Project Management Institute - Project of the Year Award

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Washington River Protection Solutions'

AP Farm Ventilation Upgrades Project

July 16, 2014 – September 29, 2016

Prepared by Brad Bricker for WRPS based on input from the AP Farm Ventilation Upgrades Project Team

1. Introduction/Summary

This section provides the project background as the basis for evaluating the answers to the following sections.

1. Provide a brief overview of the project.

During the operational lifespan of the Hanford Nuclear Site, approximately 56 million gallons of nuclear and chemical waste were produced and stored in large underground tanks situated in geographical groupings known as “tank farms.” The waste still resides in these tanks awaiting long-term disposal. The Waste Treatment and Immobilization Plant (WTP)—currently under construction at the Hanford Site—is slated to turn the waste into a form of solid glass for final long-term disposition.

The last tank farm to be constructed at Hanford was AP Farm. Comprising eight tanks with a capacity of 1.265 million gallons each, AP Farm construction began in 1983 and the tanks were put into service in August of 1986. Constructed simultaneously with the tanks was the original AP Farm primary ventilation system.

The radioactive and hazardous waste which is stored in many of the aging Hanford tanks requires constant ventilation. The waste produces flammable gases which collect upwards into the unoccupied “headspace” portion of the tanks. The tank waste also produces a significant amount of heat through radioactive decay. By constantly ventilating—or using a vacuum force to pull air out of—the tanks, these hazards are mitigated. The flammable gases are removed before they can reach a dangerous concentration. The heat is reduced as moisture is sucked away and as the pull of air allows convention currents to cool the surface of the waste.

Unfortunately, the old ventilation system at AP Farm was inadequate for maintaining vacuum. When the decision was made to designate AP Farm as the staging point for waste being transported from tank farms to WTP for treatment, upgrading the AP Farm ventilation system became a critical piece of the mission to transfer and treat Hanford waste.

2. Describe the organizational need addressed by the project.

As the Department of Energy Office of River Protection’s (DOE-ORP) Tank Operations Contractor, Washington River Protection Solutions (WRPS) is responsible for managing Hanford’s radioactive waste and preparing it for delivery to WTP. After AP Farm was designated to stage all WTP-bound Hanford tank waste, WRPS had to ensure AP Farm would be able to host millions of gallons of waste from the other 169 Hanford Site tanks. Waste transferred from these other tanks would introduce additional flammable gas and radioactive heat hazards. The AP Farm ventilation system needed to be upgraded to handle these hazards.

3. Briefly describe the solution that was implemented.

In order to upgrade the AP Farm ventilation system, a new ventilation system needed to be designed, fabricated, and installed. The new ventilation design called for a system which would continuously draw air from the AP Farm tanks, separate moisture and radioactive particles from the air, and send filtered air into the atmosphere while sending condensate back into tank AP-106, all while monitoring the system for emissions, leaks, pressure, liquid levels, etc. This new system consists of several major components:

- Two de-entrainers are the first stop for air as it is pulled from the AP Farm tanks. The de-entrainers remove more than 99% of moisture condensate from the tank headspace air. The de-entrainers allow the air to move on to the exhausters while the condensate is collected in a seal pot for return back to AP-106.
- Two exhausters (as pictured at night on the cover of this application) receive air from the de-entrainers, heat the air to prevent remaining moisture from depositing on air filters, pre-filter and then filter the air to remove radioactive particles, and finally send the air up and out of 40’ tall exhaust stacks. There are four places on each exhauster heater/filter housing where condensate is collected and sent to the exhauster seal pots for return back to AP-106. The exhausters also house the fans which pull the air through the ventilation system and a Human Machine Interface (HMI) for monitoring various components of the ventilation system.
- The new AP ventilation system has three seal pots: one for the de-entrainers and one each for the exhausters. The exhauster seal pots drain down into the de-entrainer seal pot, which in turn drains directly

to AP-106. The seal pots retain just enough condensate volume to form a vapor barrier to prevent tank vapors from being able to exit the tanks through the drain lines which return condensate back into AP-106. Any additional condensate beyond what is required to maintain the vapor seal returns back into AP-106 through a condensate drain line.

- Air inlet stations allow filtered air to flow into the AP Farm tank headspace to maintain specified tank vacuum by the continuous ventilation while air is being ventilated from the headspace. Each of AP Farm's eight tanks has its own air inlet station.
- Steel ducting transports air through the ventilation system, while drain lines convey condensate back to AP-106.
- Electrical conduit and vaults contain the wires and components which feed power to the electrical and mechanical constituents of the ventilation system.
- The Variable Frequency Drive Building contains the equipment which interfaces with the exhausters to determine how fast the fans should be pulling air through the ventilation system. The building also houses the system's power distribution controls.

The AP Farm Ventilation Upgrades Project went from an installation concept in 2014 to a fully operable system by September 29, 2016. The project team utilized WRPS engineers to design the installation of the new system, and supervised the services of subcontractors to perform the bulk of fabrication and installation of the new ventilation system until it was successfully handed off to WRPS operations personnel for ongoing operations and maintenance.

4. Describe the outcomes of this project on the project stakeholders and on society in general.

Strictly from a mechanical ventilation perspective, the new system introduces such improvements as compliance with ANSI standards for ventilation, the ability to ventilate at a variable rate up to 429% higher than before, the ability to introduce filtered air into the AP tanks, the ability to release filtered air out of the tanks in the case of ventilation system shutdowns, redundant mechanical systems, and a whole host of new safety and technological features. Beyond major ventilation performance improvements necessary to support waste feed delivery to WTP, the AP Farm Ventilation Upgrades Project was very successful as evidenced by a plethora of positive outcomes for stakeholders:

- On behalf of the DOE-ORP, WRPS, and WTP team, the AP Farm Ventilation Upgrades Project represents a major achievement towards being able to transfer and disposition legacy Hanford Site waste.
- On behalf of DOE-ORP, all project schedule milestones—referred to as Performance Based Incentive, or "PBI" milestones—were completed on time.
- On behalf of the operations personnel who are charged with running the new AP Farm ventilation system, feature upgrades and enhancements over the old system have made operations much safer, easier, and reliable.
- On behalf of the Hanford workforce, the new AP Farm ventilation system represents many improvements to safety and monitoring, resulting in enhanced protections for workers.
- On behalf of future tank farm ventilation upgrades for retrievals and operations at other tanks farms, the two-year, $16 million AP Farm Ventilation Upgrades Project achieved many firsts and unique approaches which have set a baseline for best practices and now provide lessons learned for future ventilation upgrade endeavors. The hard earned knowledge of the AP Farm Ventilation Upgrades project team has already proven useful in informing design for ventilation systems at A Farm and SY Farm.

2. Sponsor Letter

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17-TF-0007

Ms. Lisa L. Rosenblum, Vice President of Public Relations
Columbia River Basin Chapter
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Ms. Rosenblum:

PROJECT OF THE YEAR NOMINATION – WASHINGTON RIVER PROTECTION SOLUTIONS LLC'S AP FARM VENTILATION UPGRADES PROJECT

The U.S. Department of Energy, Tank Farms Projects is pleased to endorse the subject nomination for the Project Management Institute's Project of the Year Award for 2017.

The Hanford Area Tank Farms consist of 177 tanks, which originally contained 56 million gallons of hazardous waste collected from more than four decades of plutonium production into 18 tank farms. The U.S. Department of Energy, Office of River Protection's (ORP) mission is to retrieve, treat, and dispose of legacy Hanford waste in a safe, efficient manner represents the largest and most complex environmental remediation project in the nation today.

