Priorities: Getting the Most From Your Capital Improvement Plan

Jason DeStigter

Aging water and wastewater infrastructure, managing capital costs, and the ability to fund capital programs, are issues that are continuously ranked by water and wastewater utility leaders as the top five industry issues in Black & Veatch's annual report, "Strategic Directions: U.S. Water Industry."

The urgency of the highlighted issues demonstrates the growing need for comprehensive asset management programs and solutions around the prioritization and optimization of capital expenditures.

Good practice asset management focuses on balancing performance, cost, and risk. Additionally, a critical component in any asset management program is the development and proper implementation of a robust capital prioritization and optimization process.

Over the course of the past decade, Black & Veatch has developed an innovative budget prioritization and application process that uses advanced analytics to quantify and optimize planning outcomes that explicitly take into account uncertainty and risk.

This article provides an overview of the process and highlights the following:

- How the process supports improved utility decision making
- How improved decision making enhances value from infrastructure investments and new plant and system improvements
- Examples from a recent utility capital planning engagement

Building an improved understanding of risk and how that risk can impact a utility both financially and in other ways (such as environmental impacts, safety, etc.) is a key outcome of the process.

Capital Prioritization and Planning

The goal of the budget prioritization and optimization process is to minimize long-term system costs, while maintaining high levels of service and mitigating unacceptable system risks. Figure 1 is a high-level flowchart of the capital prioritization and optimization process used to achieve this goal. Each of the steps in the flowchart is described in the subsections that follow the figure.

Project Identification and Justification

Project identification is a key step to ensure that projects are identified in a manner consistent to capture both the full costs and benefits associated with each improvement or change to an asset or system. Identified projects typically have several investment drivers, such as growth, regulatory, safety, efficiency or cost savings, repair and rehabilitation, and customer service.

The prioritization and optimization process has the flexibility to include all of these different types of projects. Projects are gathered from the current capital improvement plan (CIP), master plans, asset management systems, and condition assessment evaluations.

Once the candidate projects are determined, a data-collection step validates the inputs that will later be used in the prioritization process. This helps assure that assumptions are valid, realistic, and reasonable. The required skill sets that are necessary for this project identification and assumptions evaluation include engineering, regulatory, commercial/financial, and utility asset management.

Jason DeStigter, P.E., is a manager within Black & Veatch's asset management practice in Overland Park, Kansas.

The capital prioritization and optimization process described helps utilities achieve balance among performance, cost, and risk through objective investment planning.

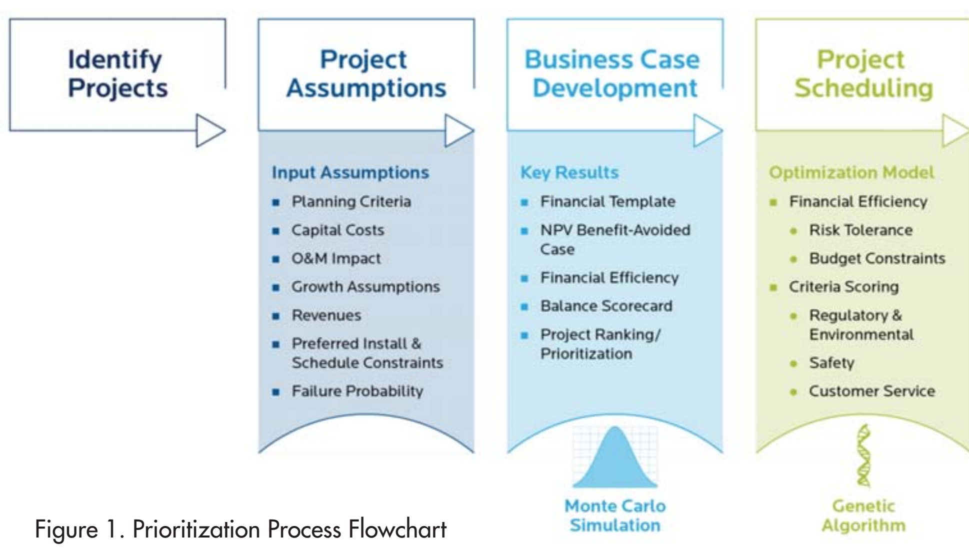

Figure 1. Prioritization Process Flowchart

Project Assumptions

Once each project is identified, an associated assumptions form is completed as part of the capital prioritization process. A template was developed to consistently and transparently develop the assumptions necessary for each project and it's tailored to each utility performing this process. Additionally, this form serves as an important quality control tool as it ensures assumptions are reviewed prior to their use in the financial templates.

