Environmental Sampling and Analysis, Getting It Right!

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ABSTRACT

The Department of Energy's Hanford Site in southeastern Washington State was established in the 1940s as part of the Manhattan Project. Hanford's role was to produce weapons-grade nuclear material for defense, and by 1989, when the Site's mission changed from operations to cleanup, Hanford had produced more than 60 percent of the nation's plutonium. The legacy of Hanford's production years is enormous in terms of nuclear and hazardous waste, especially the 270 billion gallons of contaminated groundwater and the 5 million cubic yards of contaminated soil. Managing the contaminated soil and groundwater are particularly important because the Columbia River, the lifeblood of the northwest and the nation's eighth largest river, bounds the Site.

Fluor Hanford's Soil & Groundwater Remediation Project (S&GRP) integrates all of the activities that deal with remediating and monitoring the groundwater across the Site. The S&GRP uses a detailed series of steps to record, track, and verify information. The Sample and Data Management (SDM) Process consists of 10 integrated steps that start with the data quality objectives process that establishes the mechanism for collecting the right information with the right people. The process ends with data quality assessment, which is used to ensure that all quantitative data (e.g., field screening, fixed laboratory) are the right type, and of adequate quality to support the decision-making process. Steps 3 through 10 of the process are production steps and are integrated electronically.

The detailed plans, procedures, and systems used day-to-day by the SDM process require a high degree of accuracy and reliability. Tools must be incorporated into the processes that minimize errors. This paper discusses all of the elements of the SDM process in detail.

INTRODUCTION

Telling the story of "Environmental Sampling And Analysis, Getting It Right!" requires briefly describing the Hanford Site and its operations, the evolution of the associated regulatory environment, and the development of systems and processes to monitor and track the environmental data. The Hanford story has been written over several generations of stakeholders

and during changing regulatory environments. At the same time, our knowledge of the waste and the regulations governing its storage, treatment, and disposal have also evolved – an oddity for scientists and engineers that a particular date on the calendar changes how waste is classified for disposal.

Established in the 1940s to produce material for nuclear weapons as part of the Manhattan Project, Hanford is often referred to as the world's largest environmental cleanup project. The Site covers more than 580 square miles in a relatively remote region of southeastern Washington State in the U.S. (Figure 1). The production of nuclear material at Hanford has left a legacy of tremendous proportions in terms of hazardous and radioactive waste. From a waste-management point of view, the task is enormous: 1,700 waste sites; 500 contaminated buildings; 450 billion gallons of liquid waste were discharged to the soil column,; 270 billion gallons of contaminated groundwater; 53 million gallons of highly radioactive liquid waste stored in 177 underground tanks; 9 reactors; 5 million cubic yards of contaminated soil; 22 thousand drums of mixed waste; 2,300 tons of spent nuclear fuel; and 17.8 metric tons of plutonium-bearing material…for just a partial listing.
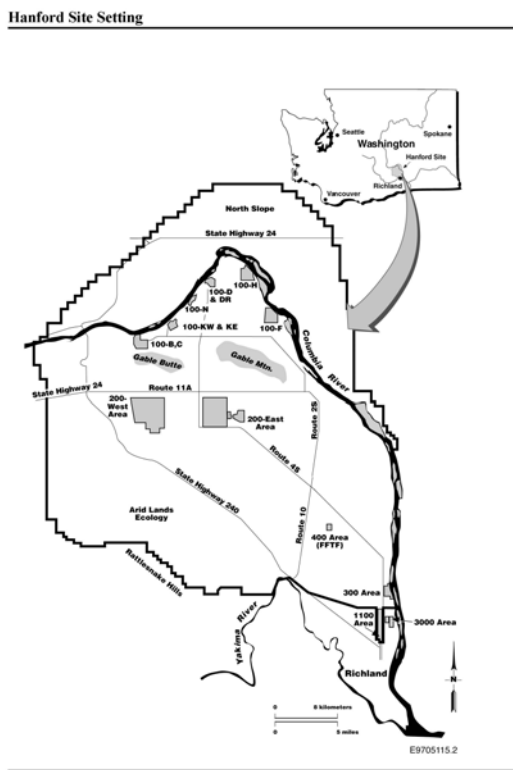

Fig. 1. Hanford is a 586-square-mile reservation bordered by the Columbia River in southeastern Washington State.