Currently, Washington River Protection Solutions (WRPS) is ORP's Tank Operations Contractor responsible for managing Hanford's tank waste and preparing it for delivery to the Waste Treatment and Immobilization Plant (WTP), where the waste will be vitrified into a stable glass form before final disposition at a national repository.

One of the requisite steps for accomplishing this important waste management mission is to construct the physical infrastructure necessary for transporting tank waste from the tank farms to the WTP for processing. Tank AP-107 was chosen as the staging and transfer point for all tank waste leaving Hanford's tank farms for processing. Subsequent to the choosing of Tank AP-107, it became imperative to upgrade the AP Farm's ventilation capabilities in order to accommodate this new and important role.

From 2014 through fiscal 2016, the AP Farm Ventilation Upgrades project team worked hard to design and construct a new ventilation system capable of supporting waste transfers from any existing Hanford tank to AP Farm, and from there on to processing. On any project of this size there will be challenges and complexities. The project team was able to confront these obstacles with sound tools and processes as well as creative problem solving, and the project was delivered successfully and on time. But more important than how the project was done is what it will do going forward.

The work that was accomplished by the AP Farm Ventilation Upgrades project team is profound. The project team has built a best-in-class tank ventilation system, has developed new ways of protecting the Hanford workforce, and has set a new benchmark for future ventilation upgrade projects. But most importantly, the team's final product is really an AP Farm ready to serve as the gateway for all Hanford waste on its way to a safer, more stable future. ORP is proud of the work that has been completed at AP Farm in partnership with WRPS as we work hand in hand to retrieve, treat, and dispose of legacy Hanford waste. For these reasons I am happy to endorse this nomination.

If you have any questions, please contact me at (509) 376-6597.

Jeremy Johnson

For Harold J. Stafford
Tank Farms Projects Program Manager

TF:HJS

cc:
B.M. Bricker, WRPS
D. Scott JR, WRPS
WRPS Correspondence

3. Benefits/Value

Show that the benefits/value of your project were realized by answering the following:

1. Identify the expected positive benefits/value of the project on the organization.

The AP Farm Ventilation Upgrades Project benefitted the WRPS organization by aligning with and being integral to the fulfillment of WRPS' Mission, Vision, and Core Values.

- **WRPS' Mission**: *WRPS is committed to the safe and efficient management, retrieval and treatment of Hanford's radioactive and hazardous tank waste, to protect the nearby Columbia River*.

  WRPS has a long track record of safely and efficiently managing and retrieving waste, and the AP Farm Ventilation Upgrades Project is on the forefront of bringing online WRPS' capability to treat tank waste. After collecting waste retrieved from AY-102, A Farm and other tanks, AP Farm will feed waste from tank AP-107 to the Low-Activity Waste Pretreatment System (LAWPS) for processing.

- **WRPS' Vision**: *Be ready to feed waste to the Waste Treatment Plant on schedule*.

  As of this writing, the DOE-ORP, WRPS, and WTP team are targeting to commence conversion of tank waste into a stable glass form—a process known as vitrification—as early as 2022. DOE-ORP, WRPS, and WTP are working hard to complete the many tasks necessary to achieve this goal, including tank retrievals and completion of the LAWPS facility. Completion of the AP Farm Ventilation Upgrades Project historically represents achievement of one of the building blocks to being able to send decades-old legacy Hanford waste out of the tank farms and into a treated configuration where it will no longer pose a threat to humans or to the environment.

- **WRPS' Core Values**: *safe, innovative, reliable, technically inquisitive, integrity*.

  The AP Farm Ventilation Upgrades Project effectively embodies each of WRPS' core values. The project was executed safely during fiscal years 2014-2016 with no OSHA recordable incidents. The team was creative and innovative in coming up with ways to increase safety and efficiency, as evidenced in section 3 below. The team was technically inquisitive, as demonstrated by the team's intimate integration of engineering, construction management, and field workers. Finally, the team exemplified integrity by making right decisions, whether by stringent adherence to not-to-exceed funding limits or by developing a final product which serves as an exemplary model for future ventilation upgrade projects.

2. Identify the expected positive benefits/value of the project on society.

All of the expected positive benefits of the AP Farm Ventilation Upgrades Project fall into the categories of *safety* and *efficiency* (and many benefits fall into both categories)

Safety includes

- Safety of the Hanford workforce during executing the project
- Safety of the Hanford workforce during operations of the new AP Farm ventilation system
- Safety of the Hanford workforce and environment during storage of waste from other tanks
- Safety of the Hanford workforce and environment during future transfers of waste for processing

Efficiency includes

- Saving time and money during project execution
- Saving time and money during operations and maintenance of the new AP Farm ventilation system
- Saving time and money during execution of future tank farm ventilation upgrade projects

3. Describe what processes/tools were used to verify if the expected project benefits were achieved.

The AP Farm Ventilation Upgrades Project created many safety- and efficiency-related benefits on behalf of project stakeholders. Here are a few of the demonstrable ways in which the expected project benefits were achieved. It is worth noting that when the team precludes the need for workers to physically enter AP Farm that workers are spared from donning respiratory equipment, thereby avoiding hazards and expended time and cost.

- The team designed the exhaust stacks on the exhausters to be 40' tall, 13' higher than previous tank exhausters. This protects workers by allowing potentially hazardous emissions to be released and disperse at a safe distance from workers.
- The team installed three seal pots—two from the exhausters which drained down to the third from the de-entrainers. This protects workers and the environment by creating a double vapor barrier preventing gases from leaving the tanks. The two exhauster seal pots were also located in their own vaults accessible by stairs. This protects workers and the environment since the vaults act as secondary containment, and because workers can access the seal pots easily and safely.
- The team designed the ventilation system with redundant components for emergency or maintenance conditions: two de-entrainers, two exhausters, three seal pots, and backup power. This protects workers and the environment in case of a component failure or electrical outage.
- The team installed a new AP Farm access gate and staged the subcontractor trailers as well as furnished equipment in very close proximity to the new exhauster site. This saved time and money by eliminating the distance and cycle time that workers needed to travel to perform the work.
- The team decided to cut and sample pieces of a light pole which had been removed during the project, rather than just dispose of it. This saved time and money for future projects by examining now the effect of tank farm soil on light pole integrity.
- The team used ground scanning to confirm the absence of obstructions underground at the site for the exhausters. The resulting data allowed excavation with heavy equipment, rather than by hand, as is the norm in the tank farms. This protected workers and saved time and money by getting the job done quicker and without manual effort.
- The team realized that instead of digging new power conduit trenches in AP Farm, they could use currently existing trenches located outside AP Farm. This protects workers and saved time and money by eliminating the need for long excavations and related worker entry into the tank farm.
- The team located power distribution controls in a building outside AP Farm. This protects workers and saves time and money by eliminating the need to enter AP Farm to control the system power.
- The team needed to excavate three areas, (1) for the de-entrainer seal pot installation, (2) down to the top of tank AP-106, and (3) the 30' distance in between, all to install the drain lines between the seal pot and tank AP-106. Instead of traditional excavation methods, the team installed caissons (vertical cylinders of corrugated steel) where the seal pot and AP-106 excavations would occur, and performed all of the excavating using a vacuum truck. This protected workers and saved time and money by drastically reducing the footprint and duration of the excavation work.
- The team needed to connect drain lines from the de-entrainer to its seal pot. Rather than field install the drain lines using several 90-degree elbows, the team shop fabricated a customized drain sweep. This protected workers from additional farm entries and from radiological buildup which occurred in 90-degree elbows in other tank farms, and saved time by eliminating the need to fabricate lines inside AP Farm.
- The team developed and installed on the exhausters new customized software allowing for remote operations. This protects workers and saves time and money by eliminating the need for operations personnel to be physically present in. the field.

