean water and properly secured (i.e. to prevent introduction of contaminants) before and after each use.	
17. All H ₂ O ₂ transfer systems are designed to avoid areas where peroxide can be trapped. Design ensures that any pressure/ gas	

PeroxyChem Policy: “Prohibiting Wooden Pallets For H₂O₂ Drums”

The purpose of this letter is to document PeroxyChem’s position regarding the storage of Hydrogen Peroxide drums on wooden pallets and provides a clear rationale of why we have taken this position.

PeroxyChem Policy: “The storage of Hydrogen Peroxide drums on wooden pallets is prohibited.”

Since PeroxyChem initially began the manufacture of Hydrogen Peroxide in the 1930’s at former (BECCO plant in Tonawanda, NY), there have been countless care histories of fires, both major and minor in nature, that have been directly attributed to the storage of peroxide drums on wooden pallets. As a more recent example, PeroxyChem’s major distributors lost an entire warehouse to fire in the early 1990’s, at a cost in excess of \$1,000,000. The follow- up investigation determined that a single wooden pallet, ignited by a leaking drum of 35% Hydrogen Peroxide, initiated this warehouse fire.

Although the fire hazards associated with higher peroxide concentrations (e.g. 70% H₂O₂) are well known and understood, it is actually the lower concentrations (e.g. 50% & 35% H₂O₂) that very often can result in a more serious incident, due to the “time delay” factor. Unlike 70% H₂O₂, which can ignite a combustible material within a few minutes, the lower H₂O₂ concentrations, when igniting. This time delay ignition typically occurs when it is least expected. Under the right conditions (i.e. high temperature/low humidity; and dry, porous, combustible surface), the combined effect of slow peroxide decomposition and evaporation can cause the peroxide to slowly concentrate. Once the concentration reaches about 70%, further decomposition evaporates the remaining water and the temperature rapidly rises to the point where a combustible material will spontaneously ignite with the pure oxygen released by the decomposing peroxide.

PeroxyChem’s experience is that wooden pallets, typically constructed from dry, very porous softwoods are ideal candidates for peroxide induced fires. Unlike the hard, non-absorbent wooden floors of the trucks typically used in the transportation of peroxide drums, wooden pallets provide an absorbent surface, which is very conducive to the slow H₂O₂ decomposition/evaporation/concentration effect described above. This is why wooden pallet fires have been quite common, whereas fires caused by peroxide spillage on truck floors have been extremely rare. Another problem with wooden pallets is that they are assembled with nails that over time can protrude out of the wooden surface and actually create a puncture hazard for plastic drums.

Please call PeroxyChem Engineering Services for assistance at 716-879-0447 or visit the PeroxyChem website at www.peroxychem.com for more information

PeroxyChem Policy: “Prohibiting Wooden Pallets For H₂O₂ Drums”

It was specifically due to this relatively high frequency of wooden pallet fires caused by peroxide contact, that the National Fire Prevention Association (NFPA) has also adapted PeroxyChem’s policy prohibiting the use of wooden pallets for peroxide service. NFPA 430”Code for the Storage of Liquid and Solid Oxidizers” (2000 Edition) includes the following statement in paragraph 2-4.2; **“Hydrogen Peroxide (Classes 2 through 4) stored in drums shall not be stored on wooden pallets.”** This NFPA prohibition applies to all Hydrogen Peroxide concentrations greater than 27.5%.

Furthermore, the North American Peroxide Producers Association and the European Chemical Industry Council support PeroxyChem’s position.

Following are a few reasonable alternatives to wooden pallets:

- Use of non- wooden pallets (e.g. plastic) for peroxide drum service.
- Shipment and/or storage of peroxide drums loose, without pallets.
- Treatment of wooden pallets with an effective fireproofing agent.

Please call PeroxyChem Engineering Services for assistance at 716-879-0447 or visit the PeroxyChem website at www.peroxychem.com for more information

Appendix B
CHEMetrics Field Test Kit Instructions

Sodium Persulfate CHEMets®

0 - 7 & 7 - 70 ppm

Safety Information

Read MSDS before performing this test procedure. Wear safety glasses.

Test Procedure

1. Fill the sample cup to the 25 mL mark with the sample (fig 1).
2. Place the CHEMet ampoule in the sample cup. Snap the tip by pressing the ampoule against the side of the cup. The ampoule will fill leaving a small bubble to facilitate mixing (fig 2).
3. Mix the contents of the ampoule by inverting it several times, allowing the bubble to travel from end to end each time. Wipe all liquid from the exterior of the ampoule. Test results should be obtained **within one minute** after snapping the ampoule tip.
4. Use the appropriate comparator to determine the level of sodium persulfate in the sample. If the color of the CHEMet ampoule is between two color standards, a concentration estimate can be made.

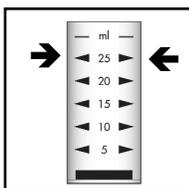


Figure 1

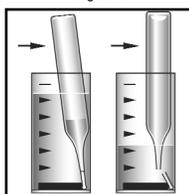


Figure 2



Figure 3

- a. Place the CHEMet ampoule, flat end downward into the center tube of the low range comparator. Direct the top of the comparator up toward a source of bright light while viewing from the bottom. Rotate the comparator until the color standard below the CHEMet ampoule shows the closest match (fig 3).

- b. Hold the high range comparator in a nearly horizontal position while standing directly beneath a bright source of light. Place the CHEMet ampoule between the color standards moving it from left to right along the comparator until the best color match is found (fig 4).

