MULTI-SITE RISK-BASED PROJECT PLANNING, OPTIMIZATION, SEQUENCING, & BUDGETING PROCESS AND TOOL FOR THE INTEGRATED FACILITY DISPOSITION PROJECT

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ABSTRACT

Faced with the Department of Energy (DOE) Complex Transformation, National Nuclear Security Administration (NNSA) was tasked with developing an integrated plan for the decommissioning of over 400 facilities and 300 environmental remediation units, as well as the many reconfiguration and modernization projects at the Oak Ridge National Laboratory (ORNL) and Y-12 Complex. Manual scheduling of remediation activities is time-consuming and inherently introduces bias of the scheduler or organization into the process. Clearly a well-defined process, quantitative risk-based tool was needed to develop an objective, unbiased baseline sequence and schedule with a sound technical foundation for the Integrated Facility Disposition Project (IFDP). Faced with limited available data, innovation was needed to extrapolate intelligent relative data for key risk parameters based on known data elements. The IFDP Supermodel was customized and expanded to provide this capability for conceptual planning of diverse project portfolios and multiple sites.

1. INTRODUCTION

The IFDP is a cooperative effort between Environmental Management (EM), the NNSA, Nuclear Energy, and the Office of Science. Coordinating deactivation and decommissioning activities (D&D), environmental remedial actions, surveillance and maintenance (S&M), reconfiguration, construction, waste management, project management, planning, and the overall integration of activities of two sites comprised of several hundred facilities is a time consuming difficult process. An unclassified final product that can withstand scrutiny from all stakeholders is essential.

The IFDP deals with over 780 projects ranging in type from D&D, environmental remedial actions, S&M, reconfiguration, construction, waste management, and project management, planning, and integration [1]. The facilities at ORNL are estimated to cover a total of 1.2 x 10^5 m^2 (1.3 x 10^6 ft^2), and contain legacy waste volumes of around 27 840 m^3 (36 410 yd^3) of solid waste, and 1.17 x 10^4 m^3 (3.10 x 10^5 gallons) of liquid waste [2]. Decommissioning activities are anticipated to generate over 2.68 x 10^5 m^3 (3.50 x 10^5 yd^3) of building debris. Remedial actions will generate around 3.82 x 10^5 m^3 (5.0 x 10^5 yd^3), and S&M of over 300 facilities. Y-12 is comprised of 15 building complexes, covering over 3.53 x 10^5 m^2 (3.8 x 10^5 ft^2). Remediation is estimated to generate over 496 m^3 (650 yd^3) of building debris and 3.06 x 10^5 m^3 (4.0 x 10^5 yd^3) of soil [3].

Throughout remediation of both sites, facilities must be maintained in a manner to minimize additional risk while maintaining compliance with existing operational parameters and/or safety bases. In addition to the challenges inherent in D&D, new construction projects will be initiated to handle the treatment and storage of anticipated waste volumes. Initial cost estimates ranged from 4 to 8 billion dollars (without escalation), with the total square foot reduction targets set at 5.02×10^5 m^2 (5.4×10^6 ft^2)[1]

The planning, prioritization, and sequencing of projects at this massive multi-site scale, demands custom solutions, skills, and expertise. Projects of this size inherently introduce extra challenges, including data gaps, budget constraints, risk levels, regulatory drivers, and a need for a quantitative risk assignment.

The Ranking and Sequencing Model (RSM) commonly referred to as the 'Supermodel' for its flexibility and range of function serves as an electronic repository for site specific facility information, as well as software that produces outputs useful for baseline planning, risk assessment, ranking, sequencing and analysis. The same ranking and sequencing (i.e. Supermodel) process was used successfully at the Savannah River Site (SRS) to develop an integrated facility closure plan for the 1,013 facilities, 251 waste sites, and 16 HLW tanks. The Supermodel output was audited by the U.S. Inspector General and found that:

> "The risk Model (RSM) was designed…to make deactivation and decommissioning decisions already considers the impact of off-site receptors when assigning a risk score. Thus, if Environmental Management used the Model [RSM] and focused on risk for prioritizing its D&D activities, this issue would have already been addressed. This would have lead to reduction of the annual S&M Costs by $2.2M instead of $306K and reduced the D&D costs incurred by $20M and conducted the additional D&D of over 20 facilities [4]."

