Office of Enterprise Assessments
Follow-up Assessment of Progress on Actions Taken to Address Tank Vapor Concerns at the Hanford Site

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Acronyms

ACGIH	American Conference of Governmental Industrial Hygienists
AIHA	American Industrial Hygiene Association
ALARA	As Low As Reasonably Achievable
AOP	Abnormal Operating Procedure
CFR	Code of Federal Regulations
CHAT	Chemical Hazard Awareness Training
COPC	Chemicals of Potential Concern
CTEH	Center for Toxicology and Environmental Health
CVST	Chemical Vapor Solutions Team
CWBT	Central Washington Building and Construction Trade Council
DOE	U.S. Department of Energy
DST	Double-Shell Tank
EA	Office of Enterprise Assessments
FY	Fiscal Year
HAMTC	Hanford Atomic Metal Trades Council
HPMC	HPM Corporation
IH	Industrial Hygiene
IHT	Industrial Hygiene Technician
IP	Implementation Plan
IPT	Integrated Project Team
ISM	Integrated Safety Management
L&I	Washington State Department of Labor and Industries
NIOSH	National Institute of Occupational Safety and Health
OEL	Occupational Exposure Limit
OEL-C	Occupational Exposure Limit – Ceiling Limit
OJT	On-the-Job Training
OR	Overarching Recommendation
ORP	Office of River Protection
OSHA	Occupational Safety and Health Administration
PBI	Performance Based Incentive
PID	Photon Ionization Detector
PNNL	Pacific Northwest National Laboratory
PTR-MS	Proton Transfer Reaction Mass Spectrometry
RL	Richland Operations Office
SCBA	Self-Contained Breathing Apparatus
SEA	Special Emphasis Area
SME	Subject Matter Expert
SRNL	Savannah River National Laboratory
SST	Single-Shell Tank
TVAT	Tank Vapor Assessment Team
TVIS	Tank Vapor Information Sheet
TWA	Time-Weighted Average
VMEP	Vapor Management Expert Panel
VOC	Volatile Organic Compound
WBS	Work Breakdown Structure
WC	Workers' Compensation
WRPS	Washington River Protection Solutions, LLC

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EXECUTIVE SUMMARY

The U.S. Department of Energy (DOE) Office of Worker Safety and Health Assessments, within the independent Office of Enterprise Assessments (EA), at the direction of the Secretary of Energy, conducted a follow-up assessment of progress on actions taken to address concerns about vapors in and around the Tank Farms at the Hanford Site. EA assessed the progress of actions taken at Hanford to address the recommendations from the Savannah River National Laboratory (SRNL)-led Tank Vapor Assessment Team (TVAT) report from October 2014. Specific focus areas for EA's follow-up assessment were the technical solutions proposed to address vapor releases and worker exposures and the extent of workers' and medical personnel's engagement in developing and implementing the actions recommended by the TVAT.

Concerns about tank vapors at the Tank Farms have existed since at least July 1987 and have been the topic of numerous assessments. In response to several vapor events in the spring of 2014, Washington River Protection Solutions, LLC (WRPS), the prime contractor for Tank Farm operations, commissioned SRNL to conduct the TVAT assessment to take a broad look at the issue and offer independent analysis and recommendations, including providing WRPS the data needed to resolve longstanding Tank Farm vapor issues and worker concerns. The TVAT report provided 10 overarching recommendations addressing cultural and technical aspects, along with 47 supporting recommendations that were designed to improve communication and trust, as well as the safety and health management program as it pertains to Hanford tank vapors. After a series of reported exposures in the spring of 2016 and complaints from several bargaining units and other stakeholders, the Secretary of Energy directed EA to perform this follow-up assessment of progress by the DOE Office of River Protection (ORP) and WRPS in addressing and implementing recommendations from the TVAT report.

Currently, managing Tank Farm vapor issues is a challenge because of longstanding, complex issues in vapor characterization and the identification and control of fugitive releases (vapor sources that are not associated with known emission points, such as ventilation stacks or breather filters) and potential exposures to personnel. To further compound the challenge, the current environment involving lawsuits, injunctions, press inquiries and extensive coverage, union stop-works, congressional oversight, and multiple internal and external reviews creates another barrier to open communication on key issues.

Notwithstanding these challenges, ORP and WRPS senior management have demonstrated their commitment to addressing the TVAT recommendations by providing funding, effort, and staff resources. In February 2015, WRPS established a project team to address the TVAT recommendations through an implementation plan to achieve the "Tank Farm of the Future," in which there is greater reliance on technology and engineered controls than on personal protective equipment and administrative controls. The implementation plan designated actions to address the recommendations as near-term (Phase 1) and longer-term (Phase 2). Overall, most of the planning decisions were appropriate. Phase 1 actions included such items as expanded sampling and characterization of Tank Farm vapors, prototyping of new types of personnel monitoring and vapor detection equipment, and strengthening the industrial hygiene program, including increased hiring and training of industrial hygiene staff. ORP demonstrated increased management attention by assigning an Integrated Project Team in March 2015, dedicated to providing oversight and monitoring the progress of these actions, and in June 2016, ORP and WRPS each assigned a full-time senior manager to champion the effort.

Following the reported vapor exposure events in the spring of 2014 (before the TVAT assessment), WRPS re-established efforts to address the vapor issues through the Chemical Vapor Solutions Team (CVST), including a focus on new technology to facilitate comprehensive identification and characterization of Tank Farm vapor hazards. The 12-member CVST is also a mechanism for giving employees (including the site medical staff) an opportunity to both learn about vapor issues and express their opinions and ideas. Half of the CVST members are Tank Farm workers. The CVST has been active to varying degrees since before the TVAT assessment and has contributed to development and implementation of some of the actions to address the TVAT supporting recommendations.

The TVAT report recommended continuing research, development, and implementation of new vapor detection technology. The new instruments underwent bench-scale testing at Pacific Northwest National Laboratory and are being pilot-scale tested, including software and data quality tests, in two Tank Farms. The instrumentation is state-of-the-art, remotely operated, and integrated with Tank Farm software. The approach WRPS used for selecting, evaluating, and benchmarking the instrumentation was sound, and the new technology has the potential to effectively detect and quantify many tank and non-tank vapors and sources.

Beginning in the summer of 2014 and based on the draft TVAT report, WRPS required workers to use at least a half-face air purifying respirator when working in the single-shell tank (SST) farms. Subsequently, starting in November 2014 after the TVAT report was issued, WRPS required all workers in SST farms, and doing any work with a low threshold odor potential in double-shell tank farms, to use self-contained breathing apparatus (SCBA). In the summer of 2016, following a Hanford Atomic Metal Trades Council (HAMTC) union stop-work order and a Federal court order[1], WRPS implemented progressively stringent requirements for using SCBA during Tank Farm activities. A key component of Phase 1 that can provide more confidence in the adequacy of respiratory protection less stringent than SCBA is a new respirator cartridge testing station. This station was designed and constructed to quantitatively determine the level of protection that several types of respirator cartridges can provide against actual tank vapors. WRPS expects the results to provide additional information on the performance of the cartridges in protecting against many of the actual gases in the tank headspace and to support a more complete technical basis for using air-purifying respirators, which pose less physical stress for the workers and fewer hazards than SCBAs, from an industrial safety perspective. WRPS recently started testing cartridges at the station, and sample data analysis is in process. Following mediation between HAMTC and WRPS utilizing Federal Mediation and Conciliation Services, WRPS reached an agreement with HAMTC on August 31, 2016, to use the results of cartridge testing as a basis for lifting the stop-work requirements for use of SCBA if the respirator cartridges are proven effective in protecting workers against tank vapors.

Another key area of the TVAT recommendations involved improvements in the industrial hygiene program. In response, WRPS has hired and trained approximately 100 industrial hygiene technicians and additional industrial hygienists in the 2014-2015 timeframe. Area monitoring has increased, both inside and outside the Tank Farms, to better characterize vapor releases if they occur. Technology improvements to automate the industrial hygiene rounds and routines programs are being piloted and have the potential to improve the accuracy, data recording, and communication of air monitoring data on a real-time basis. Overall, most aspects of the industrial hygiene program are sound and improving.

[1] No: 4:15-CV-5086-TOR, *Order Setting Briefing Schedule and Regulating Defendants' Actions in the Interim,* United States District Court, Eastern District of Washington, Thomas O. Rice, Chief United States District Judge, August 3, 2016.

Although ORP and WRPS have made progress on several fronts since the TVAT report and most of the recommendations are being adequately addressed, several fundamental challenges are impeding progress. Solutions to vapor concerns include both technical and cultural aspects; both must be further addressed.

Technical Aspects

With regard to the implementation plan for addressing TVAT recommendations, WRPS has not included the recommendations in their existing formal processes, such as the WRPS Problem Evaluation Request System, to verify and document corrective action completion and effectiveness. Although WRPS has made progress with the industrial hygiene program, EA identified some limitations or vulnerabilities in the respirator cartridge testing process, progress on headspace sampling, the Industrial Hygiene Chemical Vapor Technical Basis, the process for updating the list of chemicals of potential concern, the need to re-focus on industrial hygiene programs not related to the vapor issues, and the need for additional rigor in the industrial hygiene technicians' training and qualification process.

Cultural Aspects

WRPS has expended considerable time and effort to improve communication protocols regarding vapor issues, and WRPS has indicated that most actions addressing TVAT recommendations related to communications are complete. However there are still issues with communications between management and the workers regarding tank vapors and this has been further complicated by the ongoing litigation. The CVST has not been successful in soliciting a broader base of worker input and communicating to the entire workforce about Tank Farm vapor issues. Focus groups conducted as part of this assessment indicated that few workers interacted with or received information from the CVST. Further, the actions that WRPS has taken to address TVAT recommendations regarding workers' health and safety concerns have not been fully effective in alleviating the concerns. The focus groups of union-represented workers during this assessment expressed perceptions of communication similar to those reported by the TVAT assessment in 2014, indicating little improvement in addressing employee concerns. ORP demonstrated awareness of some of the communications weaknesses during interviews and focus groups. Although the TVAT recommended evaluating the communication system associated with vapor events, WRPS has not planned or completed an assessment of the effectiveness of communications related to vapor issues or events.

Workers continue to occasionally report odors and/or experience symptoms resulting from vapors in or near Tank Farms and are concerned about those exposures, as the odors and/or vapors they experience are not always characterized or identified. A key conclusion of the TVAT report stated that "the body of testimony and data examined by the [TVAT] strongly suggests a causal link between chemical vapor releases from Hanford waste tanks and subsequent adverse health effects, particularly upper respiratory irritation, experienced by many Hanford Tank Farm workers." Further, the TVAT report stated that "Management must acknowledge the health risk associated with episodic releases of tank vapors." However, as indicated in the focus groups, many workers perceive that management does not acknowledge the health risk associated with such releases, and these perceptions contribute to erosion of trust between workers and management. Several workers expressed concerns about retaliation (both from management and from peers) if they raise issues regarding tank vapors.

Some workers (including some of the new industrial hygiene technicians themselves) have negative perceptions of recently hired industrial hygiene technicians' capabilities and their training and qualification process. The TVAT report recommended that industrial hygiene technicians, industrial hygiene professionals, and management increase their field presence and undergo specific risk communication training to improve their ability to deliver effective risk communication to the employees. There was also a recommendation for increased field presence of industrial hygiene technicians and

professionals to provide timely communications regarding worker exposures and health risks. Although industrial hygiene technicians' field presence has increased, much of the workforce at the Tank Farms does not have as much trust and confidence in the industrial hygiene technicians as they do in the radiological control group.

Another factor that contributes to the erosion of trust encompasses workers' compensation administration and long-term evaluation of employee health relating to potential exposure to tank vapors. Hanford differs from other DOE sites in how it administers the workers' compensation program and occupational medicine service. The DOE Richland Operations Office (RL) holds the contract for both Penser, the third-party workers' compensation administrator, and HPM Corporation, the occupational medicine provider for Hanford contractors (including the companies under contract with ORP). RL is also the "statutory employer" for the employees of all covered Hanford contractors, under the terms of a memorandum of understanding with the Washington State Department of Labor and Industries. The centralization of workers' compensation information within RL adds another layer of complexity that creates a barrier for communicating information necessary for WRPS (and other Hanford contractors) to perform effective injury/illness case management. Additionally, regarding the TVAT recommendation to conduct epidemiological studies focused on evaluating potential long-term health consequences for Tank Farm workers, the current efforts to design a clinical study at Hanford using workers' compensation cases may have limited value, because of the small sample size; only about 55 workers' compensation claims related to the Hanford Tank Farms workers have been filed since 2012.

Path Forward

EA's recommendations in this report are intended to provide an independent perspective for consideration by ORP, WRPS, and others to adjust their focus on addressing tank vapor issues. Recommendations address the areas highlighted above relative to:

- Improved communications and trust
- Increased worker involvement
- Improved industrial hygiene and tank headspace sampling programs
- Improved documentation of present activities, action closure and effectiveness, and path forward for Phase 2, including details on engineering controls
- Process improvements in workers' compensation
- Enhanced medical protocols for and communications with Tank Farm workers reporting symptoms from vapor exposures
- Inclusion of the Tank Farm Worker designation in health studies and medical surveillance and screening programs sponsored by the DOE Office of Environment, Health, Safety and Security.

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1.0 PURPOSE

The U.S. Department of Energy (DOE) independent Office of Enterprise Assessments (EA) conducted a follow-up assessment of progress on actions taken to address tank vapor concerns at the Hanford Site. EA conducted the onsite portions of this assessment June 21-23 and August 1-11, 2016.

2.0 SCOPE

This follow-up assessment evaluated the progress of actions taken at Hanford to address the recommendations from the Savannah River National Laboratory (SRNL)-led *Hanford Tank Vapor Assessment Report* from October 2014. This follow-up assessment included a special focus on evaluating the technical solutions that the Hanford Tank Vapor Assessment Team (TVAT) proposed to address the vapor releases and reported worker exposures. It also addressed the extent to which workers and medical personnel are engaged in the development and implementation of recommended actions.

3.0 BACKGROUND

The DOE Office of River Protection (ORP) was established in 1998 to manage the 56 million gallons of liquid or semi-solid radioactive and chemical waste stored in 177 underground tanks at the Hanford Site. ORP serves as DOE line management for the Tank Farms, which maintain the 177 underground storage tanks in 18 groups or "farms" of 2 to 16 tanks each, and the Waste Treatment and Immobilization Plant, which is under construction and will be used for retrieval, treatment, and disposal of the waste stored in the underground tanks. The Tank Farms are managed and operated by Washington River Protection Solutions, LLC (WRPS) under contract to ORP. As of September 30, 2016, WRPS employed 2094 personnel, 909 of whom are represented by labor organizations that belong to Hanford Atomic Metal Trades Council (HAMTC). The ORP Office of the Assistant Manager for Tank Operations provides Tank Farm oversight.

Concerns about tank vapors have existed since at least July 1987. A DOE Type B investigation report on vapor issues in 1992 (*Type B Investigation of Hanford Tank Farms Vapor Exposures,* Richland Field Office, April 1992) provided insight into several vapor events similar to recent exposures, including an event on July 3, 1987. In that event, three workers reported symptoms related to exposures near an exhauster for Tank 103-C and two of the workers missed work because of the exposure, one for 7 weeks and the other for 13.5 weeks. Shortly after the event, colorimetric detector tube sampling showed no significant hazardous vapor concentrations. However, four and six days after the exposure, sampling of the area detected significant concentrations of ammonia (greater than 60 ppm) and elevated levels of various unidentified organic vapors between 70 and 90 ppm. The Type B investigation report examined several other reported exposures between 1987 and the time of the investigation and concluded that the direct cause was failure to characterize the work environment and develop the appropriate engineering controls.

Concerns about exposure to vapors in the Tank Farms continued and were the topic of numerous assessments. In September 2003, allegations of deficiencies in worker protection at the Hanford Tank Farms that led to worker vapor exposures and illness prompted an investigation in 2004 into the vapors

issue by a predecessor organization to EA, the DOE Office of Independent Oversight and Performance Assurance. That investigation report (*Investigation of Worker Vapor Exposure and Occupational Medicine Program Allegations at the Hanford Site*, April 2004) reported conclusions similar to those of the 1992 Type B investigation. In referring to the previous assessments, it also concluded that the overarching weakness was that the overall strategy for protecting workers from vapors was not adequately defined and documented at a level that could be translated into an adequate set of engineered controls, administrative controls, and personal protective equipment. Although many improvements have been made in Tank Farm operations and worker protection over the years, the overall strategy of protecting workers from vapors has not evolved sufficiently to address workers' concerns about chemical vapor impacts associated with Tank Farm operations.

During a short time span in the spring of 2014, more than two dozen Tank Farm workers received medical evaluation following reported exposures to vapors emanating from waste storage tanks or other sources. While most of those workers reported experiencing odors and/or short-term effects and returned to their work site (pending the results of their medical tests), many workers were concerned about potentially more severe short-term effects, as well as potential long-term health effects. As part of re-examining the Hanford tank vapor issue, WRPS commissioned SRNL to conduct the TVAT assessment to take a broad look at the issue and offer independent analysis and recommendations. The TVAT issued its report October 30, 2014. On November 21, 2014, United States Senators Patty Murray and Maria Cantwell and Congressional Representative Adam Smith sent a letter to the Secretary of Energy recognizing the TVAT report and requesting DOE to take swift and definitive actions to implement the recommendations within the report. The letter also outlined requested actions for DOE to ensure funding of the implementation plan (IP) and to clearly outline a "process to monitor, document, and report progress and assure continuous improvement" as recommended in the report.

Part of the TVAT's charter was to review and comment on the WRPS IP to determine whether the IP addressed the intent and expectations of the TVAT's recommendations. WRPS submitted a written draft of the IP to the TVAT on December 14, 2014, and the TVAT provided its comments to WRPS on December 31, 2014. Major areas of comments included "specifying quantifiable or tangible results of actions, interim milestones/deliverables, and parties responsible for the actions and results." Similar to the letter from the Congress described above, the TVAT response emphasized that "effectively responding to the report not only requires specifying actions for expeditious execution of all TVAT recommendations but also requires clearly defining a process to monitor, document, and report progress and assure continuous improvement." WRPS submitted the IP to ORP on February 9, 2015, and ORP issued the letter of direction to proceed with the IP the same day. To provide oversight of contractor actions to address the TVAT recommendations, ORP formed the Hanford Tank Vapor Implementation Plan Oversight Integrated Project Team (IPT) and issued the team charter on March 26, 2015. The IPT issued a Vapor Implementation Plan Oversight Plan on June 10, 2015, to detail the team's approach for oversight of WRPS's activities associated with Phase 1 of the IP.