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OPERATIONAL OVERVIEW OF THE HANFORD SITE

In 1943, under the auspices of the Manhattan Project, the U.S. Army Corps of Engineers selected Hanford to produce plutonium for national defense. This objective required a large complex that included multiple facilities: fuel manufacturing, nuclear reactors, chemical processing, waste management, and research.

By 1944, two of nine production reactors had been constructed, and were irradiating uranium to produce plutonium. Eight of the reactors, which ran until 1971, were graphite-moderated and used water from the Columbia River for once-through cooling. The ninth reactor, a dual-purpose unit (N Reactor), used recirculating water coolant and produced plutonium for defense applications, as well as steam for electricity. N Reactor, now deactivated, operated until 1987.

Two test reactors and one commercial unit were also built and operated at Hanford: the Plutonium Recycle Test Reactor (PRTR), the Fast Flux Test Facility (FFTF), and a unit owned and operated by Washington Public Power Supply System, respectively. The PRTR was a heavy-water-moderated test reactor. The PRTR has been deactivated. FFTF, a sodium-cooled reactor, was used to test fuel and material for advanced commercial nuclear power plants. In 1993, FFTF began transitioning towards permanent shutdown. The commercial nuclear power plant, WNP-2, is a boiling water reactor that is still operating today.

Chemical-processing operations during nuclear production generated highly radioactive liquid wastes. About 245 million liters (65 million gallons) of high-level waste are stored at the Hanford Site in 177 large single- and double-shelled underground tanks. Of the original 149 single-shell tanks, 67 have leaked, or are assumed to have leaked, about 3.8 million liters (1 million gallons) of contaminated liquid to the soil column – recent estimates push the number even higher. The 28 double-shell tanks built since 1968 have a tank-within-a-tank design and have not leaked.

The solid waste generated from past operations consists of low-level radioactive waste, low-level mixed waste, transuranic waste, and hazardous chemical waste. The current inventory of solid waste buried or stored in underground trenches and above-ground facilities is about 87,000 cubic meters (114,000 cubic yards) in the 100 Area; 379,000 cubic meters (495,000 cubic yards) in the 200 Area; and 159,000 cubic meters (208,000 cubic yards) in the 300 Area. A commercial low-level radioactive waste disposal facility, operated by US Ecology, is located on the Site on land leased to Washington State.

THE REGULATORY FRAMEWORK

In the 1980s, legislation was passed that made Hanford subject to environmental regulations. In 1989, the DOE, U. S. Environmental Protection Agency (EPA), and Washington State Department of Ecology (Ecology), signed a comprehensive cleanup and compliance agreement for achieving compliance with the Comprehensive Environmental Response Compensation and Liability Act (CERCLA) remedial-action provisions and with the Resource Conservation and Recovery Act (RCRA) treatment, storage, and disposal-unit regulations and corrective action provisions. The Hanford Federal Facility Agreement and Consent Order, or Tri-Party Agreement (TPA) [1] frames the cleanup work at Hanford. More specifically, the TPA does the following:

- ➢ Defines and ranks CERCLA and RCRA cleanup commitments.
- ➢ Establishes responsibilities.
- ➢ Provides a basis for budgeting.
- ➢ Reflects a concerted goal of achieving full regulatory compliance and remediation with enforceable milestones in an aggressive manner.

The TPA is a legally binding agreement consisting of two main documents and one associated Plan: the Legal Agreement, the Action Plan, and the Community Relations Plan. The Legal Agreement describes the roles, responsibilities, and authority of the three agencies in the cleanup, compliance, and permitting processes. It also sets up a process for resolving disputes and describes how the agreement will be enforced. The Action Plan implements the cleanup and permitting efforts, which includes milestones for initiating and completing specific work and procedures the three agencies will follow. The Community Relations Plan describes how the public will be informed and involved throughout the cleanup process.