The form contains a section for qualitative and quantitative assumptions for each project. Qualitative assumptions are based on the main drivers for each utility to complete a project, including planning criteria assumptions (e.g., regulatory, safety, service level, environmental, criticality, etc.). Each planning criterion is then scored using predefined scoring scales and definitions.

Quantitative assumptions include capital costs, operations and maintenance (O&M) costs (before and after the project is completed), growth rates, potential revenues (if any), failure costs (including lost revenue), and failure probability curves. Assumptions are commonly developed using the results of condition assessments and by obtaining feedback from utility staff during a series of assumptions form workshops.

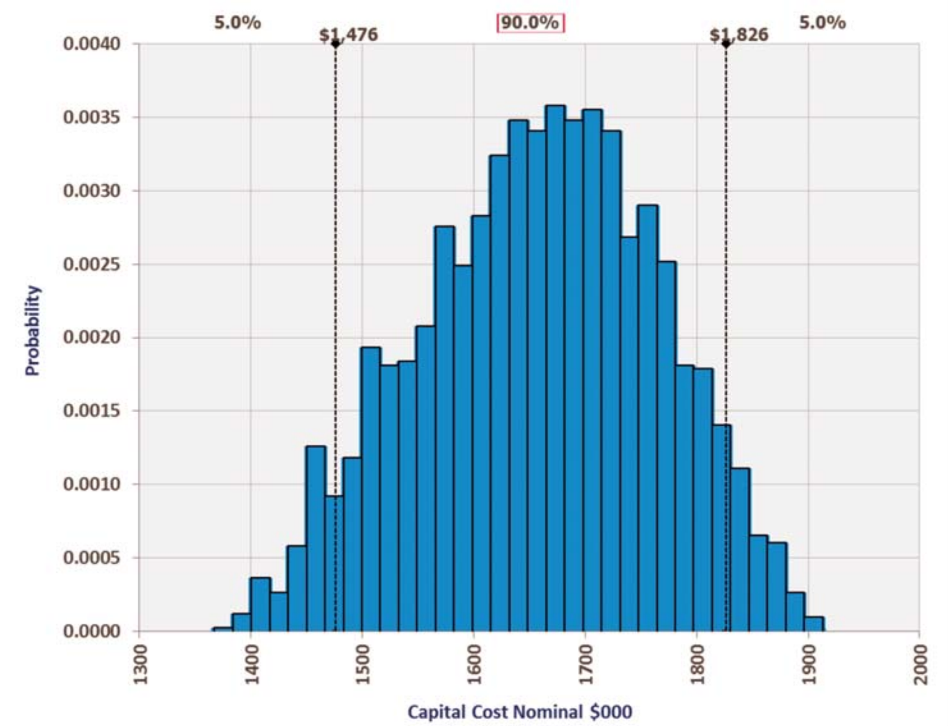

Figure 2. Example Probability Distribution

Table 1. Criteria Weighting Factors

Prioritization Criteria	Weighting Factor
Financial Efficiency	55 percent
Regulatory	15 percent
Safety	15 percent
Service Level	15 percent

Financial Efficiency Simulation and Ranking

The process links each project assumptions form to a financial template that is used for Monte Carlo simulations, which calculate the range of net present value (NPV) cost for each project through its life cycle. The probabilistic results generated by the financial templates form the basis for prioritizing the financial efficiency and cost-effectiveness of projects. Rather than single-point estimates, the results are probability distributions of projected NPV costs, such as the one depicted in Figure 2.