One conclusion of the TVAT report was that the ongoing emission of tank vapors, which contain a mixture of toxic chemicals, was inconsistent with providing a safe and healthful workplace free from recognized hazards as required by DOE regulation 10 CFR 851, *Worker Safety and Health Program*. The TVAT report provided 10 overarching recommendations (ORs), as well as 47 supporting recommendations, that were designed to improve the safety and health management program as it pertains to Hanford tank vapors. Based on a preliminary draft of the TVAT report, WRPS required workers to wear at least half face air purifying respirators in the single-shell tank (SST) farms beginning in the summer of 2014. Subsequently, starting in November 2014, WRPS required the use of self-contained breathing apparatus (SCBA) in all SST farms and for any double-shell tank (DST) farms with a low threshold odor potential.

After the TVAT assessment, WRPS's interim approach to preventing worker exposure to Tank Farm vapors was to require that all work involving waste-disturbing activities was to be conducted using SCBA, except when wearing SCBA would present a higher risk to workers (e.g., the relatively high risk of working in a confined area with no room to maneuver while wearing SCBA).

In the spring of 2016, over 50 Tank Farm workers received medical evaluation following reported exposures to unusual odors, reported respiratory symptoms, or reported proximity to workers reporting unusual odors or respiratory symptoms at the Tank Farms. Most of the workers returned to work without medical restriction. Following these reported events, HAMTC issued a stop-work order on July 11, 2016, and a Federal court order providing for interim measures was issued on August 3, 2016, resulting from requests for preliminary injunctions by the lawsuit plaintiffs on July 21, 2016. The interim measures imposed by the court were voluntarily proposed by DOE and WRPS in consideration for extended time to respond to Motions for Preliminary Injunction filed by the State, and separately by Hanford Challenge (an advocacy group) and Local 598. To address the stop-work order and in accordance with the court order, WRPS expanded the SCBA control to include any work inside a Tank Farm boundary and ceased all waste-disturbing work activities unless needed for safety. On August 31, 2016, following mediation between HAMTC and WRPS utilizing Federal Mediation and Conciliation Services, HAMTC signed a memorandum of understanding with WRPS on the conditions necessary to lift the stop-work order, requiring SCBA for all work inside the Tank Farms. The conditions address the results of respirator cartridge testing (further described in Appendix B, Section B.6) showing satisfactory protection from tank vapors, as well as a review by a third-party qualified independent entity, chosen by HAMTC, to review and concur on the results. These tests are ongoing.

After the series of reported exposures in spring 2016 and complaints from several bargaining units and other stakeholders, the Secretary of Energy directed EA to perform a follow-up assessment of ORP's and WRPS's progress on addressing and implementing recommendations from the TVAT report, with a special focus on evaluating the technical solutions already proposed to address the vapor releases and reported worker exposures, as well as the engagement of workers and medical personnel in the development and implementation of recommended actions. This report documents the results of the follow-up assessment.

Today, management of the Tank Farm vapor issues is a challenge because of longstanding, complex issues in vapor characterization, identification and control of fugitive releases (vapor sources that are not associated with known emission points, such as ventilation stacks or breather filters), and potential exposures to personnel. To further compound the challenge, the current environment involving lawsuits, injunctions, press inquiries and extensive news coverage, union stop-works, congressional oversight, and multiple internal and external reviews creates another barrier to open communication on key issues.

4.0 METHODOLOGY

The DOE independent oversight program is described in and governed by DOE Order 227.1A, *Independent Oversight Program*. EA implements the independent oversight program through a comprehensive set of internal protocols, operating practices, assessment guides, and process guides. Organizations and programs within DOE use varying terms to document specific assessment results. In this report, EA uses the term "recommendation" as defined in DOE Order 227.1A. These recommendations are derived from the aggregate consideration of the results of this assessment and are provided for senior line management's consideration for improving program or management effectiveness.

This EA follow-up assessment was performed in accordance with the *Plan for the Office of Enterprise Assessments Follow-up Assessment of Progress on Actions Taken to Address Tank Vapor Concerns at the Hanford Site*, Revision 1, dated July-August 2016. The plan outlines the objectives and criteria specific to this assessment. EA's assessment team included experts in worker safety and health, safety management, industrial hygiene, occupational medicine, and organizational/safety culture. Assessment activities included review of key documents; interviews with workers who reported symptoms; interviews with subject matter experts (SMEs), including technical SMEs on engineering and abatement controls; interviews with ORP and WRPS project management and leadership regarding the broader perspective and the path forward for resolution of Tank Vapor problems; and field observations at the Tank Farms and other locations. EA interviewed Richland Operations Office (RL) leadership and staff assigned to workers' compensation, HPM Corporation (HPMC) staff, representatives of Penser (the third-party workers' compensation administrator), the RL administrator for Energy Employees Occupational Illness Compensation Program activities, and the union presidents from HAMTC and the Central Washington Building and Construction Trade Council (CWBT). Both union presidents and their respective safety representatives provided excellent support to encourage participation in EA focus groups and interviews. Additionally, EA set up a "Hotline" telephone number for workers wishing to contribute any information to the assessment. EA also conducted 22 focus groups with employees and administered a questionnaire to focus group participants. The focus groups targeted populations most likely to work in and around the Tank Farms, such as HAMTC and CWBT union members with job assignments in the Tank Farms; several employees who reported symptoms during vapor events; Mission Support Alliance (Hanford's integrated infrastructure contractor) support workers; WRPS supervisors; engineers; and ORP Facility Representatives. A total of 119 contractor employees participated in the focus groups.

Overall results are presented in Section 5.0, and EA recommendations are provided in Section 6.0. The members of the EA assessment team, the Quality Review Board, and EA management responsible for this assessment are listed in Appendix A. Appendix B provides EA's evaluation of actions in response to each of the 10 TVAT ORs, and Appendix C provides a list of the TVAT supporting recommendations. Appendix D provides a matrix reflecting the relationship between TVAT overarching and supporting recommendations and the IP Phase status from WRPS Stoplight Chart (further described in Section 5.1) as of June 21, 2016.

5.0 OVERALL RESULTS

5.1 ORP and WRPS Response to the TVAT Report

Assessment Objective

Determine whether DOE and WRPS line management are addressing the recommendations of the TVAT.

To manage the implementation of the TVAT recommendations, WRPS established a TVAT Project Team that developed an IP to address the 10 ORs and 47 supporting recommendations. The IP focused primarily on the supporting recommendations and provided only general descriptions of actions specifically addressing the 10 ORs. The IP designated actions to address the recommendations as near-term (Phase 1) and longer-term (Phase 2). WRPS categorized most of the actions within 30 of the 47 recommendations as Phase 1; actions associated with the remaining 17 were primarily categorized as Phase 2 longer-term recommendations to be revisited and revised as necessary after Phase 1 completion. DOE agreed with this approach and directed WRPS to implement Phase 1 as proposed. Phase 1 actions started in fiscal year (FY) 2015, with completion by FY 2016. Phase 2 actions would begin in FY 2017 and continue through FY 2019. However, there was acknowledgement that challenges in funding, technology, and other factors could push the completion timeframe beyond FY 2019. According to the IP, Phase 1 of the TVAT project

focused on four key program elements: expanded sampling and characterization of tank headspace gases; evaluation and procurement of new field and personnel monitoring equipment; evaluation and implementation of tailored personal protection equipment; and increased hiring and training of industrial hygiene (IH) staff. Depending on the results from Phase 1, the IP states that "Phase 2 actions, costs and schedules (FY 2017-2019 and beyond) currently identified in the plan will be reviewed and, as needed, revised to reflect any updates to the technical basis, as well as the ongoing deployment of new technology and/or findings from research and development activities." The IP also states that institutionalization of an enhanced IH program will be addressed in Phase 2. For the most part, WRPS's assignment of actions to Phase 1 and 2 was appropriate, and EA observed progress in each of the four key program elements. EA also identified a few obstacles or areas needing additional focus, as further described below. Appendix B presents EA's detailed evaluation of each OR, including an analysis of progress on key supporting recommendations as they pertain to the ORs.

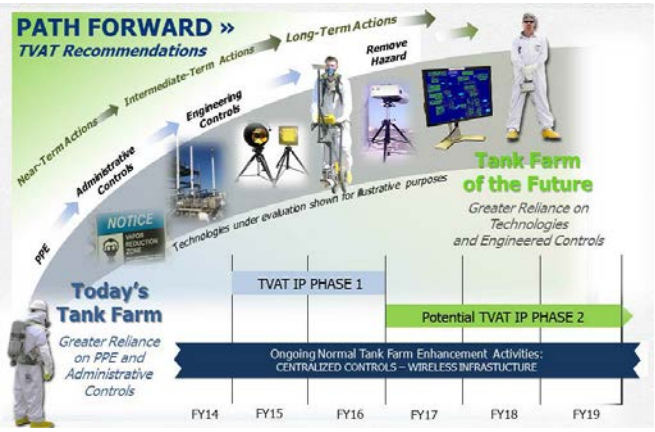

Figure 1: WRPS Path Forward to Tank Farm of the Future

The WRPS Project Team's approach to implementing the TVAT recommendations included development of the project schedule and field execution schedule, and the definition of work scope as indicated in the work breakdown structure (WBS) and associated WBS Dictionaries (descriptions of the WRPS work scope in the initial WRPS IP proposal to ORP). The approach involved a multi-disciplinary effort that included WRPS management, Engineering, the Chief Technology Officer, and IH. The TVAT report stated, "Through the avenue of the Chemical Vapor Solutions Team [CVST] approach, WRPS is striving to implement the mandate from ORP to develop and implement detection and control technologies that will be effective in managing both acute and chronic exposures, thereby creating 'the Tank Farm of the future.' The TVAT endorses these efforts." WRPS has identified the path for improvement as progressing from "Today's Tank Farm," where there is greater reliance on personal protective equipment and administrative controls, to the long-term endpoint of the "Tank Farm of the Future" (see Figure 1), where hazards are eliminated where possible or controlled through greater reliance on technology and engineered controls.

WRPS has made progress in implementing actions to address the TVAT recommendations. The respirator cartridge testing station has the potential to provide more confidence in the adequacy of lower levels of respiratory protection. Several new types of personnel monitoring and vapor detection equipment are being prototyped. The IH program has been strengthened, including increased hiring and training of IH staff and new automated technology being implemented for IH rounds in and around the Tank Farms. The CVST has contributed to development and implementation of some of the actions to address the TVAT supporting recommendations. Sections 5.2, 5.3, and Appendix B provide further details on these and other examples of progress in addressing the TVAT recommendations.

ORP has provided significant oversight of WRPS efforts to address the TVAT recommendations and established the IPT, chartered on March 26, 2015, to conduct continuing oversight of the TVAT IP. ORP issued the IPT's Vapor Implementation Oversight Plan on June 10, 2015. The IPT meets weekly with the WRPS Project Team to monitor and assess TVAT-related activities performed in accordance with the WRPS field execution schedule. ORP completed 50 operational awareness activities and 4 formal, focused assessments on 3 of the 6 key technical assessment areas outlined in the WRPS IP. ORP also routinely performed less-formal assessments (e.g., Facility Representative surveillances and SME

reviews) that addressed various aspects of IP implementation. In addition, ORP established a Vapor Management Expert Panel (VMEP) composed of external experts, including two members of the original TVAT team, to help ensure that actions committed to since the TVAT report are carried out and are effective in protecting workers from potential vapor exposures.

Although progress is evident in many areas, ORP and WRPS face significant challenges in overseeing and managing the implementation of the TVAT recommendations as a project improvement plan that includes such items as prioritizing, scheduling, tracking, setting and meeting milestones, documenting closure, and performing and documenting assessments to verify the effectiveness of completed corrective actions. EA identified the following concerns about the approach to addressing the TVAT recommendations:

- WRPS's categorization of actions supporting the recommendations was limited to either Phase 1 or Phase 2, in the *Implementation Plan for Hanford Tank Vapor Assessment Report Recommendations*, submitted to ORP on February 9, 2015. In response, ORP's letter dated February 9, 2015, directed WRPS to implement this two-phased approach to addressing the TVAT report's recommendations. ORP stated that it gives highest priority to Phase 1 actions, which will reduce the potential for chemical vapor exposures in the near term and aid in the effort to more fully evaluate the bolus exposure hypothesis (a theory hypothesizing short duration, localized, high concentration exposures) or identify other potential exposure pathways. IP activities were prioritized within the Tank Operations Contract Integrated Priority List and scheduled based on logic and resources. A high-level schedule covering actions from 2014 through 2019 and rough order-of-magnitude estimate were provided to ORP. Key performance goals (ORP) and key deliverables (WRPS) were established for both FY 2015 and FY 2016 and tracked on a monthly basis. ORP established two related fee-bearing performance based incentives (PBIs) for FY 2015: PBI 14.0, Vapors Management, and Special Emphasis Area (SEA 7), *Safety Program Implementation*, for completion by September 30, 2015, and seven related fee-bearing PBIs for FY 2016, including PBI-19.0, Vapors Management, and SEA 7, for completion by September 30, 2016. However, no project-style critical path or further prioritization for individual IP Phase 1 actions (in relationship to the other recommendations) have been established, except for the PBIs and SEAs, and no interim milestones.
- Several actions deferred to Phase 2 are key to current worker health but were not resolved in Phase 1 as illustrated in the following examples:
    - One recommendation was to identify an Occupational Exposure Limit-Ceiling Limit (OEL-C) for each analyte in Hanford tank headspaces (i.e., the unfilled area between the tank contents and the top cover of the tank). After reviewing the initial draft IP, the TVAT provided comments in a letter to the WRPS President, dated December 31, 2014, which indicated that the TVAT's intention in this recommendation was for the initial actions "to present a starting point that could be quickly implemented, namely to use current OEL-TWA x 5 and OEL-STEL x 3 values as the default OEL-Cs for use in comparison with any very short term exposure measurements [for all 59 COPC chemicals and for the newly identified reactive chemicals]." The update to the OEL-Cs was not completed as part of Phase 1, and WRPS identified only limited Phase 1 actions to address updating the OEL-C.
    - WRPS categorized modifying the medical case evaluation process as a Phase 2 action. Based on focus group and interview data, medical case evaluation is key to regaining employee trust, as noted below and in more detail in Appendix B.
- Some TVAT Recommendation Phase 1 items are significantly behind schedule and may not be completed on time or have already passed their due date. For example, for TVAT supporting recommendation SC3, "Detecting Technologies," the WBS indicates a due date of April 3, 2016, but as of August 5, 2016, the schedule showed this item as only 59% complete.
- Although the WBS, the field execution schedule, and/or the WBS Dictionaries provide actions and deliverables addressing the IP recommendations, the deliverables for a number of the individual IP

recommendations are not well defined, and there is little documentation in any system demonstrating completion of actions or deliverables addressing the recommendations. The WRPS Stoplight Chart (a chart providing a brief status of overall actions addressing the 47 recommendations) lists 10 specific recommendations as completed or completed/ongoing; however, the WBS does not demonstrate that the actions supporting these recommendations have been completed. As described in the following paragraphs, EA also determined that some of these actions and ongoing activities are not effectively implemented. WRPS plans to issue a "Results and Recommendation Report" encompassing the status of all Phase 1 recommendations at the end of Phase 1.

- Each OR is supported by a number of TVAT recommendations, which are summarized in a table in the TVAT report (see Appendix D). Most recommendations support multiple ORs. However, the direct applicability of many of the individual recommendations to a specific OR was not defined. The IP adopted the same table to cross-reference ORs with TVAT recommendations, and the scope of the IP specifically stated that the IP addresses the 10 ORs. However, in developing the IP, WRPS provided no further explanation of the specific relationship of any TVAT recommendation to an OR. As a result, the completion status of most ORs is not well documented.

EA also noted several concerns about actions to address specific overarching and supporting recommendations, as summarized below. These concerns are discussed in more detail in Appendix B of this report.

In regard to communication (ORs 1 and 9), the TVAT report stated: "It is clear that WRPS is making efforts to engage with stakeholders and initiate additional communication about vapor issues. Nonetheless, the TVAT identified a significant need to re-build the communication program to better communicate the nature and application of the tank vapor risks. Communication gaps were identified at all levels." The IP identifies five of the eight risk communication actions and one risk management action related to communication as completed/ongoing. Although WRPS is pursuing several promising communication strategies, they have not yet produced sufficiently positive outcomes. The TVAT OR 1 summary states: "Management must acknowledge the health risk associated with episodic releases of tank vapors." Data from focus groups indicates that several workers perceive that ORP and WRPS management does not believe there are health risks associated with episodic releases of tank vapors. Additionally, only one of the managers who were interviewed stated that they acknowledged the health risk associated with episodic releases of tank vapors and that they communicated to stakeholders their acceptance of the TVAT observation that workers are being affected by vapors at the Tank Farms. Some workers perceive that odor equates to long-term harm because they believe the odors indicate that they are also breathing harmful odorless chemicals that are not being monitored. ORP and WRPS management have not been effective in addressing this perception and concern.

Although the TVAT recommended evaluation and improvement of the communication system associated with vapor events (RC9) and WRPS listed this as completed/ongoing activity in its Stoplight Chart, WRPS has not planned or completed any formal evaluations of vapor event communications. EA noted that ORP was aware of some of the shortcomings in the effectiveness of WRPS communication efforts. EA saw essentially the same employee perceptions of poor communication and distrust as reported by the TVAT. Further, the large discrepancy in perceptions between union and non-union employees evident in the focus groups indicates a significant problem in communication with the union workers. Several employees indicated that in the current environment, they are uncomfortable with open dialogue with management about vapors, and several employees expressed concerns about retaliation (both from management and from peers) if they raise issues regarding tank vapors.

EA acknowledges that the ongoing lawsuits and news media reports may be impeding management's ability to improve communications with workers. However, the management challenge for WRPS and ORP is to regain the trust of the employees. Data gathered from focus groups and interviews is similar to

data described in the TVAT report, indicating minimal improvement in trust between DOE and WRPS management and the workforce.