DATABASES, RECORDS MANAGEMENT, AND ENVIRONMENTAL SAMPLING/ANALYSES

The Action Plan that supports the TPA requires that Ecology and EPA have access to all data that is relevant to work performed, or to be performed, under the Agreement. Further, the Action Plan specifies two additional requirements: 1) that EPA, Ecology and their respective contractor staffs have access to all the information electronically [Administrative Record]; and 2) that the databases [Environmental Databases] are accessible to, and used by, all personnel doing TPA-related work.

Hanford has several Environmental Databases to document and track the progress of Site cleanup: the Hanford Environmental Information System (HEIS), the Hanford Well Information Data System (HWIS), the Waste Information Data System (WIDS), and the Hanford Geographic Information System (HGIS). HEIS contains the date, time, location, and results from samples taken during activities such as field investigations and groundwater monitoring. HWIS contains the details of the wells and boreholes on the Site. WIDS tracks the waste sites – from discovery through cleanup. Each of the databases is supported by several applications for either entering or retrieving information. HGIS keeps track of the locations for waste (WIDS) sites, wells and boreholes, and other sampling site locations.

On the backend of the Environmental Databases is the sample and data-management (SDM) process. The SDM process (Figure 2) starts with establishing data quality objective (DQO) **[Step 1]** and preparing a Sampling and Analysis Plan (SAP) **[Step 2]**. S&GRP has adapted EPA's *Guidance on Systematic Planning Using the Data Quality Objectives Process* [2] for environmental decision-making and data acquisition planning and coordination projects. An SAP is prepared for all sampling and analysis activities that support the TPA.
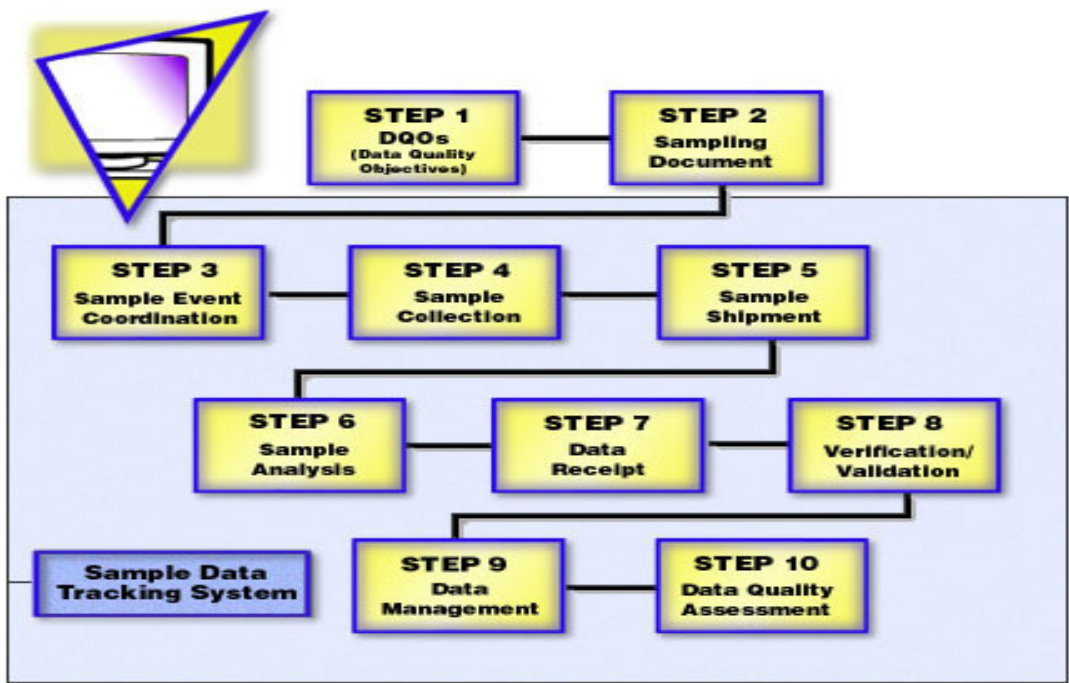
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Fig. 2. The Sample Data Management process is complex.