4. Describe what benefits-related complexities had to be overcome.

During the course of the project, WRPS safety requirements were updated. The update included the requirement that any field work occurring in AP Farm be performed while wearing Self-Contained Breathing Apparatus (SCBA) masks and air bottles. The new safety requirement added time and cost to the administration and execution of the project. The project team found creative ways to mitigate the resulting cost and schedule impacts, while fully implementing the new requirements. The project team still completed the project on time and with no recordable safety events.

4. Schedule

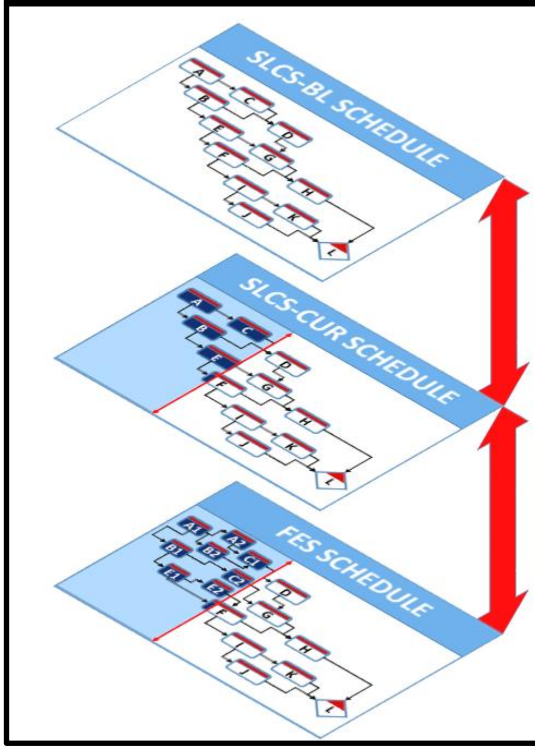
Show that the project schedule was effectively developed and managed by answering the following:

1. Describe what processes/tools were used to develop and manage the schedule.

The AP Farm Ventilation Upgrades schedule was originally developed as part of the project proposal to DOE-ORP. The schedule was developed by assimilating a variety of inputs such as project scope organized by Work Breakdown Structure (WBS), risks, deliverables, and knowledge from the integrated project team. These inputs were considered by project subject matter experts who arranged activities and milestones using relationships, durations, and resources to construct the project schedule.

Once the AP Farm Ventilation Upgrades Project proposal was formally integrated into WRPS' Performance Management Baseline (PMB), the schedule became part of WRPS' Summary Lifecycle Baseline Schedule (SLCS-BL). The project schedule which was previously developed now needed to be managed. This was accomplished using Primavera P6 software, critical-path scheduling, and a hierarchy of project schedules (see Image 1):

Image 1: AP Farm Ventilation Upgrades Project Schedule Hierarchy



- The SLCS-BL schedule began unchanged from the original incorporated PMB schedule. SLCS-BL was resource-loaded from the proposal, and was the basis for tracking Budgeted Cost of Work Scheduled for earned value analysis.
- The Summary Lifecycle Baseline Schedule with Status (SLCS-CUR) was a monthly copy of the SLCS-BL which received updates for completed work, interim progress, remaining durations, and logic changes. SLCS-CUR was the basis for Budgeted Cost of Work Performed for earned value analysis.
- The Field Execution Schedule (FES) was the detailed working plan schedule for near-term discrete work. Control account managers, project managers, and the integrated project team met weekly during the project to provide input to the FES in the form of percent complete, forecast dates, duration changes, etc. The FES contained all field work and was directly linked to the SLCS-CUR using P6 system coding.

These three project schedules were vertically integrated—from the FES at the lowest level of detail to the SLCS-CUR to the SLCS-BL at the highest level. This means that activities and milestones were in alignment between each schedule, and a change to any one schedule propagated through each of the other schedules. The schedules were also horizontally integrated, meaning that the logic between each predecessor and successor activity could be traced from the beginning of the project all the way through completion on September 29, 2016.

2. Describe how these processes/tools were used to effectively manage the schedule's critical path.

The AP Farm Ventilation Upgrades Project employed three primary means of using the schedules to manage the critical path.

- *Schedule meetings*. Schedule meetings occurred weekly and brought together constituents of the integrated project team to review the FES. The meetings were used to gather schedule data and to maintain accountability for week-to-week changes in schedule float. Thanks to horizontal schedule integration, the project could monitor the effects of weekly changes to the scheduled project end date.

- *Variance analysis reports*. Earned value schedule performance was calculated on a monthly basis. This measured the variance between how much the project accomplished to date, versus how much it had planned to accomplish to date. If variances were significant, a variance analysis report would be produced to explain the cause, impact, and corrective action for the variance. These reports were communicated to management and to DOE-ORP.

- *Rules of Performance (ROP) system*. Before feeding percentages complete to SLCS-CUR for calculating the budgeted cost of work performed, the FES was sent through the ROP. This system is used to maintain the connection of performance earned in the lower level FES schedule and convey that for use in the SCLS-CUR in order to maintain vertical schedule integrity. This system is a direct feed from the working schedule and assists the project in properly claiming completed work scope and ensuring schedule activity information is accurately portrayed to management. Through this system the proper information and critical path activities are closely monitored in order to ensure accurate data representation and project completion.

3. Describe how effective management of schedule contributed to the project's success.

Effective management of the AP Farm Ventilation Upgrades Project schedule contributed to the project's success by conveying real-time data regarding schedule performance and impacts, and by clearly communicating ongoing project status to all stakeholders.

Project participants provided input to schedule meetings. Project float was thereafter communicated up through WRPS management. Variance analysis reports explained performance deviations to management and DOE-ORP. The SLCS-CUR and SLCS-BL schedules were under configuration management, and changes could only be made through the change control process after providing appropriate notification to WRPS management and to DOE-ORP. Completing the project on time while overcoming a wide variety of hazards and challenges could not have been possible without well-executed scheduling tools.

Finally, effective management of the project schedule contributed to the project's success by allowing the team to manage the driving paths to accomplishing all four PBI milestones:

- PBI-10.4.3 titled "Complete exhauster installation design in support of 241-AP primary ventilation system replacement" was completed September 30, 2015
- PBI-10.4.4 titled "Complete installation of new foundation, set exhauster skids, set work platforms (both for exhauster and for stack access), and set new stacks onto foundation in support of 241-AP primary ventilation system replacement" was completed May 21, 2015
- PBI-10.4.5 titled "Complete fabrication and installation of new air inlet stations on eight (8) AP farm DSTs in support of 241-AP primary ventilation replacement" was completed September 15, 2015
- PBI-15.7.1 titled "Complete construction, testing, and turnover of the new 241-AP primary ventilation system" was completed September 29, 2016, effectively completing the AP Farm Ventilation Upgrades Project

4. Describe what schedule-related complexities had to be overcome.

From July 30, 2014 until October 7, 2015, the AP Farm Ventilation Upgrades Project was operating under not-to-exceed funding limitations, and from October 2015 until January 2016 was operating under continuing resolution funding limitations. When DOE-ORP gave authorization to implement the project work scope into WRPS' PMB, funding for the entire project was not released at that time. Rather, DOE-ORP gave advanced work authorization for WRPS to begin performing the work with strict not-to-exceed funding limitations. During the period listed above, funding came to the project in six discrete chunks. This piecemeal approach to funding the project created a major schedule complexity because future funding and its timing was uncertain. For example, during any given phase of work the project needed to consider how both field work and long lead procurements factored into the schedule's critical path, and the team had to judiciously prioritize which field work and which procurements would be funded in order to keep the project on track with the least impact to scheduled milestones.