With regard to headspace sampling (OR 3), WRPS has embarked on a sampling campaign that is designed to support the collection and analysis of gases in the tank headspace. However, much remains to be done before the concerns identified in the TVAT report will be fully addressed. In addition, the foundation IH Chemical Vapor Technical Basis document, which has not been updated since 2006, is out of date with respect to the Chemicals of Potential Concern (COPC) list, chemical health effects, and changes in OELs that have occurred in the past decade. WRPS has recognized the need for an update of the technical basis document as a Phase 2 improvement action.

The TVAT's concerns about an exposure assessment strategy (OR 4) were that the WRPS IH program was not designed to detect and quantify postulated acute transient exposure events, and that insufficient attention had been given to various control strategies for acute exposures to vapors, such as OEL-Cs and irritation exposure-response thresholds. Although WRPS has indicated that the additional research needed to address some of the TVAT concerns will likely be deferred to Phase 2 of the IP, WRPS has not adequately addressed the more immediate concerns where interim actions have the potential to improve the IH program. For example, WRPS has achieved only limited progress in implementing OEL-Cs for postulated acute exposures, or 10% of the OELs when a ceiling limit is not provided, as a hazard control as recommended by the TVAT.

With regard to workers' compensation (OR 5), Hanford is somewhat different from other DOE sites in its administration of the workers' compensation (WC) program. DOE is the WC self-insurer for the purposes of compliance with the State of Washington Revised Code Title 51, pursuant to a memorandum of understanding between Washington State Labor and Industries (L&I) and DOE. RL is responsible for management and administration of the RL self-insurance program under the terms of the memorandum of understanding. RL contracts with Penser to be the third-party administrator that processes all claims for Hanford employees of site contractors designated in the memorandum of understanding. RL is therefore the "statutory employer" for WC claims of all covered contractors, including WRPS. RL also holds the contract with the medical provider, HPMC. HPMC does not have direct access to WC medical data from outside medical providers and therefore may not receive all pertinent information from Penser related to treatment, because outside medical providers sometimes do not provide all treatment information to Penser. This arrangement creates an obstruction in the flow of injury/illness information from a treating physician through Penser, through HPMC, to the actual employer (WRPS) such that they can conduct effective case management and determine recordability/reportability in accordance with the Occupational Safety and Health Administration (OSHA) and the DOE injury reporting process. Effective case management refers to following cases and working with outside medical providers who provide direct care to aid in expeditious return to work, and to ensure that based on the care rendered (use of prescription medications, use of splints intended to immobilize, etc.), the appropriate OSHA recordability requirements are fulfilled. Although the availability and evaluation of IH monitoring data are part of an evolving process with the addition of new monitoring technologies, the RM8 action associated with communicating the proper interpretation and use of sampling data for chemicals and vapors to medical providers is listed as "complete" in the WRPS IP, not an ongoing activity.

TVAT Response Conclusions

Overall, WRPS line management has made measurable progress in addressing the TVAT recommendations, with oversight by ORP. In many cases, WRPS has taken appropriate actions to address the tank vapor issues, and ORP is providing dedicated resources for oversight. However, there are some key obstacles to resolving the Tank Farm vapor issues. In particular, although WRPS, with ORP oversight, has taken many actions to improve communications regarding vapor issues, the actions

have not been effective in alleviating worker concerns. Such issues as poor definition and closure of action items, needed improvements in identified actions for the IH program, the WC process, and specific items described in Appendix B of this report also detract from effective resolution of the vapor issues. Significant management attention is needed to address these obstacles to success.

5.2 New Technology

Assessment Objective

Determine whether the new technology and supporting equipment selected for tank vapor control and measurement have the potential to be effective in reducing and/or measuring worker exposure.

Overall, WRPS has made measurable progress in the identification, prototyping, and field deployment of new detection equipment. WRPS is using an integrated safety management (ISM) approach as the basis for the selection of new technology and supporting equipment. That is, a systematic and holistic approach is being applied to the Tank Farms and beyond in the identification and analysis of hazards prior to the selection of instrumentation and engineering controls. The focus of Phase 1 is hazard identification and the development and implementation of instrument prototypes. The selection of new detection instrumentation is intended to address current Tank Farm vapor instrument deficiencies with respect to new technologies and to focus on real time and space measurements, remote operation, spectroscopy, wireless communications, and integrating software. While the selected vapor detection instrumentation is commercially available, the field application of this technology, integration, and remote operation are unique to the Hanford Tank Farms.

WRPS selected several different types and quantities of instruments that have been bench-scale tested at Pacific Northwest National Laboratory (PNNL) and are now being pilot-scale tested and deployed in the A Tank Farm (SSTs) and the AP Tank Farm (DSTs). New technology equipment is further described in Appendix B, Section B.7. The design of the new technologies was based on addressing the composite Tank Farm hazards and was not intended for or limited to validating the bolus theory that was expressed in the TVAT report and noted in the IP. Appropriately, detector technology for the identification and analysis of Tank Farm vapors focuses on emissions from the waste tanks, but it may also be useful in detecting fugitive emissions (emissions from sources other than directly from the headspace). For example, the new Proton Transfer Reaction Mass Spectrometry (PTR-MS) mobile laboratory recently identified Tank Farm chemical vapors for which the vapor source was not the waste tanks, and a number of mobile laboratory efforts to date have been based on previous odor events triggering Abnormal Operating Procedure (AOP) 15, *Response to Reported Odors or Unexpected Changes to Vapor Conditions* (i.e., AOP-15 events).

Although not specifically addressed in the IP, WRPS has taken several additional actions related to engineering controls:

- In January 2016, WRPS Engineering completed a report on atmospheric dispersion modeling of 200 East Area Tank Farm actively ventilated stacks and structures to determine their potential for contribution to vapor exposure/odor events, evaluating stack heights, and identifying likely locations for sampling equipment placement.
- Based on the results of the report, WRPS designed and installed exhauster upgrades and stack extensions in the AP Tank Farm, which were turned over to WRPS Operations in late September 2016.
- WRPS is designing a 242-A Evaporator vessel vent extension and is evaluating further actions on the AW Tank Farm, slated for the 2017/2018 timeframe.

In addition to the newly installed Tank Farm detector technologies and progress on engineering controls, technology improvements to the IH rounds and routines programs have been designed to improve the accuracy, data recording, and communication of IH technician (IHT) monitoring data on a real-time basis. The IHT monitoring system being prototyped uses an iPad-based system for the field, replacing manual data logging of direct reading instrument data. The system locates pre-determined monitoring grid points and notifies the IHT to take the required measurements. The data is extracted from the detection instruments directly via Bluetooth and transmitted to the Site-Wide Industrial Hygiene Database.

The respirator cartridge testing station provides a unique measurement and test system for evaluating respirator cartridges when exposed to actual headspace gases. WRPS assembled a team of over 50 workers from various Tank Farm organizations (e.g., IH Sampling, Radiological Control, Engineering, Training, and Planning) to develop and operate the system. The respirator cartridge testing station is further described in Appendix B, Section B.6. The system is designed to determine the breakthrough times of actual headspace vapors for certain respirator cartridges.

Although the respirator cartridge testing station shows promise in evaluating the application of certain cartridges to actual headspace gases, EA noted a few potential limitations (further described in Appendix B, Section B.6):

- The application of the respirator sampling data is limited to the tank from which the sampling data was obtained and the conditions of the tank at the time the samples were obtained.
- The sample volume at the established duration and flow rates may be insufficient to detect vapor concentrations of 10% of an OEL for certain chemicals that have particularly low OELs.
- Although respirator cartridge breakthrough rates vary with pressure, temperature, and humidity conditions, as well as the breathing rate (i.e., sampling rate) of the respirator wearer, only one set of such conditions was obtained for each respirator cartridge test.
- The specific waste tanks selected for sampling were selected partly because of current operations and may not have included the tanks with the greatest number of COPCs present or with the highest vapor concentrations.
- The effort to expedite sampling of a number of tanks may have produced an insufficient quantity of sample data to ensure that the sample results are statistically valid.
- The impact of variations in sample flow rate on respirator cartridge chemical absorption had not been considered or documented.
- WRPS has not fully evaluated the impact of environmental factors (humidity, pressure, temperature, and sample flow rate) on the accuracy, effectiveness, and efficiency of the sampling media.

New Technology Conclusions

WRPS has achieved measurable progress, in a relatively short time, in evaluating and deploying new detector technologies to better detect, characterize, and report the results of potential acute vapor exposures on a real-time basis. WRPS is evaluating multiple detector sensors, dispersion modeling, and real-time software integration technologies, which are being bench-scale tested at PNNL and pilot-scale tested and deployed in the AP and A Tank Farms during Phase 1 of the IP. These technologies have the potential to significantly improve measurement and characterization of vapors at the Tank Farms. However, EA identified several potential limitations in the test protocols for the respirator cartridge testing station.

5.3 Worker Involvement

Assessment Objective

Determine whether Tank Farm workers and medical personnel have been effectively involved in the development and implementation of actions to address TVAT recommendations.

After the vapor events in 2014, WRPS re-established the 12-member CVST, which was originally established in 2012. The CVST consists of 12 members (with 12 alternates), half of whom are members of a bargaining unit, who also serve on the various CVST sub-teams. CVST meetings are open to all employees to attend. The CVST has been active to varying degrees since the TVAT report and has contributed to development and implementation of some of the actions to address the TVAT supporting recommendations. The CVST is WRPS's primary mechanism for giving employees an opportunity to both learn about vapor issues and express their opinions and ideas. The site medical staff has also been active in the CVST.

However, the CVST is a small percentage of the total union-represented population (union-represented members constitute less than one percent of the total union-represented population at the Tank Farms), and very few participants in the EA focus groups reported any involvement in or communications from the CVST. The CVST charter indicates that the External Affairs Manager assigns a Communications Specialist to promote both internal and external communication of the CVST activities; however, interviews indicated that the CVST Communications Subcommittee has not been very active recently. According to interviews, this subcommittee is being revitalized and reconstituted to include a wider cross-section of work groups, but those efforts are not complete, and the results were not apparent from focus groups. Other than the requirement for a Communications Specialist, WRPS has not provided an institutional process to keep workers informed of CVST activities and obtain feedback from workers on CVST activities.

Apart from the CVST, WRPS has no effective mechanisms for routinely involving the WRPS workforce in the selection and implementation of new technologies (with the exception of field IH monitoring instrumentation, where IHTs have been actively involved in the selection of monitoring locations in the Tank Farms). For example, the bulk of the prototype development activities are subcontracted, and subcontractors use their own employees, so WRPS IH and workers have been only minimally involved in these activities.

EA also found little indication of worker involvement (outside of the CVST) in the following activities related to the vapor issues:

- IP development, particularly in the determination of action priorities (i.e., whether the recommendations would be addressed in Phase 1 or in Phase2)
- Developing headspace sampling priorities
- IHT training
- Searching for the sources of fugitive emissions
- Communication strategies for keeping workers informed of vapor issues
- Addressing problems with and improvements in WC processes and communications.

WRPS has not initiated effective processes to solicit workers' input and involvement in addressing TVAT recommendations. Many of the union workers in the focus groups believed that there were no effective mechanisms for workers to provide ongoing input about tank vapor issues, and focus group participants in general shared very few instances of workers suggesting ideas or providing input on how to resolve tank

vapor issues, unless a participant's work directly involved a specific project. The union participants also had a low perception of management's interest in their views.

Worker Involvement Conclusions

Overall, the CVST is a mechanism for giving employees an opportunity to both learn about vapor issues and express their opinions and ideas. However, from a broader perspective, the CVST has not been effective in soliciting worker input and communicating to the entire workforce about Tank Farm vapor issues. Further, WRPS has not otherwise initiated effective processes to solicit worker input and involvement in addressing the TVAT recommendations. As a result, increased management attention and involvement are needed to ensure that CVST activities are representative of worker input and are communicated to the entire workforce, and to ensure that other avenues of communications are available and coordinated to provide an effective suite of communications and fully tap the resources of the workforce in resolving vapor issues.

6.0 RECOMMENDATIONS

EA provides the following recommendations for senior DOE and WRPS line management's consideration for improving program or management effectiveness. Recommendations go beyond the specifics associated with this assessment and are derived from the aggregate consideration of the results.

- **ORP and WRPS should establish and implement strategies that include enhanced, empathetic dialogue regarding ongoing actions, along with notification of and response to events, to promote better communication and improved trust among workers with respect to tank vapor issues.** Consider the following actions:
  - Reinforce and reassure workers that managers want and need to hear their ideas and input on Tank Farm vapor issues and that management will not tolerate any form of retaliation for raising concerns or for providing input or feedback, either from peers or managers. Use safety culture tools and assessments as necessary to address these concerns and to determine whether concerns about retribution or retaliation reach beyond expressing concerns about vapors.
  - Clarify information and briefings regarding vapor events to include an explanation that measurements taken well after the event are not indicative of what was present during the event.
  - Establish a feedback loop with employees to be used after management meetings, fairs, and other communication efforts in order to determine what employees heard and whether communications were effective. Issues raised by workers during such meetings should be collected and tracked to completion. The status should be provided to the individual who asked the question to ensure that it was answered satisfactorily, and then shared with all workers on a regular basis.
  - Implement a system of holding regular focus group meetings with representative cross-sections of employees to obtain real-time feedback on progress in communication initiatives. As stated in the TVAT report summary for OR 9, "holding focus group meetings on a regular basis will help WRPS evaluate the effectiveness of its communications, encourage participation, and assure transparency across interested parties."
  - Promote, encourage, and reward greater worker involvement in the CVST and any other mechanisms for obtaining worker input on formulating and implementing strategies to address tank vapor issues, including the development and deployment of new technologies in the Tank Farms. Ensure that worker involvement is an integral part of new vapor control strategies as Phase 1 results from vapor detection and characterization are finalized and addressed.
  - Expedite improvements to the system for notifying all affected workers of vapor releases. At a minimum, WRPS needs to increase the number of radios available so that every worker entering a Tank Farm can receive timely Shift Office Event Notifications of AOP-15 events.

- Document the overarching goals and objectives for the integrated suite of vapor control measures with respect to the site ISM process, including existing and planned engineering controls as well as the implementation of new detection, abatement, and respirator cartridge testing technologies, and communicate this information to workers.
- Ensure summary reports from HPMC evaluating laboratory results related to group health status in present Tank Farm workers are flowed down to the workforce.

- **WRPS should enhance its management processes for responding to the TVAT recommendations to clearly identify details of the actions, action owners, action status, and objective evidence for closure.** The WRPS issues management system is a potential method. Consider the following actions:
  - Include all Phase 1 actions and Phase 2 actions as they are developed.
  - Include the recommendations of the Parity Gap Analysis described in Appendix B, Section B.2 (e.g., the recommendations concerning design and controls).
  - Include quality assurance elements and assessments in accordance with DOE Order 414.1D, *Quality Assurance*, to ensure the effectiveness of project plan deliverables.
  - Ensure that action status is regularly communicated to and easily accessed by the workforce.

- **WRPS should expedite improvements in the IH program as recommended by the TVAT, including additional tank headspace sampling with a focus on the waste tanks that pose the greatest risk to workers, further development of short-term chemical vapor exposure limits, and update of the COPC list.** Consider the following actions:
  - Establish and implement a strategy to identify the sequence of additional tank headspace sampling based on the tanks that pose the greatest risk. Continue involving Tank Farm workers in developing headspace sampling strategies.
  - Establish and document a technical basis for the current 59-chemical COPC list to account for the 11 additional COPCs added since the IH Chemical Vapor Technical Basis was last updated in 2006. Consider including the data on dimethyl mercury from the ORP mercury and dimethyl mercury exposure assessment report in the next update of the COPC list.
  - Expedite the revision and updating of the IH Exposure Assessment Strategy to make it more useful and consistent with the American Industrial Hygiene Association's *Strategy for Assessing and Managing Occupational Exposures*, including further implementation of ceiling limits as a hazard control as recommended by the TVAT.
  - Obtain ongoing feedback from IH trainers and recent trainees (IHTs and industrial hygienists) to improve the quality of classroom presentations and field on-the-job training (OJT) for new staff.

- **As Phase 2 actions are developed, WRPS should consider refocusing and documenting the analysis and use of engineered controls to reduce the potential for vapor exposures to workers, such as increasing the stack heights for selected tanks. Ensure the participation of IH and other key professionals in the selection and evaluation process.**

- **RL, ORP, Penser, HPMC, WRPS, and other Hanford Site contractors should work together to expeditiously address the obstruction in the flow of injury/illness information. WRPS (and presumably other Hanford Site contractors) need timely and accurate injury/illness information to conduct effective case management to determine recordability/reportability under OSHA and DOE injury reporting processes and, most important, to provide the appropriate services to the workers.** Consider the following actions:
  - Improve communication and trust between the RL WC manager and WRPS (and other contractors') WC representatives.

- Benchmark policies affecting contractors' access to pertinent information for case management and to categorize recordability/reportability issues against other DOE sites with multiple prime contractors. Ensure that the ORP and/or RL legal department is involved in policy improvements.
- Further develop medical and exposure surveillance programs by collecting and maintaining a database of information for all worker health and safety including exposure levels, locations of exposures, and worker reactions to exposures. This information could then be utilized for future epidemiological studies to assist in determining adverse health outcomes to workers exposed to chemical vapors at levels found at the tank farms.

- **The DOE Office of Environment, Health, Safety and Security should consider including the Tank Farm Worker designation in its health studies to determine worker health effects from exposure to hazardous materials associated with DOE operations and in its medical surveillance and screening programs for current and former workers.** This designation is discussed in Appendix B, Sections B.4 and B.5.

- **HPMC should reassess communication protocols to ensure that workers fully understand the medical evaluation activities when workers report symptoms from vapor exposures.** Consider the following actions:
  - Describe the purpose of the tests being performed.
  - Describe the limitations of the tests and procedures for determining potential long-term effects.
  - Better utilize the dedicated risk communicator to have regular, scheduled interactions with the workforce regarding vapor-related activities.

- **HPMC should reassess the laboratory test panel for acute exposures and annual monitoring of Tank Farm workers.** Consider the following actions:
  - Draw samples acutely and 24-48 hours post-event to allow for post-event comparison.
  - Eliminate tests that replicate parameters in other laboratory tests.
  - Implement a heavy metal screening if such elements may be present in an exposure from certain activities (e.g., filter changeout).
  - Routinely reassess the content of exposure laboratory evaluation, recognizing that medical evaluation is an evolving process.