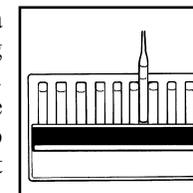


Figure 4

Test Method

The Sodium Persulfate CHEMets®¹ test method employs the ferric thiocyanate chemistry.² In an acidic solution, sodium persulfate oxidizes ferrous iron. The resulting ferric iron reacts with ammonium thiocyanate to form ferric thiocyanate, a red-orange colored complex, in direct proportion to the sodium persulfate concentration.

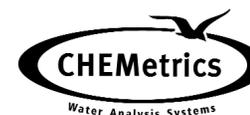
Various oxidizing agents such as hydrogen peroxide, ozone, ferric ions and cupric ions will produce high test results.

1. CHEMets is a registered trademark of CHEMetrics, Inc. U.S. Patent No. 3,634,038
2. D. F. Boltz and J. A. Howell, eds., Colorimetric Determination of Nonmetals, 2nd ed., Vol. 8, p. 304 (1978)

Reorder Information

Cat. No.

<i>Test Kit, complete</i>	<i>K-7870</i>
<i>Refill, 30 CHEMet ampoules</i>	<i>R-7870</i>
<i>Sample Cup, 25 mL, package of six</i>	<i>A-0013</i>
<i>Comparator, 0-7 ppm</i>	<i>C-7807</i>
<i>Comparator, 7-70 ppm</i>	<i>C-7870</i>



CHEMetrics, Inc., 4295 Catlett Road, Calverton, VA 20138-0214 U.S.A.
 Phone: (800) 356-3072; Fax: (540) 788-4856; E-Mail: orders@chemetrics.com
www.chemetrics.com June 06, Rev. 3

Hydrogen Peroxide CHEMets® Kit

K-5510/R-5510: 0 - 0.8 & 1 - 10 ppm

Safety Information

Read SDS (available at www.chemetrics.com) before performing this test procedure. Wear safety glasses and protective gloves.

Test Procedure

1. Fill the sample cup to the 25 mL mark with the sample to be tested (fig. 1).
2. Place the CHEMet ampoule, tip first, into the sample cup. Snap the tip. The ampoule will fill leaving a bubble for mixing (fig. 2).
3. To mix the ampoule, invert it several times, allowing the bubble to travel from end to end.
4. Dry the ampoule. Test results should be obtained **between 30 seconds and 1 minute** after snapping the ampoule tip.
5. Obtain a test result using the appropriate comparator.
 - a. **Low Range Comparator (fig. 3):** Place the ampoule, flat end first, into the comparator. Hold the comparator up toward a source of light and view from the bottom. Rotate the comparator until the best color match is found.
 - b. **High Range Comparator (fig. 4):** Place the ampoule between the color standards until the best color match is found.

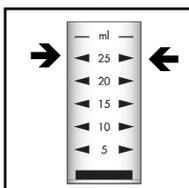


Figure 1

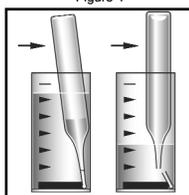


Figure 2



Figure 3

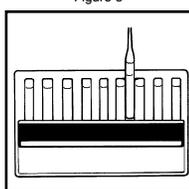


Figure 4

Test Method

The Hydrogen Peroxide CHEMets®¹ test method employs the ferric thiocyanate chemistry.² In an acidic solution, hydrogen peroxide oxidizes ferrous iron. The resulting ferric iron reacts with ammonium thiocyanate to form ferric thiocyanate, a red-orange colored complex, in direct proportion to the hydrogen peroxide concentration.

Various oxidizing agents such as peracetic acid, ozone, ferric ions and cupric ions will produce high test results.

Testing for peroxide in the presence of PAA requires a modified test procedure. Contact technical@chemetrics.com for more information.

1. CHEMets is a registered trademark of CHEMetrics, Inc. U.S. Patent No. 3,634,038
2. D. F. Boltz and J. A. Howell, eds., *Colorimetric Determination of Nonmetals*, 2nd ed., Vol. 8, p. 304 (1978)

Visit www.chemetrics.com to view product demonstration videos.
Always follow the test procedure above to perform a test.



www.chemetrics.com
4295 Catlett Road, Midland, VA 22728 U.S.A.
Phone: (800) 356-3072; Fax: (540) 788-4856
E-Mail: orders@chemetrics.com

May 16, Rev. 9



Technical Data Sheet

Hydrogen Peroxide Ferric Thiocyanate Method

Applications and Industries: Industrial effluents, wastewater, seawater, aseptic packaging; Food & beverage industry

References: D.F. Boltz and J.A. Howell, eds., *Colorimetric Determination of Nonmetals*, 2nd ed., Vol. 8, page 304 (1978).

Chemistry: In an acidic solution, hydrogen peroxide oxidizes ferrous iron. The resulting ferric ion reacts with ammonium thiocyanate to form ferric thiocyanate, a red-orange colored complex, in direct proportion to the hydrogen peroxide concentration. Results are expressed as ppm (mg/L) hydrogen peroxide (H₂O₂).

Sample Handling: Hydrogen peroxide is not stable in aqueous solution; the hydrogen peroxide content of aqueous samples, particularly when the concentration is low, will decrease rapidly. Agitation or exposure to sunlight or other strong light will accelerate the reduction of hydrogen peroxide in solution. Analysis should be performed immediately after sample collection, and excessive agitation and exposure to light should be avoided.

Interference Information:

Ferric iron and persulfate interfere positively if present at any level.

