Developing a New Model to Estimate the Costs to Decommission DOE's Active Facilities – 16368

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ABSTRACT

The Active Facilities Data Collection System (AFDCS) is a major means the U.S. Department of Energy (DOE or Department) uses to estimate its out-year environmental liability for the active and surplus facilities across the Department. The previous AFDCS cost model was based on cost assumptions that date back to the mid-1990s. The model is being replaced with a model that reflects more recent facility disposition experience and costs. DOE's Office of Environmental Management's (DOE-EM) historical cost collection database provides the basis for the new AFDCS cost model. This paper describes the process that was used to update the AFDCS facility data inputs, analyze this data, and formulate historical costs and parameters. This process created a robust and reliable cost model that will provide DOE with a valid estimate of the facilities' disposition costs.

ACTIVE FACILITIES DATA COLLECTION SYSTEM (AFDCS) OVERVIEW

DOE has thousands of buildings and structures located at numerous locations across the country. These facilities support numerous ongoing missions, including scientific research, nuclear energy and weapons programs, among others. These facilities are known as "active" facilities. An additional number of "surplus" facilities are slated for demolition, a process primarily managed by DOE-EM. As part of its yearly financial reporting process, DOE prepares the annual Agency Financial Report, which includes information on the DOE's environmental liabilities. This environmental liability includes scope as far ranging as addressing the nation's spent nuclear fuel, managing and disposing of radioactive wastes, remediation of its contaminated environmental media, disposing of surplus facilities, and the eventual disposition of its "active" facilities – i.e., those facilities currently used by its ongoing missions. A primary means of calculating the environmental liability for surplus and active facilities has been, and continues to be, the Active Facilities Data Collection System (AFDCS).

The scope of the AFDCS is to estimate the future costs for the "facility disposition" of over 2,400 contaminated buildings and structures. The list of active facilities are based on DOE's real property database (i.e., FIMS), with additional site input required for the cost models to generate the AFDCS liability estimate The field site data is contained in a Microsoft SQL database, which also includes a website for site data input. Additional facilities, many of which are now or will shortly become surplus, have bottoms-up estimates that are prepared by specific DOE sites and are not included in the list of facilities modeled by AFDCS.

Many of the AFDCS-included facilities may not become surplus for decades. The scope of facility disposition includes stabilization of the facility and included materials, deactivation of the facilities, decommissioning (also referred to as D&D), and surveillance and maintenance (S&M) while the facilities await decommissioning. The AFDCS environmental liability includes only those facilities and structures that are contaminated with radionuclides, hazardous chemicals, and asbestos, and does not include remediation of soil or other environmental media. Additionally, some elements, such as removal of special nuclear materials or legacy waste from operations, are included in a “Restructured Environmental Liability” (REL), a separate category of environmental liability from AFDCS.

The previous AFDCS cost model was initially developed in the 1990s, before DOE EM had significant experience decommissioning facilities. The old model was based on decommissioning methods expected to be employed and projections of expected costs. Because of its age it could not incorporate either the experience of the last 20 years or data on the actual costs to accomplish the billions of dollars in cleanup projects executed by DOE-EM since then.

ENVIRONMENTAL COST ANALYSIS SYSTEM (ECAS) OVERVIEW

The Environmental Cost Analysis System (ECAS) is DOE-EM’s historical cost collection system. ECAS contains data on 278 projects (124 D&D, most containing multiple buildings and structures) covering 9 major DOE sites. The system consists of a relational database, documented processes for data input, technical support, and a requirement for DOE-EM projects to provide compliant data upon project completion. Its purpose is to provide DOE estimators with accurate actual data for cost estimating and project analysis tasks.

ECAS is based on cost data collected at project completion. It includes costs and other parameters (e.g., building area, waste volumes). Data is organized so that it can be extracted by:

- Original site work breakdown structure;
- ECAS Project;
- Project Type;
- ECAS subproject;
- Levels and types of contamination; and
- Other project-level descriptions.

The ECAS costs are all derived from accounting system exports. The non-cost parameters are derived from project documentation, project and environmental closeout reports, safety documentation, waste management databases, and similar detailed documentation. The data are “normalized” by arranging it so that it is in a standard ECAS project format, allowing comparison across sites.

Of particular importance to AFDCS, the ECAS costs and parameters are organized using the Environmental Cost Element Structure (ECES) codes, which break out scope by type of work. This allows the actual costs for work types such as project management (ECES code .02.01), characterization (ECES code .31.07), decontamination (ECES code .31.08), equipment removal (ECES code .31.09), and demolition (ECES code .31.17), along with other categories.