Appendix A
Supplemental Information

Dates of Assessment

Onsite Assessment: June 21-23 and August 1-11, 2016

Office of Enterprise Assessments (EA) Management

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Appendix B
Detailed Analysis of Progress on TVAT Overarching Recommendations

B.1 TVAT OR 1 - Hanford Site contractor and DOE management actively demonstrate commitment to improve the current program and ultimately resolve the vapor exposure concerns.

EA reviewed the current status of Phase 1 actions addressing the recommendations most relevant to OR 1, namely actions listed as completed for RM1a, RM1b, RM1c, RM1d, RM10, RC8, and RC9 (see Appendix C). The remaining 13 actions associated with OR 1 were scheduled to be complete by September 30, 2016, or in some cases may have been recategorized as Phase 2. To understand progress on addressing OR 1, EA focused on management commitment to and oversight of actions taken to address Tank Farm vapor releases, communications with Tank Farm workers, how management has acknowledged the health risks associated with the episodic releases of tank vapors, and enhancements to the IH program.

WRPS management, with ORP oversight, has taken many positive steps and commitments toward addressing the TVAT recommendations, as discussed in other sections of this report. For example, since the exposure events in April through May 2016, WRPS has instituted several different initiatives to improve employee communications (see Appendix B, Section B.9 for further details). Prior to the TVAT assessment, WRPS re-established the CVST, half of whose membership is Tank Farm bargaining unit workers. WRPS has initiated tank headspace sampling and respirator cartridge evaluations to identify the vapors that are present and determine whether various respirator cartridges are effective in a tank vapor environment (see Appendix B, Section B.6 for further details). WRPS is also engaged in pilot-scale testing of real-time vapor detection and measurement equipment arrays in the Tank Farms (see Appendix B, Section B.7 for further details).

In June 2016, WRPS contracted with the Center for Toxicology and Environmental Health (CTEH) to develop presentations for all workers regarding trends and measurements and to put the Tank Farm environment into perspective. CTEH specializes in communications following safety-related emergencies and comprises Certified Industrial Hygienists, physicians, and other safety professionals. CTEH is interviewing IHTs and other personnel to understand issues and develop a communications strategy for FY 2017 for the entire workforce.

ORP has provided significant oversight of WRPS efforts to address the TVAT recommendations and established the IPT to conduct continuing oversight of the TVAT IP. ORP approved the IPT charter on March 26, 2015, and a Vapor Implementation Oversight Plan on June 10, 2015. The IPT meets weekly with the WRPS Project Team to monitor and assess TVAT-related activities performed in accordance with the WRPS field execution schedule. ORP completed 50 operational awareness activities and 4 formal, focused assessments on 3 of the 6 key technical assessment areas outlined in the WRPS IP. ORP also routinely performed less-formal assessments (e.g., Facility Representative surveillances and SME reviews) that addressed various aspects of IP implementation. In addition, ORP established the VMEP, which is composed of external experts and includes two members of the original TVAT team to help ensure that actions committed to since the TVAT report are carried out as intended by the TVAT and are effective in protecting workers from potential vapor exposures. The VMEP is active, meets monthly, and is completing its first annual report.

ORP selected several IP Phase 1 actions (two in 2015 and seven in 2016) for award fee in the Performance Evaluation and Measurement Plan. For example. in the Special Emphasis Area, SEA 7, *Safety Program Implementation,* one evaluation criteria under the Industrial Health and Safety focus area, states: "Demonstrate two-way engagement with the workforce in communicating issues, evaluating options, developing improvements, implementing improvements, and evaluating effectiveness of Tank

Vapors Assessment Team Implementation Plan items." Another evaluation criteria under the Industrial Health and Safety focus area states: "Perform an evaluation of potential Tank Farm vapor hazards and interim control options pending IP Phase 2, to determine the appropriate control set for work within the Tank Farms."

WRPS, with ORP oversight, has expended considerable time and effort to communicate to the workforce regarding the results of vapor exposure monitoring and their plans to improve real-time vapor detection, measurement, and abatement since the reports of vapor exposures in the April/May 2016 timeframe. WRPS management provides considerable routine IH monitoring data that indicates chemical concentrations below the OELs (or zero) to support their message on the safety of the Tank Farm environment. Most of the collected data is not related to vapor events. However, when IH monitoring and sampling is conducted in response to vapor events, it is often performed well after the events occur, leaving ample time for any measurable vapors to subside, and thus is not representative of the concentrations at the time of the event. The monitoring and sampling can be used as clearance samples to allow work to resume.

Focus groups and interviews indicate that a noticeable lack of trust remains between segments of the workforce and WRPS management, particularly workers who have reported being exposed to odors or vapors in or around the Tank Farms and have had symptoms they believe to be associated with the exposure. Communication attempts have not allayed all the fears corresponding to the symptoms that the workers attribute to these exposures. Although WRPS has made numerous communication attempts, EA found none that clearly expressed management's acceptance and acknowledgement that some workers have been affected by vapors in or near the Tank Farms. OR 1 of the TVAT Report stated, "Management must acknowledge the health risk associated with episodic releases of tank vapors" and "workers are nonetheless being affected by vapors on the tank farms. Acceptance of this observation should be communicated to all internal and external stakeholders." EA found little management acknowledgement of health risk or of communications to stakeholders accepting the observation that workers are being affected by vapors at the Tank Farms. Additionally, there is a corrective action (RM 10) stating, "All levels of management demonstrate that they are committed to reducing the potential for Tank Farm vapors releases and continuously improving management systems to assure all workers are properly protected." It is currently listed as "Completed – ongoing activity," but WRPS and ORP have not documented how this action was completed. Many union focus group participants have the perception that WRPS management does not openly acknowledge the risks of tank vapor exposures.

Visible actions in the Tank Farms to perform respirator cartridge testing and to identify and pilot vapor abatement technologies did not begin until mid-2016, giving workers the perception of a significant delay. Union leadership expressed frustration over the fact that the exposure data was typically obtained sometime after the transient exposures occurred, rather than in real time, and was therefore not representative of the conditions when the exposure occurred. The exposed workers want to know exactly what they were exposed to, what the exposure levels were, and what health effects are associated with such exposures.

Most of the WRPS and ORP managers interviewed stated that data collected over many years demonstrates that except for some specific work tasks, the environment in and around the Tank Farms is generally safe for workers and poses little health threat from vapors, based on the existing data. During one of the focus groups, a participant commented, "The feeling that I get after years and years of being told there is nothing hazardous in the vapors is that, although management tells us we need to report odors, they are really not too interested; they've already told us there is nothing there." Some members of WRPS and ORP management expressed frustration because they perceive that some workers will not listen to or try to understand the exposure data presentations and continue to believe that odor equals harm. Management representatives expressed a concern that WRPS messages are being "hijacked" by

current litigation and news media reports that often contain inaccurate information. Managers are also frustrated by their perception that nationally recognized exposure standards are no longer being used or required for determining whether work can be performed; they feel that the union uses odor events to drive requirements, whereas management wants to use documented exposure levels and established Federal guidance. Based on interviews, managers are generally convinced that workers are already well protected from any long-lasting harmful effects due to exposure to vapors/odors in the vicinity of the Tank Farms. However, WRPS has not made measuring changes in worker perceptions a priority. (See Appendix B, Section B.9 for further details on measuring changes in worker perceptions.)

OR 1 Conclusions

ORP and WRPS have demonstrated a commitment to improving the current program and resolving the vapor exposure concerns through the IP, and WRPS has also recently obtained outside expertise to improve communication techniques. Although WRPS management has used several methods to communicate with the workforce regarding vapor exposures, they have not determined whether the communications have been effective. EA observed that distrust between management and the workforce remains an issue. Some workers perceive that odor equates to long-term harm because they believe the odors are an indicator that they are also breathing harmful odorless chemicals that are not being monitored. Management has not been effective in changing that perception.

B.2 TVAT OR 2 - Implement measurable benchmarks to assure operational and cultural parity among chemical vapor, flammability, and radiological control programs.

EA reviewed the current status of Phase 1 actions addressing the recommendations supporting OR 2, namely DR1, DR2, DR 6, (see Appendix C). Appendix B, Section B.3 provides a detailed summary of the status of DR1 and DR2. WRPS expects a National Institute of Occupational Safety and Health (NIOSH) programmatic evaluation performed in July 2016 to address DR6.

To understand progress on addressing OR 2, EA focused on actions that have been and will be taken to ensure that the IH program achieves operational and cultural parity with the radiological control program, including the "as low as reasonably achievable" (ALARA) principle. A goal of Phase 2 is to institutionalize the revised IH program.

WRPS has taken steps to achieve operational parity between the IH program and the radiological control program. A *Parity Review of the WRPS Industrial Hygiene Program Relative to Radiological Protection Program* (Parity Gap Analysis) was completed and issued on April 16, 2015. A subcontractor who is a Certified Health Physicist familiar with the rigor and scope of radiological control programs conducted this review. It contains specific recommendations to enhance the IH program. WRPS is still in the process of evaluating and implementing the recommendations of this review. The Environment, Safety and Health Director and IH Manager are both relatively new to the WRPS organization (each in the position for one year or less) and are still learning about the Tank Farm environment, culture, and history, and they are both actively engaged in bringing the IH program into operational and cultural parity with the radiological control program. There is a history of instability in retaining WRPS Environment, Safety, and Health Directors and IH Managers. In the past five years, WRPS has had seven Environment, Safety, and Health Directors; two were acting and five were permanent assignments. During the same timeframe, there were a total of seven IH Managers; four were IH Program Managers and three were Field IH Managers. Under these circumstances, it is difficult to maintain continuity in management of corrective actions and program improvements.

The WRPS IH Department is planning to complete a Chemical Vapor Guidance Manual in Phase 2 to clearly specify IH procedures and requirements. FY 2016 PBI 19-0, Fee Bearing Milestone #3, is to

prepare a draft Chemical Vapor Guidance Manual. Key portions of the manual are Work Planning and Control of Chemical Vapors (ALARA), Work Planning, Performance Indicators, Communications (internal, external risk), training, Industrial Hygiene Routines, and Enhanced Characterization (sampling – headspace, personnel, and area monitoring). The deliverable is a letter transmitting the performance expectation completion notice and the draft Chemical Vapor Guidance Manual.

In addition, IH is developing a chemical vapor permit/IH permit, which is intended to be similar to the radiological work permits currently in use at the Tank Farms. The Chemical Hazard Awareness Training (CHAT) for all employees has been expanded to include additional aspects of chemical hazard awareness and "hands on" performance. A pilot version of the new training presented in April 2016 has been revised based on recommendations from the initial participants and is currently under review and approval by the IH program. WRPS has hired and trained approximately 100 new IHTs and additional industrial hygienists. Their training was expanded to include more performance-based requirements, an enhanced qualification card process, and OJT with demonstration requirements. Nine industrial hygienists and nine IHTs were initially assigned to the TVAT Chemical Vapors team to assist with IP actions; only two Certified Industrial Hygienists remain on the team due to recent staff resignations. The IHT role has been modified to become more like the health physics technician role, with established rounds and routine monitoring plans aligned with specific work projects (e.g., waste retrieval and tank closure). Industrial hygienists and IHTs are also included in work planning and control processes and pre-job reviews/briefings. The WRPS Chief Technology Officer's vision and methodology for new instrumentation is designed to achieve parity with the radiological controls program through the use of ISM system principles (e.g., detailed hazard analysis, real-time detection and measurement of vapors, substitution of automated systems where feasible, and implementation of vapor abatement technology).

EA observed that the rigor and scope of several aspects of the IH program have improved since the TVAT report. However, WRPS's actions to improve the IH program (e.g., CHAT training enhancements, development of the Chemical Vapor Guidance Manual, and development of a chemical vapor permit/IH permit) are not yet complete. Despite the enhancements, the IH training program still falls short of the rigor evident in the health physics training program – for example, the lack of oral examinations in the IH and IHT qualification process. In addition, WRPS has not conducted any effectiveness reviews of the revised training program. IH management is aware that the training needs to be continually improved but has not made a concerted effort to obtain feedback from trainers and recent trainees to improve the classroom presentations and field OJT for the IHTs.

The specific actions, designated action owners, due dates, objective evidence, effectiveness reviews, and correlation with the recommendations in the Parity Gap Analysis are currently insufficient to determine whether the IH program will be successful in achieving operational parity with the radiological controls program. The IP effort has only partially reached measurable benchmarks to achieve either operational or cultural parity, and the IP does not include all of the recommendations in the Gap Analysis. WRPS lists the actions for RM1a, RM1b, and RM1c as completed and ongoing. All of the other Phase 1 actions listed for OR 2 in the IP are currently listed as "in process" or "scheduled."

Cultural parity with the radiological controls program will take much longer to achieve than operational parity. Because of the large number of new industrial hygienists and IHTs and the limited time they have had to implement the revised program, they have not yet proven to their fellow work project team members that they are an integral part of the work team. True integration and cultural acceptance will be achieved only when Tank Farm workers understand the industrial hygienist and IHT roles and accept them as necessary and valuable. EA asked focus group participants to discuss their interactions with IH personnel by asking, for example, "Are they knowledgeable, easy to understand, receptive and responsive to workers' concerns and input?" Participants voiced mostly positive comments about IH personnel, though several mentioned variability in IHT capabilities because some of them are still relatively new.

Participants also noted that because of the large influx of new IHTs and the lack of more experienced senior people in the field to help them, some IHTs appear to have difficulty in getting up to speed. In the focus groups that EA conducted with IHTs, some said that they believe other work groups view them as a burden, e.g., "we just slow up work progress." Some IHTs believe that other work groups avoid interacting with them and do not value their services.

From the focus groups and interviews, EA gained a perspective about IHT perceptions regarding the IHT training and qualification program. Some IHTs expressed concerns about the adequacy of their training. They stated that their classroom instructors lack sufficient subject matter expertise and field experience. They also expressed that, due to the scarcity of experienced senior IHTs, many of the newer IHTs are not getting adequate OJT and mentoring. One IHT summed it up by saying, "New hires need walk-throughs at every Tank Farm. Some new IHTs crave knowledge. Some have a lot of potential. But they need to be mentored by senior people in the field. They are being thrown out into the field before they know enough."

EA also heard concerns about the accuracy of IHT training records. According to some, records show that IHTs have demonstrated their proficiency on procedures that some never actually performed. They stated that some proficiency evaluations are done in groups, and some questioned whether this is an acceptable testing method because it cannot be determined whether every individual in the group knows how to do the procedure.

OR 2 Conclusions

WRPS has started the process of improving the IH program to meet the expectations of achieving operational and cultural parity with the radiological controls program. However, none of the associated actions specific to Phase 1 are complete, and some of them have been extended into Phase 2. Several workers perceive deficiencies in the capabilities of IHTs because some of them are still relatively new and may not yet be up to speed, and some IHTs perceive deficiencies in their training and qualification program. Cultural parity will take increased WRPS focus and a good deal of time to achieve.

B.3 TVAT OR 3 - Establish a program to sample proactively the headspace of tanks to validate and enhance chemical characterization.

EA reviewed the current status of Phase 1 actions addressing the recommendations most relevant to OR 3, namely SC1, DR1, and DR2 (see Appendix C). To understand progress on addressing OR 3, EA focused on actions addressing the current status of tank headspace sampling and the review of the COPC list. Since the issuance of the TVAT report in 2014, WRPS has made progress in headspace sampling and in developing a process for updating the COPC list, as discussed in the following paragraphs. However, interviews with WRPS indicated that headspace sampling to meet the expectations of SC1 for Phase 1 is unlikely to be performed during waste tank disturbance conditions because of recent waste retrieval work stoppages beyond the control of WRPS. Similarly, discussions with PNNL and WRPS indicated that updating of the COPC list to "ensure it is current" (DR2) will not be completed in Phase 1 as indicated in the WBS Dictionary for DR2, although PNNL is developing a draft process for updating the COPC list as a Phase 1 action. In addition, the current Tank Farm work restrictions on waste-disturbing activities make it unlikely that there will be a "reprioritization of COPCs under tank-disturbing conditions" as envisioned in DR1 for Phase 1, both on the Stoplight Chart and in the WBS Dictionary for DR1. Overall, however, the WRPS plan for headspace sampling described in WRPS TFC-PLN-163, *Industrial Hygiene Sampling and Analysis Plan for Tank Head Space and Exhaust Stack Sampling*, meets the expectations stated in the TVAT report, with the possible exception of measurement of reactive chemical species (e.g., ozone) that prior sampling methods would not have detected.

The TVAT, ORP, and WRPS appropriately judged headspace sampling as a critical activity to better define and/or validate the characterization of the chemical constituents of the tank vapor headspaces, since it is these vapors, once they leave the tank headspace, that are likely to be the chemicals of most exposure concern to Tank Farm workers. Such headspace sampling also serves as the basis for IH monitoring and sampling programs in the Tank Farms, as well as the selection of vapor detection instrumentation, and it is an important activity with respect to identifying and improving engineering controls. The headspace sampling campaign intended to address the TVAT recommendations is well-described in TFC-PLN-163 and in individual tank or farm sample plans. In FY 2016, the six SSTs in A Tank Farm (Tanks A-101 through A-106), as well as one DST (SY-102), have been sampled in accordance with TFC-PLN-163. For each tank, two trains of sample media (e.g., charcoal adsorption tubes, and other sample media) were placed at the upper, middle, and lower levels of the tank headspace to address the potential for vapor stratification within the headspace, resulting in a total of six sample trains per tank headspace. After a period of exposure to the tank vapors, the sample media from each sample train were analyzed in the 222-S onsite laboratory to determine the presence of 156 chemicals, including the current 59 COPCs. In addition to these samples, short-term (10-second) grab samples were collected for Tanks A-101 and A-103, as a validation sample for the sample trains that were placed directly into the headspace. ORP emphasized the need for headspace sampling by incentivizing the collection of a minimum of 20 samples through PBI-19.0, Fee Bearing Milestone #4. ORP specified in the PBI that headspace samples should be collected as described in the applicable tank sampling and analysis plan, and that the plan should identify the type of sample, the technical need for the sampling activity, the location of the sample, and the sampling requirements. The deliverable specified for this activity was to be a letter transmitting the performance expectation completion notice and a copy of the chain of custodies documenting completion of headspace samples and delivery of the samples to the 222-S laboratory. At the time of EA's onsite visit, the samples had been collected in accordance with the plan and WRPS was awaiting the laboratory results.