In Figure 2, the x-axis of the probability distribution shows the range in NPV capital costs for the project given a designated planned installation year. The y-axis of the distribution shows the relative probability of a certain cost occurring. Input distributions for the following assumptions are included in the financial template for each candidate project (note: not all projects will include values for all of these assumptions):

- Capital cost
- O&M before project install
- O&M after project install
- Revenue (linear, nonlinear, rate, and volume basis)
- Failure consequence

A benefit of this process is the ability to evaluate ranges of potential costs and even avoided costs (e.g., failure costs). By modeling the full range of consequences, project risk exposure can be evaluated and quantified for decision making purposes.

In order to take into account the magnitude and probability of cost risk, several financial efficiency parameters are calculated. These financial efficiency parameters help organize the probabilistic results into results that can be easily compared across projects for comparison and prioritization.

The first parameter is the expected financial efficiency of the project that measures a ratio of the NPV benefit of the project compared to the project cost. Risk exposure is measured by calculating a risk-mitigated ratio for the project that looks at the extremes of the probability distribution of NPV results. This metric measures the amount of risk or uncertainty mitigated by implementing the project.

The prioritization process is also used to identify projects where the financial benefits do not necessarily outweigh the costs of doing the projects. Projects such as these may have additional factors other than cost that risk influencing their selection, such as safety considerations or regulatory constraints. These factors are taken into account during the prioritization process through the balanced score results discussed later, as well as by constraining the optimization model.

For each project, the optimization model includes constraints on the earliest available install year and the latest required install year to allow for qualitative drivers to schedule projects. The next section discusses in further detail the optimization model.

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Prioritization and Timing of Projects

One of the valuable aspects of the financial efficiency approach is that the financial templates and assumptions forms are able to evaluate a wide variety of project installation years in a relatively short amount of time through simulations. At this step in the optimization process, projects are timed so that utility risk tolerance levels are not exceeded.

Table 2. Example Financial Prioritization Results

Count	Project ID	Expected Outcome NPV ($000)	Capital Costs Nominal$ ($000)	Install Year
1	Project G	-36,710	1,419	2014
2	Project Q	-19,686	2,361	2014
3	Project X	-10,912	6,401	2015
4	Project H	-5,636	26,480	2019
5	Project B	-4,041	5,875	2016
6	Project W	-3,981	256	2014
7	Project E	-3,731	8,778	2017
8	Project K	-3,359	2,199	2019
9	Project T	-2,392	1,794	2014
10	Project D	-1,201	2,846	2017
11	Project I	-815	13,355	2015
12	Project M	-550	5,586	2015

The optimization model uses the combination of the budget scenario and nonfinancial planning criteria constraints with the NPV results to maximize the NPV benefit for the utility given these constraints. In other words, it checks every combination of project installation dates that will:

- Maximize NPV benefit
- Stay within the annual budget and schedule constraint levels for each scenario

The NPV benefits and budget/schedule constraints are achieved using a genetic algorithm software tool. Similar to the @Risk™ Monte Carlo simulation software, the optimization process uses an off-the-shelf Microsoft Excel™ add-on software module (Evolver™) to perform the genetic algorithm. The module software is a companion tool to the simulation software as part of the Palisade's Decision Tools Suite, which is an integrated set of programs for risk analysis and decision making.

Project timing optimization is then conducted for all projects to arrive at a portfolio optimization result. Particular focus is given to investments that have a significant budget impact or are being considered for delay beyond their planned installation date due to utility budget constraints.

The projects are first scheduled based on the risk tolerance levels of the utility. Once all projects are within the defined risk tolerance, projects are scheduled based on the maximum financial benefit to the utility. The result is a target schedule without regard to budget constraints. Next, budget constraints are incorporated into the scheduling process and any changes to install years due to budget constraints are then recalculated.

In addition to prioritizing projects using financial efficiency, the planning criteria are used to balance all relevant nonfinancial issues. Each project is scored against each planning criterion using a scale of 1 to 10, with standard definitions and scoring scale for each criterion. The score is then multiplied with the applicable weighting percent for that criterion to create a balanced scorecard result for the project. Table 1 provides an example of the criteria weighting factors that a utility can use when developing the balanced scorecard.