The ECAS Project Types (and "Project Type Details") were developed in 2008 and are used to classify DOE-EM work into similar types of projects, so that these projects could be compared. While applied at the project level (and for D&D projects, often covering several buildings), applying these classifications allowed us to both understand populations of typical DOE buildings and develop experience in determining the project type (e.g., Plutonium Storage Facility) to assign to a building.

ECAS data is ideal for revising the AFDCS cost model. ECAS contains actual costs that can be used to estimate the costs to disposition like-buildings in AFDCS using the same D&D phases– including S&M, stabilization, deactivation, and decommissioning. All ECAS costs are derived from DOE sites, and cover work within radioactive facilities, hazardous environments, environmental and waste regulatory constraints, security provisions and the other conditions that reflect the difficulty of work of this type at DOE sites. This is an improvement compared to traditional methods of estimating DOE productivity reduction work coefficients and applying them to industry cost factors. Finally, ECAS supports a parametric process – ECAS data is internally based on $/unit quantity as opposed to activity-based (e.g., crew hours per linear foot [LF] of pipe). Using an activity-based estimating approach for such poorly defined projects would require detailed buildup of hypothetical assemblies with many assumptions for no improvement in quality.

DEVELOPMENT OF THE STRUCTURE FOR THE AFDCS MODEL

The initial challenge in developing the new AFDCS cost model was obtaining sufficient facility information necessary to develop accurate costs while minimizing the effort that the sites had to perform to provide that information. The previous cost model had 15 different model types (7 facilities, 8 "Other Structures and Facilities," (OSFs)) as well as an asbestos category. Of these, 98% of the radiologically and chemically contaminated facilities (and 2/3 of the estimated costs) were in three categories: 1) radioactive contamination, 2) radioactive mixed waste contamination, and 3) hazardous material contamination. These three categories had cost factors ($/SF) within 20% of each other and provided no way to differentiate between buildings with minor levels of contamination and those with high levels of radioactivity.

Using our experience with the ECAS normalization process, we developed provisional "Building Types" and "OSF Types" for the new AFDCS to completely replace the previous model type, the final versions of which are shown in Table I. We also identified a "Principal Contaminant" descriptor, shown in Table II, which provides the level and extent of contamination within the Building Type. DOE sites must enter the building/OSF type and principal contaminant (based on the past and current mission as well as the current condition of the facility) into the system for each contaminated facility.

Table I – AFDCS Building and OSF Types

Building Type	OSF Type
01-Plutonium SNM Facility	20-Contaminated Trailer/Shed
02-Uranium SNM Facility	21-HVAC/Utility Building
03-Hot Cells	22-Other HVAC-Filter Pits, Duct
04-Major Rad Lab	23-Waste Collection System Bldg
05-Reactor	24-STP Building/Equipment
06-Liquid Waste Processing	25-Cooling Tower
07-Solid Waste Processing	26-Waste Storage Pad
08-Manufacturing	27-Stack
09-Accelerator	28-Process Waste Tank
10-Minor Rad Lab	29-Oil Tank
11-Small Process/Assembly Facility	30-Rad/Haz Piping
12-Industrial&Office	31-Trench/Culvert/Pit/Basin
13-No Liability(Asbestos Only)	
14-Excluded	

Table II – AFDCS Principal Contaminants

Principal Contaminant List
1-Rad Exclusion Area – Limited
1-Rad Exclusion Area – Extensive
2-High Rad Area – Limited
2-High Rad Area – Extensive
3-High Airborne Cont Area – Limited
3-High Airborne Cont Area – Extensive
4-Airborne Cont Area – Limited
4-Airborne Cont Area - Extensive
5-Contamination Area – Limited
5-Contamination Area - Extensive
6-Rad-Controlled Area – Limited
6-Rad-Controlled Area - Extensive
7-Chemical Contamination Area – Limited
7-Chemical Contamination Area – Extensive
8-Asbestos-Friable – Incidental
8-Asbestos-Friable – Situational
8-Asbestos-Friable – Extensive
9-Asbestos-Non-Friable - Incidental
9-Asbestos-Non-Friable - Situational
9-Asbestos-Non-Friable - Extensive
10 – N/A

We developed the Building Type/Principal Contaminant categories based on three overall criteria:

1) How well did the Building Type/Principal Contaminant fit the AFDCS inventory of facilities.
2) Did the category allow us to use ECAS actual data.
3) How easily could the sites assess and categorize the buildings/OSFs. The sites must be able to clearly and easily distinguish among the categories to provide the most accurate information.