This paper describes the process and tool, tailored to IFDP, used to ensure consistency, reliability, repeatability, and technical defensibility of a risk-based project sequence and baseline cost profile, as well as the application to support the evaluation of the initial CD-1 schedule, contained in the IFDP Plan.

2. PROCESS

Using Supermodel to help rank and sequence units for disposition is a multistep process that can be broken down into the following sections:

- Data collection/input
- Calculations and/or data extrapolation
- Generation of Risk Parameters
- Weighting of Risk Parameters
- Ranking and Sequencing
- Evaluation and Analysis

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[1] Cost and square foot reduction based on addition of values from references

The Supermodel process of ranking and sequencing is illustrated in Figure 1 below.

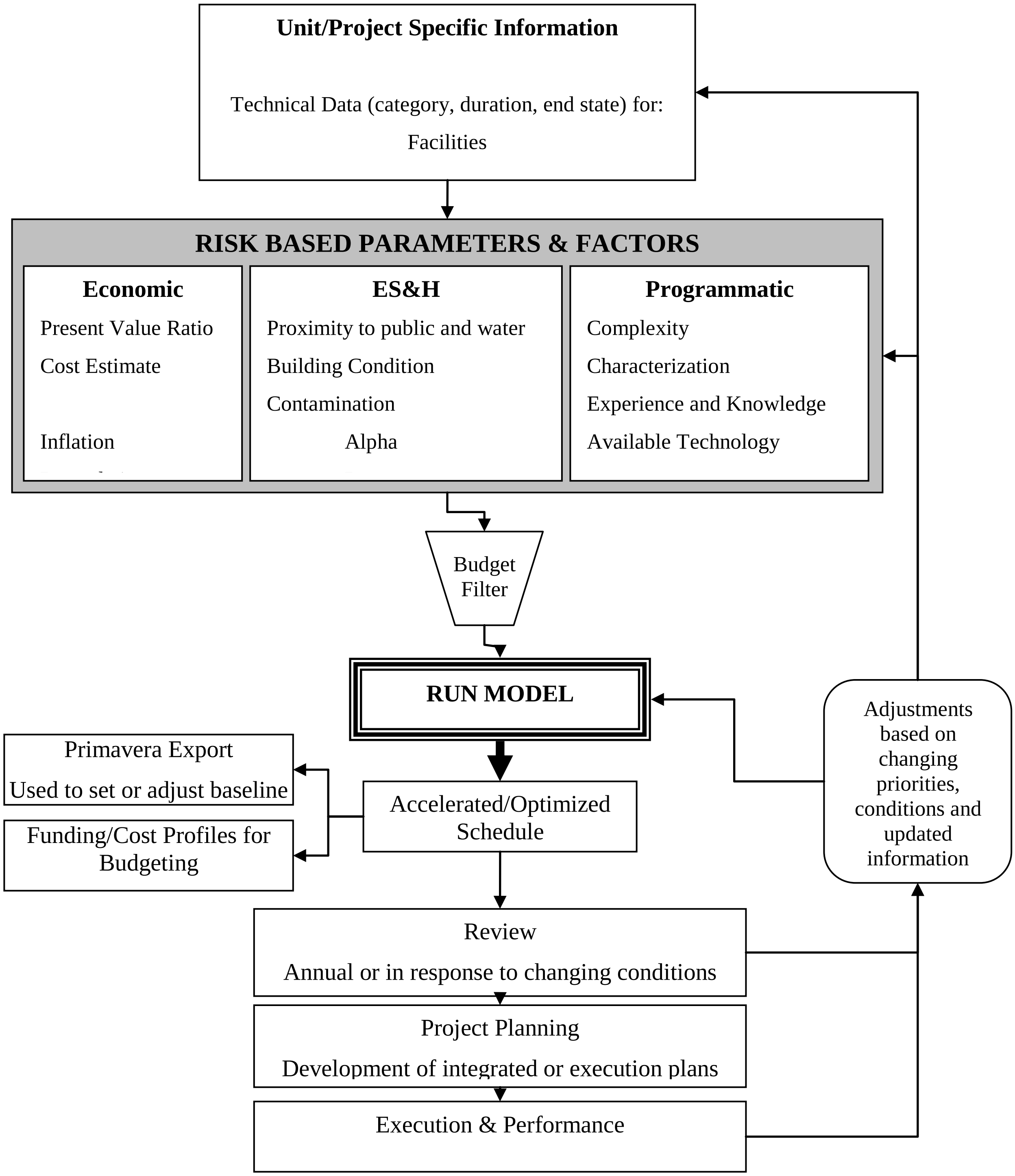

Figure 1. Project Ranking and Sequencing (i.e. Supermodel) Process.