The final step of the prioritization process is to incorporate planning criteria scores, project rankings, and budget constraints into the implementation schedule.

Process Results

As described previously, the prioritization process involves combining project prioritization based on financial risk with project prioritization using a balanced scorecard approach (financial efficiency and planning criteria). Table 2 shows the expected outcome NPV results for a subset of projects for a recent client.

The combination of the quantitative and qualitative results provides a balanced scorecard evaluation for each project. Each project is evaluated using a weighted criteria matrix scoring process. In the example in Table 3, four planning criteria are used in the scoring process:

- Financial efficiency
- Regulatory and environmental
- Safety
- Customer service

Each criterion is defined at the beginning of the prioritization process before the assumption forms are completed.

Financial efficiency is evaluated using the financial evaluation template, and the other three criteria are scored when the assumptions form is complete. Prioritization results are used to derive the capital plan schedule in order to schedule projects to minimize financial risk, while at the same time taking into account the

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Table 3. Example Project Rankings

Weightings			Financial Efficiency (55%)	REg. & Env (15%)	Safety (15%)	Customer Service (15%)	TOTAL SCORE
PROJECT	DEPT.	YEAR					
A	Water Distribution	2014	9	0	2	4	5.9
B	Water Distribution	2019	0	8	8	9	3.8
C	Water Distribution	2016	3	5	0	9	3.8
D	Water Distribution	2018	1	0	0	9	1.9
E	Water Distribution	2017	2	5	0	9	3.2
F	Water Distribution	2017	2	0	0	7	2.2
G	Water Distribution	2015	1	0	2	5	1.6
H	Water Supply	2014	10	0	2	6	6.7
I	Water Supply	2019	1	0	3	3	1.5
J	Water Supply	2015	1	5	3	6	2.7
K	Water Supply	2015	0	6	0	0	0.9