We evaluated the categories against the AFDCS population by examining each facility, along with a number of “Excluded Facilities” which have outside estimates as well, to make sure that the Building Types were well correlated to the population of AFDCS buildings and OSFs. Based on facility data from FIMS, such as the Asset Type, Contamination Category, Hazard Category, and Usage Code, we were able to assign “default” Building Types and Principal Contaminants to the most recent list of AFDCS contaminated facilities. Once the default values were assigned, the information was provided to the applicable DOE sites in site-specific Excel spreadsheets for them to validate and/or correct. This was done as part of an outreach program with webinar presentations, follow-up conference calls, and a process for resolution of comments and responses. The sites’ preliminary data supported the model development and initial model estimates.

With the Building Type, Principal Contaminant, and building area (or other unit quantity) defined for each building or OSF, we now had defined the input data for the AFDCS cost model.

CREATION OF THE COST MODEL

Since the new AFDCS cost model needed to be able to interface with the AFDCS SQL database, we recognized early on that we would need to build the cost model workbook to facilitate that interface, and make it available early in the process to ensure functionality. We chose the model architecture shown in Figure 1.

The cost model has two portions – the AFDCS cost model workbook and the AFDCS cost model basis. The cost model workbook is focused on the specific function of calculating the AFDCS environmental liability costs from the building information and unit cost information. The backup for the cost model workbook is contained in the cost model basis. The cost model workbook could be viewed conceptually (and very simplistically) as multiplying building areas by cost/SF by Building Type using the Excel lookup functions, and then totaling the costs. The reality is much more complex. For example, the cost estimating relationships are not all linear, there is significant logic ensuring factors are correctly applied, and there are derivative factors that are required for formulations.

A second element of defining the cost model was to more clearly define the scope so that it could be interfaced with the ECAS data. The high-level scope structure of S&M, stabilization, deactivation, and decommissioning from the previous model remained appropriate. However, since the 1990s, there is a better understanding of which facility disposition activities will be budgeted for by the ongoing mission and which should be part of its environmental liability, and in the AFDCS estimate. We needed to define our scope in greater detail to reflect that understanding, avoid duplication of costs, and allow the ECAS actual cost data to be appropriately applied. We developed the next level of scope as shown in Table III, cost model calculation categories.

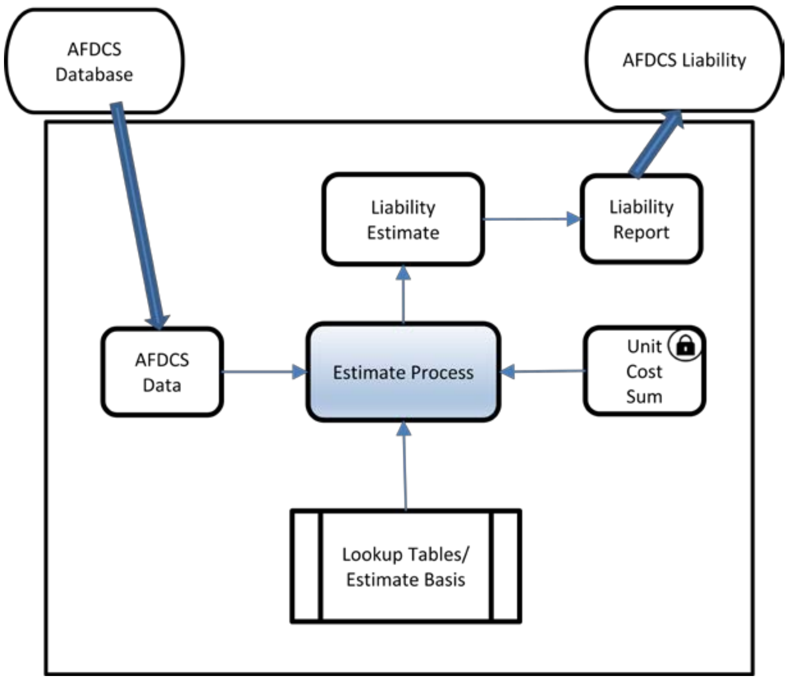

Figure 1 – AFDCS Cost Model Flow Diagram

The first three major categories, stabilization/deactivation, decommissioning, and asbestos removal, were matched to the major scope elements of the previous model to allow comparison between models. The S&M in the "S&M, Stabilization, and Deactivation" category matched the previous approach of 7 years "pre-stabilization," 3 years "post-stabilization" and prior to deactivation, and 2 years "post-deactivation" prior to beginning decommissioning. Stabilization/deactivation waste management was subdivided into five categories of waste: regulated hazardous (Haz), low-level radioactive (LLW), mixed hazardous-radioactive (MLLW), transuranic (TRU), and sanitary/construction debris (San). The waste costs include management of the waste on-site, transportation to the disposal site, and disposal site fees on a site-by-site basis.

