



U.S. Department of Energy
Office of River Protection

P.O. Box 450, MSIN H6-60
Richland, Washington 99352

AUG 24 2007

07-ESQ-115

Mr. John C. Fulton, President
and Chief Executive Officer
CH2M HILL Hanford Group, Inc.
2440 Stevens Center Place
Richland, Washington 99354

Dear Mr. Fulton:

CONTRACT NO. DE-AC27-99RL14047 – ASSESSMENT OF CH2M HILL HANFORD GROUP, INC. (CH2M HILL) COMPUTER SOFTWARE QUALITY ASSURANCE (QA), A-07-ESQ-TANKFARM-004

Reference: DOE O 414.1C, "Quality Assurance."

This letter forwards the results of the U.S. Department of Energy, Office of River Protection assessment of computer software conducted during the period June 18 through 22, 2007, and requests your actions to correct the assessment issues. The assessment evaluated implementation of the Software QA requirements of the Reference, focusing primarily on safety software.

CH2M HILL has made progress in implementing the requirements of DOE O 414.1C, however documentation required to demonstrate the quality of some software was not prepared. Personnel did not always follow procedures, and some safety software was incorrectly classified. The assessment resulted in six Findings and five Observations.

Within 30 days of receipt of this letter you should respond to the assessment Findings. For the Findings, your response should include:

- The causes of the Findings;
- The corrective actions that have been taken to control or remove any adverse impact from noncompliant conditions (remedial actions) and the results achieved;
- The corrective actions that will be taken to identify the extent of condition, correct the cause(s), and prevent further Findings; and
- The date when all corrective actions will be completed, verified, and compliance to applicable requirements achieved.

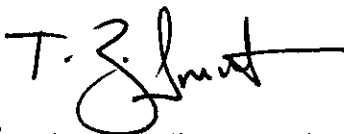
Mr. John C. Fulton
07-ESQ-115

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If you have any questions, please contact me, or your staff may contact William J. Taylor, Assistant Manager, Office of Environmental Safety and Quality, (509) 376-7851.

Sincerely,


for Shirley J. Olinger, Acting Manager
Office of River Protection

ESQ:SAV

Attachment

cc w/attach:

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CH2M HILL Correspondence

U.S. DEPARTMENT OF ENERGY
Office of River Protection
Environmental Safety and Quality

ASSESSMENT: CH2M HILL Hanford Group, Inc. Computer Software Quality Assurance

REPORT: A-07-ESQ-TANKFARM-004

FACILITY: Hanford Tank Farms

LOCATION: Richland, Washington

DATES: June 18 through 22, 2007

ASSESSORS: Samuel A. Vega, ORP, Lead Assessor
Debra R. Sparkman, DOE-HQ Central Technical Authority, Technical Participant
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APPROVED BY: Patrick P. Carrier, Team Lead
Verification and Confirmation Official

Executive Summary

The U.S. Department of Energy (DOE), Office of River Protection (ORP) conducted an assessment of Software Quality Assurance (SQA) at the Hanford Tank Farms from June 18 through 22, 2007. The assessment evaluated CH2M HILL Hanford Group, Inc. (CH2M HILL) implementation of the SQA requirements of DOE O 414.1C, "Quality Assurance." A SQA subject matter expert from the DOE Headquarters Office of the Chief of Nuclear Safety participated in the assessment.

The assessment found that CH2M HILL made some progress in implementing the requirements of DOE O 414.1C. However, efforts to revise existing legacy software documentation to meet current SQA requirements were not timely, and not effectively managed by CH2M HILL. Personnel performing activities affecting software quality did not always follow procedures resulting in some software being incorrectly classified. CH2M HILL also made safety software classification errors because the questions on the Hanford Information System Inventory Software Quality and Safety Checklist were not structured to consistently assure correct determinations. The assessment team found several examples of missing or inadequate software documentation, confirming the findings of a recent CH2M HILL assessment. The assessment team did not find evidence of errors in any of the computer codes themselves.

CH2M HILL incorrectly applied the management assessment process to one assessment conducted to evaluate implementation of DOE O 414.1C requirements for SQA. CH2M HILL initially identified the assessment as a management assessment, but it was not performed by a manager, it was not performed from within an organization, and it did not focus on the organizational performance issues that are to be the object of management assessments. This occurred when managers originally scheduled to participate dropped from the assessment team. When the assessment team identified the noncompliance to CH2M HILL management, they appropriately re-designated the assessment as a specialty assessment.

The Office of Chief Information Officer (CIO) conducted training on the new SQA requirements, but there was evidence that not all participants in SQA processes understood how to assure software quality. Also, the graded approach requirements required further definition to assure software quality requirements were correctly graded and applied.

The office of the CIO must resolve inconsistencies between the CIO's company-wide SQA procedures and local procedures used by implementing organizations.

Reviewed utility calculation spreadsheets, were well controlled and documented. The assessment team identified one spreadsheet in Engineering where the independence of the verification was compromised. Also, the cells in a spreadsheet in a Site Form for determining exposure from airborne contamination were not locked as required by CH2M HILL procedures. This problem with the unlocked cells seemed to the assessment team to be a recurrence of a condition identified in a 2004 ORP assessment, but the team did not have the sufficient time to review additional spread sheets to determine if there were other examples of this problem.

The assessment team identified six findings as follows:

- Finding A-07-ESQ-TANKFARM-004-F01 – CH2M HILL did not correctly classify software in accordance with DOE O 414.1C.
- Finding A-07-ESQ-TANKFARM-004-F02 – Personnel did not follow procedures when classifying, managing, maintaining, and conducting oversight of software.
- Finding A-07-ESQ-TANKFARM-004-F03 – Verification independence for a utility calculation spreadsheet was compromised.
- Finding A-07-ESQ-TANKFARM-004-F04 – Engineering did not maintain version control on scripts for the Liquid Observation Well Van software.
- Finding A-07-ESQ-TANKFARM-004-F05 – Vendor supplied software media were not protected from damage or destruction.
- Finding A-07-ESQ-TANKFARM-004-F06 – CH2M HILL did not provide adequate direction to effectively implement the graded approach for software to ensure consistent results.

The assessment also identified five observations which are discussed within this report.