Chlorine up to 40 ppm and ozone up to at least 1 ppm do not develop color (i.e. do not cause a false positive result) with this chemistry. Both ozone and chlorine react with and consume hydrogen peroxide in solution, causing a decrease in the hydrogen peroxide concentration in the sample, but do not cause a negative interference with the test chemistry.

Cupric copper may interfere positively.

Peracetic acid (PAA) interferes positively. It is possible to minimize this interference by adding potassium iodide solution to the sample prior to analysis. Contact CHEMetrics' Technical Services staff at technical@chemetrics.com for details.

Oxidized manganese (permanganate, Mn⁷⁺) interferes positively.

Sample pHs between 1 and 8 are tolerated. Samples with extreme pHs or that are highly buffered should be adjusted to pHs of approximately 4-7 prior to analysis.

Safety Information: Safety Data Sheets (SDS) are available upon request and at www.chemetrics.com. Read SDS before using these products. Breaking the tip of an ampoule in air rather than water may cause the glass ampoule to shatter. Wear safety glasses and protective gloves.

Available Analysis Systems: Visual colorimetric: CHEMets® and VACUettes®. Instrumental colorimetric: Vacu-vials®

Storage Requirements: Products should be stored in the dark and at room temperature.

Shelf Life: *When stored in the dark and at room temperature:* Visual colorimetric: The CHEMets and VACUettes refills have shelf lives of 4 years. The color comparators have 2-year shelf lives. Instrumental colorimetric: The Vacu-vials kit has a shelf life of 2.5 years.

Accuracy:

CHEMets and VACUettes kits: +/- 1 color standard increment

Vacu-vials kit: ≤ 0.1 ppm at 0 ppm, +/- 0.08 ppm at 0.50 ppm, +/- 0.30 ppm at 1.50 ppm, +/- 0.45 ppm at 4.50 ppm

CHEMetrics, Inc., 4295 Catlett Road, Midland, VA 22728, www.chemetrics.com
ph: 800-356-3072 or 540-788-9026, fax: 540-788-4856, email: technical@chemetrics.com

Appendix C
Final Responses to Regulator Comments

**Responses to EPA Comments, Follow-up Comments, and 2nd Round
Comments on the
Draft Remedial Action Work Plan Addendum
Area of Concern E
Dated August 2017**

**Atlantic Fleet Weapons Training Area – Vieques
Former Naval Ammunition Support Detachment
Vieques, Puerto Rico**

Presented below are review comments on the Draft Remedial Action Work Plan Addendum, Area of Concern E, dated August 2017, Atlantic Fleet Weapons Training Area – Vieques, Former Naval Ammunition Support Detachment, Vieques, Puerto Rico (hereinafter referred to as the Draft RAWP Addendum).

GENERAL COMMENTS

- 1. Addendum:** The figures included in the Draft RAWP Addendum do not include the groundwater flow direction. For example, Figure 1-3 (Groundwater COC Concentration Map) does not include the groundwater flow direction. As a result, it is unclear if MW-4 is located downgradient of MW-01 and MW-05, as discussed in Sections 2.2.6 (Post-Injection Persulfate Persistence Monitoring) and 2.2.7 (Groundwater Performance Monitoring).

EPA Comment: Revise the figures in the Draft RAWP Addendum to include the groundwater flow direction.

Navy Response: The groundwater flow direction has been added to the figure, which shows MW-04 is in the downgradient direction from the source area around wells MW-01 and MW-05.

- 2. Addendum:** Sections 2.2.6 (Post-Injection Persulfate Persistence Monitoring) and 2.2.7 (Groundwater Performance Monitoring) indicate that persulfate and groundwater performance monitoring will only be conducted at MW-01, MW-04, and MW-05; however, it is unclear why contingency monitoring at MW-07 and MW-08 is not proposed should displacement of contaminants occur due to the oxidant solution injections.

EPA Comment: Revise the Draft RAWP Addendum to include persulfate and groundwater performance monitoring at MW-07 and MW-08 if displacement of contaminants occurs due to the oxidant solution injections and/or reference details/historical documents related to how these potential outcomes will be addressed.

Navy Response: Based on performance monitoring conducted on wells MW-07 and MW-08 following the previous injections, continued monitoring of those wells following the upcoming injection is not warranted. In March 2010, 3,344 lbs of sodium persulfate and 3,200 lbs of sodium hydroxide in a 2,009-gallon solution (followed by 20 gallons of chase water per well) were injected into four wells at the site, including MW-04, which is closer to wells MW-07 and MW-08 than the two wells planned for injection under the Work Plan Addendum (i.e., MW-01 and MW-05). Similarly, in June 2010, 1,672 lbs of sodium persulfate and 1,600 lbs of sodium hydroxide in a 1,024-gallon solution (followed by 20 gallons of chase water per well) were injected in the same four wells. Following those injections, wells MW-07 and MW-08 showed no detections of any COCs (see Figure 1-3). The injection planned under the Work Plan Addendum will be of comparable volume (1,400-gallon sodium persulfate solution, 275-gallon hydrogen peroxide solution, 20 gallons chase water for each of two wells). Because the MW-07 and MW-08 data collected following the prior injections indicated

displacement of contaminants did not occur due to the oxidant injections, because the dosage was (and will continue to be) designed to minimize pore volume displacement by targeting 50 percent of pore volume, because the estimated radius of influence is 10 to 12 feet and wells MW-07 and MW-08 are located between 25 and 50 feet from the target treatment area, and because injection will not take place in the well closest to MW-07 and MW-08, inclusion of MW-07 and MW-08 in performance monitoring is not warranted. However, as noted in the comment, well MW-04, which is located closer to the target treatment area, will be included in performance monitoring.