Decommissioning was divided into the direct decommissioning activities summarized in the ECAS ECES codes discussed above. It also included a separate waste management section due to the much higher quantities of waste (and hence costs) per unit area generated during decommissioning. Asbestos was categorized based on the previous arrangement and data provided by the sites, with friable separated from non-friable and the removal separated from the disposal. All facilities where asbestos is the only contaminant are assigned Building Type 13;

asbestos removal and disposal in facilities that are contaminated with radiological or chemical constituents are included in the equipment removal scope element.

The final major category had four general calculations that were applied more generically. The project management costs represented those direct costs applied to the ECAS ECES costs – costs for project management, engineering and work planning, mobilization, and other general project costs. The support factor included those overall site costs, such as site management, security, roads and grounds, general overhead, and similar costs. We developed a waste-cost-by-site factor to account for the substantially lower disposal costs for those sites with on-site disposal. Finally, the difference in cost due to different levels of radioactivity and other contamination as applied to each Building Type was calculated.

Table III - Cost Model Calculation Categories.

Category	Description of Calculation Category
1.0	Surveillance and Maintenance (S&M), Stabilization, and Deactivation
1.1	S&M (Pre-Stabilization)
1.2	Stabilization
1.3	S&M (Post Stabilization)
1.4	Deactivation
1.5	S&M (Post-Deactivation)
1.6	Stabilization Waste Management, Transport, Disposal
2.0	Decommissioning of Buildings/OSFs
2.1	Decommissioning Characterization
2.2	Equipment Interior Stabilization/Removal
2.3	Decontamination
2.4	Demolition
2.5	Demolition Waste Management, Transport, Disposal
3.0	Removal of Asbestos
3.1	ACM Characterization (same as 2.1)
3.2	Non-Friable ACM Removal
3.3	Friable ACM Removal
3.4	Non-Friable ACM Disposal
3.5	Friable ACM Disposal
4.0	Other Calculations
4.1	Project Management (PM)
4.2	Support Factor
4.3	Waste Cost by DOE Site
4.4	Variation of costs by Principal Contaminant severity

We now had the AFDCS cost model workbook in place with the calculations identified and populated with placeholder factors. We tested the Workbook to ensure its functionalities were working as designed and producing reliable calculations. We then initiated conversations with the contractor responsible for systems support of the Access database and defined the interface between the database and the Microsoft Excel AFDCS cost model workbook. This interface allowed modifications to the database to proceed in parallel with cost model development, as discussed in a later section.

DEVELOPMENT OF THE ECAS DATA SUMMARY

ECAS, as a repository for historical costs and parameters, has extensive data; but that data had never been applied to a task of this magnitude. Previous use had generally consisted of estimators identifying ECAS projects similar in scope to projects that they were estimating, and comparing those projects at various levels to support or augment their estimates. The AFDCS cost model would require more significant data organization and correlation on a larger scale and would require data from diverse projects to be captured in single equations.

The first step in developing the ECAS Data Summary was to evaluate all of the ECAS D&D projects to identify those that were most applicable to the AFDCS building and OSF population. Forty-one projects were selected based on scope applicability, data quality, and time available for analysis. For example, some projects were selected because of specific scope (e.g., contaminated sewage treatment plant) and others omitted (e.g., the ECAS database is over-weighted in Industrial & Office buildings, so only the best were used). Projects were selected from seven sites over an eleven-year period to achieve geographic and temporal diversity.

Projects were then deconstructed into their component buildings and structures. For instance, a Plutonium SNM Facility (AFDCS Building Type 01) might have cooling towers, waste processing facilities, warehouses, and office trailers, and similar support buildings and structures included with it in a single decommissioning project. In most cases all relevant costs and parameters could be differentiated based on the ECAS subproject; in some cases original site data (available as ECAS backup) was required, or the data was pro-rated in a few cases for supplemental parameters for minor facilities.

The buildings and OSFs were then assigned Building Types and Principal Contaminant values in the same fashion as a site would assign values to an AFDCS facility. ECAS provides project type descriptors, data on contaminants of concern, subproject data, and narrative documentation on projects that provided most of this information. However, in some cases additional ECAS backup source documentation (project closeout reports, etc.) was reviewed as well.