Once DOE and the lead regulatory agency approve a SAP, then two documents are filled out to begin the process that leads to physically taking samples. Sample event coordination **[Step 3]** involves completing a request for analytical services (RAS) and a sampling authorization form (SAF). The SAF is the focal point for much of the quality control associated with the SDM process.

Next, sample numbers, related to the SAF, are released, and field paperwork and bottle preparation necessary to support the sampling activity are completed and samplers to document the requested analyses for each sample **[Step 4]**. After the samples are collected and packaged, the samples and the chain of custody (COC) form are shipped to the appropriate laboratory **[Step 5]**. After the laboratory performs the specified analyses of the environmental samples **[Step 6]** and submits the results, the data packages and electronic data deliverables (EDD) are received and logged in **[Step 7]**. The data-package results are compared with the COC documentation to ensure that the requested data deliverables were received. If discrepancies are noted, then a sample disposition record (SDR) is prepared and issued for follow up.

An administrative verification process **[Step 8]** may be initiated on selected data packages to ensure copy quality and completeness before the data packages are transmitted to the records-holding area. By procedure an administrative verification may be used for new analytical information with little or no performance history, or indications of poor and declining quality of the data packages. In practice, an administrative verification is performed on all data packages. A technical verification may be initiated for three reasons: to ensure technical completeness when

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a new analytical resource is being used, there is a decline in the quality of the data packages or the client requests a review of the analytical data.

In addition to administrative and technical verification, the data package may also be subject to a validation process. Data is validated using procedures specific to the type of data. There are data-validation procedures for both chemical and radiochemical analyses. Several areas are typically included in data validation: holding times, preservation methods, calibration criteria, blanks, duplicates, and control samples. Once verification and validation tasks are complete, a copy of the final data package is distributed **[Step 9]** to personnel on the SAF and to Record and Information Management for inclusion in the Administrative Record (TPA requirement) and data validation qualifiers are entered into HEIS.

Finally, the data-quality assessment (DQA) process **[Step 10]** compares completed field-sampling activities to those proposed in corresponding sampling documents and provides an evaluation of the resulting data. The purpose of the data evaluation is to determine if quantitative data are of the correct type and adequate quality and quantity to meet the project DQOs and/or decision criteria to support the decision-making process.

AUTOMATING THE SDM PROCESS

Many tasks and associated forms are inherent in the SDM process. An application called Sample Data Tracking (SDT) helps in managing this complex process and minimizing user error, With SDT, users can manage the work flow and track the various required forms. To ensure high-quality EDD, an application name Electronic Data Deliverable Processor (EDDPro) is used for receipt and examination of EDDs. These two applications are described below.

Sample Data Tracking

SDT connects to the HEIS database that contains the date, time, location, and results from samples taken during activities such as field investigations and groundwater monitoring. SDT is used in planning, scheduling, and tracking analytical services. It is used to prepare SAFs, COC forms, labels for sample containers, and status reports for all aspects of sampling, analysis, and reporting associated with environmental samples. The SAF is the key to the sample management side of the SDM process and SDT. The Data Package form is the data management side of the SDM process and SDT. SDT then is considered the work flow process tool for the SDM process.

The SAF (Figure 3) provides the authorization for the expenditure of funds to collect and analyze environmental samples **[Step 3]**. The SAF provides access to, and links, the numerous forms used in the SDM process. Each step in the process has a separate electronic form as outlined below.
- The **SAF Sample form** (Figure 4) displays all of the samples related to the SAF Number selected. New sample numbers may also be created.
- The **SAF Status form** tracks the status of the SAF.
- The **Sample Organization form** tracks the sample organizations related to the SAF.