5. Cost

Show that the project cost was effectively developed and managed by answering the following:

1. Describe what processes/tools were used to determine the project cost.

The AP Farm Ventilation Upgrades Project cost was determined using two processes. Prior to project commencement, potential project costs were determined through the estimating process. Subsequent to project commencement, actual project costs were monitored and reported through the monthly accounting process.

Pre-project costs were first estimated as part of the AP Farm Ventilation Upgrades project proposal. A baseline estimate was developed and maintained in Cost Estimating Input Sheets in the Cost Plan estimating system. The cost estimate included such data as scope descriptions, assumptions and exclusions, basis of estimates, estimate stage and method, legal drivers and reference documents, and resource loading detail. Estimating techniques for preparing the AP Farm Ventilation Upgrades Project estimate included bottom-up estimating, analogous estimating from historical actual costs of similar scope, and estimating from analysis of vendor quoted pricing. The project cost estimate was used to resource load the baseline schedule, which became the basis for reporting earned value performance during the project lifecycle.

Once the AP Farm Ventilation Upgrades Project commenced work, actual project costs were determined through accounting systems. The AP Farm Ventilation Upgrades Project utilized the Hanford Business Management System (BMS) for accurate cost accumulation. Sources for actual costs during the year included labor timekeeping; equipment, material, subcontract, and other Hanford contractor accounts payable; and indirect cost overhead rates.

2. Describe how these processes/tools were used to effectively manage the project costs.

The AP Farm Ventilation Upgrades Project estimate was used to effectively manage project costs by providing as accurate a cost scenario as possible during the project planning phase. A good estimate from the project's planning phase creates a reasonable starting point for measuring project performance. A good estimate also contributes to project success from a project management standpoint as it ensures that the project baseline and approved scope is clearly documented and available for reference, ensuring the project managers and execution staff understand the scope which has been approved.

The accounting process was used to effectively manage project costs by providing as accurate a cost scenario as possible during the project execution. Timely and ongoing collection of actual costs from numerous input sources was required for accurate knowledge of project costs. And knowledge of project actual costs was essential for performance reporting and competent financial management of the project.

The AP Farm Ventilation Upgrades Project's estimate to complete (ETC) was used to effectively manage project costs by providing a time-phased forecast for project costs. The original project estimate is the basis for the budgeted cost of work scheduled and enters configuration management. The ETC, however, utilizes contemporary project knowledge to forecast project cost. The project ETC adds actual costs to date with a current estimate of remaining costs to produce the forecast cost. ETC is paramount to effective management of project costs by forecasting what will be the project's ultimate financial performance based upon current knowledge and planning. This forecasting allows for making managerial adjustments as necessary to keep project spending on track.

3. Describe how effective management of cost contributed to the project's success.

There are several ways whereby effective management of cost contributed to AP Farm Ventilation Upgrades Project success:

- *Traceability*. Project actual costs tracked through the Hanford BMS could be traced from the project costing module to the general ledger within the accounting system and to the specific source document (e.g. subcontract and material sources to invoices and labor sources to electronic timesheets). Every single project cost can be reviewed and accounted for. This is imperative for both internal cost controlling as well as for external cost reporting.

- *Cost Monitoring*. Timely collection of actual costs allowed for up-to-date monitoring of project costs. For example, the control account manager reviewed labor charges on a regular basis during the project. There were cases when costs were mistakenly attributed to the AP Farm Ventilation Upgrades Project, and correction of these costs was made possible through cost monitoring.
- *Variance Analysis*. Cost variance thresholds were used by the project to identify significant cost variances requiring management attention and action. When a cost variance (i.e. a deviation from the cost baseline by the actual costs) tripped predetermined thresholds, the control account manager produced Variance Analysis Reports (VARs). For each tripped threshold, the control account manager was required to use a VAR to explain the cause of the variance, the impact of the variance, and the corrective action being pursued for the variance. Variance analysis is intended in this way to identify emerging trends and head off cost problems early.
- *Reporting*. The project control account manager regularly reported on project costs. Depending upon the magnitude of a cost variance, a control account manager may have to report a cost variance only internally (within the WRPS chain of command) or also externally (to DOE-ORP). Reporting cost variances monthly kept WRPS management and DOE-ORP apprised of current project performance.

4. Describe what cost-related complexities had to be overcome.

As previously stated, from July 2014 until January 2016, the AP Farm Ventilation Upgrades Project was operating under not-to-exceed or continuing resolution funding limitations. Not-to-exceed conditions were a major cost complexity, as funding arrived in six incremental steps rather than all at once. Had the funding been allocated upfront, project total lifecycle costs could have been monitored from inception. Instead, the team needed to: track cost performance against what had been allocated to date; absolutely not spend past the not-to-exceed limitations; and maintain an understanding of how much funding was required to complete the project. Major portions of field work were completed by subcontract crews, to whom the project team had to pass on not-to-exceed funding limitations. The funding limitations imposed on the AP Farm Ventilation Upgrades Project as a whole prevented the team from being able to award the entire subcontract scope at once. Subcontract costs needed to be carefully monitored to avoid spending beyond not-to-exceed limitations.

During project execution, the largest variance from estimated costs came from producing the engineering design required for the ventilation upgrades. This significant variance was caused by factors related to labor and increased scope density. The factors relating to labor include high turnover of engineering staff responsible for the engineering design, and a communication gap resulting from multiple groups within engineering design working on the same scope. The factors relating to increased scope density include items not accounted for in the project estimate but required to make ready the exhausters for use at AP Farm, for which they were refurbished from previous use: HMI relocation, electrical redesign for alternate power, and incorporation of the VFD building into design.

The project also experienced cost overruns during readiness testing due to equipment failures and communication issues. Many of the new and improved features of the AP Farm Ventilation Upgrades proved to be a headache to a project team trying to perfect a wholly new and untested collection of components, but were ultimately highly beneficial for safety and efficiency in the long run.

Over the life of the AP Farm Ventilation Upgrades Project, the team was able to mitigate many of these early cost setbacks. The team realized major efficiencies during portions of equipment fabrication and installation. The structural steel for the exhausters was installed with much less labor than anticipated. The project team was able to self-perform some steel fabrication modifications rather than rely on a second-tier subcontractor. The team further recouped costs through efficiencies in procurement and installation of the VFD building, the de-entrainers, and the drain line equipment.

6. Scope

Show that the project scope was effectively developed and managed by answering the following:

1. Describe what processes/tools were used to document the project scope.

The AP Farm Ventilation Upgrades Project managed two kinds of scope: the scope of the entire project as performed by WRPS through its prime contract with DOE-ORP, and project scope which was performed by subcontractors. While the subcontracted scope is a bounded subset of the overall project scope, it is worth addressing both levels of project scope because the project team needed to manage both its prime scope and its subcontracted scope. On the $16 million AP Farm Ventilation Upgrades Project, the largest three subcontract releases alone comprise $5.2 million of the overall project cost.