The asbestos removal scope received particular attention since over 1,300 of the 2,500 contaminated AFDCS facilities are solely contaminated with asbestos. Although ECAS has some information on asbestos costs and waste, often the information is combined with other costs or waste categories. A subset of 25 ECAS buildings was reviewed extensively, including details from closeout reports on asbestos (friable or non-friable, generation quantities) and a supplemental analysis was performed to match the resulting data with the AFDCS Principal Contaminant data.

After the data was initially compiled, it was analyzed for consistency. Actual D&D project data has inconsistencies, either because there are normal variations (different facility characteristics, project execution efficiencies, etc.) or variations that would impact its applicability to AFDCS (e.g., a new alternate waste treatment facility included with a liquid waste handling facility D&D costs, substantial contaminated soil removal included with a buildings waste volume). Anomalous data was initially reviewed against ECAS basis documents, and corrected if possible. In cases where the data from a single project was eccentric enough to substantially skew the overall results, the project was either removed from the analysis or adjusted to within a normal range and documented as such.

The final result was a list of 133 buildings and structures that covered all but two of the Building Types: 03-Hot Cells and 09-Accelerators, which are discussed below. These ECAS buildings contained all of the characteristics, costs, and parametric values necessary to support the development of the cost estimating relationships required by the Cost Model Workbook tables.

DEVELOPMENT OF UNIT QUANTITIES

Supplemental to the development of the ECAS data, we developed a data set of “unit quantities,” such as surface areas of rooms, feet of piping and conduit, and potential debris volume, to support the modeling process. ECAS has limited quantitative data on building characteristics in its database, although it references additional information as text. The limited unit quantities in ECAS are skewed to the high-contamination items – gloveboxes, process tanks, process piping, etc. Past modeling experience has shown that having supplemental data on unit quantities can provide better data correlation and aid in establishing more reasonable parameter ranges.

A unit quantities analysis was performed using construction model data based on composite buildings created from data number of data sources. Site submittal and FIMS data by Building Type established the parameters as to the nominal building area, structure type (e.g., steel frame), and similar parameters. This allowed construction quantities to be calculated from supplemental estimating tools.

COMPLETION OF THE AFCDS COST MODEL BASIS

The ECAS data and supplemental unit quantities was now ready to be converted into cost estimating relationships that would be incorporated in the AFDCS cost model in the categories shown in Table III. Numerous analyses were performed; these analyses are discussed in more detail in Appendix 1. In a number of cases the data was sufficiently robust that regressions could be performed to yield equations of the form Cost = A*(SF)^B + C, where A, B, and C are constants and the SF is the SF of the AFDCS building or OSF. In other cases, where the data was more sparse, the costs or costs factors were averaged among several example buildings.

There were two Building Types that were not represented directly in ECAS: Building Types 03-Hot Cells and 09-Accelerators. Factors for the costs for characterization, decontamination, and demolition were derived for similar buildings. For the hot cells equipment removal we used a prototype building (Oak Ridge Building 2026), developed functional space area (FSA) costs for all areas except hot cells and used a cost estimate for a similar building to develop the hot cell FSA costs. We cross referenced that hot cell FSA cost against costs for similar areas in reactors. For accelerator equipment removal we used a similar approach and used an estimate for a cyclotron facility (NASA-Glenn Cyclotron), developed FSA parameters, applied $/SF for the general areas and then used the estimate for the dismantlement of the cyclotron itself. The resultant costs ($/SF) at an overall building level were validated against ECAS buildings of similar complexity and contamination levels.

There were several cost model basis products resulting from these analyses. The most important were several Excel lookup tables that were incorporated into the cost model workbook. The second was a series of backup workbooks that provide that audit trail from the ECAS and other fundamental data to the cost estimating relationships. We conducted internal verifications of the data, separately performing the calculations, and confirming that values were properly applied. In addition to the cost model workbook and the cost model basis and backup data, we also developed a cost model report. One of deficiencies of the previous cost model was a lack of documentation both regarding operations and discussing exactly the scope that was being estimated. The AFDCS Cost Model Report has sections addressing these areas.

We did a test run of the AFDCS cost model with data from the 4th quarter FY2015 reporting and the results are shown in Table IV below. Since this result is based on FY15 data it is expected to change as the sites review and finalize their input for FY16, upon which this estimate is based, is expected to change

Table IV – Preliminary AFDCS Cost Model Results

AFDCS Category	
Total number of Buildings an OSFs	2,420
Total Area (Square Feet)	41.5 M
Rad/Chem Building Liability	$13.0 B
Asbestos Building Liability	$3.0 B
Other Structures and Facilities Liability	$1.8 B
Total Liability	$17.9 B

The estimated cost is modestly higher than the value reported in the previous model. Since the detailed scope on which that model was based was less defined it is difficult to determine reasons for that difference.