Prior to the FY 2016 IH sampling campaign, sporadic sampling of the tank headspaces had been performed, but with different and varied goals and objectives. ORP also incentivized headspace sampling in FY 2015 through PBI-14.0, Fee Bearing Milestone #1. ORP specified in the PBI that headspace samples should be collected from 10 independent tanks during non-waste disturbing activities by September 2015. This sampling was to support the development of IH rounds and routines program, chemical cartridge evaluations, sampling protocols, support the Alternative Respiratory Protection Assessments, and to validate/update historical data. In FY 2015, IH sampled 16 additional tanks, but the sampling did not include stratification samples, and in a number of cases (such as four tanks sampled in November and December 2014), samples were collected from the tank risers or exhausts but not the headspace. Other samples were limited in the number of chemicals sampled; some sampling campaigns focused only on a few selected chemical groups, such as nitrosamines, with no samples collected for a number of the other COPCs. From FY 2005 through 2014, additional tank headspace samples were obtained, but the data (which was entered into an older engineering database) is difficult to interpret, did not address a number of the current COPCs, was intended to meet environmental and engineering process goals and objectives, and was not designed for assessing potential worker exposures. From FY 1997 through 2005, several tank vapor samples were obtained from the A Tank Farm. The tanks chosen support characterizing the locations (e.g., A Farm) where most field work will be taking place over the next five to ten years in the Tank Farms. This data suffered from the same deficiencies as previously described, but in addition, it was not validated and did not detect any chemical concentrations above 10% of an OEL. Overall, the numerous waste tank core samples, liquid and sludge samples, and exhauster samples collected over the years (some in support of sampling the hydrogen concentration for determining whether explosive concentrations were present within the tanks) yield some, but limited, tank headspace data relevant to potential worker exposures.

Some of the specific limitations EA identified in the more recent tank headspace sampling, from a worker exposure perspective, are as follows:

- Of the 177 tanks in the Tank Farms, the only data directly useful for assessing and/or validating the presence, location, and abundance of the current 59 COPCs in the tank headspace and meeting all the current IH sampling requirements outlined in TFC-PLN-163 is for the seven tanks sampled in FY 2016.
- With the exception of DST SY-102, all of the FY 2016 data is associated with SSTs. Most of the sampled SSTs have a limited volume of tank waste (generally sludge), comprising only a third of the volume of the tank or less, and thus are likely to have lower chemical concentrations of vapors in the headspace.
- All seven of the recently sampled tanks were in a static quiescent state. Although plans were under way for IH to sample tanks during waste-disturbing activities (e.g., waste transfers or waste mixing) as recommended by the TVAT, waste-disturbing activities are temporarily on hold.
- In 2015, to maximize the effective use of resources, headspace sampling was performed only in conjunction with other Tank Farm activities. In 2016, headspace sampling was expanded to also include those tanks which workers perceived had higher risks. Workers helped select the tanks and tank systems that were tested in 2016.
- Each sample train requires considerable laboratory support for sample analysis. The chemical constituents of the headspaces are key to determining hazard controls, but the samples collected during FY 2016 did not receive the same laboratory analysis priority as the respiratory cartridge samples (see Section B.6). The 222-S laboratory had an analysis backlog of up to six weeks, and headspace samples had not been analyzed at the time of the EA onsite assessment, due to the higher priority of cartridge sample analysis for potentially reducing the use of SCBA.
- The number of samples collected exceeded the initial plan. However, some were impacted due to the stop work and the motion for Preliminary Injunction restrictions/agreements. There are currently no plans for sampling additional tank headspaces before the end of IP Phase 1, and some of the previously planned headspace sampling campaigns have been deferred to Phase 2.
- Some potential reactive chemicals (e.g., ozone) have been postulated through chemical analysis but have not been sampled in the current or prior headspace sampling campaigns.

With respect to the review of the COPC list, EA reviewed the IH Chemical Vapor Technical Basis document, which defines the process for developing and updating the list, and met with WRPS SMEs and staff from PNNL who WRPS has tasked to develop a process for updating the list and adding it to the IH Chemical Vapor Technical Basis document. This is a foundation document designed to: (1) incorporate the development and listing of COPCs; (2) define the chemical OELs and the OEL development process for chemicals that do not have OELs, including chemical health effects; and (3) establish the basis for some field IH instrumentation alarm set points. Conceptually, the IH Chemical Vapor Technical Basis is an excellent document, but it is outdated in a number of areas. Efforts are under way in Phase 1 of the IP for PNNL to develop a process for updating the COPC list contained in this document. By design, at the completion of Phase 1 of the IP, the IH Chemical Vapor Technical Basis document, which was last updated in 2006, will not have addressed a number of key TVAT concerns or concerns identified by EA during this assessment. For example:

- The potential exposure to workers from chemical carcinogens in the tanks is not addressed.
- The revised COPC list includes 11 additional chemicals of concern that are not described in the IH Chemical Vapor Technical Basis or elsewhere, and the technical basis for adding these chemicals is not documented in the IH Chemical Vapor Technical Basis.
- Synergistic effects on worker exposures (i.e., the effect of exposure to multiple chemicals that is potentially greater than the sum of their individual effects) have not been addressed.
- A number of chemical OELs and knowledge of health effects have changed since 2006, but the IH Chemical Vapor Technical Basis has not been updated to reflect these changes.

- Skin effects of chemicals are not addressed in the technical basis, although a standalone Tank Farms report is on file for skin exposure and personal protective equipment requirements for Tank Farm condensate associated with Tank Farm operations.
- WRPS has not updated the technical basis for the continued use of a 2 ppm alarm limit for volatile organic compounds (VOCs), which does not reflect the mix of known or postulated COPCs in the Tank Farms. The primary direct reading instruments deployed in the Tank Farms for detecting total VOCs are photon ionization detectors (PIDs) that generate an alarm when they detect VOCs over the alarm limit of 2 ppm. However, the original basis for this 2 ppm alarm set point was established before 2006, when the limit of detection of the PID instrumentation was 1 ppm. The PID alarm of 2 ppm was established based on this 1 ppm detection limit multiplied by a factor of two to limit the number of spurious alarms. At that time, there was no correlation between the 2 ppm limit and the mix of chemicals assumed to be in the waste tanks or in the farms. However, during the past 10 years, PID instrumentation has evolved, detection capabilities have improved, and more is known or hypothesized about the mix of chemicals in tank vapors likely to be detected in a Tank Farm, such as the Tank Farm Vapor Information Sheet (TVIS) short list of priority chemicals. The current alarm set point for VOCs does not reflect the advances in PID detector technology or the projected mix of VOCs in the Tank Farms; it is based solely on an outdated PID detection limit, with no direct relationship to the chemicals to which a worker may be exposed. In 2015, ORP requested that the new headspace data include direct reading instrument readings for a comparative analysis against the laboratory results to reassess the validity of the 2 ppm action limit for acute toxicants. That process was not executed. However, in late 2015 WRPS conducted a reassessment of the action limit and recommended, internally, a reduction to 1 ppm. WRPS actions are pending.

Although the IP indicates that headspace sampling activities will continue beyond FY 2016, headspace sampling during waste-disturbing activities has been temporarily suspended, as previously discussed.

OR 3 Conclusions

WRPS has embarked on a headspace sampling campaign that is designed to support the collection and analysis of headspace samples to support improvements in IH monitoring and sampling, engineering controls, and the optimal selection of detection instrumentation in the field as envisioned by the TVAT. A well-designed headspace sampling campaign, such as that described in TFC-PLN-163, is critical for assessing potential worker exposures, evaluating and modifying field vapor detector instrumentation and IH sampling and monitoring programs, and designing and implementing engineering controls. However, much remains to be done in obtaining and analyzing headspace data in accordance with the current plan. Similarly, the IH Chemical Vapor Technical Basis document, which has not been updated since 2006, is out of date in a number of areas that are important in assessing potential worker exposures, particularly with respect to the COPC list, chemical health effects, and changes in OELs over the past decade. WRPS has recognized the need for an update of the technical basis document as a Phase 2 improvement action.

B.4 TVAT OR 4 - Accelerate development and implementation of a revised IH exposure assessment strategy that is protective of worker health and establishes stakeholder confidence in the results for acute as well as chronic exposures.

EA reviewed the current status of several Phase 1 actions addressing the recommendations most relevant to OR 4, namely RCH4a and RCH4b (see Appendix C). To understand progress on addressing OR 4, EA focused on actions addressing procedures and strategies for identifying and addressing both chronic and acute vapor/gas exposures.

With respect to the identification, detection, and evaluation of any acute transient vapor/gas exposures, a number of instrument prototyping and software development projects were initiated in Phase 1, although

full-scale implementation of these actions addressing OR 4 has been deferred to Phase 2 of the IP. For example, prototype detection technologies are being implemented in a DST farm (AP Tank Farm) and in an SST farm (A Tank Farm); these technologies offer the possibility of better detecting and characterizing short-term tank vapor releases throughout the Tank Farm (see Appendix B, Section B.7). In addition, to better detect short-term acute exposures, WRPS has developed or expanded IHT monitoring in and around the Tank Farms through an enhanced vapor monitoring program for routine surveillance and detection of selected tank vapors (i.e., VOCs, ammonia, and mercury) at the Tank Farm fence boundaries, and an expanded IH rounds and routines program for detecting selected tank vapors from within the Tank Farms at selected monitoring points. The IH rounds and routines program (an activity indicated on the Stoplight Chart for RCH4a) has consolidated monitoring activities on the A and AP Tank Farms, and typically rounds are performed twice per week. The enhanced vapor monitoring program is similarly focused on the same farms. Rounds for the enhanced vapor monitoring program are performed twice per shift, and the monitoring results for VOCs, ammonia, and mercury are documented and reported to the workforce in the daily report. EA reviewed both programs and concluded that overall, when combined, these activities provide another beneficial way to potentially identify and document short-term or elevated vapor levels within the Tank Farms. There are, however, a few areas where the programs are not fully effective: (1) the selected monitoring locations do not include non-waste tank fugitive emission sources, as discussed in Appendix B, Section B.7; (2) there is no documented basis for the frequency of performing the rounds; and (3) EA noted that the data logging function of the instruments is not always used and therefore does not record data between monitoring locations.

Accelerating the development of a revised IH exposure assessment strategy (as recommended by the TVAT in this OR) is, according to WRPS, contingent on receiving the results of headspace sampling (see Appendix B, Section B.3). The TVAT also recommended implementing the OEL-C or 10% of the OEL as an exposure control, including the use of the American Conference of Governmental Industrial Hygienists (ACGIH) exclusion rule "for a rapid selection of limiting values for the 500 or so chemicals for which OELs have been established." WRPS has deferred the revision of the IH exposure assessment strategy to Phase 2, since (as stated in the IP) developing postulated bolus exposure limits will require new technologies to measure these transient events, which have not been observed with existing field instruments. In addition, WRPS's IP response to the TVAT OR stated that for many chemicals, bolus OELs determined from scientifically validated health studies are not available and may need to be developed by external experts. Although EA concurs that some COPCs may not have short-term ceiling limits and will require further study in Phase 2, several changes to the existing IH exposure assessment strategy and more use of known ceiling limits for acute exposures could be implemented in the interim as recommended by the TVAT. For example:

- The current WRPS *Industrial Hygiene Exposure Assessment Strategy Procedure* (TFC-PLN-34) does not provide any guidance on when and how to document an exposure assessment consistent with the American Industrial Hygiene Association (AIHA) publication *A Strategy for Assessing and Managing Occupational Exposures* (a referenced document in TFC-PLN-34). Attachment A of TFC-PLN-34 provides a useful worksheet for documenting a qualitative exposure assessment. However, based on EA's limited sampling of work activities and interviews, this form is not routinely completed for each work activity. Section 2.4 of the procedure instructs industrial hygienists to develop written hazard and exposure assessments, but it is not clear whether the intention is only to complete the Exposure Assessment Worksheet of Attachment A or something else. TFC-PLN-34 also references the Job Hazards Analysis process, which may serve as a useful documented hazard analysis but does not meet the expectations for an IH exposure assessment as set out in the "Definitions" section of the same procedure, and does not include an evaluation of health risk. Many of the WRPS IH sample plans that EA reviewed are excellent vehicles for prescribing sampling and monitoring requirements for specific work activities, but they are not exposure assessments since they do not include an evaluation of health risk as defined by the AIHA. Even so, the sample plan document identifies many of the sample plans as "exposure assessments."

- A chemical exposure hazard assessment, an element of the exposure assessment process, is conducted but not always clearly and consistently documented for each TVIS or when a TVIS is updated, as required by TFC-ESHQ-S IH-C-48, *Managing Tank Chemical Vapors*.
- WRPS has achieved only limited progress in implementing OEL-Cs for acute exposures (or 10% of the OELs where ceiling limits are not provided) as a hazard control, as recommended by the TVAT. For example, TVISs continue to be based only on 8-hour time-weighted average exposures. Although some chemicals may not have well-established ceiling limits, WRPS has not fully used the known ceiling limits or excursion limits defined by ACGIH. An exception is the IH sample plans, which include sampling for ammonia, formaldehyde, VOCs, mercury, and nitrosamines for comparison to short-term exposure limits and ACGIH-based exclusion limits, as well as time-weighted averages.
- Although there have been significant efforts to define and implement a designated medical surveillance group for vapors and vapor-related work tasks, similar groups have not been developed for non-vapor worker exposure groups (e.g., shop welders) as required by TFC-PLN-34. (See related discussion in Section B.5.)

OR 4 Conclusions

WRPS has expanded the IH rounds and routines program and has initiated an enhanced vapor monitoring program that when combined, provide another beneficial way to potentially identify and document short-term or transient elevated vapor levels within the Tank Farms. The TVAT's concerns with respect to OR 4 was that the WRPS IH program was not designed to detect and quantify acute transient exposure events and that there was insufficient attention to various control strategies for acute exposures to vapors, such as OEL-Cs and irritation exposure-response thresholds. WRPS has indicated that the additional research required to address some of these TVAT concerns will likely be deferred to Phase 2 of the IP. However, WRPS is not adequately addressing the more immediate interim actions that could improve the IH program, such as development and implementation of a revised IH exposure assessment strategy or development of OEL-Cs for acute exposures (or 10% of the OEL as a ceiling where ceiling limits are not provided) as a hazard control.

B.5 TVAT OR 5 - Modify the medical case evaluation process and reporting procedures to recognize the appropriate uses and limitations of the available monitoring data and other potential exposure information when evaluations are made regarding tank chemical vapor exposures.

EA reviewed the current status of actions addressing the recommendations most relevant to OR 5, namely RCH2, RCH4c, and RM8 (see Appendix C). To understand progress on addressing OR 5, EA focused on actions addressing WC issues, toxicological studies, and medical protocol for Tank Farm workers. In addition to actions taken by WRPS management and staff, EA reviewed actions taken by RL, HPMC managers, SMEs, and medical staff members.

WRPS designated both actions supporting recommendation RCH2 to be completed in Phase 1. These actions are being addressed through a contract with PNNL; results are anticipated in 2017 and thus will not meet the Phase 1 commitment date. RCH4c recommends long-term epidemiological studies of Tank Farm workers. Based on review of the VMEP draft proposal, neither this proposal nor the NIOSH yet-to-be-determined study is expected to answer the issue. RM8, addressing communication to medical providers, is reported as completed in Phase 1. The communication may have been considered completed by the interactions between the HPMC Medical Director and Kadlec emergency department staff, and development of a new lab request form for Tank Farm exposures. However, validation of the process indicated that regular re-enforcement is required. Also, these actions do not address the education of external medical providers of WC cases to help them determine work-relatedness. Educating treating physicians to the requirements of OSHA recordability and the need to provide information on the level of

care (prescription medications, splints intending to immobilize, etc.) so that employers can properly categorize and record the injury/illness to comply with OSHA regulations would significantly improve the process.

OR 5 of the TVAT report conveyed a concern that IH data was inappropriately used to determine the validity of workers' medical claims. The report stated that it is important to accept that individuals are being exposed to work-related vapors in and around the Tank Farms and experiencing real symptoms. From an occupational medicine perspective, the key issues related to this recommendation were threefold:

1. Realize that if IH exposure data is used to determine the work-relatedness of an exposure, then an understanding of the limitations of such values and a better characterization of the possible toxicants causing symptoms will improve acceptance of WC claim validity.
2. Accept that Tank Farm workers have likely been exposed to waste tank or other vapors and respond accordingly.
3. Develop processes/protocols to monitor the Tank Farm Worker as a unique category of worker in the near and distant future (see discussion under RCH4c, below).

The TVAT recommended enhancing IH data gathering and characterization because of Hanford workers' perception that such data determined the work-relatedness of an injury/illness and therefore impacted the acceptance of their WC claims. Interviewed employees perceived that the third-party administrator, Penser, likewise uses IH data to accept or deny claims based on work-relatedness, even though Penser does not actually accept or deny claims (L&I accepts and denies claims). EA observed essentially the same perceptions as the TVAT report described in 2014.

Penser stated that it does not use IH data to determine recommendations of claim acceptance when submitting its recommendations to L&I. However, Penser does pass IH data to L&I-approved medical providers who render care and make WC determinations (i.e., determining whether an injury/illness is work-related). The raw IH data usually does not have a cover letter explaining the meaning and limitations of such data with respect to work-relatedness. Therefore, raw IH data stating that toxicants were below 10% of the OEL should not be used to determine work-relatedness of an injury or illness because the context of the sampling results is not known. Additionally, the process does not include an explanation of the time between the event and the sampling data, the inability to sample for all toxicants in the COPCs (as well as others), and the effect of synergy among toxicants. When IH data is passed to the private medical community, the medical providers may conclude that the injury/illness is not work-related based on that information, because most private medical specialists have minimal background in interpreting raw IH data and the probability of claim denial may increase.

In addition, workers perceive access to claim filing/medical evaluation to be difficult. Some claimants perceive that help in navigating the WC process for appropriate medical evaluation is lacking. Although WRPS (like most other contractors) has a WC point of contact dedicated to this task, workers expressed complaints in this area. The RL WC Manager is also available to provide help for employees if requested. Based on EA's interviews, communication between the WRPS WC point of contact and the RL WC Manager appears to be non-existent.