The AP Farm Ventilation Upgrades Project prime scope was first documented at a high level in the WBS dictionary using Cost Plan software. As documented in the WBS dictionary, the scope for the AP Farm Ventilation Upgrades Project is contained in a single control account (level 5 of the WBS) with eight discrete WBS elements (level 6 of the WBS) for project management, engineering design, installation, procurement of materials, field construction, ventilation upgrades, engineering support, and construction support. The WBS provided the framework for quantitative planning, data collection, performance measurement, and progress reporting. The elements of the WBS dictionary were further defined and managed in the Cost Estimating Input Sheets (using Cost Plan software), which include a more detailed scope description, assumptions and exclusions, basis of estimates, estimate stage and method, legal drivers and reference documents, and detailed resource estimates for labor, materials, and subcontracts. Once the project proposal was submitted, DOE-ORP reviewed and negotiated the proposed scope with WRPS. Negotiated changes were implemented or resolved, and DOE-ORP issued a contract modification to WRPS' Tank Operations Contract to include the AP Farm Ventilation Upgrades Project. In order to make changes to the Performance Management Baseline through these software systems, approval from DOE-ORP was necessarily obtained through the Baseline Change Request process (described in further detail in Section 9, Project Change Management).

The AP Farm Ventilation Upgrades Project subcontract scope was defined in statements of work (SOW). SOWs were authored by a construction manager/buyer's technical representative who well understood the necessary subcontract scope. The SOWs were assigned their own WBS structure by the construction manager for monitoring performance of major subcontracted work elements. Subcontract release SOWs were stored, approved, and revised in Asset Suite software. Once the subcontract releases were issued by WRPS procurement to the subcontractors, the scope was only changed through the Contract Action Log and subsequent Contract Change Requests (described in further detail in Section 9, Project Change Management).

2. Describe how these processes/tools were used to manage the scope.

Subsequent to establishment of the baseline plan, project performance was managed and tracked within the working-level field schedule (described previously in section 4, Schedule). Progress was loaded from the FES schedule into the WRPS ROP database, which includes weighting for each schedule activity based on the value of project scope. As progress for all WRPS projects are collected monthly, an overall percent complete is declared for the Tank Operations Contract, including the AP Farm Ventilation Upgrades Project. Actual project costs were captured by the Hanford site-wide Business Management System and fed into WRPS' COBRA cost processor. By utilizing the project baseline, project progress, and project actual costs, monthly earned value was calculated for the AP Farm Ventilation Upgrades Project. Project performance was documented and reviewed at the control account level (level 5 of the WBS) by the Control Account Manager. If performance for work activities did not meet thresholds established by management, variance analysis was used to describe the cause of the performance gap, and the cost and schedule recovery initiatives required to amend the performance gap. As potential changes to AP Farm Ventilation Upgrades Project scope were identified, a screening process was used by the contract management group within WRPS to determine whether a change to the contract truly existed. If the project did require a change in scope, the Baseline Change Request process was used to incorporate the changes into the Performance Management Baseline.

For subcontract scope, schedule progress from subcontractors was also received and fed into the FES. Subcontractors provided accruals on a monthly basis through the Automated Accrual System, which were later reversed as invoices for the services were received, approved, and processed. In this way, subcontracted earned value performance could be managed similarly to the overall prime scope. As potential changes to subcontractor scope emerged, the Contract Action Log and Contract Change Request processes were utilized to manage changes

3. Describe how effective management of scope contributed to the project's success.

One crucial key to successful management of the AP Farm Ventilation Upgrades Project was to have a well-defined scope baseline before the start of the project. Having scope organized into a WBS structure—along with WBS dictionaries, assumptions, and exclusions, and basis of estimates—as part of the AP Farm Ventilation Upgrades Project proposal was instrumental to project performance in many ways. Following are some examples of how the project benefitted and effective management was facilitated through well-defined project scope:

- *Knowing what is in scope*. Having a well-defined scope baseline allowed the project team to understand clearly what is in project scope and to plan resources accordingly. Clarity of scope was critical to planning adequate labor resources, preparing long-lead procurements, directing engineering design efforts, and exploiting opportunities for value engineering.
- *Knowing what is not in scope*. When questions arose as to whether engineering, procurement, or field work activities should be performed, the project team was able to reference the definitive scope baseline for an answer. By having a well-defined project scope, the team was able to avoid costly scope creep.
- *Delegation of responsibilities*. By integrating the WBS with an Organizational Breakdown Structure, the project derived a Responsibility Assignment Matrix (RAM). Project controls accounts, as defined by the RAM, provided an efficient means of parsing and assigning project scope to various project managers for performance of the scope.
- *Effective tracking and analysis*. The well-defined scope baseline provided the means for the project team to track and analyze progress. As scope-related complexities occurred during the year, the project team referred to the baseline scope in order to re-plan activities and stay focused on project deliverables.

4. Describe what scope-related complexities had to be overcome.

Scope related complexities were encountered for prime contract scope as well as for scope performed by subcontractors. Examples of AP Farm Ventilation Upgrades Project prime scope complexities addressed by the project team:

- During engineering design of the new AP Farm Ventilation System, the project team had to adapt to WRPS' conversion to a whole new design process for documentation and workflow.
- SY Farm was originally slated to be the next tank farm to receive ventilation upgrades. The team transitioned to working on AP Farm after a programmatic reprioritization.
- Due to funding availability and prioritization, the engineering design team assigned to complete the AP Farm Ventilation Upgrades was different from the team which initiated the design. The incoming team handled the turnover in order to assure a more seamless design transition.
- In order to develop software for the AP exhausters, the team migrated software originally developed for exhausters at the AN and AW Farms, and spent months performing updates to ensure continuity on behalf of operations and maintenance personnel.

Examples of AP Farm Ventilation Upgrades Project subcontract scope complexities addressed by the project team:

- The project team while performing field work ran into a variety of changed conditions (e.g. abandoned air lines, concrete, and a French drain found during project excavation) and responded and adapted with creative solutions.
- The project team built a cantilevered concrete pad for the de-entrainers over a preexisting excavation as a proactive and novel approach to sequencing work to maximize both safety and schedule.

7. Stakeholders

Show that stakeholder expectations and communications were effectively managed by answering the following:

1. Identify the key stakeholders and why they were key to your project.

Key stakeholders for the AP Farm Ventilation Upgrades project included DOE-ORP, the Hanford workforce, and project subcontractors.

- *DOE-ORP*. The Office of River Protection is the federal Department of Energy's field office responsible for the retrieval, treatment, and disposal of Hanford's waste in a safe, efficient manner. DOE-ORP was key to the AP Farm Ventilation Upgrades project because the office is the project's direct customer and performed contract oversight and safety and compliance-related work for the project. DOE-ORP has a prime contract with WRPS, and is responsible for contracting the AP Farm Ventilation Upgrades project.

- *Hanford Workforce*. For a variety of reasons, the Hanford workforce was a key stakeholder to the AP Farm Ventilation Upgrades project. The Hanford workforce includes those who work in or near the AP Farm and whose safety depends, in part, upon the AP Farm ventilation equipment, those who will operate and maintain the AP Farm ventilation equipment, and those who will be transferring waste to and from the AP Farm for WRPS' waste feed delivery mission. Because of the needs of the Hanford workforce, the project team had to design the new ventilation system for longevity, reliability, operability, convenience, standardization, compatibility, and most importantly—SAFETY.

- *Project Subcontractors*. The AP Farm Ventilation Upgrades project teamed with a variety of skilled and competent project subcontractors. These project subcontractors contributed critical expertise and labor towards successful execution of the project scope. Project subcontractors fabricated ventilation system components, refurbished existing system components, and installed ventilation system equipment in the field. It was important for the project team to work closely project subcontractors to ensure a quality project outcome.