- 3. Addendum:** The Draft RAWP Addendum does not indicate if the ISCO injection and performance monitoring wells are compatible with the potential heat that may be generated by the exothermic reaction associated with the use of hydrogen peroxide. Similarly, it is unclear if vapor intrusion into nearby buildings will be monitored due to the potential of the exothermic reaction to generate gases which can volatilize and transport COCs.

EPA Comment: Revise the Draft RAWP Addendum to discuss whether the ISCO injection and performance monitoring wells are compatible with the potential heat that may be generated by the exothermic reaction associated with the use of hydrogen peroxide. In addition, revise the Draft RAWP Addendum to discuss whether vapor intrusion monitoring in nearby buildings will be conducted due to the potential of the exothermic reaction to generate gases which can volatilize and transport COCs.

Navy Response: The Draft RAWP Addendum provides details on procedures to minimize in-situ exothermic reaction associated with the use of hydrogen peroxide. As described in Injection Protocol under Section 2.2.3 of the Draft RAWP Addendum, a pre-injection test will be conducted with groundwater extracted from one of the two targeted treatment wells MW-01 and MW-05. The groundwater will be placed in four glass jars. Hydrogen peroxide concentrations at 2, 4, 6, and 8 percent will be added to the jars, and the reaction will be observed for up to 60 minutes. The test will provide insight into the reactivity of the site's groundwater, and an appropriate dose of hydrogen peroxide with which to start the injections. If visual/tactile observation suggests off-gassing or heat may be problematic (a subjective determination) during hydrogen peroxide injections, the hydrogen peroxide concentration will be lowered, to avoid the effects suggested in the comment.

Vapor intrusion monitoring is not warranted at the site given the low concentrations of VOCs present and the fact that the nearby buildings are either not occupied or were destroyed by Hurricane Maria.

SPECIFIC COMMENTS

1. Section 2.2.1, Mobilization and Preparation, Page 2-1:

Addendum: The last sentence of Section 2.2.1 states, "Prior to initiating injections, secondary containment will be established, and a water leak test will be performed;" however, details (e.g., standard operating procedure) related to the secondary containment and the water leak test are not provided and/or referenced.

EPA Comment: Revise the Draft RAWP Addendum to provide and/or reference details related to the secondary containment and the water leak test.

Navy Response: The last sentence of Section 2.2.1 has been revised as follows: "Secondary containment will be provided for oxidant storage area and oxidant mixing area to prevent potential spills. The specific secondary containment approach may vary depending on field conditions and equipment/materials availability, but may include Rain for-Rent-type L-bracket containment systems (or similar), which use a synthetic liner. Alternatively, a synthetic liner or plastic sheeting may be used in conjunction with sandbags or a soil berm. Further, prior to starting the pump for injection, equipment interlocks, tooling, and valves will

be checked by the Subcontractor. A leak test will be performed using water to ensure there is no leakage of injection hose, pipe, valves, and connection to the wellhead assembly or manifold.”

2. Section 2.2.2, Chemical Delivery and Storage, Page 2-1:

Addendum: The text states, “Materials that are sensitive to moisture will be protected from rain and other sources of water prior to use;” however, details related to how the materials will be protected from the rain and other sources of water prior to use are not provided and/or referenced.

EPA Comment: Revise the Draft RAWP Addendum to provide and/or reference details related to how the materials will be protected from the rain and other sources of water prior to use.

Navy Response: The text in Section 2.2.2 has been revised to indicate that moisture-sensitive materials will be kept sealed in their containers, covered with tarps/plastic sheeting, and/or stored indoors, as applicable, prior to use.

3. Section 2.2.3, Oxidant Solution Injection, Page 2-2 on:

Addendum: It is stated in the document that MW-03 upgradient, MW-07 and MW-08 downgradient are not necessary to include in further LTM.

EPA Comment#1: Downgradient wells MW-07 and MW-08 have to be included during the remedial action phase of the project to monitor any downgradient migration of the oxidant and COCs.

Navy Response: Please see the response to General Comment #2.

Addendum: A pre-injection test will be conducted with groundwater extracted from one of the two targeted treatment wells. The groundwater will be placed in four glass jars. Hydrogen peroxide concentrations at 2, 4, 6, and 8 percent will be added to the jars, and the reaction will be observed for up to 60 minutes. The test will provide insight into the reactivity of the site’s groundwater, and an appropriate dose of hydrogen peroxide with which to start the injections. The dose described below may be adjusted during the in-situ treatment based on these observations or observations made during injection.

EPA Comment #2: Please provide more detail regarding the metrics that will be used during this observation method.

Navy Response: Please see the response to General Comment #3. Professional judgement based on visual/tactile observations of off-gassing/heat is sufficient to determine the appropriate hydrogen peroxide dose because the concentration does not need to be an exact.

EPA Follow-up Comment: In general, the proposed pre-injection test does not appear to be well-grounded. This comment is provided for several reasons discussed below.