Hanford is somewhat different from other DOE sites in its administration of the WC program. DOE is the WC self-insurer for the purposes of compliance with Washington Revised Code Title 51, pursuant to a memorandum of understanding between L&I and DOE. RL is responsible for management and administration of the DOE self-insurance program under the terms of the memorandum of understanding. RL contracts with Penser to be the third-party administrator that processes all claims for Hanford employees of site contractors designated in the memorandum of understanding. RL is therefore the "statutory employer" for WC claims of all covered contractors, including WRPS. RL also holds the contract with the medical provider, HPMC. Other sites' medical providers can contact and consult with

treating physicians in WC cases and obtain pertinent information. Other sites' medical providers can also treat occupational illnesses/injuries based on their capabilities. HPMC is limited by contract to first aid treatment only. HPMC does not have access to WC data from outside medical providers, and therefore may not receive all pertinent information from Penser related to treatment, as outside medical providers sometimes do not provide all treatment information to Penser. Although not specifically cited in the TVAT report, EA observed that this arrangement creates an unnecessary obstruction in the flow of injury/illness information from a treating physician through Penser, through HPMC, to the actual employer (WRPS) such that they can conduct effective case management and determine recordability/reportability under the Occupational Safety and Health Act and the DOE injury reporting process. Effective case management refers to following cases, working with outside medical providers who are providing direct care to aid in expeditious return-to-work, and to ensure that, based on the care rendered (use of prescription medications, use of splints intended to immobilize, etc.), the appropriate OSHA recordability requirements are fulfilled.

Employee WC medical data can only be shared with other DOE Federal employees with a need to know, but still not with the contractors' case managers or WC representatives who must make case determinations for their companies. For contractors, even if procedures to obtain the information are put in place, access to the information is still denied.

In addition, the HPMC return-to-work process does not always inform the employee's managers and safety representatives of information they need to determine recordability. An example is the use of prescription medication. The Site Occupational Medical Director expressed the impression that contractors had access to pertinent information through Penser.

The unusual limitation of access to the WC data not only impedes a company's responsibility for case management for its employees, but also contributes significantly to the distrust that exists between the workforce, the contractor WC representatives, and the RL/Penser processes.

Progress in each of the recommendations most pertinent to OR 5 is discussed in the following paragraphs.

RCH2: *Classify and conduct toxicological testing on a reasonable number of distinct types of Hanford tank headspace vapors (e.g., potential classes of tank vapor types such as ammonia rich, ammonia poor, nitrosamine rich).*

WRPS has contracted with PNNL to evaluate the toxicology of identified headspace toxicants. Literature searches are in process to research the toxicology of even minor identified constituents and potential interactions in the headspace. If completed as designed, this process may address some of the concerns related to the toxicology of potential toxicants to which Tank Farm workers may be exposed (IH sampling improvement is also part of the process). Conveying this information to the workforce is important to address concerns that potential harmful toxicants are not characterized or understood. Characterization of chemicals is important, but because of sampling time delays and the possibility that a grab sample may not provide for sampling of all possible toxicants, the immediate toxicant causing adverse effects(s) may not be documented. Workers with potential exposures should receive evaluation and treatment based on symptomology, not based on IH data alone.

RCH4c: *Routine medical surveillance is a key workplace evaluation tool needed to predict health impairment from vapor exposures; appropriately designed epidemiology studies focused on Tank Farm workers are recommended to evaluate potential long-term health consequences.*

EA reviewed the Phase 1 actions for this TVAT recommendation. The first action – to update the employees' job task analyses to include review of the medical surveillance program for chemical

compounds found in the current IH technical basis – was noted as completed. However, there are no documented plans to re-visit updating the employees' job task analyses after each future revision of the IH technical basis document (see Appendix B, Section B.3 for further discussion of the recommendation to revise the IH technical basis document). The second Phase 1 action, which is to support the study and evaluation and potential development of epidemiology studies focused on long-term health consequences, will not be fully addressed by September 30, 2016. The VMEP proposed a study of L&I WC claims from January 2012 to the present, but this does not address long-term health consequences. In 2012, "Tank Farm Worker" was designated as a separate and unique (Hanford) surveillance group, to allow HPMC to monitor this cohort at Hanford. Approximately 55 WC claims related to Hanford Tank Farms have been filed since 2012. In addition, some individuals who felt they had sustained a vapor injury were not entered in the L&I process. Total claims contain a majority who had cost reimbursement, and those with pathology are a very small subset of that number. Such a small sample size makes generalization to the entire Tank Farm workforce questionable. HPMC also indicated that a new ($750,000) medical record document system, to enhance data gathering, will be initiated in 2017.

RM8: *Modify the medical case evaluation process and reporting procedures to recognize the appropriate uses and limitations of the available monitoring data and other potential exposure information when evaluations are made regarding vapor exposures.*

The potentially inappropriate use of IH data to confirm/deny WC claims and the difficulty in WC data flow for reporting procedures were discussed earlier in this section.

Additionally, the TVAT stated that risk communication to the workforce required improvement. Two aspects of that effort have not been fully effective: the individual HPMC/worker interface, and the dissemination of information to the workforce by knowledgeable medical professionals.

With respect to the individual HPMC/worker interface, the HPMC exposure protocol is not fully effective. In one case, a symptomatic employee exposed to ammonia vapors with objective findings (changes to pre- and post-bronchodilator pulmonary function tests) was returned to the workplace without restrictions by HPMC after administering prescription medication. Returning the employee to the workplace without restriction supported WRPS management's perception that no significant exposure occurred. Even though this employee continued to interact with the HPMC medical practitioner daily, the symptoms worsened until the worker had to be taken from the workplace directly to the Kadlec Emergency Department on the third day after the event. HPMC's existing protocol does not mandate physician evaluation of such cases or immediate hospital transfer of exposed employees with symptoms causing distress. Although this case does not negate the sound occupational medicine usually demonstrated by HPMC, it demonstrates a weakness in the process.

EA's evaluation of this case noted that three months after the exposure event, while the employee was still under a personal physician's care, WRPS classified this as a first aid case, and Penser had not completed the WC determination. The WRPS IH data documented the employee exposures below 10% of OEL. The lack of medical information available to WRPS to associate the employee's time away from work with the exposure event resulted in WRPS classifying this as a first aid case instead of a lost-time recordable case.

For the most part, the prescribed lab panel of medical tests for suspected acute exposures and the annual monitoring of the Tank Farm Worker group are adequate. Some tests in HPMC's bloodwork lab panel during annual physicals have significant value, such as screening for the metabolite of benzene (which is found in at least 46% of tank headspaces) and screening for mercury (because organic and elemental mercury are present in the tanks).

HPMC's communications to the workers are not fully effective. EA conducted two focus groups with workers who had reported symptoms from vapor exposures in or around the Tank Farms, and also directly interviewed four workers reporting symptoms who were not part of the focus groups and several others from focus groups addressing other criteria. The workers did not always seem to understand what test results meant and what was being evaluated, and there was concern about "screening for the right things." These findings indicate that HPMC has not adequately communicated the purpose of the tests being performed.

A dedicated risk communicator is on the HPMC staff but is not being fully utilized to address the identified concerns. The risk communicator's interactions with the workforce are ad hoc, and although talks to the CVST are helpful, the information does not always flow down to the workforce. HPMC also has an epidemiologist on staff who generated an annual report evaluating laboratory results related to organ function in present Tank Farm workers. This report compared the Tank Farm Workers group to a standard population without Tank Farm workers (Washington Closure Hanford); this study concluded that there did not seem to be any significant difference between the Tank Farm Workers and the non-Tank Farm workers, according to their laboratory test results. However, this report did not flow down to all Tank Farm workers.

There is a good interface between HPMC and the Kadlec Medical Center emergency department. It is a busy emergency department, but has dealt with relatively few Tank Farm exposure events. EA's examination of the implementation of the Hanford Tank Farm Worker vapor exposure protocol indicated that the Kadlec emergency department staff does not universally understand and cannot easily access this protocol. HPMC has worked with the Kadlec Medical Center emergency department to get the Hanford vapor exposure laboratory protocol on its laboratory requisition slip, which will be associated with the Tank Farm Worker protocol. Implementation is imminent and will be a positive step in ensuring the consistency of initial evaluation of potentially exposed workers.

OR 5 Conclusions

HPMC is identifying adverse effects of potential toxicants on the Tank Farm worker population, which is a positive step. RL professionals who determine WC claims may not fully understand the limitations of IH data collected from an event. Additionally, the treating physicians external to HPMC are not provided an explanation of the limitations on use of IH data. All responsible entities have not fully accepted that workers can be and have been affected by chemical vapors during Tank Farm activities. Consequently, workers have not received the support needed to effectively navigate the WC process. Mechanisms for long-term monitoring of the workforce have not been developed or implemented sufficiently to understand resultant health impacts. Additionally, contractors' access to their employees' information on WC cases is not readily available to those with a need to know so they can properly categorize and report cases in accordance with Federal law and DOE requirements. HPMC's communications to the workers are not fully effective. The dedicated risk communicator on the HPMC staff is not being fully utilized to address the identified concerns.

B.6 TVAT OR 6 - To reduce the impacts of bolus exposures, utilize real-time personal detection and protective equipment technologies specifically designed to protect individual employees.

EA reviewed the current status of Phase 1 actions addressing the recommendations most relevant to OR 6, namely EA1, RM6, and RM7b (see Appendix C). To understand progress on addressing OR 6, EA focused on the development and expedited deployment of new technologies for real-time response to detect vapor plumes from stack vents and fugitive emission sources and confirmation that respiratory protective equipment is effective in reducing exposure to tank vapors to below acceptable levels through new respirator cartridge testing technologies.

OR 6 and OR 7 both address detector technology development: OR 6 focuses on real-time personal detection, while OR 7 focuses on new facility detection technologies and engineering controls. The TVAT supporting recommendations referenced above are applicable to both ORs. EA's evaluation of OR 6 focused on new technologies in general (personal and field detection technologies), and evaluation of OR 7 focused on engineering controls and fugitive emission sources.

With respect to the evaluation and deployment of new detector technologies to better detect, characterize, and report the results of potential acute vapor exposures on a real-time basis, WRPS has achieved observable progress in a relatively short time. WRPS is evaluating multiple detector sensors, dispersion modeling, and real-time software integration technologies and is bench-scale testing them at PNNL and pilot-scale testing them in the selected Tank Farms (AP and A Tank Farms) during Phase 1 of the IP. PBI-19.0, Fee Bearing Milestone #1, is to complete the Chemical Vapor Implementation Plan activities for the Technology Readiness pilot-scale demonstration phase for vapor monitoring and detection equipment system(s). WRPS must complete phased testing and provide the documented basis (final test report) for vapor monitoring and detection equipment systems by September 30, 2016.

As described by the WRPS Chief Technology Officer, WRPS is using an ISM approach as the basis for selecting new technology and supporting equipment. That is, WRPS is applying a systematic and holistic approach to identify and analyze hazards in and around the Tank Farms before selecting instrumentation and engineering controls. The focus of Phase 1 is hazard identification and the development and implementation of instrument prototypes. The selection of new instrumentation is intended to address current Tank Farm vapor instrument deficiencies and to focus on real time and space measurements, remote operation, spectroscopy, wireless communications, and integrating software. The selected vapor detection instrumentation is commercially available, but the field application of this technology, integration, and remote operation are unique to the Hanford Tank Farms. The new Phase 1 Tank Farm vapor detection technology is being bench-scale tested at PNNL and pilot-scale tested and deployed in the A Tank Farm (SSTs) and the AP Tank Farm (DSTs). New technology equipment includes direct reading instruments (installed and mobile) for detecting VOCs, ammonia, and other chemicals; spectroscopic equipment, which provides chemical speciation information for numerous VOCs; meteorological instrumentation; and remote grab sample capabilities. In addition, a PTR-MS mobile laboratory capable of detecting 46 of the 59 COPCs is providing general Tank Farm area monitoring for VOCs and background air monitoring. The design of the new technologies was based on the composite Tank Farm hazards; it was not intended solely to validate the bolus theory expressed in the TVAT report and noted in the IP. Appropriately, detector technology for identifying and analyzing Tank Farm vapors is not limited in application to emissions from waste tanks. For example, the new PTR-MS mobile van recently identified Tank Farm chemical vapors for which the vapor source was not the waste tanks, and a number of van activities to date have been based on the locations of previous AOP-15 odor events.

During Phase 1, WRPS has also been field testing new personal chemical detection devices to enhance real-time detection of worker exposures through the use of state-of-the-art direct reading instruments. Commercially available personal direct reading instruments being field tested in the Tank Farms include wireless chemical badges, photoionization detectors for VOCs, portable six-gas monitors, and ammonia monitors. Each of these personal chemical detection monitors has wireless capabilities such that monitoring results can be communicated and integrated into a centralized software analysis and reporting system on a real-time basis.

In addition to the newly installed Tank Farm detector technologies and real-time personal chemical detection monitors, technology improvements to the IH rounds and routines programs have been designed to improve the accuracy, data recording, and communication of IHT monitoring data on a real-time basis. The IHT monitoring system being prototyped uses an iPad-based system for the field, replacing manual data logging of direct reading instrument data. The system locates pre-determined monitoring grid points

and notifies the IHT to take the required measurements. The data is extracted from the detection instruments directly via Bluetooth and transmitted to the Site-Wide Industrial Hygiene Database.

Overall, WRPS has made measurable progress in the identification, prototyping, and field deployment of new detection equipment. However, EA identified two areas where implementation of the TVAT recommendations has not been fully effective:

- Although the objectives for individual detection systems are well documented, the overarching goals and objectives for the integrated suite of vapor control measures, including existing engineering controls, as well as design and implementation of new IH detection and sampling instrumentation technologies, are not well documented. Although there is no documented overarching plan that identifies the goals and objectives for the design of new technologies with respect to ISM, there are individual plans or reports for: (1) CVST Technology Down Select; (2) Technology Maturation Plan; (3) Bench Scale Test Plan; and (4) Pilot Scale Test Plan. Collectively, however, these documents do not adequately describe the overall goals and objectives for the design and implementation of new technology in the Tank Farms, particularly as it relates to ISM.
- The overarching goals and objectives for the selection and implementation of new technologies have not been adequately communicated to the workforce. Apart from some CVST technology education efforts and an "instrument day," WRPS has not implemented a well-designed, ongoing, coordinated effort to inform the workforce of new and emerging technologies (i.e., no communication plan). Similarly, apart from the CVST, WRPS has limited mechanisms for routinely involving workers in the selection of new technologies, except for field IH monitoring instrumentation. (See further discussion in Appendix B, Section B.9.)

With respect to TVAT Recommendation RM7b concerning the effectiveness of current respiratory protective equipment in reducing potential worker exposures to tank vapors, WRPS has made progress by: (1) increasing the reliance on supplied air for workers in both the SST and DST farms until the source of tank vapors is better characterized; and (2) developing and prototyping a state-of-the art respirator cartridge testing station.

The respirator cartridge testing station provides a unique measurement and test system for evaluating respirator cartridges when exposed to actual headspace gases. Air purifying respirator cartridges have been tested in six locations: the AP exhauster, three DSTs (Tank SY-102, BY-108, and AX-101), one SST (Tank A-101), and the AZ 702 stack. Operation and changeout of the sample media associated with the respirator cartridge testing station is labor intensive. To meet this challenge, WRPS assembled a team of over 50 workers from various Tank Farm organizations (e.g., IH Sampling, Radiological Control, Engineering, Training, and Planning) to develop and operate the system. The initial test on the AP exhauster included two cartridges with 16 hours of run time on each cartridge, swapping out media every two hours. The 222-S laboratory on site is analyzing the sample media on a priority basis. Due to the magnitude of IHT resources and analytical support required for each respirator cartridge test, WRPS revised the respirator cartridge test plan from testing 14 cartridges from 4 respirator cartridge vendors to 2 cartridges (a particulate and organic vapor combination cartridge and a chemical-only cartridge) from 1 vendor. The respirator cartridge testing system has the potential to determine the level of breakthrough of certain respirator cartridges against actual headspace vapors, but EA noted a few potential limitations:

- The application of the respirator sampling data is limited to the tank from which the sampling data was obtained and the conditions of the tank at the time the samples were obtained. The respirator cartridge breakthrough sample data assumes a mix and concentration of headspace or exhauster chemical vapors that is unique to the tank being sampled and at the time the tank was sampled. If the tank contents are disturbed, such as though a retrieval process, it is not evident that the respirator cartridge sampling data would remain valid.

- Although each respirator cartridge test is 16 hours in duration, sample media are exchanged every two hours during the 16-hour period. The sample volume collected during the two-hour period at the established sample flow rates may be insufficient to detect vapor concentrations of 10% of an OEL for certain chemicals that have particularly low OELs. The sample flow rate for the absorbent material was set in accordance with the appropriate analytical method used for each analyte, ranging from 33 mL/min to 2000 mL/min.
- Respirator cartridge breakthrough rates vary with pressure, temperature, and humidity conditions, as well as the breathing rate (i.e., sampling rate) of the respirator wearer. Only one set of such conditions was obtained for each respirator cartridge test and was based on the pressure, temperature, and humidity of the vapor in the headspace or exhauster and not the environmental conditions of the respirator wearer. It was not clear whether the sampling data would be valid for all cases or would need to be modified if these environmental conditions changed.
- The specific waste tanks selected for sampling have been limited because of current operations and may not have included the tanks with the greatest number of COPCs present or with the highest vapor concentrations.
- The effort to expedite sampling of a number of tanks may have produced an insufficient quantity of sample data to ensure that the sample results are statistically valid. PBI-19.0, Fee Bearing Milestone #2, is to complete a chemical cartridge effectiveness evaluation for bounding tanks (four) based upon tank mixtures.
- The impact of variations in sample flow rate on respirator cartridge chemical absorption has not been considered or documented. If several types of powered air purifying respirators are planned for use, each with a different flow rate, then knowledge of sample flow rates is important in determining the respirator cartridge changeout schedule.
- WRPS has not fully evaluated the impact of environmental factors (humidity, pressure, temperature, and sample flow rate) on the accuracy, effectiveness, and efficiency of the sampling media. For example, the CVST report on the status of respirator cartridge testing presented during the EA visit indicated that no data could be obtained for several of the recently tested cartridges because of unexpected humidity concerns in the headspace vapor samples. Most of the test data from the AP Tank Farms sample tube media, as well as the data from three samples from Tank A-101, was lost due to high humidity in the influent vapor streams.