3. DATA COLLECTION/INPUT

Core project data is required to conduct a technically defensible project planning, prioritization, sequencing model. The first project challenge was to gather available information and enter it into the Supermodel.

The Supermodel serves as an electronic repository for site specific facility information. Through an interface, the user can view, input, and edit information. Key inputs have been identified from extensive field experience, and collected from available sources. These fields are discussed in more detail in later sections. The support of site Subject Matter Experts (SMEs) was relied on to validate and in some cases supply these values. This exercise not only provides essential information in an easily accessible format to be used in further calculations, but it also identifies gaps in information. Data from the Facility Inventory Management Systems (FIMS) was used as baseline facility data for facility D&D projects. Data from Bechtel Jacobs Company (BJC) Oak Ridge Environmental Information System (OREIS) was used for environmental projects. Data for construction/modernization projects was provided by P2S.

3.1 Filling Data Gaps

In the conceptual planning process, all data was not yet assembled and or validated. The Supermodel required key data elements to be used in its ranking and sequencing calculations. Therefore a method to generate the core data was needed to run the RSM.

For large or numerous projects it is not always cost effective to fully characterize all data components (e.g. amount of contamination, complexity, etc.). Schedule constraints may also limit the amount of project data which can be accumulated and provided or data may not simply be available. It became important to determine appropriate defaults to be used in the absence of existing values or data. The values are vital in evaluating sites and units against one another to determine a rank and sequence. To fill the gaps of these data fields a matrix translation process was developed making use of known properties to intelligently extrapolate the missing information. For this process the unit category was relied on heavily. All of the projects were assigned into one of the following project categories and/or designations:

- Standard Industrial Facility
- Radiological Facility
- Chemical Facility
- Hazard Category 1
- Hazard Category 2
- Hazard Category 3
- Hazard Category 4
- Landfill/Pit/Burial/Dump Area
- Tanks/Pipelines
- Basin/Pit/Pond
- Septic System/Leachfield
- Foundation/Pad
- New Construction/Modernization
- Reconfiguration/Upgrade
- Legacy Waste
- Well

From these designations reasonable assumptions can be made, which generate default data or core technical parameters required by the Supermodel, based on a known project hazard category. For example, facilities (decommissioning projects) which were classified as belonging to a particular hazard category provide sufficient understanding of function and hazards to determine relative levels of higher contamination and complexity, while an industrial facility was given low or no radiological or chemical contamination, but assumed to have some asbestos, and a relatively low complexity. Table 1 is an example of a matrix used for translation. Where unit (i.e. project) technical information was available, the descriptions were used to provide direct crosswalks. When no information was available, the unit category was relied on. In Table I, the 'Complexity' matrix is shown.

Table 1: Risk Translation Matrix – Complexity Example.

Category	Criteria (Description)	Category
High	One or more of the following: Reactor or Pool	Hazard Category 1
Medium-high	One or more of the following: Glovebox, Hotcell, Process Liquids	Hazard Category 2
Medium	One or more of the following: shared utilities, internal stack	Hazard Category 3 or 4
Medium-low	One or more of the following: Cranes (overhead), elevators, tanks (Aboveground storage tank (ASTs) or Underground Storage Tanks (USTs)	Chemical or Radiological Facilities
Low	None of the above complexities	All other hazard categories

For example, if a unit has a glovebox it is assumed to be of Medium-high complexity. If no information is available, other than the category, then a direct extrapolation from the category itself is used. In this manner, the objective information available was used to fill the core data set, minimizing bias in the initial values. Once the information has been entered in a quantitative manner, it can be used to evaluate, analyze and rank the units.

4. CALCULATIONS

Supermodel was built as an aide to planning and scheduling, and has the capacity to calculate fields based on supplied information. Examples of this are the duration calculation and the rough order of magnitude (ROM) cost estimator. Simply put, nuclear facilities take longer to decommission and industrial facilities take the least amount of time and ranges can be made using square footage and/or size of the project. If detailed cost estimates do not exist, then the Supermodel automatically calculates ROM cost estimates for each project.