CONTINGENCY

In addition to the estimated costs as developed in the cost model workbook, a contingency model was developed to estimate the contingency using the AFDCS model output, performance data from actual projects, and uncertainty adjustments from a recognized source. The historic project data used was based on calculating cost-variances-at-complete ([budget]-[actual]/[budget]) for each ECAS facility type. The cost variance percentages were sorted and evaluated at the 1st and 3rd quartile as representative of generalized project cost range. The Association for the

Advancement of Cost Engineering International (AACEI) Estimate Class Accuracy Range was used to adjust costs based on the lack of project definition. Estimate Class 5 was assumed for all facilities using an estimate accuracy range of -30% to +50%.

The contingency model used the AFDCS data as the model basis. Within the model, each AFDCS facility had a variable representing the cost variance percentage, and an uncertainty variable based on the AAECI estimate class range. Each variable was represented in the contingency analysis by a triangular distribution: a pessimistic estimate, expected estimate (AFDCS estimate), and an optimistic estimate of the costs based on the cost variance percentage and the uncertainty ranges described above.

A Monte Carlo simulation was used to provide a range estimate of the anticipated final facility disposition costs. The modeled value produced an overall contingency of 27% at an 80% confidence level.

IMPACTS ON THE AFDCS DATA INPUT

As discussed earlier, the Office of Finance and Accounting (DOE-OFA) engaged their IT contractor to update the AFDCS SQL database in parallel with the development of the AFDCS cost model. Prototype versions of the Cost Model Workbook were developed and explained to the IT contractors. After several sessions, the interface tables were frozen and a set of formal requirements were developed. The development activities then proceeded in parallel. The changes to the database required changes to variables, removal of “vestigial” SQL processes and information, changes to the input screens, and general streamlining.

The development of the AFDCS cost model, and the updating of the AFDCS SQL database to provide the revised model input data is only the beginning of the process that in FY16 will generate revised values. Beginning in February, the revised web portal will be available for site input. Training materials (such as decision trees for determining Building Types) and training sessions have been prepared to provide site and program staff information on the changes and what backup and supporting documentation is required.

POTENTIAL AREAS FOR ADDITIONAL DEVELOPMENT

The implementation of the AFDCS cost model should provide a substantial improvement in the confidence that DOE and its auditors have in the reliability of its liability estimate. However, there are other areas in DOE outside of DOE-OFA and the AFDCS that can potentially benefit from this work.

The development of the data by Building Type and Principal Contaminant provides direct data that can be used by other DOE organizations in estimating project costs. Previously using ECAS data required evaluating ECAS projects and choosing one or more with similar characteristics to the project being estimated. The development of these more generic types, with the averaged values of multiple projects and summarized direct cost categories (e.g., equipment removal) makes accessing the ECAS data easier. There have also been some additional discussions about using elements of the asbestos model to model asbestos removal for other federal agencies.

Other areas hold additional possibilities. For AFDCS a decision was made that the cost and effort to resolve scope and costs by building at the FSA level was not cost-effective, although some data was developed at the FSA level to fill data gaps and corroborate other cost factors. In other applications, costs defined at the FSA level could provide an easily-used parametric tool that would allow quick and accurate estimates to better account for the unique characteristics of a building. For instance, the difference between buildings with many gloveboxes or only a few gloveboxes would be readily distinguishable, whereas the Building Type approach has less resolution. More detailed analysis of the ECAS data could probably develop costs at the FSA level.

Additionally, there are lower levels of resolution for some of the categories – equipment removal can be subdivided into glovebox, hot cell, process piping, and several other types of equipment removal. While ECAS alone may not be able to resolve costs at this level, combining it with other actual costs should allow additional resolution. This takes the data to a level where individual activities can be estimated.

Finally, the ECAS data input process, where contractors provide actual project costs in an ECAS-compatible format, is still being refined. A better definition of how the data will be used will help focus the process.

CONCLUSION

The result of the AFDCS cost model development has been to enhance the AFDCS cost models by ensuring consistency with current DOE-EM and industry standards and, providing a more accurate and reliable assessment of DOE’s active facilities environmental liability. The work holds the direct promise of enhancing DOE’s ability to get more value out of its ECAS data for more detailed cost estimating. Finally, some of the techniques developed for use of Building Types, Principal Contaminants, and FSA may be applied to estimating, benchmarking, analyzing, and monitoring progress on other DOE projects and other projects in radioactive environments.