OR 6 Conclusions

Overall, WRPS has made measurable progress with respect to the identification, evaluation, and implementation of new detector technologies, at least on a prototype scale, and with prospects for respirator cartridge testing with actual headspace vapors. Initial data on the performance of these new detector and respirator cartridge testing technologies is being gathered and validated. However, the potential limitations on the respirator cartridge testing have not been fully identified and sufficiently evaluated. Furthermore, WRPS has not documented the overarching strategy for selecting and implementing the new detector technologies and has not adequately communicated this strategy to the workforce.

B.7 TVAT OR 7 - Accelerate implementation of tailored engineering technologies to detect and control vapor emissions and exposures experienced in the Hanford Tank Farms ("Tank Farm of the future"[2]).

EA reviewed the current status of Phase 1 actions addressing the recommendations most relevant to OR 7, namely SC3 and SC4 (see Appendix C). To understand progress on addressing OR 7, EA focused on actions associated with fugitive emissions, including observation of most of the new technology currently being prototyped in the field. RM6 addressed engineering controls by stating: "investigate and implement best available technologies to detect and control vapor plumes from fugitive sources as well as from vents and stacks." As discussed in OR 6, however, the WRPS WBS Dictionary for RM6 focuses exclusively on the *detection* of vapor plumes and does not address the *control* of vapor plumes as noted in the TVAT report. Concerning engineering controls, the TVAT report describes the following for OR 7 and RM6:

> Continue to investigate control options for vents and stacks, as appropriate for each Tank Farm, including using exhausters (permanently or temporarily, as appropriate) for actively venting tanks that are presently passively vented, increasing stack heights, using air flow promoters on the stacks to enhance dispersion of the stack exhaust, relocating stacks away from the work areas ("stacks in the sticks"), and routing exhaust from the stacks to a control device. Resolve the efficacy of the three control technology alternatives identified in the November 12, 2004 *Report on the Feasibility Study for Control of Vapors from Waste Storage Tanks in the 241-C, 241-AW, and 241-AN Tank Farms* by D.M. Baker (known as the Baker report) as well as other promising technologies that may have been identified more recently. Recognize, however, that vent and stack controls alone will not entirely eliminate short-term vapor exposures. In addition, events such as opening cabinets in the Tank Farm, removing foam from above pit cover blocks, removing wrapping from reusable contaminated equipment, and changing out filters will still pose potential for short-term releases, as will fugitive sources such as some valve pits and waste isolation disposal sites. Also, evaluate the use of large fans to sweep air across the Tank Farms (orchard fans) for effectiveness in dispersing episodic wafts or puffs, and evaluate the use of box fans at passive vents to enhance dispersion.

However, the IP was not explicit in defining or assessing the effectiveness of the ongoing efforts with respect to engineering controls, or in defining the path forward and priorities (if any) for engineering controls. As a result, worker perceptions are that insufficient attention is being applied to expedite the development and implementation of engineering controls.

This gap in identifying specific actions related to engineering controls was identified by the VMEP in October 2015, and ORP noted this in its February 24, 2016, transmittal of ORP's monthly assessment of Tank Farms Project Operations for December 2015. Consistent with the IP and Project Schedule, WRPS subcontracted to SRNL to hold a Vapor Control Technology workshop in July 2016 to solicit vapor control technology from interested vendors. However, at the time of the EA visit, SRNL had not completed an evaluation of the vendor workshop.

Although WRPS did not specifically include them in the IP under RM6 actions, efforts with respect to engineering controls were ongoing. WRPS reported the following progress on engineering controls:

[2] In the summary for OR 7, the TVAT report stated, "Through the avenue of the [CVST] approach, WRPS is striving to implement the mandate from ORP to develop and implement detection and control technologies that will be effective in managing both acute and chronic exposures, thereby creating the 'the Tank Farm of the future.' The TVAT endorses these efforts..."

- In January 2016, WRPS Engineering completed a report on atmospheric dispersion modeling of 200 East Area Tank Farm actively ventilated stacks and structures to determine their potential for contribution to vapor exposure/odor events, evaluating stack heights and identifying likely locations for sampling equipment placement.
- Based on the results of the report, WRPS designed and installed exhauster upgrades and stack extensions in AP Tank Farm, which were turned over to WRPS Operations in late September 2016.
- WRPS is designing a 242-A Evaporator vessel vent extension and is evaluating further actions on AW Tank Farm slated for the 2017/2018 timeframe.

With respect to fugitive emissions, WRPS is deploying new detector technologies to better detect, characterize, and report the results of acute vapor events on a real-time basis as described in OR 6. According to interviews, WRPS has focused on the detection of their sources from waste tank components (e.g., valve pits, piping connectors), particularly with respect to IHT rounds and monitoring with hand-held detectors. However, other fugitive emission sources may exist within and outside the Tank Farms that are not linked to the waste tanks and their associated piping and components. The TVAT report cites examples of fugitive vapors from offgassing from waste disposal sites, incidental releases from maintenance activities, removing wrapping from reusable contaminated equipment, and unrelated activities such as spraying of herbicides. Other sources of fugitive emissions may include underground waste cribs, ground water monitoring wells, sewers, and above-ground oil storage tanks. These non-waste tank fugitive emission sources, which may contribute to odors and chemical exposures to workers, have not been adequately defined, identified, evaluated, or investigated. For example, the chemical library used to identify sources from installed detectors is based on the COPC chemicals and not the fugitive emission chemical sources (paints, sewage, etc.). Although the IP for SC3 and SC4 identify broader actions for identifying fugitive emissions sources, the WBS Dictionaries for SC3 and SC4 only address waste tank sources. Further, there is no agreed-upon definition of a fugitive emission release. According to WRPS staff, the PTR-MS van subcontractor recently identified vapor sources outside the Tank Farms. These include sewers, diesel generators, and shop painting activities that may be associated with non-waste tank fugitive emissions. However, the current IHT rounds and monitoring do not include consideration of or monitoring for potential fugitive emission sources that are not related to waste tanks. In addition, since the bulk of these two recommendations are subcontracted, WRPS IH and workers have been only minimally involved in identifying and evaluating fugitive emission sources.

OR 7 Conclusions

WRPS has made significant progress in prototyping new detector technologies to detect vapor emissions and exposures as addressed in OR 6 and continues in the development and implementation of vapor-related engineering controls. Overall, with respect to both OR 6 and 7, WRPS has begun the process of developing a Tank Farm of the future. WRPS has initiated mobile and remote monitoring so that potentially hazardous vapors can be qualitatively and quantitatively identified and reported on a real-time basis and engineering controls for vents and stacks are underway. However, based on the expectations identified in the TVAT report, WRPS has made limited progress in identifying and controlling fugitive emissions from non-waste tank vapor sources. In addition, WRPS has not sufficiently documented and communicated to the workforce a strategy for the implementation of engineering controls that addresses the longstanding concerns about engineering controls for vapor reduction, the TVAT concerns and recommendations, and the present and future goals and objectives.

B.8 TVAT OR 8 - Augment the Hanford Tank Farm IH programs to further develop competencies to address the Tank Farm vapor exposure issues.

EA reviewed the current status of Phase 1 actions addressing the recommendations most relevant to OR 8, namely RM1b, RM1c, RM1d, RM3, RM4, RC5, and RC7 (see Appendix C). To understand progress on

addressing OR 8, EA focused on the various actions taken to further develop IH program competencies to adequately address Tank Farm vapor exposure issues. A goal of Phase 2 is the institutionalization of the improved IH program. In the FY 2016 Performance Evaluation and Measurement Plan, under the SEA 7, Safety Program Implementation, one of the eight evaluation criteria for the industrial health and safety focus area states: "Demonstration of a highly effective Industrial Hygienist and industrial hygiene technicians' integrated training and field work process. Success is defined by demonstrated overall knowledge and field competency resulting from technical training, supervised on-the-job training, and ability to function in a professional manner consistent with industry standards. Performance to be judged under normal and abnormal operating conditions per observations and drill performance."

WRPS has increased its IHT staff from 77 in 2013, to its current level of 177 in 2015. It has also increased its industrial hygienist staff from approximately 20 to approximately 36. Hiring processes are ongoing. The qualification process for both industrial hygienists and IHTs now includes assignment to shift work to observe field work in the Tank Farms as part of the OJT qualification process. The industrial hygienist and IHT qualification programs have been modified to be more functionally equivalent to the radiological control program (e.g., formal qualification cards, written examinations, and performance tests). In addition, the IHT role has been modified to become more like the health physics technician role. IHTs now have established rounds and routine monitoring plans that are aligned with specific work projects (e.g., waste retrieval and tank closure). Industrial hygienists and IHT staff are also routinely included in work planning and control processes and pre-job reviews/briefings. (See Appendix B, Section B.2 for additional information on IH program parity with the radiological controls program.)

WRPS is committed to increasing its IH staff to meet the Tank Farm vapor challenges. WRPS has had difficulty in finding Certified Industrial Hygienists with experience that is immediately translatable to the Tank Farms vapor environment. New IH staff members have, for the most part, completed initial training and are becoming more experienced in this environment. Although the IH program is on the road to achieving functional parity with the radiological controls program, a number of actions would further improve its progress. These actions are captured in the form of recommendations contained in the *Parity Review of the WRPS Industrial Hygiene Program Relative to Radiological Protection Program* (Parity Gap Analysis) issued on April 16, 2015. Examples include establishing oral examinations as part of the industrial hygienist and IHT qualification and requalification process and conducting periodic (at least every three years) assessments of all IH program elements. In addition, WRPS has not conducted effectiveness reviews of the revised training program. IH management is aware that this training needs to be continually improved in order to achieve parity with the radiological controls program but has not obtained feedback from trainers and recent trainees to improve the classroom presentations and field OJT for their IHTs.

Of the 17 actions listed in Phase 1 of the IP under OR 8, 10 are currently listed as completed. The remaining actions are listed as "scheduled" or "in process."

OR 8 Conclusions

WRPS is on the path to meeting the near-term TVAT recommendations in OR 8. Although the IP was written before the Parity Gap Analysis was completed, the recommendations in the Gap Analysis comprise additional valid actions to facilitate achieving IH program parity with the radiological controls program that are not reflected in the IP.

B.9 TVAT OR 9 - Effectively communicate vapor exposure issues and actions proactively with all stakeholders.

EA reviewed the current status of Phase 1 actions addressing the recommendations most relevant to OR 9, namely RC3, RC6, RC8, and RC9. To understand progress on addressing OR 9, EA focused on: (1) the need to quickly alert all affected workers when vapor releases occur, (2) the need to keep workers well informed of the findings from investigations of odors and vapor events, and (3) the need to actively involve workers in finding ways to prevent worker exposures to potentially harmful vapors. ORP included an incentive in the FY 2016 Performance Evaluation and Measurement Plan, under SEA 7, Safety Program Implementation, as one of the eight evaluation criteria under the Industrial Health and Safety focus area, which states: "Demonstrate two-way engagement with the workforce in communicating issues, evaluating options, developing improvements, implementing improvements, and evaluating effectiveness of Tank Vapors Assessment Team Implementation Plan items."

WRPS is pursuing several strategies to try to improve communications with workers about tank vapor issues, including:

- Holding a barbeque lunch in June 2016 to show and explain new vapor technologies to employees.
- Hiring more IH personnel to enhance monitoring and improve communications with workers about monitoring results and their implications.
- Continuing CVST biweekly meetings since 2014 (intended to provide opportunities for worker input and involvement in resolving vapor issues).
- Reinvigorating the CVST Communications Subcommittee in August 2016, which tries to find ways to improve communications with the workforce about the status of the work being done.
- Presenting management briefings about vapor events during May and June 2016.
- Usually reporting IH vapor monitoring results at morning briefings with work crews.
- Within the past year, developing enhanced Chemical Hazard Awareness Training (CHAT).
- Providing risk communication training to enhance managers' skills in communicating the hazards associated with Tank Farm work (training sessions provided in April and July 2016 by Dr. Vincent Covello, Director of the Center for Risk Communication, an internationally recognized risk communication consulting company).
- Holding three monthly luncheons during the summer of 2016 to provide an opportunity for workers in specific workgroups to voice concerns about vapors to upper level managers (June 29, employees from the Effluent Treatment Facility; July 21, employees from the Maintenance Organization; and August 16, employees from Business Operations).
- Testing a new public address system to see whether it would be effective in notifying all affected workers of Tank Farm vapor releases (AOP-15 events). A pilot public address system has been fabricated and is scheduled to be deployed around the AP Tank Farm boundary in September 2016. Once the initial function and other up-front testing is completed, a "field test" of the pilot system is scheduled to be conducted for approximately 30 days in AP Tank Farm.
- Recently creating a website (hanfordvapors.com) that contains a variety of information about vapor issues. This website "went live" on June 27, 2016.
- Hiring CTEH to provide expert advice on how to improve risk communications. The contract with CTEH was executed on June 6, 2016.
- Providing all-employee messages, emails, *Solutions* articles (weekly newsletter), and briefings at various other types of meetings with managers, employees, and union officials.

During Phase 2 of the project, the IP states that WRPS plans to: (1) address any opportunities for improving the way employees are notified of vapor releases (based on an assessment of alternatives during Phase 1), and (2) continue efforts initiated during Phase 1 to develop and implement a program to manage and oversee overall improvements for vapors, focusing on improving worker engagement.

Program elements are planned to include the development and management of a chemical vapor communications plan, performance indicators, and program effectiveness reviews.

EA primarily used focus groups to assess the progress of actions addressing OR 9. EA conducted 22 focus groups composed of peers who perform similar types of jobs and obtained a great deal of information concerning many aspects of communications and perceptions about worker training and worker involvement. EA targeted the population that routinely works in and around the Tank Farms to hear workers' perspectives on actions taken to address the TVAT recommendations. Each focus group discussion lasted about 80 minutes. A total of 119 contractor employees participated in focus groups. Eighty-five participants were represented by unions, and 34 were not. EA also reviewed numerous documents and websites, conducted interviews, and attended meetings that took place while on site. EA observations are organized around three specific TVAT recommendation areas:

1) *With respect to the need to quickly alert all affected workers that a vapor release has occurred*, the TVAT recommended performing an alternatives assessment for the current Shift Office Event Notification process to identify other methods to ensure that all workers who could be impacted by vapor events are immediately alerted.

In almost all focus groups, participants cited relatively recent instances in which employees affected by a vapor release were unaware of the release and continued to work in areas that should have been immediately evacuated. Many participants do not believe that the Shift Office Event Notification process is an effective mechanism for quickly notifying all workers potentially impacted by a vapor event. Many believe that there are gaps in the notification system. They believe that not all workers are informed as soon as they should be. Some do not carry their phones when working in the Tank Farms, and they are not always with a person carrying a radio. Some security and emergency response personnel of Mission Support Alliance (Hanford's integrated infrastructure contractor) do not receive timely notifications of vapor releases. Some focus group participants said that they find out about vapor releases from news reports, Facebook posts, or calls from relatives outside the area.

When EA asked the focus groups "How could the system for notifying workers of vapor releases be improved?" frequent responses included:

- Issue company cell phones or radios to all who might be affected by a vapor release.
- Simplify the messages so it is quicker and easier to tell what areas you should stay away from or evacuate. This is especially important for emergency responders.
- Install sirens or a public address system that can issue warnings throughout the Tank Farms and adjacent areas.

As indicated above, a new public address system is scheduled to be piloted in AP Tank Farm in the near future.

2) *With respect to keeping workers informed of the findings from investigations of odors and vapor releases*, the TVAT recommended: "Communicate in a timely fashion to all employees the results of incident investigation, including description of event, results of any samples taken, lessons learned, and corrective actions planned and completed."

EA asked focus group participants to characterize the strengths and weaknesses of the briefings they had attended on recent vapor events. In most focus groups, there was agreement that the presenter lacked the expertise to address employees' questions. Some said their presenters just read a prepared script. Many said that it would help if presentations included persons with more expertise on this issue, either as co-presenters or by being present as resources. They stated that these experts could provide better answers to questions on the spot. Participants often said that when the presenters did not know the answers, they

would promise to find out and get back to them; in most cases they did, but a few participants said they are still waiting for the answers. Several believe they have not received satisfactory answers to important questions about exposures to tank vapors.

There is much dissatisfaction about briefings on vapor releases among union workers, and focus group results indicate a large discrepancy in perceptions between union and non-union workers. Although WRPS has recently made much information about Hanford tank vapor events and issues available on a new website (www.hanfordvapors.com) and via emails, many union workers indicated through focus groups and interviews that they do not use these sources and most workers are unlikely to seek out this information on their own. Some focus group participants stated that the information being provided to them is just data. They want to know what it actually means in terms of long-term health effects. Several participants believe that management should hold briefings more often. TVAT recommendation RC9 is to "evaluate and improve the communication system associated with vapor events." The IP stated that WRPS will accomplish this during Phase 1 by increasing the frequency of worker briefings, feedback sessions, and regular interface meetings. However, EA did not observe an increase in the frequency of such events and, as previously stated, WRPS has not held any focus groups or other worker feedback sessions to try to ascertain whether their communications are effective.

***3) With respect to employee input and involvement in teams and programs that are associated with Tank Farm vapor issues*, the TVAT report states that "it is imperative to involve the workforce as a legitimate partner in identifying and resolving safety and health issues. In order to develop and sustain a culture of trust and buy-in and in which every worker understands she or he provides value to the enterprise, complete disclosure and transparency regarding decisions associated with Problem Evaluation Requests, CVST, and other work teams involved in assuring worker safety and health must be maintained."**

While on site, EA attended a meeting of the CVST, during which the CVST discussed progress in testing and implementing new technologies. After the vapor events in 2014, WRPS re-established the 12-member CVST, which was originally established in 2012. The CVST consists of 12 members (with 12 alternates) of Tank Farm workers (half of whom are bargaining unit) who also serve on the various CVST sub-teams. CVST meetings are open to all employees to attend. The CVST is a valuable mechanism for giving employees an opportunity to both learn about vapor issues, such as the new technologies discussed in the meeting, and express their opinions and ideas. However, the CVST is a small percentage of the total union-represented population (union-represented members constitute less than one percent of the total union-represented population at the Tank Farms), and very few participants in the EA focus groups reported any involvement in or communications from the CVST. Some WRPS managers expressed their perception that CVST members who appear to support management may be shunned by their colleagues, but WRPS management did not take sufficient actions to alleviate this concern or to find additional ways to communicate to employees and elicit their engagement. The frequency of CVST meetings has declined since 2014. Further, management has relied primarily on the CVST for worker feedback and has not been successful in creating broader-based processes for workers to provide their input and ideas about resolving tank vapor issues.