4.1 Duration

Duration categories were defined based on the end state, facility/project type, and size. Durations divisions were developed based on the facility type (category), proposed end state (Demolish or In-Situ Disposal), and the size of the facility (i.e., ft^2 or m^2).

The major steps/phases in the project lifecycle considered include:

1) Determination of Action. Preparation of project scoping document, early-decision-making, etc.
2) Conceptual Planning and Engineering. Reviewing data to determine extent of action, develop characterization plan and/or conceptual design, develop, conduct characterization and document results, conduct risk and safety assessments, define and conduct activities

to inform and involve stakeholders (including public review), evaluate decommissioning alternatives (including analysis and responses), and documenting final decision;

3) Planning and Engineering. Prepare D&D plan, Environmental Remediation Plan (or equivalent), finalize conceptual design and engineering drawings, prepare Health and Safety Plan, conduct and document Readiness Review or Assessment, preparation of waste, security, or other required project execution documentation, prepare work packages, and procurements;

4) Project Execution. Conduct decommissioning, environmental remediation, and/or construction

5) Closeout and Final Documentation. Prepare project completion documentation, including Comprehensive Environmental Response and Liability Act (CERCLA) confirmation documents, and Final Reports, establish S&M and/or long-term monitoring (if applicable), and approval by DOE and regulators.

Facilities with a low ROM estimated cost (<$50K), regardless of size, are assigned a minimum duration of four (4) months. Although the actual time to demolish a small facility is one month or less, there would be planning, budgeting, subcontracts, and other preparation efforts required as part of a larger or related facility or project. The costs of these projects are therefore distributed over a longer time period. Supermodel allows for the duration to be overridden by applying the actual scheduled duration to a particular project when that information is available.

4.2 Cost Estimates

ROM estimates are automatically calculated for each individual project, using the ROM estimating model initially developed at the Idaho National Laboratory (INL) (DOE Idaho Falls, Idaho, USA) and updated with actual costs from SRS decommissioning project. The ROM estimating methodology was documented previously in the Innovation in Facility Planning paper [5].

ROM estimating uses numeric ROM percentage factors corresponding to low, average, and high facility hazards. ROM factors raise or lower the cost estimate to account for presence or absence of the following hazards: Asbestos, Beta/Gamma Radiation, Alpha Radiation, and Hazardous materials. Additional adjustments are applied to take into account other factors which affect decommissioning cost: Characterization, System Complexity, Facility Type, and End State. Estimates for each category (High, Average, and Low) are made by SMEs for the facilities, based on facility walkdowns or in the data translation process. As is the case for durations, the cost estimates can be overridden, (such was the case for IFDP by P2S) by applying actual estimates, provided from cost estimating personnel.

4.3 End State

The end state of a project/unit (i.e., facility, waste site, and construction) has a significant impact on cost and duration. The following end states were identified and used for facility D&D projects: Demolish Restricted and Unrestricted, depending if the land can be reused, or In-Situ Disposal, also known as In-Place Closure. For Environmental actions the end state is determined by the method of treatment. Examples include Remove, Treat and Dispose, Closure Cover, Natural Attenuation and No Action.

Safe Storage and Deactivation are interim options in a facility's lifecycle prior to completion of the final end state. The end state decision is important in the planning process since it defines the extent of facility decommissioning and site remediation. The end state also factors into the cost, schedule, and work scope of the project.

In the Supermodel, end states for facilities were defaulted to demolish. Environmental projects were defaulted to in-place closure. End states for construction projects did not apply.

5. GENERATION OF RISK PARAMETERS

Supermodel takes into account thirteen technical parameters, organized into three risk parameters: Economic, Programmatic, and Environmental Safety and Health (ES&H). Each parameter is assigned a quantitative value which is used in further calculations in the model. In this way, activities can be ranked relative to one another.

5.1 Economic Parameters

Economic parameters include calculation of the present value ratio (PVR), and the total decommissioning cost. These parameters are expressed primarily in terms of net present value (NPV) of achieving a given activity, ultimately determining the time value of estimated costs vs. avoided costs which include continued S&M, repairs, and upgrades.

PVR factor is the sum of the present value of the future D&D cost plus the present value of the S&M costs, and any other fixed (e.g., roof replacement) and/or escalating costs for each year, from the start year defined in the Supermodel (or the year the facility first becomes available for disposition, whichever is later) to the end year defined in the Supermodel.