2. Describe what processes/tools were used to manage stakeholder expectations and communications.

- *Integrated Project Team.* The AP Farm Ventilation Upgrades integrated project team provided oversight and management of the project, and included representatives from each of the key stakeholders. By conducting weekly and monthly meetings, the integrated project team was the primary means for communicating with each stakeholder constituency. Representatives from DOE-ORP, various facets of the Hanford workforce, and project subcontractors were able to come together regularly to give input and become apprised of project progress.

- *Project proposal*. The AP Farm Ventilation Upgrades project proposal to DOE-ORP included scope, schedule and cost baselines. While the project proposal was not widely distributed to all the project stakeholders, the proposal scope, schedule and cost baselines provided the basis for performance metrics and expectations which were communicated to the project team.

- *Performance Based Incentives*. The AP Farm Ventilation Upgrades PBIs were four performance-fee milestones for objectively measuring project progress along critical path activities. The four PBI deliverables included performance of work related to (1) completing exhauster installation design, (2) installation of exhauster and stacks, (3) installation of air inlet stations, and (4) complete turnover to operations of the new ventilation system.

- *Monthly performance reporting*. The AP Farm Ventilation Upgrades project monthly performance reports describe project performance for each month of the project. This description includes field work completed as well as metrics related to cost and schedule (earned value) performance.

3. Describe how these processes/tools were used to manage stakeholder expectations and communications.

- *Integrated Project Team*. The integrated project team was a quorum which included all major project stakeholders, including DOE-ORP, a variety of vested participants from the Hanford workforce, and the project subcontractors. The integrated project team was the way in which project stakeholders met often and in person to discuss any and all issues related to the AP Farm Ventilation Upgrades project.

- *Project proposal*. The AP Farm Ventilation Upgrades project proposal provided stakeholders with a baseline against which to measure success. For example, the proposal baselines informed stakeholders as to what schedule timelines were expected, how the project team was performing against original cost estimates, and defined scope which would be performed by the Hanford workforce and by subcontractors.

- *Performance Based Incentives*. The AP Farm Ventilation Upgrades project PBIs were a convenient focal point for the project team and the project stakeholders to benchmark big-picture AP Farm Ventilation Upgrades progress.

- *Monthly performance reporting*. The AP Farm Ventilation Upgrades monthly performance reporting was a key tool for communicating to all stakeholders because it provided a monthly snapshot of progress to date. Stakeholders were made aware of engineering and field work accomplishments. Earned value data served to show where the project was ahead or behind on work scheduled for completion

4. Describe how effective management of stakeholders contributed to the project's success.

All four communication tools described above worked together to keep the project participants and the project stakeholders on the same page. Taken together, these communication tools provided the framework for meaningful monitoring of project performance, and created avenues for incremental stakeholder buy-in. The integrated project team began by creating a common goal and desired end-state for all project stakeholders. Then the project proposal definitized the work that was to be performed over the project lifecycle. The PBI milestones demonstrated achievement of major critical path activities. Finally, the monthly reporting communicated the granular monthly details of how work actually progressed against the plan.

5. Describe what stakeholder-related complexities had to be overcome.

The funding complexities imposed by not-to-exceed limitations and by continuing resolution illustrates well the need for, and benefits of, well-integrated stakeholders. The project team was funds-limited by five rounds of advanced work authorization and by some months working under continuing resolution. The associated challenges related to schedule, cost, and scope have been articulated previously. These funding challenges also required a high degree of coordination and communication between stakeholders. DOE-ORP was responsible for issuing funding to the project team, who was in turn tasked with spending the limited funds as judiciously as possible to balance critical path activities with long-lead procurements and ongoing field work. Much of the fabrication and field work was performed by project subcontractors, who were in turn funds-limited in some cases by the project team. Without ample coordination and communication between project stakeholders, the project would not have been completed nearly so successfully.

Another stakeholder-related complexity overcome by the AP Farm Ventilation Upgrades project team on a number of occasions was that of conflicting priorities. There were a variety of instances where one stakeholder's preference for executing the project was in conflict with another stakeholder's preference. For example, a project stakeholder wanted to perform multiple pressure test on individual system segments as they were being assembled. Other stakeholders would have preferred to perform a single pressure test at the end of system installation. The project decided to perform multiple pressure tests during installation, which enabled the final whole-system pressure test to pass with flying colors on the first try. While stakeholders might not have always been in agreement, the time taken to listen to and coordinate their needs made for a much better final product.

8. Risk

Show that risks were effectively managed during the project by answering the following:

1. Identify the key risks and explain why they were key to your project.

One of the most challenging hazards posed by Hanford's tank farms are chemical vapors, which have the potential to enter a worker's breathing zone. Chemical vapors are generated by tank waste, then diffuse out of the liquid and solid waste and accumulate above the waste in the headspace portion of the tanks. Chemical vapors are then ventilated from the tank headspace through passive or active mechanical means into the atmosphere well above the worker breathing zone. Chemical vapors can also be released from tank waste when the waste is actively disturbed or moved, such as during retrieval operations or during transfer of waste from one tank to another.

The AP Farm Ventilation Upgrades project involved field work in the AP Farm, modification and installation of ventilation equipment and components, and support of active waste transfers from the AY-102 retrieval project. Each of these circumstances represented a potential risk of exposure to chemical vapors. Fortunately, Hanford workers are protected from chemical vapors through a strict control strategy implemented by WRPS and DOE-ORP (including elimination and substitution of hazards where possible, engineering controls, administrative controls, and the proper use of personnel protective equipment). However, the AP Farm Ventilation Upgrades project faced various potential cost or schedule impacts due to vapor-related factors, such as changes in vapors management strategy, enhancements to vapors identification, implementation of recommendations from a Tank Vapor Assessment Team (TVAT), and improvements to industrial hygiene sampling and monitoring.

Examples of key AP Farm Ventilation Upgrades project risks related to chemical vapors include:

- Changes to respiratory equipment requisite for working in the project area
- Restrictions to AP Farm access and field activities due to chemical vapors concerns
- Changes to project technical requirements and equipment needs based on vapors modeling and evaluations
- Increased potential for chemical vapors contact in the event that the old AP Farm exhauster shuts down
- Potential for damage to existing ventilation ductwork and equipment during execution of project field activities

2. Describe what processes/tools were used to document risks.

Management of risk activities associated with the AP Farm Ventilation Upgrades project was ongoing since the submission of the project proposal to DOE-ORP. Since that time, the project used a risk register as the primary tool for documenting project risk. During project development, the integrated project team of subject matter experts worked to identify potential risks by reviewing existing data. The 34 initial project risks were documented in the original risk register. This number grew to 42 identified risks by project's end, as the project team continued to identify and consider additional risks as they arose.

Once project risks were identified, they were assigned a risk level—High, Medium, or Low—based on two criteria: likelihood of occurrence and risk consequence. Likelihood of occurrence includes a range of five values from "very unlikely" (less than 10% likelihood) to "very likely" (greater than 90% likelihood). Risk consequence includes a range of five values from "negligible" to "crisis" depending upon estimated cost and schedule impacts. Of the original 34 risks—based on the criteria of likelihood of occurrence and risk consequence —3 were categorized as High risk, 19 as Medium risk, and 12 as Low risk.

3. Describe how these processes/tools were used to manage risk.

After risks were identified and assigned a risk level on the AP Farm Ventilation Upgrades risk register, handling strategies were then devised for each risk with the goal of driving down risk level to a lower, residual risk level. Handling strategies are specific action items which involve means of either avoiding, transferring, mitigating, or accepting project risks. Each handling strategy was assigned to an owner who was responsible for ensuring implementation of the action items involved.