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APPENDIX 1 – SIMMARY OF COST MODEL BASIS

Cate-gory	Description of Calculation Category
1.0	Surveillance and Maintenance (S&M), Stabilization, and Deactivation
1.1	S&M (Pre-Stabilization) - S&M activities occur whether a facility is in an operation, decommissioning, or shutdown mode. ECES codes .06.XX designate S&M activities in the ECAS projects. These costs were collected and averaged on a $/SF/yr basis for three categories of buildings – Nuclear Facilities (BTs 01-05), Significant Radiological Facilities (BTs 06-09 and radiological OSFs), and Minor Radiological Facilities (BTs 10-20 and principally-chemical OSFs) base on their pre-stabilized condition. For this category the values were multiplied by 7 years.
1.2	Stabilization - All stabilization activities except painting of highly contaminated areas are REL. The cost of painting highly contaminated area was calculated by using a cost factor from RS Means and applying a productivity factor based on an Oak Ridge estimate to account for the work in highly-contaminated areas. The areas were calculated from the percentage of building areas of the highly-contaminated FSAs, accounting for the wall and ceiling areas, and applying a cost/SF painting factor.
1.3	S&M (Post Stabilization) [$/SF] - Same as 1.1, except for a period of 3 years.
1.4	Deactivation [$/SF] - Deactivation in the ECAS database contain both AFDCS activities (liquids removal, pre-removal equipment decontamination, and utility isolation) and non-AFDCS activities (legacy waste and unattached materials and equipment removal). ECAS buildings were chosen where the AFDCS deactivation activities were the overwhelmingly predominant deactivation effort. These buildings were collected and the deactivation costs averaged on a $/SF basis by building type, with building types for which there were no ECAS analogues assigned values of building types with similar levels of contamination.
1.5	S&M (Post-Deactivation) [$/SF] - Same as 1.1, except for a period of 2 years.
1.6	Stabilization Waste Management, Transport, Disposal [$/SF] - Waste costs were calculated for Stabilization and Deactivation; no significant waste costs were identified for S&M. Stabilization wastes were assumed at 1 drum of LLW per worker day assuming a two man crew in the contaminated areas. Deactivation waste was assumed to only be generated by removal of liquids and pre-removal equipment decontamination and quantities of waste were estimated by building types for types 01-08.
2.0	Decommissioning of Buildings/OSFs
2.1	Decommissioning Characterization [$/SF] - Characterization was calculated as a cost in $/SF for all buildings based on a regression of ECAS data. The regression also used the areas to be characterized (i.e., including floors, walls, and ceilings) derived from the Unit Quantities analysis. Since the number of ECAS OSFs was more limited, factors were selected from the ECAS data and averaged by Radiological OSFs, Chemical OSFs, Stacks, Oil Tanks, and Piping. Process Waste Tanks were evaluated separately using ECAS tank data, since the costs are not linear with gallons.
2.2	Equipment Interior Stabilization/Removal [$/SF] - Equipment Removal costs were initially evaluated based on weighted averages of ECAS data by Building Type for Building Types 06-20. A more detailed analysis was performed, where equipment removal costs were developed by FSA. These costs were then pro-rated across the individual building types based on the average FSA