- The **SAF Operable Unit form** tracks the operable units related to the SAF. An operable unit is a grouping of waste sites either functional or geographic.
- The **Planned Analysis form** is used for an introduction to the Planned Analysis for the SAF Number chosen.
- The **Add Planned Analysis form** is used to add and delete Planned Analysis records.
- The **Order Planned Analysis form** is used to order the Planned Analysis records and group them into bottles. This form is viewed by Service List Name and ordered by the Order Number.
- The **Field Services form** provides an introduction to the Field Services for the SAF Number chosen. It is basically for viewing the records by bottles only. All of the Field Services forms can be accessed from this form.
- The **Field Services Sample form** is used to assign sample numbers to Laboratory codes.
- The **Create Sample Number form** creates sample numbers in the database and inserts them into the Sample table.
- The **Void Sample Numbers form** enables the user to void unused samples and un-void samples to use.
- The **Quick Add Field Services form** is used to add and delete Field Services records that have not been assigned to a Chain of Custody and do not need to be edited.
- The **Add Field Services form** is used to add/delete Field Services records.
- The **Edit Field Services form** is used to edit the bottle type, number and volume of the bottles available from Planned Analysis. If the user edits the bottles, the changes are available only until they exit out of the Add Field Services form or change laboratories in the form.
- The **Chain of Custody form** allows users to view, create, and delete Chains of Custody. The user can also add samples to the chains of custody and print sample labels.**[Step 4]**
- The **Add Chain of Custody Samples form** (Figure 5) is used to assign and un-assign samples to the Chain of Custody.**[Step 5]**
- The **Sample form** allows users to add and update sample and result information.
- The **Sample Log Book form** is used to relate logbooks to the samples.
- The **Sample Disposal form** documents what project or laboratory disposed of the sample and when a sample was disposed. It has two forms: one opened from the Sample form; the other, opened from the Data Package form.**[Step 6]**
- The **Sample Summary Comment form** allows the user to make any comment for the sample to show up in the Sample Summary Report.
- The **Sample Relate form** is used to track the relationship among samples.

Fig. 3. Sampling Authorization Form (SAF)

Fig. 4 Sample Form

Fig. 5. Chain of Custody (COC) Form

The Data Package form (Figure 6) shows all of the Data Package records in the database and automates recordkeeping for tasks associated with the data packages received from the laboratories **[Step 7]**:

- The **Data Package Status form** tracks the status of the Data Package.
- The **Assigned Sample Delivery Group (SDG) form** relates sample numbers to SDG Numbers. The SDG is used to track data packages.
- The **Transfer SDG form** is used to reassign samples to other SDG Numbers.
- The **Data Package Sample Disposal form** records the date and method of disposal by sample number.

The **Returned Analysis form** is an introduction to the Returned Analysis for the SDG Number chosen. This form is only for viewing and updating Returned Analysis records for individual samples.

- The **Check In Returned Analysis form** is used to add and delete Returned Analysis records ordered in the Field Services.
- The **Add Returned Analysis Manual form** is used to add items not ordered in the Field Services to the Returned Analysis.
- The **Update Returned Analysis form** is used to update the records in the Returned Analysis.
- The **Sample Disposition Record form** is used to view, add, update and delete Sample Disposition Records (SDRs).
- The **SDR Report form** is used to select the SDR information and view the SDR report.
- The **Select SDR form** relates sample numbers to SDR Numbers.
- The **Data Package Validation form** (Figure 7) is used to view, add, update and delete validation records. The Validation Services Request (VSR) Number is used to identify the Data Package Validation form **[Step 8]**.
- The **SDG Validation form** relates SDG Numbers to VSR Numbers.

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- The **Data Package Validation Status form** is used to track the status of the Data Package Validation.

Three key forms left to review are the Reports form, the Analysis form, and the Admin forms. The **Reports form** (Figure 8) provides access to all SDT reports. It allows users to view SDT reports for a specific SAF or SDG Number. The Analysis form shows all of the Analysis records in the database. The Admin forms include forms to update system options, refresh tables, and change passwords.