Once handling strategies were executed, each risk was monitored and controlled. This was accomplished primarily through regular monthly risk meetings with members of the integrated project team. At these risk meetings, each AP Farm Ventilation Upgrades project risk was reviewed along with its current handling actions. Risks over time changed in status from the default of “open” to either “realized” (when the anticipated risk occurred on the project) or “closed” (when the risk to the project no longer existed). Risks also changed risk level, moving between High, Medium, and Low depending on changes in project circumstances and the effectiveness of handling actions. By project completion, 4 outstanding project risks were considered risk level High, 7 were medium, 12 were low, and the remainder were by then closed.

4. Describe how effective management of risks contributed to the project’s success.

Use of WRPS’ risk management process of risk planning, risk identification, risk assessment, risk handling, and risk monitoring and control—coupled with the projects team’s use of the risk register tool—contributed to the project’s success in several ways

- *Promoted forward thinking*. By bringing together the diverse integrated project team early and continuously to talk about emerging and ongoing risks, the project team was able to identify risks and their potential impacts well before they were realized.
- *Kept risks manageable*. By ideating multiple reasonable handing strategies and creating accountability for executing the handling strategies, the project team was able to definitize a large and diverse set of risks into an achievable set of strategic actions.
- *Monitored changes in risk*. By meeting regularly to discuss the risk items contained in the risk register, the project team was able to quantify and trend overall and specific increases and decreases to project risk.
- *Communicated project risks*. By documenting and quantifying project risk through the risk register, the project team was able to succinctly and coherently identify and communicate project risks both upwards to senior management as well as outwards to project team members and stakeholders.

5. Describe what risk-related complexities had to be overcome.

During project execution, nine project risks were realized:

- *SCBA equipment required for performing in-farm work*. The project team had to transition and adapt to performing field work wearing SCBA respiratory equipment.
- *Funding not available when required*. As described previously, the project team allocated and prioritized resources to cope with several rounds of not-to-exceed funding.
- *Vapor concerns restrict AP Farm access*. The project team held weekly integration meetings and used SCBA respiratory protection as required to complete the project.
- *Field conditions differ from drawings*. The project team leveraged engineering field walk downs, ground scanning, and potholing to identify and mitigate differing conditions as early as possible.
- *Existing exhauster does not meet design requirements*. The project team identified exhauster deficiencies early and refurbished the exhausters as needed.
- *Design review not completed in time*. The project team utilized daily conference calls with the engineering manager to communicate project needs and discern availability of engineering support.
- *Design resources not available when needed*. The project team looked for other ways to reduce the overall project schedule to mitigate impacts from unavailable design resources.
- *AP Farm legacy exhauster shuts down*. The project team trained field crews to be able to continue working in the event of an unexpected ventilation shutdown.
- *Respiratory impacts from AY-102 transfer*. The project team prepared to use respiratory controls as necessary to deal with potential risks associated with tank waste transfers.

9. Project Change Management

Show that proposed changes to project scope, cost, and schedule were effectively managed by answering the following:

1. Describe what processes/tools were used to document and approve changes.

   As described in section 6.1 on Scope, the AP Farm Ventilation Upgrades Project team managed overall project scope as approved and funded by DOE-ORP, but also defined and managed the subset of scope performed by subcontractors. Both the prime project scope and the subcontracted portion of scope were subject to contract changes. Two different processes were used to document and approve changes for these two levels of scope.

   - *Baseline Change Request (BCR) Process*. Changes to the scope, cost, and schedule of the AP Farm Ventilation Upgrades Project **prime contract** were handled using WRPS' BCR process. The BCR process gathers information related to a proposed contract change and ensures that the proposed changes are approved by the necessary authority. BCR inputs include a BCR form, WBS dictionaries, original and revised schedules, detailed cost comparisons, cost estimating input sheets, and other planning worksheets or guiding documents. This information is then combined into a BCR package and assigned a BCR number. The BCR package is reviewed by WRPS' Change Control Board, and is approved by the WRPS Project Manager, WRPS' Project Integration manager, and as necessary by DOE-ORP. Every BCR is recorded in WRPS' BCR Log, which maintains the historical record of contract changes made through the BCR process.

   - *Contract Change Request (CCR)* and *Contract Action Log (CAL) Processes*. Changes to the scope, cost, and schedule of the AP Farm Ventilation Upgrades Project **subcontracts** were handled using WRPS' CCR and CAL processes. The CCR process is performed in Asset Suite software and is used to formally document and track changes to a subcontractor's scope, cost, and schedule. The changes are reviewed and approved in Asset Suite by the same functional authorities who approved the original subcontract SOW, cost, and schedule. The CAL process is used to expeditiously approve changes to time and material subcontracts which support—but were not clearly identified or estimated in—the original scope of work. The actual Contract Action Log is maintained in an Excel spreadsheet by the construction manager. Periodically a CCR is initiated to reconcile the outstanding activities contained in the Contract Action Log.

2. Describe how these processes/tools were used to manage change.

   - *Baseline Change Request (BCR) Process*. The AP Farm Ventilation Upgrades Project team completed eleven BCRs during the life of the project. The eleven BCRs covered changes including Advanced Work Authorization to allow the project to start/continue under not-to-exceed funding limitations, fiscal year planning updates, resource rate changes, scope deferral, integration of detailed planning, and proposing a new PBI milestone date due to AY-102 retrieval impacts.

   - *Contract Change Request (CCR)* and *Contract Action Log (CAL) Processes*. For the largest three subcontract scope releases, covering ventilation system field work, the AP Farm Ventilation Upgrades Project team completed 15 CCRs. The subcontract CCRs covered changes including adding subcontract funding after BCRs incorporated Advanced Work Authorization for the project, extending the period of performance for a subcontract, and reconciling CAL activities (comprising 11 of the 15 CCRs). As a representation of CAL usage, the largest of the three subcontracts (over $3.5 million worth of scope performed over approximately a year and a half) had 33 CAL items, covering changes ranging from procurement of electrical parts to transportation of fabrications to additional demolition activities.

3. Describe how effective management of change contributed to the project's success.

- *Performance Management Baseline is always current*. By utilizing the BCR and CCR/CAL processes, the project PMB was modified in a timely fashion as project changes occurred. This is imperative as the PMB is the baseline against which current performance is measured. If the PMB is not reflective of all current cumulative project changes, then performance measurement methods (e.g. earned value analysis) will not be accurate.

- *Robust traceability.* By utilizing the BCR and CCR/CAL processes, all project PMB changes were tracked and traceable. Prime contract changes were tracked through the BCR Log, and subcontract changes were tracked through CCRs and the Contract Action Log. To understand the current status of the AP Farm Ventilation Upgrades project PMB and subcontracts and how the project got to its current status (such as for audit or forensic purposes), the BCR Log, CCRs, and Contract Action Log together provide a roadmap. Taken as a cumulative whole, the BCRs/CCRs/CALs provide the narrative for how the PMB went from its original state to where it was at project completion.

- *Customer notification and concurrence.* The AP Farm Ventilation Upgrades project received its authorization from DOE-ORP. Because of this, the project cannot contractually make PMB changes without notification or approval from DOE-ORP. Depending upon the type of baseline change, either notification to DOE-ORP is required (e.g. baseline schedule changes, management reserve transactions), or approval from DOE-ORP is required (e.g. changes which impact contract budget base, changes which impact key project deliverables). In this way, the BCR process is a tool for both communicating changes to the customer and validating their concurrence.