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List of Acronyms

ASME	American Society of Mechanical Engineers
CH2M HILL	CH2M HILL Hanford Group, Inc.
CIO	Chief Information Officer
COTS	Commercial-off-the-Shelf
DOE	U.S. Department of Energy
DST	Double-Shell Tank
ECN	Engineering Change Notice
ECPD	Enraf Control Panel Densits meter
HISI	Hanford Information System Inventory
HMI	Human-Machine Interfaces
LMSI	Lockheed Martin Services, Inc.
LOWV	Liquid Observation Well Van
MARS	Material at Risk System
MCS	Monitoring and Control System
ORP	Office of River Protection
PER	Problem Evaluation Request
PLC	Programmable Logic Controllers
QA	Quality Assurance
RadCon	Radiological Control
SME	Subject Matter Expert
SPMP	Software Project Management Plan
SQA	Software Quality Assurance
SQAP	Software Quality Assurance Plan
SQSC	Software Quality and Safety Checklist
TSR	Technical Safety Requirement
WFO	Waste Feed Operations

**U.S. Department of Energy (DOE), Office of River Protection (ORP)
Assessment of CH2M HILL Hanford Group, Inc. (CH2M HILL)
Computer Software Quality Assurance (SQA)**

1.0 Details

This assessment evaluated CH2M HILL's implementation of the computer SQA requirements of DOE O 414.1C, "Quality Assurance," with particular focus on safety software. CH2M HILL issued software control procedures implementing DOE O 414.1C in September 2006, and organizations responsible for software were to have registered their software and documented plans for upgrading software documentation by February 28, 2007. The assessors reviewed the implementing procedures and compared a sample of software to the requirements and processes in the procedures. The assessors selected a sample of acquired software, custom software, configurable software, and utility calculation software (spreadsheets). The team reviewed thirteen software applications and spreadsheets, seven of which were, or should have been, classified as safety software. All software evaluated by the assessment team was controlled under the requirements of American Society of Mechanical Engineers (ASME) NQA-1-2000, "Quality Assurance Program Requirements for Nuclear Facility Applications," as implemented in CH2M HILL procedures.

CH2M HILL classified all of the software reviewed by the assessment team as "legacy software," in that it was already in use at the time the new procedures were issued. For legacy software, the new procedures required software owners to develop software project management plans, SQA plans, and other documents to assure compliance with DOE O 414.1C.

At the time of this assessment, CH2M HILL had just completed an assessment of implementation of DOE O 414.1C requirements for SQA and identified several issues (Specialty Assessment FY-2007-SHQ-S-0337). Some of the issues documented in the specialty assessment were consistent with problems identified during the ORP assessment. Prior to the start of the ORP fieldwork, CH2M HILL provided the assessment team with documentation of the following issues:

- CH2M-PER-2007-1049 – This Problem Evaluation Request (PER) stated that most software system registrations in the Hanford Information System Inventory (HISI) database were missing required documentation. The ORP assessment identified additional examples of this problem.
- CH2M-PER-2007-1050 – The CH2M HILL assessor found some critical multi-use spreadsheets that were not registered in HISI.
- CH2M-PER-2007-1051 – The CH2M HILL assessor considered that the process for registering non-safety legacy software was burdensome and added little value.
- CH2M-PER-2007-1052 – The CH2M HILL assessor identified errors in the procedure for classifying and registering software.

- CH2M-PER-2007-1053 – The CH2M HILL assessor identified inconsistencies between procedures involved in the process for classifying and registering software.

1.1 Program

CH2M HILL issued revised procedures in September 2006 to implement the software requirements of DOE O 414.1C and the guidance of DOE G 414.1-4, “Safety Software Guide for Use with 10 CFR 830 Subpart A,” “Quality Assurance Requirements,” and DOE O 414.1C, “Quality Assurance.” CH2M HILL Procedure TFC-BSM-IRM-HS-C-01, Revision B, required software owners to identify necessary documentation missing or incomplete from existing SQA documentation and register their software in the HISI database by February 28, 2007. The procedure also required providing completion dates in HISI for completing/revising required documentation. The assessment found that CH2M HILL made some progress in implementing these requirements. However, commitments to update documents were not recorded in HISI, efforts to revise existing legacy software documentation to meet current SQA requirements were not timely, and these activities were not effectively managed by CH2M HILL. (This is captured in finding A-07-ESQ-TANKFARM-004-F02)

The assessors found that, overall, the CH2M HILL procedures addressed the requirements of DOE O 414.1C and ASME NQA-1-2000. However, the assessors identified several deficiencies with the processes CH2M HILL developed to meet the safety software requirements. These deficiencies are identified in the discussion that follows:

Inadequacies and Inconsistencies in Procedures

DOE G 414.1-4, Section 3.3.2, “Existing Safety Software Applications,” provides a process for applying the safety software requirements to legacy software. Essentially, this process required performing a gap analysis and identifying the SQA activities and documentation necessary to assure continued compliant operation of the software. TFC-BSM-IRM-HS-C-01 did not implement the guidance of DOE G 414.1-4, and instead required owners of existing software to identify or develop all the same documentation required for a new software development project. This created situations where procedures could not be followed as written, or following the procedures did not make sense. For example, software owners were required to create an alternatives analysis for software that was already in production. Creating this documentation for software already in production would add no value. Some procedural requirements for safety software could not be followed as written because of where within the software lifecycle that software was at. CH2M HILL had previously documented a related problem specific to non-safety software in PER CH2M-PER-2007-1051. (This is captured in Observation A-07-ESQ-TANKFARM-004-O04)

The assessors found inconsistencies within the top-level SQA Procedure, TFC-BSM-IRM-HS-C-01, and the actual application of HISI. For example, the Chief Information Officer (CIO) stated that the Quality Assurance (QA) Subject Matter Expert (SME) was required to approve the SQA Plan (SQAP) HISI entry. This was consistent with the process flow chart and the procedure steps in TFC-BSM-IRM-HS-C-01. However, the HISI application did not always require a QA SME approval. CH2M HILL identified these inconsistencies between the process flow chart and the procedure steps during the recent specialty assessment and documented it in

PER CH2M-PER-2007-1053. Resolution of this issue will be corrected and tracked by the PER and not by this assessment.