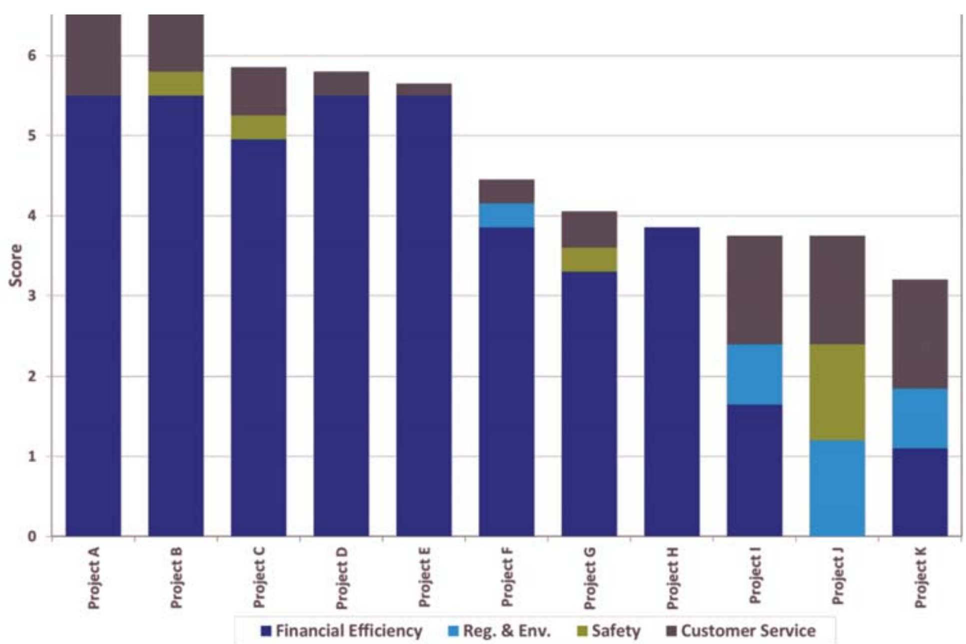

Figure 3. Example Prioritization Results

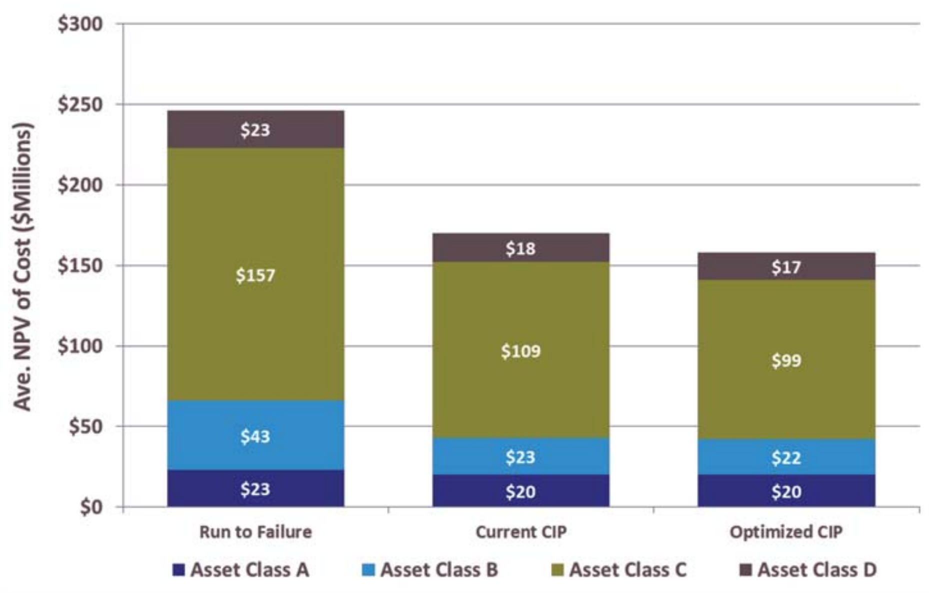

Figure 4. 40-Year Net Present Value Cost Comparison for the System

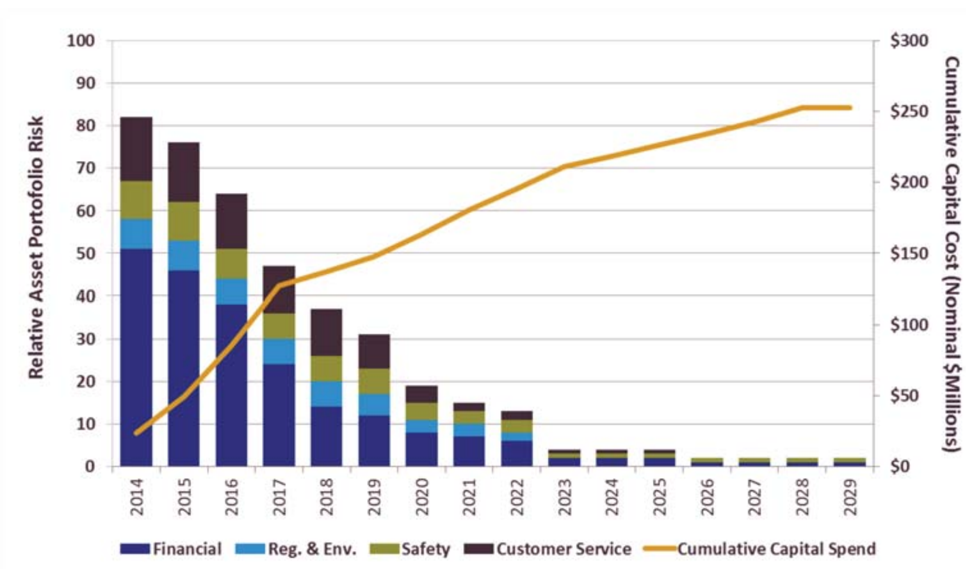

Figure 5. Portfolio Risk Reduction Compared to Cumulative Capital Spend

Most of the forecasted risk reduction achieved by the investments occurs in the first part of the study period, while more steady risk reduction occurs during the second half of the period. This validates that near-term capital dollars are being utilized on the projects and assets that expose the utility to the most risk, while projects with less or no risk are scheduled later in the study period.