	percentages of the ECAS buildings of that type
2.3	Decontamination [$/SF] - Decontamination costs were based on weighted averages of the ECAS data by Building Type. Due to the limited number of facilities in some Building Types the data was scattered. The costs/SF were averaged among several groupings of buildings – high, medium, and low contamination buildings; asbestos contaminated buildings; trailers; radiological and chemical OSFs; and Stacks, Process Waste Tanks, Oil Tanks, and Piping. These consolidated $/SF values were used directly in the Cost Model, except for Process Waste Tanks where a regression analysis was used to determine the proper coefficient and exponent.
2.4	Demolition [$/SF] - The Demolition costs were calculated using a similar approach as for Decontamination - based on weighted averages of the ECAS data by Building Type. Asbestos-contaminated building demolition was calculated based on a separate regression.
2.5	Demolition Waste Management, Transport, Disposal [$/SF] Since the waste costs are reduced for sites that contain on-site disposal (see calculation category 4.2 below), D&D waste costs needed to be based on off-site disposal. They were therefore calculated as if all sites were to be managing and shipping wastes generally based on Rocky Flats waste disposition costs. Individual projects were evaluated individually based on the quantity of waste generated. Where there were specific waste disposal costs that were more relevant than the Rocky Flats costs (e.g., disposal of a reactor vessel) these were used instead. The cost were then collected and averaged by building type and by waste type.
3.0	Removal of Asbestos
3.1	ACM Characterization [$/SF] Same as 2.1.
3.2	Non-Friable ACM Removal [$/SF] - Asbestos Removal costs were based on a comprehensive analysis of ECAS asbestos costs and parameters in BT 13 facilities, particularly and Rocky Flats but confirmed with data from other sites. Costs and quantities were developed for 25 buildings, resulting in values per SF and per CF of differing Asbestos wastes. Asbestos Removal costs were additionally based on cubic feet (CF) of the asbestos contaminated material to remove. To translate this into a unit cost of building gross square feet (GSF) requires a factor of CF/SF. This factor was established for each building type using the Unit Quantity information provided in the cost basis spreadsheet. With this information and the parametric analysis of building materials it was possible to establish unit quantities for each "Building Type" that is representative of the population of that building type in the AFDCS database.
3.3	Friable ACM Removal [$/SF] - Asbestos Removal cost is based on cubic feet (CF) of the asbestos contaminated material to remove. To translate this into a unit cost of building gross square feet (GSF) requires a factor of CF/SF. Appling the method described in 3.2 above.
3.4	Non-Friable ACM Disposal [$/SF] - Asbestos Disposal cost is based on Tons of the asbestos contaminated material to remove. To translate this into a unit cost of building gross square feet (GSF) requires a factor of Ton/SF. Appling the method described in 3.2 above.
3.5	Friable ACM Disposal [$/SF] - Asbestos Disposal cost is based on Tons of the asbestos contaminated material to remove. To translate this into a unit cost of building gross square feet (GSF) requires a factor of Ton/SF. Appling the method described in 3.2 above.
4.0	Other Calculations
4.1	Project Management (PM) [$/$] - Project Management was calculated based on

	regressions for project management costs as a percentage of all other direct costs. It is included as a factor applied to the sum of the direct costs. The regression slopes for the radiological facility project management costs were almost exactly twice those for non-radiological facilities. Project Management applies to categories 1.0-3.0 above. It also includes summarized ECAS data on "project indirect" costs.
4.2	Support Factor [$/$] - ECAS contains ECES codes associated with the direct costs of performing work (e.g., equipment removal, demolition) and different overhead and/or indirect costs: project management, project indirect, program management, and site indirects (Note: while project management is a direct cost for accounting purposes it was not for modeling purposes.). The project management and project indirect were evaluated by building type and site, the costs regressed against the direct cost, and the resulting equation used as discussed above. The program management and site indirects were evaluated by building type and site and averaged to develop a universal support factor. The Support Factor applies to categories 1.0-3.0 above.
4.3	Waste Cost by DOE Site [$/$ or %] - Waste management costs vary between sites, principally due to some sites' ability to dispose of LLW and some MLLW in on-site disposal facilities. Five sites were evaluated – three with on-site disposal, two without, and one of each type (Hanford for on-site disposal, Rocky Flats for off-site disposal) was selected as the most representative of the type. ECAS costs averaged by site and waste type (e.g., LLW, MLLW, etc.), and also by waste disposal component – on-site waste management (including on-site disposal, if applicable), off-site transportation, and off-site disposal (tipping fees). A table was developed comparing waste disposal costs (principally LLW and MLLW, the major components of decommissioning waste) at the different AFDCS Sites. Off-site disposal was set at 100%, and the disposal costs for sites with on-site disposal were discounted from that value based on the ECAS data. Additionally, for sites with off-site disposal, the distances for LLW/MLLW disposal at the DOE Nevada site (NNSS) were calculated. Costs for waste transportation were pro-rated based on the distance of that site to NNSS compared to the distance from a baseline point (Rocky Flats) to NNSS. The table, consisting of percentages of relative waste disposal costs for each site by each waste type, was applied to waste costs developed by Building Type to adjust for site-to-site differences. The Waste Cost by DOE Site factors apply to categories 1.6 and 2.5.
4.4	Variation of costs by Principal Contaminant severity [$/$ or %] - ECAS data was summarized by principal contaminant, and the data evaluated using various regressions of overall project cost/SF vs. principal contaminant type. The data best resolved as 3 linear regimes which correlated to (1) high-rad/robotic work [PCs 1-2], (2) substantially contaminated work [PCs 3-6/Ext], and (3) chemical-low rad work [PCs 6/Ext-7]. The regression slopes were used to adjust the $/SF from the "standard" Principal Contaminant category of a Building Type to its remaining Principal Contaminant categories, and then divided by that "standard" value to provide a percentage. That percentage was then used to adjust the values in the Cost Model by Building Type, by Principal Contaminant for all direct work (it does not apply to the waste costs).