This value is divided by the present value of the facility's cost estimate at the year when the facility first becomes available for disposition, representing the scenario assuming immediate disposition to the facility end state as soon as the facility becomes available, providing the PVR. If a facility's PVR is >1, then it is advantageous to complete final disposition at the earliest possible date. If the PVR is <1, then it is not advantageous to decommission the facility early. These values are user defined and can be modified as desired.

5.2 Programmatic Parameters

Programmatic parameters include system complexity, characterization required, relevant experience and available technology. These parameters are a measure of the confidence that the work can be performed as planned and within the cost and schedule projections.

System complexity is determined on a percentage of the unit basis. This factor lends itself to the final cost and duration of the unit. Values are entered as a function of the square footage of the unit that is highly complex, average complexity, low complexity, and negligible complexity. These four factors are combined to achieve a single 'complexity factor' which will be used to rank the units complexity against the rest of the units in the record set; Table 2 shows the expansion.

Table 2: Risk Translation Matrix – Complexity Example Expanded.

Category	Criteria (Description)	Category	High	Average	Low	NA
High	One or more of the following: Reactor or Pool	Hazard Category 1	60	20	10	10
Medium-high	One or more of the following: Glovebox, Hotcell, Process Liquids	Hazard Category 2	40	30	20	10
Medium	One or more of the following: shared utilities, internal stack	Hazard Category 3 or 4	30	20	10	40
Medium-low	One or more of the following: Cranes (overhead), elevators, above and underground tanks (ASTs or USTs)	Chem. or Rad. Facilities	20	10	20	50
Low	None of the above complexities	All other hazard cat.	0	10	30	60

Characterization required is assigned based on the unit category as well as the amount of information available on that unit. This is, in large measure, and assessment of the current knowledge of contamination levels in the facility. It is understood, that a clean facility will not require extensive characterization, but not knowing much about a Hazard Category 2 facility before D&D will likely cause cost and duration increases, which need to be factored into an integrated schedule.

Relevant experience for a particular activity estimates the overall ability of a team to complete the work proposed for each unit. Construction type, contamination levels, complexity, and other factors are considered in the determination of this value. A facility constructed of typical construction materials, with little or no contamination would receive a relatively low value. A facility with thick concrete walls, containing many floors, high complexity, and high levels of contamination combined with a lack of onsite personnel who are experienced in decommissioning these types of facilities, receive a larger value.

Available technology factor was assessed by evaluating whether existing technology (equipment or process), currently available onsite, was adequate to deactivate or decommission the facility, within reasonable budget and schedule constraints. If the technology was immediately available (onsite), then the facility would receive a low value. Conversely, if the technology had not yet been developed, the value would be on the high end of the relative scale.

5.3 Environmental Safety and Health (ES&H) Risk

ES&H risk parameters make up the majority of the data set. These values include building condition, proximity to public, proximity to water, alpha contamination, beta-gamma contamination, asbestos contamination and chemical contamination. These parameters represent the risks posed by the facility in its current condition to the workers, the public and the environment.

Building condition was subjectively assigned a value of Excellent, Good, Adequate, Fair or Fail. These classifications were assigned values to weigh facilities in poor conditions heavier.

Proximity factors, which include both proximity to the public and proximity to water, assign values based on the distance from the site boundary and water sources. These values are then normalized so units that are closer to the public receive higher values.

The four contamination factors (alpha, beta-gamma, chemical and asbestos) are based on the percentage of the unit that contain high, average or low amounts of the specified contamination. The assignments are typically made on a square-footage basis.

6. WEIGHTING OF RISK PARAMETERS

6.1 Unit Groups

The model allows units to be grouped into specific groups. It is recommended that groups be comprised of units with similar driving priorities. For example, if risk reduction were the only consideration in determining a sequence, all units could be assigned to the same group. In reality though, many factors govern an integrated schedule. For IFDP CD-1, projects were grouped by Work Breakdown Structure (WBS), which essentially organized the projects by process and/or geographical area. Particularly large contaminated units will ultimately be sequenced based on economic availabilities, and certain low risk units may have regulatory commitments which will influence their schedule. Similarly considerations that drive near-term (through 2015) sequencing decisions differ from those affecting longer-term sequencing.

To allow for such considerations, different scoring schemes can be applied to different groups. The Supermodel allows the user to define a scoring scheme based on any combination of the risk parameters addressed in the previous section. An appropriate scoring scheme is applied for each group depending on the important considerations affecting that group.