The CVST charter indicates that the External Affairs Manager assigns a Communications Specialist to promote both internal and external communication of the CVST activities; however, interviews indicated that the CVST Communications Subcommittee has not been very active recently. Interviews indicated that it is being revitalized and reconstituted to include a wider cross-section of work groups, but those efforts are not complete, and the results were not apparent from focus groups. Other than the requirement for a Communications Specialist, WRPS has not provided an institutional process to keep workers informed of CVST activities and obtain feedback from workers on CVST activities.

Apart from the CVST (and a dedicated technology sub-team), WRPS does not have effective mechanisms for routinely involving the WRPS workforce in the selection of new technologies (with the exception of field IH monitoring instrumentation, where IHTs have been actively involved in the selection of monitoring locations in the Tank Farms). Focus group participants reported very few instances of workers suggesting ideas or input on how to resolve tank vapor issues. For example, the bulk of the prototype development activities are subcontracted, and subcontractors use their own employees, so WRPS IH and workers have been only minimally involved in these activities.

WRPS has not adequately addressed TVAT recommendation RC9: evaluating the effectiveness of vapor event communications. In the TVAT report summary for OR 9, the TVAT recommended that "focus group meetings be held on a regular basis to help WRPS evaluate the effectiveness of its communications, encourage participation, and assure transparency across interested parties." WRPS has not held focus group meetings in response to this recommendation, addressed this recommendation in the IP, or performed formal evaluations of the effectiveness of vapor event communications. Although management agrees that such evaluations should take place, they have not yet developed a plan to do so.

Overall, there are several significant barriers to effective communications about tank vapors:

- Workers' exposure to tank vapors has become a highly charged, sensitive topic. Some focus group participants said that employees might be reluctant to bring up vapor concerns for fear of being considered a troublemaker or "problem child." Several focus group participants believed they might be subjected to retribution or retaliation for expressing concerns about vapors. Even though these responses were specific to expressing concerns about vapors, they are based on a small portion of the entire workforce, suggesting the possibility that overall, a substantial number of employees may have concerns about retribution or retaliation.
- Many workers seem to doubt whether management is sincerely concerned about tank vapors. A few participants reported attending meetings in which managers or IH personnel made comments suggesting they did not sincerely believe there is a need to be concerned about vapor exposures. One participant reported, "The feeling that I get after years and years of being told there is nothing hazardous in the vapors is that, although management tells us we need to report odors, they are really not too interested; they've already told us there is nothing there."
- Nonetheless, several focus group participants are convinced that they or some of their co-workers have been overcome by acute overexposures to vapors, and they would like an accurate explanation of what caused it, the potential long-term adverse health effects, and how to prevent future occurrences.

OR 9 Conclusions

The TVAT report stated: "It is clear that WRPS is making efforts to engage with stakeholders and initiate additional communication about vapor issues. Nonetheless, the TVAT identified a significant need to re-build the communication program to better communicate the nature and application of the tank vapor risks. Communication gaps were identified at all levels." Although the TVAT recommended evaluation and improvement of the communication system associated with vapor events (RC9), WRPS has not performed formal evaluations of the effectiveness of vapor event communications. EA saw essentially the same employee perceptions of communication and distrust as reported by the TVAT assessment. Further, the large discrepancy in perceptions between union and non-union employees indicates a significant problem with communications to the union workers. Although WRPS is pursuing several promising strategies, those strategies have not yet produced sufficiently positive outcomes, since many were only initiated in the past 6 to 12 months. EA acknowledges that the ongoing lawsuits and news media reports are impeding management's ability to improve communications with workers. However, the management challenge for WRPS and ORP is to regain the trust of all employees. Management needs

to communicate with empathy while implementing the actions needed to effectively address Tank Farm vapors.

B.10 TVAT OR 10 - Investigate and pursue external research opportunities and partnerships to address data and technology gaps related to vapor exposure, effects, and mitigation.

Based on interviews with WRPS managers, the intent of this OR is to investigate and pursue research opportunities based on data and technology gaps that will presumably be identified during Phase 1. Therefore, WRPS, with ORP approval, designated the IP actions for this OR as principally Phase 2 activities, which have not been adequately defined. However, the IP identifies 10 TVAT recommendations applicable to this OR, several of which involve Phase 1 activities (see Appendix D). Similar to other ORs, it is not clear which elements of these 10 TVAT recommendations have a direct bearing on this OR and result in any action items. For example, the second action in the IP associated with TVAT recommendation RM6 is to establish an outside panel of industry experts, which according to the IP was initiated in June 2014. This action may be synonymous with the VMEP (described below), although the VMEP Oversight Plan was drafted a year later, in March 2015. In the IP, the WRPS response to OR 10 identifies external agencies or groups supported by ORP, such as the National Institutes of Health, NIOSH, and an external expert panel (the VMEP), as well as the annual Grand Challenge process (a competition established by ORP to identify the most promising solutions to big technical challenges, which EA did not evaluate).

In general, WRPS has already initiated efforts to engage external agencies and companies to find innovative solutions for the vapor control concerns. For example, WRPS hired CTEH to examine the basis for the IH technical basis documentation, sampling, and human response to various chemicals. CTEH has also begun to develop a dashboard tool to help visualize the sampling data, with an eye toward improving the strategies for sampling and worker protection. WRPS is also working with PNNL on several Phase 1 recommendations (e.g., updating the COPC process) and is working with an external research organization to provide real-time monitoring using the best available technologies to better visualize potential releases of chemical vapors from tank and fugitive sources. WRPS plans to further expand these efforts in Phase 2, scheduled for FYs 2017 through 2019.

ORP has two ongoing activities that relate to the scope of this OR. The first involves ORP establishing the VMEP to provide assurance to ORP, WRPS, and affected stakeholders that IP actions are being carried out and are effective in protecting workers from potential vapor exposures. The purpose of the VMEP is to provide technical expertise in reviewing IP actions, update DOE on whether progress is on track to resolve vapor issues, and communicate with stakeholders and assess progress in addressing their issues. The VMEP, chartered in March 2015, reports administratively to the ORP Assistant Manager for Technical and Regulatory Support and meets approximately two days each quarter. It consists of a panel of eight senior managers and technical experts, including two of the original members of the TVAT. Each VMEP member has been assigned as a lead for maintaining overall cognizance of one or more of the 10 TVAT ORs. The VMEP Chairman and Executive Director drafted a VMEP Oversight Plan in March 2015, but the plan was never finalized and issued. On March 31, 2016, the VMEP held a Tank Vapor Health Effects Workshop, during which the need for additional studies on health effects was discussed. There are no minutes of informal or formal meetings of VMEP members, although the VMEP has committed to submit a report on oversight activities to the ORP Manager by the end of calendar year 2016.

The second ORP activity is ongoing communications with NIOSH on a variety of topics, including potential health hazard evaluations, assistance with possible epidemiological studies, personal protective equipment, and exposure monitoring. NIOSH is currently assisting ORP by providing an independent short-term, programmatic evaluation of the WRPS vapor program, focusing on four areas: medical,

exposure assessment, safety and health program management, and exposure control. The onsite portion of the NIOSH review was conducted during the last week of July 2016.

OR 10 Conclusions

The intent of this OR is to investigate and pursue external research opportunities and partnerships to address data and technology gaps related to vapor exposure, effects, and mitigation. Since many of these gaps will not be identified and/or resolved until the completion of Phase 1, most of the actions for this OR will be deferred to Phase 2. Given the significant in-process WRPS activities associated with the other nine ORs for Phase 1, this approach is appropriate. WRPS has also reached out to several external research organizations (e.g., CTEH, PNNL) to assist in the implementation of several Phase 1 actions. In addition, ORP has two ongoing activities related to the scope of this OR, namely the establishment of an expert oversight panel (the VMEP) and a commitment to work with other agencies (e.g., NIOSH). At the time of the EA onsite assessment, the VMEP had not issued any formal reports on the status of the WRPS vapor program.

Appendix C
TVAT Supporting Recommendations

Site Characterization

SC1 Develop a prioritized program to sample and characterize tank head space composition and stratification during quiescent as well as disturbed conditions.

SC2 Assess the potential for materials to plate or condense in vent risers, stacks and high efficiency particulate air (HEPA) filters, and characterize the emissions for each condition.

SC3 Implement technologies to assess fugitive sources of emissions that are not connected to tank head spaces and characterize the emissions for each non-head space fugitive source.

SC4 Identify and implement new technologies to detect, locate and quantify fugitive and episodic releases.

SC5 Identify and implement new technologies to quantify stack and vent emissions with suitable local alarms so that workers can respond in a timely fashion.

Exposure Assessment

EA1 Continue the development and expedite deployment of new techniques for real-time response and appropriate sampling for short duration intermittent releases.

EA2 Identify and implement sampling and/or in-situ analytical methods as appropriate for reactive volatile organic chemicals (VOCs), submicron aerosol, volatile metal compounds, and volatile metalloid compounds that may be present but would have been missed by past head space sampling and analytical methods.

EA3 Use modeling, including computational fluid dynamics methods, to determine the potential locations, conditions, and next steps in attempting to measure sporadic exposure events.

Dose Response

DR1 Conduct an additional review and re-prioritization of COPCs under tank-disturbing conditions to provide adequate emission characterizations, OEL development, and worker exposure surveillance.

DR2 Conduct a rigorous review of the COPC list to ensure it is current, and develop a process to document the mechanisms used to ensure COPC updates and the basis for changes in the COPC list over time.

DR3 Conduct additional evaluations of COPC toxicological studies to provide insight into the sensory and pathophysiological irritation response, including the role of mixture interactions and the potential need for additional toxicological evaluation.

DR4 Perform a comprehensive evaluation of acute odor thresholds and toxicity effect levels for each COPC to facilitate the establishment of action levels based upon the relationship between odor and toxicity thresholds.

DR5 Continue to evaluate COPC OELs within the context of observed symptomatology versus 10% of the irritations thresholds and develop a “new” acute OEL list.

DR6 Maintain a robust health surveillance program that follows up with exposed workers to evaluate short- and long-term consequences from vapor exposures.

DR7 Evaluate tank vapor mixture toxicological interactions at concentrations associated with transient plume exposures to modify OELs to accommodate mixture effects.

DR8 Develop an overall IH strategy for aerosol evaluations that focus on analytical quantifications, the evaluation of chemical aerosols for inclusion in the COPC list, as well as the establishment of appropriate aerosol OELs.

DR9 Develop a research strategy roadmap in partnership with DOE, national laboratories, and university faculty subject-matter experts to address critical questions regarding tank vapor emissions and exposures.

Risk Characterization

RCH1 Identify an Occupational Exposure Limit – Ceiling Limit – (OEL-C) for each analyte in Hanford tank head spaces.

RCH2 Classify and conduct toxicological testing on a reasonable number of distinct types of Hanford tank head space vapors (e.g., potential classes of tank vapor types such as ammonia rich, ammonia poor, nitrosamine rich).

RCH3 Use the OEL-C from analysis or subsequent toxicological testing to characterize the hazard index and risk from the tank vapor mixtures.

RCH4a (Chronic) The WRPS IH program has in place procedures for evaluating chronic chemical exposures [based on Time Weighted Average (TWA)]; it is recommended that more periodic follow-up monitoring be conducted and documented to provide needed data for the industrial hygienist to verify that worker chronic exposures have not changed with time.

RCH4b (Acute) Transient vapor/gas exposures (i.e., high dose rate) are substantially greater than what is currently measured as a TWA; alternative strategies for evaluating transient plume-like vapor exposures are recommended and adherence to excursion limit principles must be implemented (5 times OEL).

RCH4c (Medical Surveillance) Routine medical surveillance is a key workplace evaluation tool needed to predict health impairment from vapor exposures; appropriately designed epidemiology studies focused on Tank Farm workers are recommended to evaluate the potential long-term health consequences.

Risk Management

RM1a Provide and manage IH professional and technician staffing levels to properly characterize and assess worker vapor exposure in the Tank Farms.

RM1b Provide and manage IH professional and technician staffing levels to participate in all planning, execution and evaluation phases of Tank Farm work activity, similar to radiological and flammability control functions.

RM1c Provide and manage IH professional and technician staffing levels to properly recommend and evaluate the effectiveness of work practices, personal protective equipment, and engineering controls.

RM1d Provide and manage IH professional and technician staffing levels to effectively inform, advise, and train line functions and address workers' concerns regarding Tank Farm vapors. In addition, available analytical resources should be re-evaluated and increased to assure the timely reporting of sample results associated with Tank Farm vapors.

RM1e[3] DOE should increase its focus on chemical hazards and develop more specific implementation guidelines on the anticipation, recognition, evaluation, and control of chemical hazards that is comparable to the focus and rigor given to radiological hazards. Consistent guidance on implementation of IH programs in DOE facilities would assist in assuring functional parity with radiological controls.

RM2 Achieve functional parity of the IH program with the radiological control program with respect to worker training and core competencies.

RM3 Expand general chemical hazard awareness training (CHAT) for Tank Farm workers to be more consistent with the length and intensity of the radiological-hazard training currently mandated for all site workers.

RM4 Adequately staff the IH function to ensure proper resources are deployed in the planning, pre-job, job execution, and post-job ALARA review in a fashion similar to that of the radiological control function.

RM5 Redefine unacceptable chemical exposure risk to include short-term, episodic exposure to chemicals that can result in adverse health impacts.

[3] RM1e was not in the final TVAT report; however, WRPS included it in the implementation plan.

RM6 Investigate and implement best available technologies to detect and control vapor plumes from fugitive sources as well as from vents and stacks.

RM7a Establish a more effective methodology for designating Vapor Control Zones (VCZs) and Vapor Reduction Zones (VRZs).

RM7b Confirm that air-purifying respiratory protective equipment is effective in reducing exposure to tank vapors below acceptable levels.

RM8 Modify the medical case evaluation process and reporting procedures to recognize the appropriate uses and limitations of the available monitoring data and other potential exposure information when evaluations are made regarding vapor exposures.

RM9 Verify that all programs associated with vapor controls are properly vetted, evaluated, communicated and tracked to ensure timely completion.

M10 All levels of line management demonstrate that they are committed to reducing the potential for Tank Farm vapor releases and continuously improving management systems to assure all workers are properly protected.

Risk Communication

RC1 Develop more routine and transparent communications, which offer unsolicited information to the Hanford Challenge, Hanford Concern's Council, and other interested community groups regarding potential health impacts, health and safety risks, and WRPS/DOE efforts to reduce risk to employees and the community.

RC2 Improve the electronic job task analysis process to include opportunities for worker engagement and buy-in into the process and protective measures assuring the health and safety of the worker.

RC3 Improve the degree of employee involvement in and ultimate acceptance of all teams and programs that are associated with Tank Farm vapor issues (e.g., Problem Evaluation Requests, CVST).

RC4 Revise the content of the employee monitoring notification letters to include more relevant information regarding the capabilities and limitations of technology used to collect and analyze samples, which should include clear definitions for concepts such as "ND" vs. "<LOQ" vs. "<RQL."

RC5 Establish a greater IH technician and professional presence in the Tank Farms and undergo specific risk communication training and improve their ability to deliver effective risk communications to employees.

RC6 Perform an alternatives assessment for the current Shift Office Event Notification process to identify other methods to assure that all workers potentially impacted by vapor events (i.e., WRPS, Mission Support Alliance, visitors) are immediately alerted of a vapor event and understand what mitigating actions they must take to avoid possible health or safety impacts.

RC7 Deploy appropriate laboratory resources to ensure timely analysis and reporting of IH results, and ensure all exposure data is assigned correctly to all members of the Similar Exposure Group.

RC8 Communicate in a timely fashion to all employees the results of incident investigations, including a description of event, results of any samples taken, lessons learned, and corrective actions planned and completed.

RC9 Evaluate and improve the communication system associated with vapor events and results of worker compensation claims.

Appendix D
Matrix of Overarching and Supporting Recommendations
(WRPS Implementation Plan Phase Status from the WRPS Stoplight Chart as of June 21, 2016)

	Overarching Recommendations / Supporting Recommendations	OR 1	OR 2	OR 3	OR 4	OR 5	OR 6	OR 7	OR 8	OR 9	OR 10	IP Phase
	SITE CHARACTERIZATION											
1	SC1			X	X		X	X				1
2	SC2							X				2
3	SC3	X					X	X		X	X	1
4	SC4	X		X			X	X		X	X	1
5	SC5	X			X		X	X		X		1
	EXPOSURE ASSESSMENT											
6	EA1	X			X		X	X		X	X	1
7	EA2			X	X		X	X				2
8	EA3	X			X			X				1
	DOSE-RESPONSE											
9	DR1		X	X		X	X				X	1
10	DR2		X	X		X	X			X	X	1
11	DR3		X	X		X	X				X	2
12	DR4		X	X		X	X			X	X	2
13	DR5		X	X		X	X				X	2
14	DR6		X	X		X	X				X	1
15	DR7		X	X		X	X				X	2
16	DR8		X	X		X	X			X	X	2
17	DR9		X	X		X	X				X	2
	RISK CHARACTERIZATION											
18	RCH1			X	X		X	X			X	2
19	RCH2			X	X		X	X			X	2
20	RCH3				X		X	X			X	2
21	RCH4a				X							1
22	RCH4b			X	X		X	X			X	1
23	RCH4c					X						2
	RISK MANAGEMENT											
24	RM1a	X		X	X		X	X		X	X	1 Complete
25	RM1b	X			X		X	X	X	X		1 Complete
26	RM1c	X				X	X	X	X	X		1 Complete
27	RM1d	X					X	X	X	X		1
28	RM1e	X	X									2
29	RM2	X						X	X	X		1
30	RM3	X						X	X	X		1
31	RM4	X						X	X			1 Complete
32	RM5	X		X			X	X	X	X		2
33	RM6					X	X	X			X	1
34	RM7a							X	X	X		1
35	RM7b							X	X	X		1
36	RM8	X				X						2
37	RM9	X					X	X	X	X		1
38	RM10	X							X	X		1 Complete
	RISK COMMUNICATION											
39	RC1									X	X	1 Complete
40	RC2								X	X		1 Complete
41	RC3				X		X	X		X	X	1
42	RC4				X			X	X	X		1 Complete
43	RC5	X						X	X	X		1
44	RC6							X			X	1
45	RC7	X							X	X		1
46	RC8	X							X	X		1 Complete
47	RC9	X			X				X	X		1 Complete