4. Describe what change-related complexities had to be overcome.

The most significant change-related complexity for the AP Farm Ventilation Upgrades project was again the fact that the project received advanced work authorization and operated on not-to-exceed funding limitations. The major impact that this complexity had on the AP Farm Ventilation Upgrades project was that it caused a significant administrative burden, regarding both the prime contract and the project subcontracts. Because of the funding limitations imposed upon the whole AP Farm Ventilation Upgrades project, the project team was unable to award subcontracts at their full value. Full value awards would have pushed the overall project past the not-to-exceed value. It is worth noting that the project operated under not-to-exceed funding limitations for more than half of the 26 month project duration. The project's advanced work authorization status necessitated five of the eleven project BCRs and three of the major subcontract CCRs. Each BCR and CCR represents many hours of documentation, administration, review, and approval.

In large part because the project scope and subcontract scope were well defined and well organized, the project was able to avoid many change-related complexities. The AP Farm Ventilation Upgrades project did not need to process changes related to changed conditions or other potential project crises.

5. Identify the key changes during your project and why they were key to your project.

- *RPP-14-165 "AWA for AP Farm Ventilation Upgrades."* This is the BCR which initiated the AP Farm Ventilation Upgrades project. The purpose of this AWA BCR was to add activities to WRPS' PMB for engineering design and project management. This change was key because it allowed WRPS to formally commence work on this important project.
- *RPP-16-022 "Detail Planning of AP Farm of Excavation, Fabrication, Electrical, & Installation."* This is the BCR which incorporated the final 20 percent of the project's negotiated value. The purpose of this BCR was to distribute remaining budget and scope. This change was key because it eliminated the project's status as being confined to advanced work authorization and not-to-exceed funding limitations and as well it mitigated project risks related to unavailability of funding and unexpected work stoppages.

10. Lessons Learned

Show that lessons learned from previous projects (if any) and from the submitted project were effectively integrated into the project and/or organization by answering the following:

1. Describe what processes/tools were used to capture lessons learned.

Lessons learned for the AP Farm Ventilation Upgrades project were generally derived from three sources:

- The first lessons learned originated as subject matter expert input from previous ventilation upgrade and exhauster projects at AN and AW Farms. These precedent projects provided invaluable working insights which were documented and included in the AP Farm Ventilation Upgrades project proposal (e.g. as bottom-up or analogous cost estimates were established).

- The second set of lessons learned emanated from brainstorming sessions by the integrated project team. The AP Farm Ventilation Upgrades integrated project team is a cross-functional, multi-disciplinary team established to provide oversight and management of the project, and included subject matter experts from management, engineering, nuclear safety, procurement, construction and commissioning, training, operations, radiological controls, environmental safety, industrial hygiene, project controls, industrial safety, and quality assurance. Each of these matrixed functions had the opportunity to contribute lessons learned and areas for improvement during performance of the project.

- The third source of lessons learned for the AP Farm Ventilation Upgrades project was from process reviews and formal performance assessments. Process reviews and assessments apply structured methodologies to systematically investigate potential opportunities to improve work flows, remove obstacles, and reduce organizational barriers and inefficiencies.

The lessons learned from each of these sources was documented so as to make them available to the project team and to project teams for subsequent ventilation upgrade projects. Lessons learned were captured in sources such as the project proposal, primary ventilation system upgrades functions and requirements documents, and recorded lessons learned meeting minutes. Functions and requirements documents and meeting minutes together account for at least 84 specific lessons learned for the AP Farm Ventilation Upgrades project.

2. Describe how the lessons learned were integrated into the project.

Integration of lessons learned into the AP Farm Ventilation Upgrades project began at the earliest phases during proposal development and continued through project completion. Estimators and subject matter experts integrated lessons learned into project proposal baselines. Engineers integrated lessons learned into the creation of engineering design media. Construction management integrated lessons learned into conducting constructability reviews. The buyer’s technical representative integrated lessons learned into subcontract documentation and statements of work. Fabricators integrated lessons learned into building system components. Software testing personnel integrated lessons learned into software testing plans. Construction management and subcontractors integrated lessons learned into placement and installation of components and into construction acceptance testing and project turnover. The entire approach to planning, engineering, and field work execution of the AX Farm Retrieval Readiness project was influenced by the lessons learned accumulated and disseminated by the project team.

3. Describe how the integration of lessons learned contributed to the success of the project.

Lessons learned had a profound impact on the AP Farm Ventilation Upgrades project. The very act of collecting lessons learned from the Integrated Project Team for AP Farm Ventilation Upgrades promoted both cross-functional and vertical communications. It is possible on a project the size of AP Farm Ventilation Upgrades for representatives of functional organizations to become isolated from each other. Functional isolation can lead to “stove piping,” during which project decisions made by a single organizational function are made without consideration for the greater context of the project. Meeting to discuss and document lessons learned formed bridges between functions and help prevent ideas created in a vacuum. By actively giving voice to all project participants and stakeholders, the project also promoted the sort of vertical communications which may ordinarily be lost to a project's organizational hierarchy. The communications networks fostered by lessons learned was certainly a factor for project success.

4. Identify the key lessons learned and why they were key to your project and/or organization.

   There was no one single lessons learned which alone was central to the AP Farm Ventilation Upgrades project. Rather, the key lessons learned principle demonstrated by the AP Farm Ventilation Upgrades project is that by cultivating and gleaning many major and minor lessons learned from all stakeholders and the entire project team, these sustained efforts can culminate in a radically improved final product.

   Here is a small sampling of the many ways in which lessons learned played a value-added role in the AP Farm Ventilation Upgrades project:

- The project team considered a wide diversity of ergonomic factors while designing the exhauster and exhauster platforms. AP Farm exhausters are built to allow easy, unrestricted access to exhauster and stack components for monitoring and operations. AP Farm exhauster platforms are easier to ascend, have more headroom to work, and have much better night illumination (using lower power LED lights) compared to previous exhausters.

- The project team had a new type of de-entrainer developed for the AP Farm system. The de-entrainer component which removes liquid from the ventilated headspace air is built to be replaceable with minimal effort. Additionally, the de-entrainer was designed so that this component could be washed down from above and below to help minimize the frequency with which the component requires replacement.

- The project team designed a new type of vacuum pump cabinet. This new cabinet was specifically designed to withstand seasonally-fluctuating operating temperatures, while also keeping moisture out. These improvements greatly increase the longevity of the vacuum pump components.

- The project team performed exhauster software testing while the exhausters were being fabricated. While perhaps not the most convenient testing environment, this approach precluded the team from having to perform software testing in AP Farm, which eventually would have required the onerous use of SCBA respiratory protection.

- The project team installed wireless leak detection technology for the first time in a tank farm. All tank farms have leak detector systems to determine whether waste is escaping its intended pathway; AP Farm was the first farm to feature a wireless version. This eliminated the need to install hard-wiring for the leak detection system.

- The project team kept the same craft resources as much as possible for the duration of field work. This continuity of personnel allowed for a high level of trust and team cohesiveness with a minimum of costly project turnover.

Besides meaningfully integrating lessons learned from precedent projects, the AP Farm Ventilation Upgrades project has become a valuable source of lessons learned for future projects. The AP Farm Ventilation Upgrades project team has constructed a best-in-class tank farms ventilation system. Besides playing a critical role in the Hanford tank waste disposition mission, and in addition to operating like a champion since its turnover, the AP Farm Ventilation Upgrades project accomplished some Hanford firsts and set a new benchmark for ventilation upgrades project going forward. The AP Farm Ventilation Upgrades project legacy will continue, as the system has already provided lessons learned for upcoming A Farm and SY Farm ventilation upgrade projects.