Weaknesses in SQA Indoctrination and Training

When CH2M HILL issued the September 2006 procedures, the office of the CIO conducted and documented training for affected organizations. The training consisted of a slide presentation that addressed what was new in the procedures. Two individuals interviewed by the assessment team said they believed that not all participants in the SQA process understood their roles in assuring software quality; this led the assessment team to discuss training with the CIO. From these discussions and from reviewing SQA procedures, the assessment team determined that training requirements for SQA process participants were not established in procedures, training on the safety software requirements was never formally established into a CH2M HILL training course, and training beyond the initial effort was provided to new process participants by the CIO on an as requested basis. The assessment team determined that for a process as complex as safety software QA, the training requirements established were not adequate to meet TFC-PLN-02, "Quality Assurance Program Description."

The assessment team concluded that some of the issues of this assessment support the belief that not all participants in the SQA process understood their roles in assuring software quality. However, the assessment team did not have time during this assessment to validate these issues, and did not have sufficient time to investigate CH2M HILL's training requirements to verify they were adequately applied. The assessment team also did not review training profiles to verify that CH2M HILL management had adequately established training requirements for SQA activity participants. As a result, this issue is captured as an observation (Observation A-07-ESQ-TANKFARM-004-O03), and it will be up to CH2M HILL to follow-up and assure training requirements were adequately addressed.

Weaknesses in the CH2M HILL Graded Approach

The graded approach process described in TFC-BSM-IRM-STD-01 established five grade levels, (A through E) for classifying software. Levels A – C were for safety software (which were also quality-affecting software); Level D was for quality affecting software that was not safety software; and Level E was for all other software. CH2M HILL's Levels A through C were consistent with DOE G 414.1-4 grade levels. The procedure also provided direction as to what level of SQA activity control was required for each classification level based on the software type, resulting in a determination of which SQA activities required full implementation, a graded implementation, or were "N/A."

CH2M HILL did not provide sufficient direction for determining the specific SQA controls to be implemented for either full or graded implementation of SQA requirements. The direction provided in TFC-BSM-IRM-STD-01 stated, "The life cycle products and SQA work activities should be implemented based on grading levels and applicable software type. The best judgment of software quality engineering staff should take precedence over any work activities applied with a graded approach." This created a situation in which identification of graded processes was largely arbitrary.

The assessment team found that Attachment A, “Work Activities Graded Approach,” in TFC-BSM-IRM-STD-01 was sometimes inconsistent or incorrect in specifying the graded approach application of SQA activities. Examples of this include:

- For Level A commercial design and analysis software, the SQA activities for software risk management were designated as “N/A,” but for Level B, these activities were designated as requiring a graded application. This was incorrect because Level A required the highest level of SQA application.
- The attachment specified software design reviews and unit testing for acquired software, and required baseline labeling standards and authorized user lists for commercial design and analysis software. All of these were not possible or were not appropriate for purchased software.
- For software designated as quality-affecting (Level D), the table did not require training for any software types, which is inconsistent with the concept that you cannot grade QA requirements to zero.
- The attachment did not require procurement activity (were designated as N/A) for quality-affecting design and analysis or utility calculation software, but, for non-quality affecting software, these same activities required a graded application. This is incorrect because the application requiring the less rigor has more.
- For software designated as non-quality affecting, CH2M HILL had inappropriately graded several QA activities such as training, testing, configuration management, procurement and supplier management, and requirement identification as “N/A,” grading QA requirements down to zero for activities that are performed for all software procurements.

(This is captured in Finding A-07-ESQ-TANKFARM-004-F06)

Procedures Not Followed

The assessment team identified a number of situations in which personnel did not follow procedures. In some cases, processes could not be followed as written in the procedures, but the procedures were not changed to fix the processes. Instead, work arounds were established and frequently used. In other cases, personnel said they did not understand the procedures. Specific conditions contributing to this situation include the deficiencies in Attachment A of TCP-BSM-IRM-STD-01, the requirement to have all legacy software meet current procedure requirements, and CH2M HILL not establishing sufficiently robust training on the new SQA processes.

Failure to follow procedures resulted in safety software that was classified as non-safety (for example, ECLIPSE and GENIE2000 software), and safety software that was missing required software documentation (which included, to varying degrees, much of the software packages reviewed and discussed later). (This is captured in Finding A-07-ESQ-TANKFARM-004-F02)

HISI Weaknesses

The HISI was part of the overall Hanford information repository developed and maintained by Fluor Hanford, Inc. The HISI data entry and access was based on the “permissions model” that granted privileges by a user type. The software owner answered 19 questions in the HISI Software Quality Safety Checklist (SQSC). The checklist logic determined the grade level of the software, but the HISI SQSC questions led to incorrect software classifications. CH2M HILL incorrectly used the grade levels to develop the SQSC questions instead of the safety software definitions in DOE O 414.1C. The checklist questions did not consider key terms in the safety software definitions to identify safety software, such as safety management programs. The checklist addressed the design and operation of a safety Structures, Systems, and Components but failed to adequately address software used to design or perform accident analysis for a nuclear facility. Also, the checklist failed to adequately address the safety management and administrative controls software definition.

The assessors found several anomalies in the HISI database information. Two acronyms used to track the software were incorrectly entered, so that they were not unique and were not derived from the title of the system as required by TFC-BSM-IRM-HS-C-01. For example, personnel entered “COTS” instead of the acronyms for both GENIE2000 and Alpha Analyst. The assessors also found that the Liquid Observation Well Van (LOWV) program was identified in the HISI core information as custom developed software when it was acquired software. Non-Quality Affecting Software applications were identified as grade level “N/A” instead of grade Level E. (This is captured in Finding A-07-ESQ-TANKFARM-004-F01)

1.1.1 Results

The procedures CH2M HILL issued in September 2006 outlined a system of software control, but it contained weaknesses and inconsistencies. Also, personnel sometimes did not follow the procedures. Procedures did not fully define the graded approach, and requirements for grading levels were sometimes inconsistent. Local implementing procedures were sometimes inconsistent with company-wide procedures. The procedure for registering software into the HISI database omitted steps, and problems with the logic in the HISI SQSC checklist steps led to incorrectly classified software. Some organizations did not register their software in HISI correctly so that applications were not correctly identified. The assessment team documented these issues in Findings A-07-ESQ-TANKFARM-004-F01, A-07-ESQ-TANKFARM-004-F02, and A-07-ESQ-TANKFARM-004-F06, and Observations A-07-ESQ-TANKFARM-004-O03, A-07-ESQ-TANKFARM-004-O04, and A-07-ESQ-TANKFARM-004-O05.