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nonfinancial project drivers. Table 3 is an example of the project ranking table results and Figure 3 visually compares project scores for a number of example projects.

The prioritization model is used to calculate the risk-weighted 40-year net NPV of future cash flows for several scenarios of the full portfolio of capital projects, including:

- Run-to-failure scenario – assumes projects are delayed until assets fail or installation is required for another reason (e.g. regulatory constraint)
- Current CIP scenario - if the existing CIP is implemented as planned
- Optimized CIP scenario – if the recommended capital schedule using the optimization results is followed

Figure 4 calculates the risk-weighted financial results for all three capital schedules listed. The Current CIP has an expected outcome of $76 million in risk-weighted NPV savings ($247 million minus $171 million results in $76 million in NPV cost savings), while the optimized CIP scenario results in an expected outcome of $89 million in risk-weighted NPV savings ($247 million minus $158 million).

The current CIP shows a 31 percent reduction in NPV cost compared to the run-to-failure scenario, while the optimized CIP has a 36 percent reduction. The 5 percent additional reduction, or $13 million, represents a 36 percent decrease in overall system risk through optimization of the current CIP, demonstrating the value of performing capital optimization even with the same budget constraints.

The results noted in Figure 4 show the risk reduction from a risk-weighted financial perspective. The next set of example results incorporate the nonfinancial criteria, in addition to the financial efficiency results.

The planning criteria score other risks to the utility that are difficult to quantify from a financial perspective. For many utilities, these include well-established triple-bottom-line scoring criteria. Figure 5 shows the financial and nonfinancial risk reduction for an example portfolio of projects and compares it to cumulative capital expenditures by year.

As part of the capital planning process, it is valuable to understand the risk of delaying a project so that this risk can be considered in making budget decisions. Figure 6 is an example of what is developed to understand and quantify this risk for each project.

Implementation Schedule

One of the final results of the prioritization process is an optimized implementation schedule and project rankings that meet utility risk tolerance levels, achieve maximum cost effectiveness, and incorporate budget constraints.

The planning criteria scoring matrix is used to calibrate the scheduling of projects to ensure that nonfinancial criticality scores are incorporated in the planning process appropriately. For some clients, the balanced scorecard prioritization results are used as the primary prioritization and optimization metric to drive the capital plan schedule. Figure 7 shows an example implementation schedule for the optimized CIP.

For this example, since the budget constraint is based on an existing CIP, the optimization model allows for unused funds to be carried over from year to year. A corresponding set of prioritization results (similar to the example NPV and balanced scorecard tables and figures) match the optimized schedule shown in figure 7.

Conclusion

Good practice asset management programs strive to optimally balance performance, cost, and risk across the enterprise. Through good practice asset management, decision mak-