Navy Follow-up Response: After a minimum, the dose is less a function of H₂O₂ mass (like it would be for other ISCO systems); rather, the dose is intended to find an acceptable percentage of H₂O₂ that can be injected safely (here to activate persulfate, not like a "classic" catalyzed H₂O₂ application). While it is true that under different conditions (i.e., a site where sufficient historical information does not exist, the purpose is to design an application system, etc.), it may be necessary to collect a saturated soil sample to see how the various percentages of H₂O₂ react with groundwater and soil, the observations made as described in the work plan are sufficient to achieve the desired outcome, which is solely to determine the dose of H₂O₂ that can be safely applied (i.e., not react overly vigorously in situ). It is the persulfate that is intended to address the COCs, and the historical information from previous injections has provided the necessary information regarding how much persulfate is appropriate to treat the COCs. The H₂O₂ is intended solely to address any persistent persulfate, as was observed during the previous injections. Based on a guidance

document produced by PeroxyChem, a minimum targeted molar ratio for activation is 2:1 (H₂O₂ : persulfate).

EPA 2nd Round Follow-up Comment

1. The plan is still unclear. Define what metrics will be used to determine, “not react overly vigorously in situ”. Report whether “previous injections that provided the necessary information regarding how much persulfate is appropriate to treat the COCs” involved H₂O₂ and/or citric acid. Neither of these issues were addressed. The plan reports that the purpose of the H₂O₂ is to activate S₂O₈²⁻, but does not specify whether S₂O₈²⁻ will be amended to the jars, in addition to H₂O₂, for this intended purpose. The basis for the test, as proposed, does not appear to have scientific merit, nevertheless, the jar should at least contain S₂O₈²⁻ as it will be a reactant that exists in the subsurface when the two chemicals are injected.
2. The purpose of the work plan described in the test, as is, is to solely determine the dose of H₂O₂ that can be safely applied (i.e., not react overly vigorously in situ). Then the objective is to visually examine the rate of O₂(g) bubbles, as we previously indicated. Still, the workplan did not, and currently does not explain what metrics will be used other than visual observation.

One observation we have made in our lab is that the reaction between H₂O₂ and S₂O₈²⁻ is very slow in the absence of solid phase media. But the reaction of both H₂O₂ and S₂O₈²⁻, increases significantly in the presence of solid phase media. The absence of media in the pre-test will not accurately mimic the behavior of the H₂O₂ reaction in the subsurface for the intended purpose (i.e., to not react overly vigorously in situ). Therefore, the test will not provide the scientific basis to determine the dose of H₂O₂ that can be safely applied because it does not involve solid phase media.

3. It is reported that historical information from previous injections has provided the necessary information regarding how much persulfate is appropriate to treat the COCs. This information was not included in the document reviewed and no comments or recommendations can be provided regarding the validity of this conclusion. However, base activated persulfate is generally considered the most cost effective, and most commonly used method to activate persulfate. If better treatment performance results were measured using H₂O₂ activated persulfate, it is highly possible that O₂(g) may have caused volatilization of the CVOCs, which could be interpreted as oxidative losses. It is recommended that results of the previous tests be examined to assure CVOC volatilization was not a viable loss mechanism, and that all volatile compounds from the test system were captured, quantified, and accounted for in the assessment.
4. It was reported that the H₂O₂ is intended solely to address any persistent persulfate, as was observed during the previous injections. In general, persulfate persistence is good as it allows the oxidant to diffuse into porous media resulting in greater contact with the contaminants. If persulfate was persisting too long, or migrating into areas where it was unintended, it is recommended to consider an alternative approach which includes injecting at lower persulfate concentrations or rates.

Navy Response to 2nd Round Follow-up Comment:

This was discussed at the Technical Subcommittee Meeting on Thursday, May 10, 2018 and there was agreement that items relating to the percentage of hydrogen peroxide to be used will be removed from the work plan.

EPA Follow-up Comment (continued):

1. It was proposed to amend H₂O₂ at 2, 4, 6, and 8% to groundwater. Then make visual observations for the next 60 minutes. This information suggests several technical issues.
 - a. It is not proposed to measure COCs, rather it sounds like the test will involve visually watching how many O₂(g) (bubbles) are formed when the H₂O₂ reacts. An incomplete understanding of the fate of COCs will result from this test. Consequently, it is unclear how a H₂O₂ dosage determination can be made based on this “information.”

Navy Follow-up Response: The pre-test is not intended to treat the COCs (benzene, MTBE, and 1,2-DCA), as H₂O₂-activated persulfate is known to treat these types of contaminants and historical persulfate injections at AOC E have been shown to treat the COCs present in its groundwater. Rather, the pre-test on groundwater using a variety of H₂O₂ concentrations is designed to determine the highest H₂O₂ dose that can be applied safely, to avoid injecting H₂O₂ at a concentration that will react overly rigorously in situ. Of note is that citric acid is also being added to stabilize H₂O₂, adding another level of safety for evaluating the various H₂O₂ doses and ultimately selecting and using an appropriate dose. Off-gassing can be qualitatively measured by placing a nitrile glove over the glass jar reactor in the field, which is sufficient for this site.

EPA 2nd Round Follow-up Comment

Assuming citric acid is being injected to control H₂O₂ reaction, the rationale for this decision may be that citric acid exhibits acidic characteristics, and that the H₂O₂ reaction decreases at lower pH. There are much cheaper forms of acid that could be used to accomplish the same effect. However, a different matter is that ISCO with persulfate is not base activated. It is noted that the persulfate solution is *highly acidic* and will likely lower the pH < 3.5, maybe as low as 1-2. Therefore, the use of citric acid appears to have limited value for this purpose since it is already acidic.

It is evident that off-gassing is the metric that will be used to assess H₂O₂ reaction in the subsurface. In re-iterating the importance of solid phase media in H₂O₂ reaction, the absence of solid phase media will limit the usefulness of this test.