The RSM allows the user/organization to define multiple groups for different case runs and scenarios. For example, considerations that drive near-term (through 2012) sequencing decisions differ from those affecting long-term sequencing. The database allows the user to define any number of "scoring schemes" with different parameter combinations and weighting. An appropriate scoring scheme is applied for each group depending on the important considerations affecting that particular group. For example, groups can be created by dividing facilities by early commitment, and on-going processes, and assigning appropriate scoring schemes (driving factors) for each group. Scoring schemes were developed and applied specifically for IFDP project, based on site, near-term/long-term objectives, and security considerations.

7. MODEL RUN (RANK AND SEQUENCE)

The ranking and sequencing methodology is similar to those using multi-attribute decision analysis techniques and involves determining the relative weight of each criterion, and establishing a protocol for scoring each candidate action against each criterion. Within that framework, each closure project is evaluated and scored, composite weighted scores are compiled and the results are tabulated and compared.

An annual budget profile is provided by the user for each fiscal year, and the model divides them into monthly budgets. The model analyzes all of the facilities on a monthly basis, using their ranking, availability date, cost, and duration to choose when to start each unit. Effectively, the user is able to provide an analysis adhering to either budget or duration constraints. For each model run, the groups (specified by the user), are run with a specific budget, timeline and economic factors. In the sample screen shot shown in Figure 2, the available groups are run with a flat budget of 150 million dollars a year, for seventeen years.

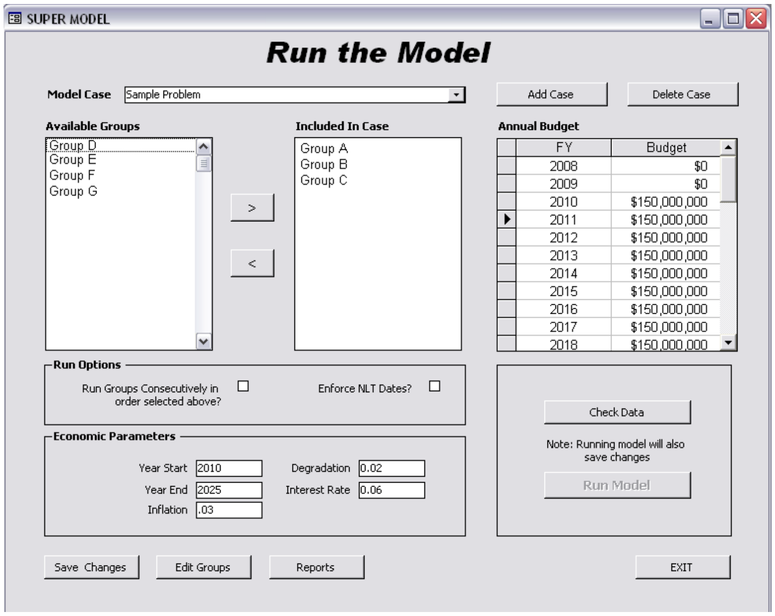

Figure 2. Model Run Preparation.

Having the ability to modify budget profiles, timelines and included units allows the user significant flexibility in developing scenarios to use in evaluation.

8. EVALUATE

After the model run, the process is not over - a full analysis of the run results and conclusions is recommended and encouraged. In addition to several analytical reports and summaries, the Supermodel produces a ranking and sequencing of facilities which is exported to Microsoft Excel® which can be imported into to Primavera Project Planner (P3 or P6) or other available scheduling software to support accelerated schedule development. Subsequent sensitivity studies, case runs, and consideration of work efficiencies, visual skyline reduction, or other considerations are conducted as necessary to produce a final schedule. The dynamic nature of Supermodel allows for the user to quickly see the consequences of a reduced budget, or a shift in availability.

The RSM allows the user to easily perform analysis of cases with different sets of assumptions. Cases may include: different priorities (represented by scoring schemes applied to unit parameters), differing budget/funding profiles, impacts of inclusion or elimination of units or groups and analyzing for remaining scope, cost, and schedule. Once populated, the RSM can be calibrated to suit a particular projects needs. Individual unit information can be updated as better information becomes available.

Figure 3 shows an example graphic output from the RSM. In this case, the model has performed the scoring and ranking of all 700 units broken into 8 groups (differentiated by color in the figure), using an annual budget of $500M. The model has sequenced the facilities over the years 2010 to 2027.