The assessment team found evidence that some personnel participating in the SQA process did not understand how to assure the quality of software and may require additional indoctrination or training. The assessment team documented this issue in Observation A-07-ESQ-TANKFARM-004-O03.

1.2 Acquired Software

The assessment team evaluated a sample of four programs that CH2M HILL purchased from vendors. These procurements included Commercial-off-the-Shelf (COTS) software and software developed under contract to CH2M HILL specifications.

LOWV Software Not Properly Documented

This software operated equipment measuring liquid levels under the crust in tank waste. After colliding with hydrogen atoms, fast neutrons from a source in a probe were reflected back into the probe as thermal neutrons. The software used the flux of thermal neutrons to identify the higher concentration of water in the liquid waste. A single owner had managed the software since its development and purchase in 1995. Because the software performed consistently and well, CH2M HILL had not changed it.

When CH2M HILL revised their software procedures to implement DOE O 414.1C, Engineering did not develop the required software project management plan, SQA plan, and other documentation for the LOWV software. The software owner obtained a verbal agreement from QA that these documents were not required until the software was changed, but CH2M HILL SQA procedures did not contain this provision. The assessment team considered this was an example of the documentation problem already identified by CH2M HILL in CH2M-PER-2007-1049.

Engineering maintained configuration control of the software by placing it in the Source Safe® “vault,” but did not maintain version control on the scripts used to configure behavior of the software for each tank. The software owner said they considered the scripts to be data, and therefore version control was not required. However, the CH2M HILL software configuration management standard identified “selected data” as a configuration item subject to revision control. ASME NQA-1-2000 defined software as “... computer programs, procedures, and associated documentation and data pertaining to the operation of a computer system” and thus is subject to SQA requirements. (This is captured in Finding A-07-ESQ-TANKFARM-004-F04)

ECLIPSE and GENIE2000 Incorrectly Classified

CH2M HILL used the ECLIPSE and GENIE2000 software packages in radiological analysis, providing human-machine interfaces for equipment performing alpha, beta, and gamma spectroscopy. Despite their health and safety use, CH2M HILL had classified both packages as non-safety and not quality-affecting. However, the assessors compared the use of these programs to the requirements of DOE O 414.1C and found that both met the requirements for quality-affecting, safety management, and administrative control safety software. The assessors reviewed the process the software owners used to classify the software and found that the HISI SQSC questions were inadequate to consistently lead personnel to the correct decision. (This is captured in Finding A-07-ESQ-TANKFARM-004-F01)

The assessors noted that CH2M HILL maintained the ECLIPSE and GENIE2000 software disks provided by the software vendors in the count room and not in a fire-rated container. The assessors also noted that the SQA process did not address maintenance of purchased software media. Software media is a quality record, and DOE required that the SQA process address how these records are protected from loss or damage. (This is captured in Finding A-07-ESQ-TANKFARM-004-F05)

222-S Laboratory LABCORE Appropriately Managed

LABCORE was the 222-S laboratory management tool CH2M HILL provided to the laboratory to manage analytical activities. The laboratory upgraded its software to the current release in 2005 using a different vendor than supplied the previous version. The assessment team did not disagree with the laboratory's classification of the system as quality-affecting, non-safety software.

The assessment team reviewed the documentation for the software along with problem reports, software changes, tests, and related configuration management documentation. The assessment team did not identify any deficiencies.

1.2.1 Results

The acquired software evaluated by the assessment team was all legacy software for which much of the newly required documentation had not been developed. Two of the programs were incorrectly classified as non-safety software. One of the incorrectly classified safety software programs was also incorrectly classified as non-quality affecting software. The assessment team documented this issue in Finding A-07-ESQ-TANKFARM-004-F01.

LABCORE had well developed problem reporting, testing, and configuration management processes.

Engineering did not maintain version control on scripts for the LOWV software. The assessment team documented this condition in Finding A-07-ESQ-TANKFARM-004-F04.

Purchased media was not protected from loss or damage, although it is a quality record. The assessment team documented this condition in Finding A-07-ESQ-TANKFARM-004-F05.

1.3 Custom Software

222-S Laboratory Material at Risk System (MARS) Database Incorrectly Classified

MARS consisted of client-server applications and an Oracle® database that were developed locally by Lockheed Martin Services, Inc. (LMSI). MARS tracked quantities of fissile and other radiological material to assure the limitations specified in a Technical Safety Requirement (TSR) were not exceeded. LMSI continued to support MARS and had an onsite representative at the laboratory.

The 222-S Laboratory incorrectly classified MARS as quality-affecting, non-safety software. Because MARS was used to assure compliance with a TSR, it was safety software as defined in DOE O 414.1C. (This is captured in Finding A-07-ESQ-TANKFARM-004-F01)

The MARS document identified as a configuration management plan addressed security but did not address the required features of configuration management:

- Identification of configuration items
- Change control
- Configuration status accounting
- Software audits

(This is captured in Finding A-07-ESQ-TANKFARM-004-F02)

Despite the incorrect classification and the incorrect configuration management plan content, the laboratory and LMSI followed Hanford Site and CH2M HILL procedures to support users and maintain configuration control of the software. Problems and change requests identified by users were logged, prioritized, and tracked. The Laboratory Change Board approved changes prior to implementation and installation. The laboratory provided evidence to the assessment team of documented and approved testing of changes. CH2M HILL provided the required documentation for MARS, although the SQA plan contained several errors.

1.3.1 Results

Based on the quality level applied to the software reviewed, custom software was appropriately controlled. However, the MARS database was incorrectly classified as non-safety software, even though it was used to assure compliance with a TSR. The configuration management plan for MARS did not meet existing SQA requirements. The assessment team documented these issues in Findings A-07-ESQ-TANKFARM-004-F01 and A-07-ESQ-TANKFARM-004-F02.

1.4 Configurable Software

Waste Feed Operations (WFO) Monitoring and Control System (MCS) Documentation Outdated

MCS has been classified as Level A safety software based on safety software criteria established in DOE O 414.1C and incorporated into the CH2M HILL software development Procedure (TFC-BSM-IRM-HS-C-01) effective September 15, 2006. Tank Farms operators used the WFO MCS to select the components of a waste transfer, including the source and destination of the transfer and the pre-determined route. The MCS was used to manually depressurize waste transfer routes by shutting down the transfer and booster pump if a route leak or misrouting was detected. MCS provided alarm displays, monitored the Double-Shell Tanks' (DST) vapor space pressures, and monitored the status of each primary ventilation system. The project was initiated

several years ago, put on hold in 2003 after the software design work was done, and the project was resumed in 2006. Implementation of the MCS monitoring system has been incremental.