Navy Response to 2nd Round Follow-up Comment:

This was discussed at the Technical Subcommittee Meeting on Thursday May 10, 2018 and there was agreement that items relating to the percentage of hydrogen peroxide to be used will be removed from the work plan.

- b. Relative to the solid phase media (aquifer material), the ground water contains limited contaminant mass and limited reactants to catalyze H₂O₂ reaction. Therefore, even if COCs were measured, it is unclear to what extent these test results are representative of subsurface conditions. Further, the H₂O₂ reaction will be marginally impacted by parameters in the ground water. Almost always, H₂O₂ reaction is dominated by solid phase media. Again, it is unclear to what extent this test is representative.

H₂O₂ reaction in the presence of groundwater and media will occur much more rapidly than with groundwater alone. As mentioned above, it is unclear how this information (i.e., visual observations) will be used to assess H₂O₂ dosage. Visual results of O₂(g) will not reveal the amount of H₂O₂ reacted, COCs degraded, nor the appropriate dosage of H₂O₂.

Navy Follow-up Response: As noted above, the amount of H₂O₂ is not important for contaminant mass reduction; it is the persulfate concentration that is important for COC concentration reduction. Historical persulfate injections and associated performance monitoring have provided the necessary information regarding the appropriate dosing intended to address the COCs. The rationale for the pre-test is to help estimate a safe dose (i.e., one that will not react overly vigorously in situ) of H₂O₂ to activate persulfate, to help avoid the long persulfate persistence previously observed.

EPA 2nd Round Follow-up Comment

1. The statement that the amount of H₂O₂ is not important for contaminant mass reduction is misleading. If the synergy resulting from combining H₂O₂ and S₂O₈²⁻ has a greater effect on CVOC loss, then the amount of H₂O₂ is important. Further, data supporting the differentiating roles of S₂O₈²⁻ and H₂O₂ on CVOC oxidation have not been differentiated.

2. Based on the information provided, it is unclear whether H₂O₂ or citric acid were used in the “historical persulfate injections where appropriate dosing of S₂O₈²⁻ was determined to address the CVOCs”. Currently, the discussion indicates that only persulfate was injected. Assuming H₂O₂ was injected in the pilot study, please clarify what concentration and effects were recorded. Clarification on this matter is recommended and would help to better understand what role these reagents served in the process.

No information has been provided that quantify and differentiate the roles of S₂O₈²⁻ and H₂O₂ in COC destruction. It is recommended that clarification be provided explaining how S₂O₈²⁻ is responsible for CVOC loss. This issue was also raised in the previous comment.

Navy Response to 2nd Round Follow-up Comment:

This was discussed at the Technical Subcommittee Meeting on Thursday May 10, 2018 and there was agreement that items relating to the percentage of hydrogen peroxide to be used will be removed from the work plan.

- c. In general, the majority of contamination is adsorbed in the solid phase media. Unless the contaminant is entirely in the ground water, i.e., no sorption, this test is incorrectly designed. Since they are not measuring COCs, this comment really does not matter.

Navy Follow-up Response: The Navy concurs that this comment is not applicable to the pre-test, which is intended to determine an appropriate percentage of H₂O₂ to inject to safely activate persulfate to help avoid the long-term persulfate persistence observed in the past.

- d. The results of this test are basically already known. The greater the H₂O₂ concentration, the greater the O₂(g) produced and the higher the temperature. The criteria by which the H₂O₂ dosage will be determined have not been provided. The basis of “professional judgement” sounds entirely subjective, no performance criteria have been specified.

Navy Follow-up Response: As described above, the sole reason for the pre-test is to determine a H₂O₂ dose (percent by weight) that can be injected safely to activate persulfate in situ. Because

the H₂O₂ dose does not have to be an exact, after a minimum targeted 2:1 (H₂O₂:persulfate) molar ratio the selection basis is, appropriately, professional judgment.

- e. If the contaminants are volatile, and H₂O₂ forms O₂(g), the compounds will volatilize from the reactor. Since they are not measuring COCs, this comment really does not matter.

Navy Follow-up Response: The Navy concurs.

- f. The test does not mimic field conditions. A complete mix bench test scenario where H₂O₂, catalysts, and COCs are completely mixed, is different from field conditions where the injection of H₂O₂ will push contaminated ground water ahead, and the H₂O₂ will be in the presence of high solid phase concentrations of catalyst. The H₂O₂ will react along the transport pathway and will likely make contact with adsorbed contaminants, and contaminants immobilized in the aquifer materials.

Navy Follow-up Response: The Navy concurs with the observation – the field test is not targeted at determining the treatment mechanisms. The treatment mechanism has already been determined, as documented in the AOC E Record of Decision.

EPA 2nd Round Follow-up Comment

The treatment mechanism, chemical oxidation, may have been previously determined. But the details provided indicate that the proposed test has little scientific merit, and limited utility.

Navy Response to 2nd Round Follow-up Comment:

This was discussed at the Technical Subcommittee Meeting on Thursday May 10, 2018 and there was agreement that items relating to the percentage of hydrogen peroxide to be used will be removed from the work plan.

- 2. The purpose of the pre-injection test has little scientific merit, “The test will provide insight into the reactivity of the site’s groundwater, and an appropriate dose of hydrogen peroxide with which to start the injections.” There is no correlation established between these tests and the actual response of the subsurface conditions during injection.