- BEFORE - **- AFTER -**

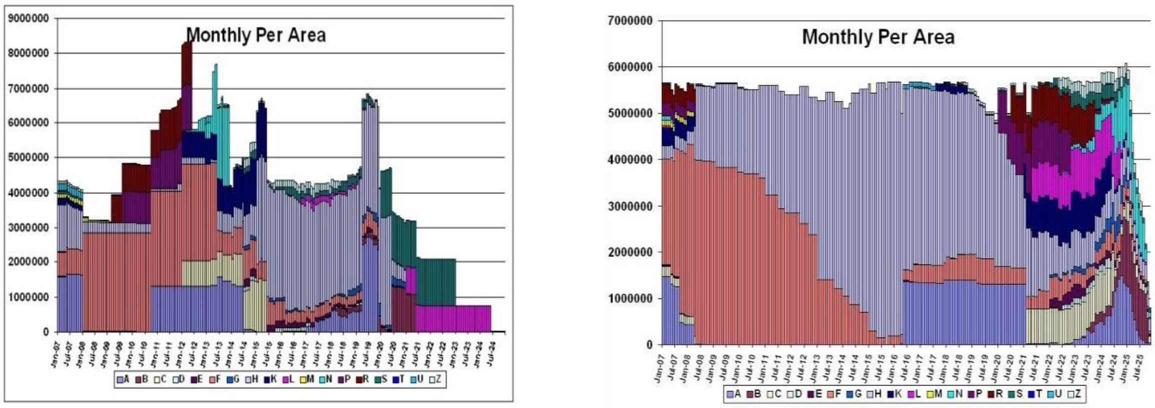

Figure 3. Example Output from Ranking and Sequencing Methodology.

Although other reports in the model show more granularity for the purposes of evaluation and analysis, the chart report shown in Figure 3 allows the user to quickly see the recommended budget for a given scenario (model run) and quickly identify peaks or lulls in the budget appropriation. The Supermodel allows users to quickly identify funding issues, in given years, providing instant visibility of issues that are not readily apparent in generating integrated facility disposition schedules in P3/P6 or other available scheduling software. Once the issue is identified, it can be quickly isolated, and analyzed. Adjustments can be made and the sequencing re-run in minutes to determine if the changes facilitated the desired result (i.e. to level the budget profile). This allows for rapid and accurate data analysis, issue identification, and solutions.

The monthly expenditure for the sequence of facilities is exported to P3/P6 or other available scheduling software to produce an optimized decommissioning schedule. Additional manual sequencing and schedule adjustments can be made, before a baseline schedule is approved, based on management guidance with respect to:

- Composite work efficiency
- Economies of scale
- Achieving full closure of areas or sub-areas of the site (e.g., so that a small number of low-priority facilities are left in an otherwise closed site)
- Visual considerations (i.e. Elimination of high profile facilities and/or 'eyesores')

9. CONCLUSION & RESULTS

The unclassified IFDP Supermodel is now loaded with default project data in order to run multiple unbiased and biased scenario analyses for rapid evaluation of budget and project impacts. It also contains comprehensive multi-site IFDP data where key information can be used in developing current and future planning process, cost estimates for all facilities, and the ability to manage and maintain site information. The next phase will be spent solidifying the technical data to fine-tune the ranking and sequencing analysis to support development of the technical and budget baseline for CD-2 and provide confidence that risk, prioritization, missions, and all key factors are being considered in an unbiased, optimized fashion to establish an realistic executable baseline cost profile and schedule.

Further analysis will be conducted during CD-2 development using the quick, risk-based, proven Supermodel process and tool, which has been customized for this purpose and IFDP, for large-scale, multi-site planning, reducing the cost and time to develop extensive cost baselines and schedules and to enable rapid adjustment based on different funding scenarios and budget changes. The Supermodel can be used to evaluate different scenarios based on budget (available funding), risk, and schedules in upcoming years. The Supermodel can be utilized regularly to assist in project planning, tracking, and implementation for closure activities and other projects.

10. ADDITIONAL FEATURES

Having unit specific information in one central database allows for the potential for additional comprehensive calculations. As the information becomes available, the Supermodel can provide forecasts and projections for footprint reduction, deferred maintenance reduction, waste profiles, waste volume generation forecasts, and S&M cost reduction profiles through the use of canned or custom reports built into the Supermodel.

11. ACKNOWLEDGEMENTS

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