AY/AZ leak detectors, Programmable Logic Controllers (PLC), and Human-Machine Interfaces (HMI) were turned over for monitoring on December 8, 2006. SY leak detectors, PLCs, and HMIs were turned over for monitoring on February 1, 2007. The assessment team reviewed the SQA documentation associated with MCS and found that CH2M HILL had not maintained the planning and quality documentation current. The CH2M HILL software development procedure required “Software applications implemented into production on or after the effective date must comply with all requirements of this procedure.” When CH2M HILL implemented MCS, project documents were not adequately revised to address work activities conducted and the SQA requirements and processes that were in place when the project was resumed in 2006. As a result, the SQA documentation and SQA processes discussed in those documents were outdated. Examples of document deficiencies noted include:

- The SQAP and the Software Project Management Plan (SPMP) both referenced cancelled documents, outdated documents, and documents that were not readily retrievable.
- The SQA referred to a non-existent appendix for the software configuration management plan.
- Requirements, design descriptions, and testing approaches were identified across multiple documents, making it difficult to track and ensuring accuracy and consistency of information.
- Configuration management did not meet requirements specified in TFC-BSM-IRM-STD-02, “Software Configuration Management Standard.”

TFC-BSM-IRM-STD-02, Revision B, “Software Configuration Management Standard,” specified use of the “Application Modification Request” system to manage software configuration changes, but WFO MCS used the CH2M HILL Engineering Change Notice (ECN) process. While not the specified process, ECNs included the appropriate level of reviews and design change documentation. ECNs were generated for hardware or software changes to the system, including vendor upgrades. The assessors noted that the ECNs were reviewed and checked by persons not performing the change. The ECNs that required changes to the software code or document text included the specific change, a level of review that was comparable to unit or component level inspection. All ECNs were approved. The assessors found the content for design changes and acceptance testing associated with those design changes was appropriate. The ECNs identified a description of the change, the approach to be taken, the actual changes to be made, and, where appropriate, the testing approach and test cases.

The assessors reviewed the requirements for verification reports for tests conducted in September 2005. The report included traceability of requirements to the verification steps. The report also included a summary stating that all test cases were exercised and passed.

The general issue with software documentation not in compliance with current SQA procedures was documented by CH2M HILL in PER CH2M-PER-2007-1049. However, because MCS is operational and currently supporting a safety function while noncompliant with SQA requirements, this issue will be captured as part of Finding A-07-ESQ-TANKFARM-004-F01.

Enraf Control Panel Densitometer (ECPD) Configuration Management and SQA Plans Inadequate

ECPD was acquired data acquisition and control software for the Enraf level gage densitometers. ECPD was used to determine and record tank sludge levels and assist in the calculation of fluid densities in the DSTs.

The assessors found that the ECPD configuration management plan did not address the required configuration management topics: identification of items, change control, configuration status accounting, and audit. Also, the SQA plan and other documents had not been updated to meet the new requirements of Procedure TFC-BSM-IRM-HS-C-01. These conditions were consistent with the condition CH2M HILL documented in the recent specialty assessment.

1.4.1 Results

CH2M HILL did not bring software documentation for the WFO and ECPD software up to current requirements following issuance of procedures implementing the requirements of DOE O 414.1C. The assessment team concluded this was consistent with the condition CH2M HILL documented in PER CH2M-PER-2007-1049. MCS, document deficiency will be addressed in Finding A-07-ESQ-TANKFARM-004-F01 because the software was implemented after the September 2006 issue date of the current SQA and safety software requirements.

1.5 Utility Calculation Software (Including Spreadsheets)

The assessment team reviewed a sample of six spreadsheets used for calculations. The assessors addressed spreadsheets because modern spreadsheet applications are very powerful tools that create potentially significant errors when they are not properly controlled.

Five of the spreadsheets the assessment team evaluated were developed and used by Engineering and one was developed and used by Radiological Control (RadCon). These were:

- 204-AR-TK-1 Liquid & Solid Composition Estimates
- Tank Waste Compatibility Spreadsheet
- Tank Waste Volume Calculator
- Airborne Contamination Exposure Calculation
- Spreadsheet Supporting the “Process Control Plan for 242-A Evaporator Campaigns 07-01 and 07-02”

- 2006 Psychrometrics

As required by TFC-ENG-DESIGN-C-32, all had a spreadsheet description document and all had completed verification checklists. In some cases, the software owners had submitted the required HISI SQSC, but in other cases they did not. Some software owners and managers said they did not understand that they were required to complete the SQSC for their spreadsheets. CH2M HILL had recently documented the missing checklists in PER CH2M-PER-2007-1050.

The spreadsheet procedure was intended to be a special implementation of the requirements included in TFC-BSM-IRM-HS-C-01, but there were several inconsistencies between the two procedures. This stemmed from differences in viewpoint between Engineering and the Office of the CIO regarding the extent of documentation required for spreadsheets. CH2M HILL had already identified and documented the inconsistencies in PER CH2M-PER-2007-0275.

Verification Independence Not Addressed

TFC-ENG-DESIGN-C-32 did not address the requirement for independence of persons performing spreadsheet verification, and the assessment team identified one case where independence of the verification was compromised. An engineer assigned to verify a spreadsheet added a table with formulas to the spreadsheet with his own approach to the problem. Engineering management explained that the spreadsheet originator then checked the table, but this confused the verification with the origination of the spreadsheet. TFC-PLN-02, Section 3.2.1, and TFC-ENG-DESIGN-C-32, Section 3.0, required that design adequacy of computer programs be verified by individuals other than those who designed the program.

Cells Not Locked

The assessment team identified one spreadsheet where the cell formulas were not locked as required by TFC-ENG-DESIGN-C-32. The spreadsheet was embedded in Site Form A-6003-021, "Air Sample Record," and was used to calculate airborne radiation exposure from sample results. The cells in another spreadsheet in the same site form were properly locked. The problem of inadequately secured spreadsheets was documented in an April 2004 ORP assessment of CH2M HILL computer software (Assessment A-04-ESQ-TANKFARM-006). At the time of the current assessment's fieldwork, the assessment team did not have the time to verify if this was recurrence of the condition causing the 2004 problem. As a result, this issue is addressed in Observation A-07-ESQ-TANKFARM-004-001.