The response is also problematic, “Professional judgement based on visual/tactile observations of off-gassing/heat is sufficient to determine the appropriate hydrogen peroxide dose because the concentration does not need to be an exact.” If the criteria for determining the selection of an appropriate dosage cannot be reported or described, there is little confidence that “Professional judgement” will integrate the various parameters needed to make a decision.

Navy Follow-up Response: Please see the responses to previous comments. The intent of the pre-test and the objective of H₂O₂ in the injection is to determine the safe amount of H₂O₂ to inject.

Addendum- The Injection Protocol subsection indicates that 2,800 gallons of water and 300 gallons of water will be mixed with the sodium persulfate and hydrogen peroxide, respectively. Similarly, Section 2.2.3 indicates that 20 gallons of water chaser will be injected per well to flush the well and the well-screen to ensure the oxidant solution is pushed into the formation.

EPA Comment #3: The source of the water is not discussed. As such, it is unclear if potable water or extracted groundwater will be utilized. This is of particular concern given that the use of extracted (contaminated) groundwater would presumably require higher hydrogen peroxide dosing, as the oxidant would be required to treat contaminants both in the injectant and in the site treatment area. Revise Section 2.2.3 to discuss the source of the water that will be used during the oxidant solution injections.

Navy Response: Section 2.2.3 has been revised to indicate potable water will be used, which will be obtained from the water supply at Camp Garcia.

Addendum - Prior to the injection event, field water quality parameters (potential of hydrogen [pH], temperature, specific conductivity, oxidation-reduction potential [ORP], and dissolved oxygen [DO]), persulfate, hydrogen peroxide, and depth to water will be monitored in MW-01 and MW-05 (ISCO application and performance monitoring wells) and MW-04 (downgradient performance monitoring well).

EPA Comment #4: The wells showing exceedances of COCs - MWs 1 and 5 - should be resampled prior to any oxidant reinjection given that the last sampling event was in January 2017, the COC concentrations are close to the remedial action goals for some COCs, and the recent hurricane activity likely added a significant amount of water to the system.

Navy Response: Annual groundwater sampling over the last 3 years has demonstrated little change in the COC concentrations and the concentration of persulfate to be injected can address a range of potential concentrations. Therefore, pre-injection COC sampling is not warranted.

Addendum: The injection amount and sequence is as follows:

- Inject approximately 1,400 gallons of 4.7% sodium persulfate solution per well, into MW-01 and MW-05.
- Following the application of persulfate, inject 275 gallons of up to 8% hydrogen peroxide per well, into MW-01 and MW-05.
- Inject approximately 20 gallons of water chaser per well

EPA Comment#5: The observations of COC “rebound” at this site may be a result of groundwater displacement from using the monitoring wells as injection wells. Injection of oxidant directly into the wells that will be used to monitor the effectiveness of the remedy is not a recommended practice. Please reconsider this approach and revise accordingly.

Navy Response: The process to be followed is that which is dictated by the AOC E Record of Decision and has been successfully demonstrated at the site. As noted previously, no injection will take place in MW-04, which will also be included in performance monitoring.

4. Section 2.2.4 Process Monitoring During Injections

Addendum: During the injection event, injection rates and pressures, injectate volume and concentrations, oxidant and activator inventory, and the start and end times for delivering the designated amount of solution to each of the wells will be monitored and recorded. During injection, a dedicated disposable bailer for each monitoring well will be used to collect samples for field parameters. Injection field parameters (pH, temperature, specific conductivity, ORP, and DO), persulfate, hydrogen peroxide, and depth to groundwater will be monitored in MW-01, MW-04, and MW-05, approximately three times a day during injection, as warranted based on ongoing observations.

EPA Comment: The use of a bailer to collect samples for the measurement of dissolved oxygen is not an acceptable protocol since air may be introduced and skew the results. Please revise.

Navy Response: A bailer will only be used during process monitoring during the injection to collect samples for field parameter monitoring, to assess the oxidant distribution. Dissolved oxygen is not a necessary parameter for persulfate injection process monitoring. Section 2.2.4 has been revised to remove DO.

EPA Follow-up Comment: Agreed that DO is not a viable parameter to measure oxidant distribution; however, neither are the other parameters listed (pH, temperature, specific conductivity, ORP). Measured values of these parameters will increase dramatically in nearby wells without any oxidant (i.e., H₂O₂ or S₂O₈²⁻) being present. It is recommended that the oxidant be measured as an indicator of areal coverage, not the proposed indicator parameters.

Navy Follow-up Response: The groundwater conductivity increases because of sodium persulfate injected, and the pH decreases as a result of sulfuric acid formed during the dissociation of persulfate. Depending on the reaction rates of the H₂O₂ with the groundwater and soil matrix, the temperature of the groundwater can increase. In addition, the ORP tends to increase based on oxidants introduced to the groundwater. Therefore, these four parameters will be measured during the injection event.

EPA 2nd Round Follow-up Comment

The groundwater conductivity will increase due to sulfate (SO₄²⁻) residuals from the S₂O₈²⁻, and from the tremendous upset the H₂O₂ will have in the subsurface system. For example, significant changes in turbidity and conductivity in ground water occurs when H₂O₂ is injected due to the O₂(g) production, pressure changes, and other related disturbances. The pH can be measured to better understand the impact of the acidic conditions in ground water, but it is not a measure of the presence of oxidants. The H₂O₂ reaction is exothermic, and will raise the temperature of the groundwater, but it is not a measure of the presence of oxidants. The ORP will increase as a result of DO and SO₄²⁻, residuals from H₂O₂ and S₂O₈²⁻, respectively. Just to be clear, the ORP will increase due to the presence of increasing concentrations of DO and SO₄²⁻, even when H₂O₂ and S₂O₈²⁻ are absent. None of these parameters indicate the actual presence of oxidant. For these reasons, the proposed groundwater monitoring parameters are invalid indicators of oxidant presence, and will not be accepted as measurements of areal distribution of oxidant, or radius of influence of the oxidant. It is recommended that the oxidant be measured using appropriate field methods. These results will be accepted as a measure of oxidant distribution, not the proposed indicator parameters.