Fig. 6. Data Package Form

Fig. 7. Data Package Validation Form

Fig. 8. SDT Reports

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Electronic Data Deliverable Processor

The EDDPro application is used to validate the format, key variables and parameters, and enter laboratory analytical data into the HEIS database.   On-site and off-site laboratories submit their analytical data electronically in accordance with the Format for Electronic Analytical Data (FEAD) that describes the data requirements for submitting analytical laboratory results. FEAD was developed and monitored by the HEIS Technical Advisory Group (HTAG) — a Hanford contractor-sponsored organization that establishes standards for the HEIS database. EDD files have a hierarchical record structure which contains a header and multiple detail records referred to collectively as a "Form."

Through EDDPro, the laboratories and internal data owners can review issues identified with their submissions of analytical data submissions and correct many of the format errors before electronically entering analytical data into the HEIS database.

EDDPro consists of a web interface (Figure 9) that allows laboratories and data owners to upload text files that contain analytical results described in the FEAD format. This web interface is used internal to the Hanford domain for data owners and internal laboratories. It is used external to the Hanford firewall for external laboratories. EDDPro manages three types of user accounts: Laboratories, Data Owners and System Administrators. The user's login ID is matched against administrative tables to determine the appropriate access to the system and the access to functions within the EDDPro system.
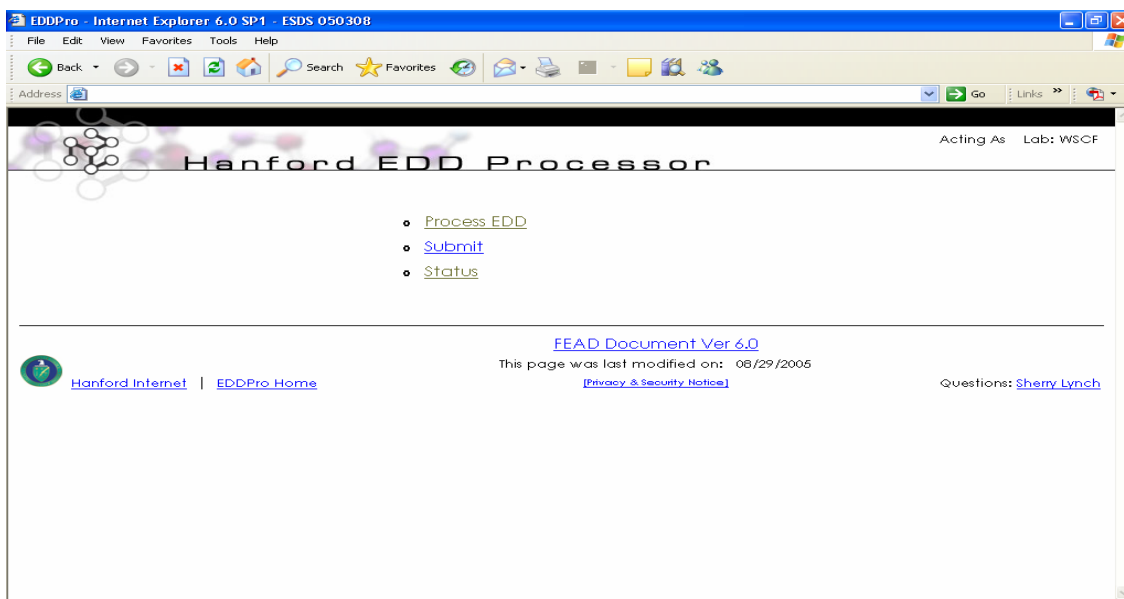

Fig. 9., EDDPro Main Menu

General validation occurs during upload and further detailed validation occurs during a process called Check EDD (Electronic Data Deliverable). The statement of work for the laboratories participating in the Fluor Hanford Analytical Laboratory Contract identifies the FEAD files and

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compliance requirements. Check EDD validates uploaded analytical result file formats against business rules and FEAD format. EDDPro shows users status tables that display validation errors found during uploading and checking processes. The users (laboratories and data owners) can see and correct the errors and then reload the data as necessary.

The difference between the internal and external web interface is the ability to add users and profiles, and set validation rules. Such administrative functions can be done on through the internal web interface. However, the user and validation tables created through the internal web interface are copied to the external web interface multiple times each day.