Need for Guidance on Spreadsheet Verification

For the engineering spreadsheets reviewed by the assessment team, Engineering had primarily verified their adequacy by inspecting cell formulas. For the air sample record spreadsheet, RadCon had run test cases on 100% of the cell formulas and compared the results to hand calculations. Both methods are acceptable, and both were allowed by TFC-ENG-DESIGN-C-32. However, the assessment team considers Engineering relied too heavily on inspection and should have conducted more testing of spreadsheets, especially with spreadsheets that contain large amounts of cells. The larger and more complicated spreadsheets are more susceptible to human error when verification of the cells is done by inspection and are less reliable than testing the

cells. While TFC-ENG-DESIGN-C-32 described both methods, it did not provide guidance on when to select one method over the other. This issue is address in Observation A-07-ESQ-TANKFARM-004-O01.

1.5.1 Results

CH2M HILL had a reasonable procedure for control of spreadsheets, although CH2M HILL had found that it was inconsistent with the documentation requirements of the higher level software control procedure.¹

The spreadsheet procedure did not address the requirement for independence of verification, and at least one spreadsheet had compromised verification independence. The assessment team documented this problem in Finding A-07-ESQ-TANKFARM-004-F03.

Some spreadsheet owners had not completed the HISI SQSC and registered their spreadsheets in HISI. At least one spreadsheet in production had unlocked cells and could therefore be inappropriately modified when used. The condition that caused this may have recurred following corrective action for a 2004 ORP assessment. The assessment team documented the possible recurrence in Observation A-07-ESQ-TANKFARM-004-O01.

The assessment team considers Engineering relied too heavily on inspection of cell formulas during spreadsheet verification and should develop a policy to increase verification by testing. The assessment team documented its viewpoint in Observation A-07-ESQ-TANKFARM-004-O02.

1.6 Oversight

CH2M HILL scheduled a management assessment to address implementation of the computer software requirements of DOE O 414.1C that was just completed at the time of the ORP assessment. CH2M HILL had completed the field work for this assessment, but the assessment report had not been finalized. Although the assessment was originally identified as a management assessment, the CH2M HILL assessment did not meet DOE O 414.1C management assessment criteria, because it was not conducted by managers of the assessed organizations, and was focused on procedure compliance. CH2M HILL management stated the assessment was originally planned as a management assessment, but participating managers dropped off the team before fieldwork began. This left only a participant from the QA organization, who was not a manager. Also, the focus of the assessment was primarily outside of QA. When the assessment team pointed out to CH2M HILL management that the assessment did not comply with management assessment requirements, CH2M HILL appropriately re-designated it as a specialty assessment.

Specialty assessments were described in CH2M HILL's DOE-approved assurance system description and contributed to compliance with DOE O 226.1, "Implementation of Department of Energy Oversight Policy." CH2M HILL managers said they considered specialty assessments

¹ This statement is not intended to endorse either Engineering's or the CIO's position on this topic.

were a valuable management tool, although specialty assessments did not contribute to compliance with DOE requirements for either management or independent assessment.

CH2M HILL provided the assessment team with a list of three independent assessments two management assessments and one QA assessment with some SQA lines of inquiry.

The assessment team determined the assessments, including the specialty assessment, sufficiently addressed SQA oversight requirements.

1.6.1 Results

CH2M HILL conducted several management and independent assessments that, to some extent, addressed SQA. However, a scheduled SQA management assessment conducted by the QA organization did not comply with the requirements of DOE O 414.1C for management assessments, when all of the managers dropped from the team. However, CH2M HILL management re-designated the assessment as a specialty assessment during the assessment fieldwork, and it did identify meaningful issues. The assessment team documented this condition in Finding A-07-ESQ-TANKFARM-004-F02.

2.0 Findings and Observations

Finding A-07-ESQ-TANKFARM-004-F01 – CH2M HILL did not correctly classify software in accordance with DOE O 414.1C.

Requirements:

- a. DOE O 414.1C, “Quality Assurance,” Section 7.o.(3), stated, “Safety software includes the following ... Safety Management and Administrative Control Software: Software that performs a hazard control function in support of nuclear facility or radiological safety management programs or technical safety requirements or other software that performs a control function necessary to provide adequate protection from nuclear facility or radiological hazards.”
- b. DOE O 414.1C Attachment 2, “Contractor Requirements Document DOE O 414.1C, Quality Assurance,” Section 5d, stated, “Using the grading levels established and approved above, select and implement the applicable software quality assurance work activities from the following list to ensure that safety software performs its intended functions. ...”
- c. DOE O 414.1C Attachment 2, “Contractor Requirements Document DOE O 414.1C, Quality Assurance,” Section 5b, stated, “Identify, document, and maintain safety software inventory.”
- d. TFC-PLN-02, Revision D, “Quality Assurance Program Description,” Section 3.3.2.15, “Safety Software,” stated, “Safety software includes the following ... Safety Management and Administrative Control Software: Software that performs a hazard control function in support of nuclear facility or radiological safety management programs or technical safety

requirements or other software that performs a control function necessary to provide adequate protection from nuclear facility or radiological hazards.”

- e. TFC-BSM-IRM-HS-C-01, Revision B, “Software Development, Implementation, and Management,” Section 2.0 stated, “Managers responsible for legacy software applications must complete section 4.1, Software Application Identification and Evaluation, and register the software in the Hanford Information System Inventory (HISI) application before February 28, 2007. The evaluation must identify required documentation and include development of the schedule to revise or develop deficient or missing documentation.”
- f. TFC-BSM-IRM-HS-C-01, Revision B, “Software Development, Implementation, and Management,” Section 3.1 stated, “[The software owner must prepare] the Software Quality and Safety Checklist in the HISI application to determine the ... safety significance of the software ...”

Discussion:

Contrary to these requirements, the HISI SQSC failed to lead software owners to the correct classification of their software. As a result, some software owners did not correctly identify the safety classification of their software. The assessment team based its conclusions on the following:

- 222-S Laboratory personnel classified the MARS database as non-safety software, even though it was used to assure compliance with a TSR. 222-S Laboratory TSR 5.2.3 specified limits on fissile material and other radiological material quantities present in the laboratory to meet requirements of the Documented Safety Analysis.
- CH2M HILL incorrectly classified both the ECLIPSE and GENIE2000 software as non-safety and not quality-affecting. These codes were used to provide human-machine interfaces for equipment performing alpha, beta, and gamma spectroscopy, so both met the requirements for quality-affecting, safety management, and administrative control safety software.
- The HISI SQSC incorrectly used the grade levels in the checklist questions rather than the definitions of safety software in DOE O 414.1C. The checklist questions did not consider key terms in the safety software definitions to identify safety software.