Navy Response to 2nd Round Follow-up Comment:

This was discussed at the Technical Subcommittee Meeting on Thursday May 10, 2018 and there was agreement that items relating to the percentage of hydrogen peroxide to be used will be removed from the work plan.

5. Section 2.2.7 Groundwater Performance Monitoring

Addendum: Groundwater performance monitoring will be initiated and performed in accordance with Section 3.1 and Worksheet #11 (Appendix C) of the RAWP (CH2M, 2015) with the following modifications:

- Groundwater performance monitoring will be conducted using three monitoring wells (MW-01, MW-04, and MW-05). These wells are either located within the area of COC RG exceedances (i.e., wells MW-01 and MW-05) or are immediately downgradient of these wells (i.e., well MW-04). As noted previously, historical information collected from wells MW-03, MW-07, and MW-08 (when COC concentrations were significantly higher) and during the original injection (under similar injection protocol) indicate further monitoring of these wells is not warranted.

EPA Comment: As stated before downgradient wells MW-07 and MEW-08 have to be included during the remedial action phase of the project to monitor any downgradient migration of the oxidant and COCs.

Navy Response: Please see the response to General Comment #2.

6. Table 2-2

EPA Comment: Please include the dates for the pH, conductivity, redox (ORP), DO and persulfate values shown in the table.

Navy Response: The dates for the pH, conductivity, redox (ORP), DO and persulfate values are already shown in the second column of the table but for clarity, this column has been moved to just before the pH column. Additionally, the dates have been corrected. Note these wells went dry and samples were collected the next day immediately when pumping began.

**Responses to PREQB Comments on the
Draft Remedial Action Work Plan Addendum, Area of Concern E,
Atlantic Fleet Weapons Training Area - Vieques,
Former Naval Ammunition Support Detachment, Vieques, Puerto Rico**

GENERAL COMMENTS

1. Several acronyms presented in the list of acronyms are not used in the report including IRACR, LUC, MOV, SAP, UIC and USFW. Please update the text accordingly.

Navy Response: The acronym list has been revised to ensure only those acronyms used in the document are included in the list.

PAGE-SPECIFIC COMMENTS

1. Page 2-2, Section 2.2.3 – Oxidant Solution Injection, Injection Protocol: Please clarify the basis for injecting the hydrogen peroxide activator after the injection of persulfate oxidant as it would appear that combining persulfate with the hydrogen peroxide activator via a metering pump during injection may provide for a more effective distribution of the activator and thus, activation of the persulfate injected. PREQB recognizes that in practice both types of delivery can be performed; however, with the proposed approach, while it is recognized that some mixing will occur, some of the injected persulfate solution may be pushed away from the injection well by the hydrogen peroxide when injected separately and may limit activation of some persulfate near the perimeter of radius of influence of persulfate injection.

Navy Response: Sequential injection of persulfate followed by hydrogen peroxide as an activator is a safer field delivery method based on CH2M experience and as described in the vendor PeroxyChem Activation Guidance.

2. Page 5-1, Section 5 - References: The Master Standard Operation Procedures, Plans, and Protocols (CH2M, 2010) as well as the Draft Area of Concern E, Remedial Action Annual Status Report 2017 (CH2M, 2017c) are not cited in the work plan. Please remove these references from Section 5 or add the citations to the work plan text (as appropriate).

Navy Response: The references have been removed as requested.

Responses to PRDNER Comments on: Vieques NPL, Area of Concern (AOC) E, Draft Remedial Action Work Plan Addendum, August 2017 Comments Made by PRDNER on November 21, 2017					
PDF Pg. #	Doc. Pg. #	Doc. Section #	Document Text / Summary of Content [Section Heading (if Applicable) in Brackets]	PRDNER Comments	Navy Response to Comments
23	4-1	4	[Project Schedule]: Initial COC monitoring: During the monitoring event when persulfate levels in all three wells are non-detect, or, by concurrence among the Navy, EPA, and PREQB, close to non-detect	Unless persulfate levels can/will be field-screened, the phrasing of the text is misleading, implying that COC monitoring will take place during the same round of sampling in which persulfate is non-detectable. PRDNER suggests re-wording the text to clarify that initial COC monitoring will take place during the first monitoring event (i.e., the first subsequent sampling round) AFTER laboratory analysis has shown that persulfate levels are non-detectable or, by concurrence among the Navy, EPA, and PREQB, close to non-detectable.	Persulfate field screening will be conducted using the CHEMetrics field kit, in accordance with Attachment A of Worksheet #11 (Appendix C) of the RAWP (CH2M, 2015). Figure 2-2 of the Draft RAWP Addendum states COC monitoring via lab sample analysis will not start until residual persulfate concentrations in three wells screened by field test kits are non-detectable or, by concurrence among the Navy, EPA, and PREQB, close to non-detectable.

*PRDNER COMMENTS ON:
VIEQUES NPL, AOC E DRAFT RA WORK PLAN ADDENDUM
NOVEMBER 21, 2017*