EDDPro has four major functional areas and three access levels. The functional areas are System Administration, Upload, Check EDD validation, and Submit to HEIS. The three access levels parallel the three types of accounts: Laboratory User, Data Owner and System Administrator. A user who is also a data owner can do everything that a laboratory user can do, but has the added function of data management. The System Administrator manages the overall setup and administration of the system tables including setting up newly stored procedures and controlling tables that specify FEAD files.

Because laboratory users only access the system occasionally, the EDDPro interfaces provide visual clues and tools to help navigate the system. The laboratories are not required to have an automated process to generate the EDD file, but the data format submitted must comply with the FEAD specifications. EDDPro will validate the uploaded files against the business rules for the FEAD requirements and generate any issues encountered. Files containing errors (other than warnings) cannot be processed until the errors are corrected or the Data Owner modifies the validation to change the business rules causing the errors.

Hanford's analytical data owners are associated with different companies and/or projects. The general assumption is that they are familiar with the laboratory processes for sample analysis, as well as the requirements for logging data into HEIS. Data owners establish the error levels for various validations that check for errors within EDDPro and can override errors for a particular EDD file. Overall, the data owner is responsible for resolving issues associated with errors encountered during HEIS processing.

The EDDPro System Administrator is responsible for updating and maintaining the EDDPro security database tables and updating system settings that control the way the EDDPro application operates.

In addition to the four functional areas and three types of accounts and user levels, EDDPro has four computer-program modules: Upload EDD, Check EDD, EDD Status and Submit to HEIS. The laboratories use the web interface to browse and locate files ready to be uploaded to EDDPro. The upload process copies the file into a table where it can be accessed for further processing. A series of integrity validation processes occurs before the file can be thoroughly checked through the other modules of EDDPro. Validation checks for integrity include the following:

➢ Ensuring that numeric data types do not contain characters
➢ Making sure that the first characters of a row do not have a carriage return

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➢ Confirming that the laboratory in the header record matches the laboratory for the file.
➢ Validating the file's laboratory user and data owner.

If any of the upload checks fail, the file is placed in rejected status. If all checks pass, the file is ready to be processed through the next step, Check EDD, which will validate and verify the data using both generic and specific validation procedures.

Once the data-parsing routine has processed successfully, the FEAD file will appear on the Check EDD page indicating it is available for further Check EDD validation. Check EDD functions ensure that the requirements set by the data owner for data integrity are followed.

The EDDPro system allows the users to review all errors encountered during processing (Figure 10). It also logs all files processed through upload, Check EDD, and Submit to HEIS functions. All errors can be viewed online through an EDD Status report. Validation errors include the Form Number, Suffix Number, field, and a descriptive message stating the error.
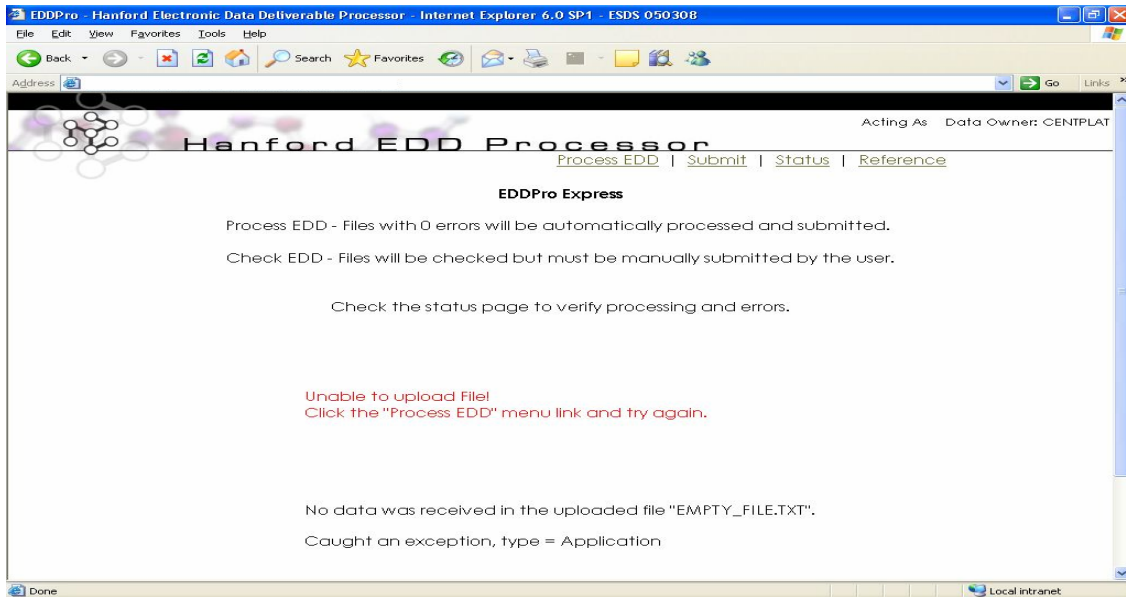