Finding A-07-ESQ-TANKFARM-004-F02 – Personnel did not follow procedures when classifying, managing, maintaining, and conducting oversight of software.

Requirements:

- a. TFC-PLN-02, Revision D, “Quality Assurance Program Description,” Section 5.2.1 states, “Activities affecting quality (work processes) shall be prescribed by and performed in accordance with documented instructions, procedures, and drawings of the type appropriate to the circumstances...”

Discussion:

Contrary to this requirement, software owners and other software quality participants conducted activities inconsistently with CH2M HILL procedures. In some cases, personnel said they had not understood the requirements. In other cases, procedures could not be followed as written but were not changed before continuing with work. The following examples led the assessment team to these conclusions:

- Commitments to update legacy SQA documentation to meet current requirements were not recorded in HISI, efforts to revise this documentation were not timely, and these activities required in Procedure TFC-BSM-IRM-HS-C-01 were not effectively managed by CH2M HILL.
- CH2M HILL had not maintained the planning and quality documentation current for MCS. When CH2M HILL implemented the MCS, project documents were not adequately revised to address work activities conducted or to satisfy the SQA requirements and processes in place when the project was resumed in 2006. As a result, the SQA documentation and SQA processes discussed in those documents were outdated. The MARS configuration management plan was not revised to include process elements specified in TFC-BSM-IRM-STD-02, "Software Configuration Management Standard."
- When CH2M HILL issued procedures to implement DOE O 414.1C, the owner of LWOV software concluded it was not necessary to develop the required documentation unless the software was actually changed. A representative of the QA organization agreed with that conclusion, even though it was inconsistent with the requirements of TFC-BSM-IRM-HS-C-01.
- The assessment team identified several other situations when processes could not be followed as written in the procedures, the procedures were not changed and work arounds were established. Specific conditions of inadequate procedures that contributed to this situation included the deficiencies in Attachment A of TFC-BSM-IRM-STD-01, and the requirement to have all legacy software meet current procedure requirements.
- The QA organization initiated a management assessment of software that did not meet the requirements of TFC-PLN-02, Section 18.3.2. The assessment was not conducted by a manager of the organization subject to the assessment.
- As identified in PER CH2M--PER-2007-1049, software owners did not prepare the SQA plans and SPMPs required by TFC-BSM-IRM-HS-C-01 for programs such as the LOWV software, ECLIPSE, and ECPD. While this issue was identified by CH2M HILL, some software owners told the ORP assessment team they did not prepare the documentation because they had not understood it was required for their software.

Finding A-07-ESQ-TANKFARM-004-F03 – Verification independence for a utility calculation spreadsheet was compromised.

Requirements:

- a. TFC-PLN-02, Revision D, “Quality Assurance Program Description,” Section 3.2.1 stated, “Design adequacy shall be verified by individuals other than those who designed the item or computer program.”
- b. TFC-ENG-DESIGN-C-32, Revision B-6, Section 3.0, Paragraph 2, stated, “The verifier of a spreadsheet shall be a technically competent individual with the appropriate education, experience, and expertise to perform the calculations and develop the spreadsheet contemplated and shall be someone other than the spreadsheet developer/owner.”

Discussion:

Contrary to these requirements, the assessment team identified one spreadsheet in which independence of the verification was compromised. The engineer who completed Software Verification Form SVF-1332, Revision 0, “204-AR-TK-1 Liquid and Solid Composition Estimates,” edited the spreadsheet to provide his own approach to solving the problem. While the spreadsheet originator said he verified the formulas in a new table added by the original spreadsheet verifier, this second verification was not documented.

Finding A-07-ESQ-TANKFARM-004-F04 – Engineering did not maintain version control on scripts for the LOWV software.

Requirements:

- a. TFC-PLN-02, Revision D, “Quality Assurance Program Description,” Section 3.2.11.2 stated, “Software configuration management includes, but is not limited to, configuration identification, change control, and status control. Configuration items shall be maintained under configuration management until the software is retired.”
- b. TFC-BSM-IRM-STD-02, Revision B, Section 3.1 stated, “...configuration components include ... selected data ... A baseline labeling system should be implemented that uniquely identifies each configuration item, identifies changes to the items by revision...”

Discussion:

Engineering did not maintain version control on the scripts used to configure behavior of the LOWV software for each tank. The software owner said Engineering considered the scripts to be data, and therefore version control was not required. However, TFC-BSM-IRM-STD-02 identified “selected data” as a configuration item. Also, ASME NQA-1-2000 defined software as “... computer programs, procedures, and associated documentation and data pertaining to the operation of a computer system.” Because the scripts were necessary for correct execution of the program for each tank, they were required to be under version control.

Finding A-07-ESQ-TANKFARM-004-F05 – Vendor supplied software media were not protected from damage or destruction.

Requirements:

- a. TFC-PLN-02, Revision D, “Quality Assurance Program Description,” Section 17.2.6 stated, “Records shall be stored in facilities, containers, or a combination thereof, constructed and maintained in a manner which minimizes the risk of damage or destruction...”

Discussion:

Contrary to this requirement, the procedures for SQA did not address maintenance of vendor-supplied software media. These software media are QA records, and the SQA process must address how this requirement is applied. The assessment team based their conclusions on the following:

- CH2M HILL Procedure TFC-BSM-IRM-HS-C-02, Revision B, addressed how acquired software was identified, procured, installed, tested, and retired. However, it did not address how to safeguard media disks, either by physical protection or backup.
- The ECLIPSE and GENIE2000 software disks provided by the software vendors were maintained in the count room. They were not in a fire-rated container or otherwise protected from loss or damage.

Finding A-07-ESQ-TANKFARM-004-F06 – CH2M HILL did not provide adequate direction to effectively implement the graded approach for software to ensure consistent results.