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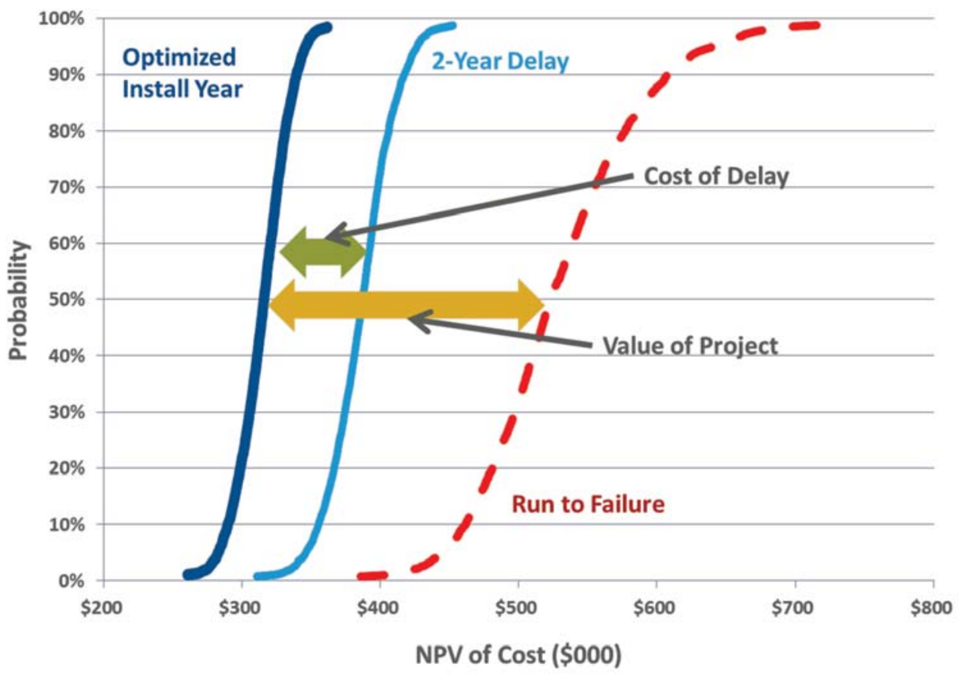

Figure 6. Project Delay Impact

The figure shows the NPV cost of a two-year delay (moving from the optimized blue curve to the grey 'two-year delay' curve). As the project is further delayed, the NPV of cost will approach the run-to-failure cost range (red-dashed curve).

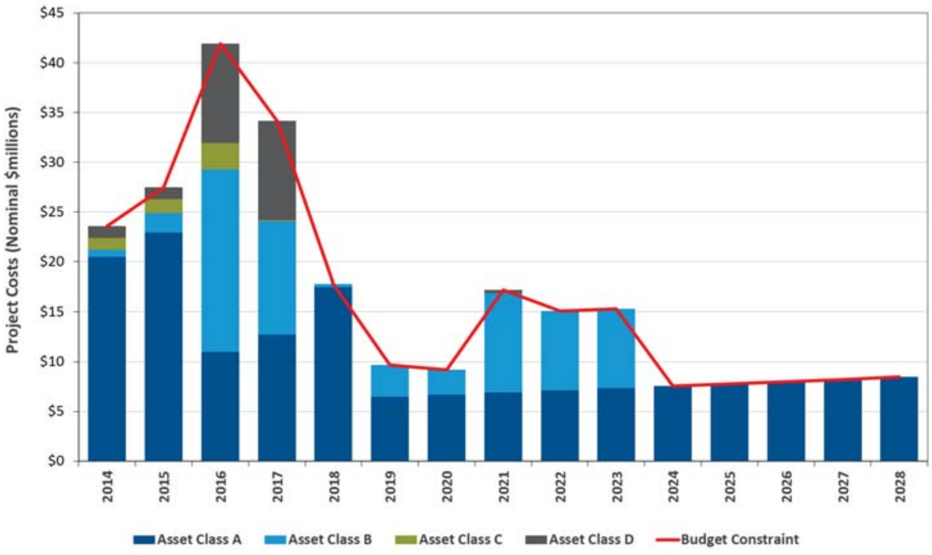

Figure 7. Capital Schedule: Optimized CIP Under Budget Constraint

The stacked bar charts in the figure break down the total capital cost by the various asset classes shown in the legend. The red curve shows the budget constraint used in t he optimization process.

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ing is made more objective and investments are better aligned with the utility strategic plan.

Capital prioritization enables objective decision making because it is driven by explicit financial risk results and a balanced scorecard that incorporates nonfinancial project and system drivers.

The incorporation of budget constraints and integration with a utility financial/rate model enable the prioritization and optimization process and help drive integrated planning across the utility. The results provide an important bridge between a utility financial plan (typically focused on balancing cost) and the balancing of system risk and performance, along with customer cost impacts.

Ultimately, the entire process helps utility management take a long-term and objective view towards achieving value for customers through the balancing of performance, cost, and risk. The water utility client referenced in this article, for example, identified more than $10 million in savings through capital prioritization, without affecting risk levels.