Fig.10. EDD Upload Errors

Once the Check EDD validation has occurred and no critical processing errors have been identified, the data owner or laboratory can select the option to have the EDD file submitted to HEIS (Figure 11). A batch job that runs once an hour, queries the data in this table and to uploads new data.   For data that resides outside the firewall, the upload to HEIS processing will cause the data to be transferred from the external web site into the HEIS server.
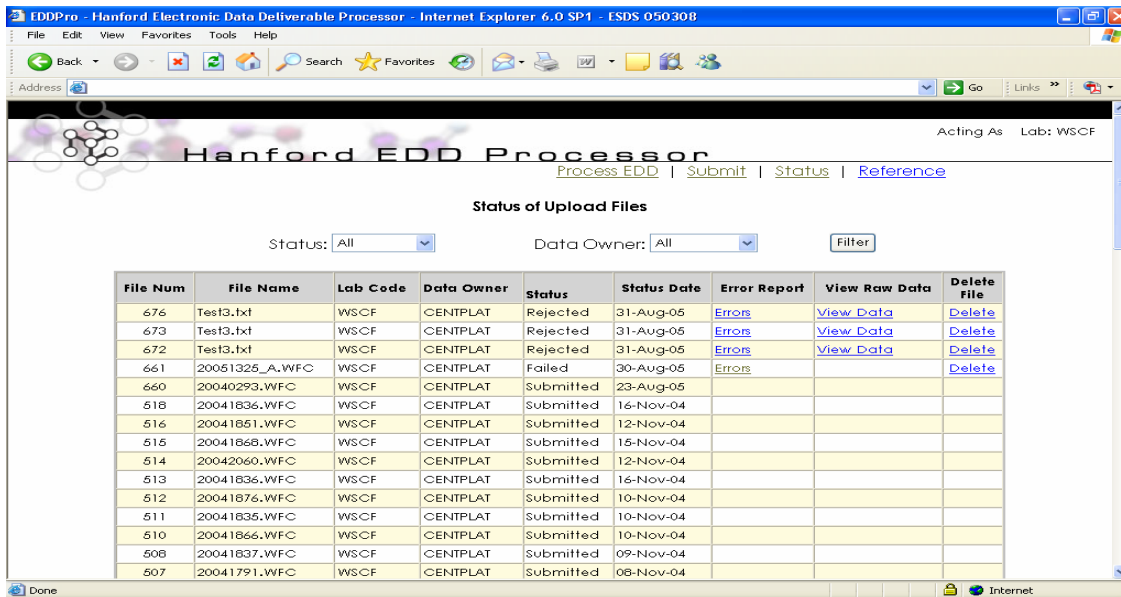
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Fig.11. File Status Screen

CONCLUSION

Hanford has a sophisticated, electronic system for accumulating and maintaining data that tracks the progress in remediating the Site's groundwater. Fluor Hanford's S&GRP is responsible for integrating all of the groundwater-related activities across the Site. S&GRP uses the SDM process, which is extremely complex, and therefore, ripe for human errors. The SDT and EDDPro applications, in conjunction with the HEIS database, reduces the opportunities for mistakes and improves the efficiency, reliability and quality of the environmental information collected to support Hanford cleanup.

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