Requirements:

- a. TFC-PLN-02, Revision D, “Quality Assurance Program Description,” Section 5.2.1, stated “Activities affecting quality (work processes) shall be prescribed by and performed in accordance with ... for determining that prescribed results have been satisfactorily attained.”
- b. DOE O 414.1C, Attachment 2, “Contractor Requirements Document,” Section 2.a.(1) stated, “[Contractors must] implement QA criteria ..[for] safety software as defined in paragraph 5, using a graded approach...”
- c. ASME NQA-1-2000, “Quality Assurance Program Requirements for Nuclear Activities,” Requirement 5, stated “The activity shall be described to a level of detail commensurate with the complexity of the activity and the need to assure consistent and acceptable results.”

Discussion:

CH2M HILL Procedure TFC-BSM-IRM-STD-01, Revision B-1, “Software Life Cycle Standard,” did not provide a sufficiently detailed process to assure consistent implementation or assure compliance with the CH2M HILL Quality Assurance Program Description, DOE

O 414.1C, and ASME NQA-1-2000. The grading criteria of TFC-BSM-IRM-STD-01, Appendix A, provided minimal direction for determining the specific tasks to be implemented for either full or graded requirements. The assessment team based its conclusions on the following:

- The table of Attachment A of TFC-BSM-IRM-STD-01 specified SQA activities with requirements graded as “full,” “graded,” and “N/A,” but it did not define either “full” or “graded.”
- The table of Attachment A of TFC-BSM-IRM-STD-01 specified SQA activities with requirements graded as “full,” “graded,” and “N/A,” but it did not specify how to apply either “full” or “graded” SQA requirements.
- TFC-BSM-IRM-STD-01 included a statement appearing to allow entirely arbitrary selection of SQA requirements during grading. Section 3.3 included a statement, “The best judgment of software quality engineering staff should take precedence over any work activities applied with a graded approach.” This statement, taken together with the lack of meaningful grading guidance in Appendix A, made the process of selecting requirements entirely a matter of judgment without guidance.

Observation A-07-ESQ-TANKFARM-004-O01 – The condition causing unlocked cells in production spreadsheets may have recurred.

Discussion:

In April 2004, ORP Assessment A-04-ESQ-TANKFARM-006 identified problems with maintaining the validity of verified spreadsheets when the team found spreadsheets on production servers with unlocked cells. CH2M HILL completed corrective action to correct the cause of this condition, but the assessment team identified another unlocked spreadsheet during the current assessment. The spreadsheet was one of three embedded in Site Form A-6003-021, “Air Sample Record,” and was used to calculate airborne radiation exposure from sample results. The assessment team considers CH2M HILL should determine if this was an isolated occurrence, or if it had the same cause as the condition reported in the 2004 assessment. If CH2M HILL determines it had the same cause, they should determine why the corrective actions from the 2004 assessment failed to prevent the occurrence.

Observation A-07-ESQ-TANKFARM-004-O02 – Engineering should consider requiring increased testing of spreadsheets.

Discussion:

CH2M HILL Procedure TFC-ENG-DESIGN-C-32, Revision B-6, “Spreadsheet Development and Verification,” allowed spreadsheet verifiers to choose a balance between inspecting the formulas in cells and running calculation test cases. While this was not inconsistent with DOE requirements, verifiers in Engineering usually chose to inspect cell formulas and rarely ran test cases. In contrast, personnel in Radcon who verified spreadsheets said they ran test cases on 100% of cell formulas and checked them with hand calculations. Some of Engineering’s

spreadsheets contained hundreds of cells with formulas, making inspection a challenging and error-likely process. Historically, cell formula errors on the Hanford Site have attracted outside attention by causing errors in calculations.

The purpose of this observation is to encourage Engineering to establish a policy on spreadsheet verification that favors testing of cell formulas over inspection.

Observation A-07-ESQ-TANKFARM-004-O03 – CH2M HILL should assure all participants in the SQA process are adequately indoctrinated or trained on software quality fundamentals.

Discussion

When CH2M HILL issued the September 2006 procedures, the office of the CIO conducted and documented training for affected organizations. The training consisted of a slide presentation that addressed what was new in the procedures. The assessment team determined that training requirements for SQA process participants were not established in procedures, training on the safety software requirements was never formally established into a CH2M HILL training course, and training beyond the initial effort was provided to new process participants by the CIO on an as requested basis. The assessment team determined that for a process as complex as safety software QA, the training requirements established were not adequate to meet TFC-PLN-02, “Quality Assurance Program Description.”

While the office of the CIO conducted training for different organizations on the September 2006 procedures, several individuals interviewed by the assessment team said they did not believe all participants in SQA processes understood their roles in assuring software quality. The assessment team considered that weak understanding of software QA principles may have contributed to the issues of this report. However, the assessment team did not have time during this assessment to validate these issues, and did not have sufficient time to investigate CH2M HILL’s training requirements to verify they were adequately applied. The assessment team also did not review training profiles to verify that CH2M HILL management had adequately established training requirements for SQA activity participants.

Observation A-07-ESQ-TANKFARM-004-O04 – CH2M HILL should implement the guidance of DOE G 414.1-4 for existing safety software.

Discussion:

TFC-BSM-IRM-HS-C-01 did not implement the guidance of DOE G 414.1-4, Section 3.3.2, “Existing Safety Software Applications,” and instead required owners of existing software to identify or develop all the same documentation required for a new software development project. The current SQA process required all software projects to meet the SQA requirements currently in place, including software already in use at the time these requirements became effective. The assessors noted that most of the software documentation reviewed did not meet current SQA requirements. Software owners said they had difficulty in meeting these requirements, because procedures could not be followed as written. For example, software owners were required to create an alternatives analysis for software that was already in production.

Observation A-07-ESQ-TANKFARM-004-O05 – The HISI database information contained several data errors.

Discussion:

The assessors found anomalies in the HISI database information as follows:

- Two acronyms used to track the software were incorrectly entered, so that they were not unique and were not derived from the title of the system as required by TFC-BSM-IRM-HS-C-01. These were the GENIE2000 and APHA ANALYST codes, which were both identified using the term “COTS” rather than their names.
- The grade level for non-quality-affecting software was listed in the HISI database as “N/A,” when TFC-BSM-IRM-HS-C-01 specified that it was Level 5.
- The LOWV application was identified in the HISI core information as custom developed software when it was actually acquired software.

3.0 Conclusion

CH2M HILL has made progress in implementing the requirements of DOE O 414.1C, however documentation required to demonstrate the quality of some software was not prepared. Personnel did not always follow procedures, and some safety software was incorrectly classified.