The Business Case Evaluation: A Hands-on Manual

Note: This manual was originally prepared for the City of San Diego, which funded its development. The City of San Diego has given its kind permission to modify and distribute this manual for the benefit of other utilities.

List of Examples

This manual was prepared by Brown and Caldwell to help staff of public water/wastewater agencies prepare "business cases" for proposed capital projects. Using the approaches and techniques described in this manual, staff can put projects forward with assurance, knowing that their proposals are in the best interest of their utility's customers, the environment, and the community at large.

The manual was originally prepared for the City of San Diego and is used there for training and for the actual performance of business case evaluations, which are required for all significant new projects.

The manual is written in four major sections and five appendices:

- The four major sections, numbered 1 through 4, introduce the concept of business case evaluations (BCEs), delve into the possible costs and benefits of projects, introduce the departments' main analytical tool (the NPV Tool), and then describe an actual BCE performed jointly by San Diego water/wastewater staff.
- Appendix A presents the draft policy of the San Diego Metropolitan Wastewater Department requiring BCEs for proposed projects.
- Appendix B shows ways of costing capital outlays and labor, which are factors in many or most BCEs.
- Appendix C introduces concepts of present value, which is used for life-cycle costing in BCEs.
- Appendix D expands on Appendix C by discussing discount rates.
- Appendix E, a paper presented at the AWWA/WEF Joint Management Conference in 2004, describes in some detail a BCE performed at another agency.

It is hoped that this manual will prove valuable to staff who prepare BCEs. The manual will be updated from time to time. Any suggestions for improvements or additions should be given to your agency's Asset Management Coordinator.

This manual provides guidelines for preparing business case evaluations (BCEs). BCEs are required for most new projects undertaken by the departments.

Why? Simply because your department wants to make sure that all its expenditures are in the best interest of its customers, the broader community, and the environment. The BCE is crucial to making sure this is the case.

1.1 What is a BCE?

Simply put, a BCE is a process to evaluate a perceived need and determine how best to address this need considering financial, environmental, and social impacts. Although the BCE will often be highly quantitative, its ultimate purpose is to support a business judgment decision on a proposed project. In preparing a BCE, you are helping the ultimate decision makers make that business judgment: Do your customers need this project? Is this project the best approach to solving a real problem? How do you best balance the costs of the project against the expected benefits? What risks are involved, and what are their real magnitudes and gravity?

Yes, this may seem to be a lot of work. But consider this: Every time your department issues bonds for a new project, it is effectively mortgaging the homes of all its customers for twenty to thirty years, adding not only the debt service for the bonds to their real monthly expenses but usually exposing them to new ongoing running costs as well. This is a serious matter for your customers and deserves serious consideration. That is why your department requires this depth of consideration before approving new projects.

1.2 How is a BCE Done?

A BCE can be done by a single person but will usually require significant input from in-house sources in planning, design, finance, operations, and/or maintenance. More often, and almost always for significant projects, the BCE will be done by a cross-functional team providing expertise in all or most of these areas. This cross-functional team is usually referred to as an "Expert Panel" or simply a "BCE Team." The team may need to meet several times to completely consider and finalize a BCE.

Example 1: What does an upgrade cost?

A wastewater utility with 245 thousand accounts is considering a major wastewater treatment plant upgrade costing $35 million, to be financed by 30-year bonds. Annual running costs at the plant will increase by $3.4 million annually.

Let's do the numbers: The impact on the typical residential customer will be about $24 each year for 30 years, or $2 a month.

The O&M portion of this $2 per month will increase with inflation. Of course, once the department commits to the upgrade, the impact will be irreversible.

	$35,000,000	bond issue
	30	year bonds
	5.8%	interest rate
	$2,475,068	annual debt service
add:	3,400,000	annual O&M cost
	$5,875,068	total annual cost
divide by:	245,000	number of accounts
	$23.98	annual cost per account
or,	$2.00	monthly cost per account

The utility described in this example is a real one. Its planned capital program will cost well over $100 million a year for the next several years. The importance of controlling capital expenditures, and of making sure that they fund the right projects at the right time, is obvious.

The person or team responsible for the BCE will usually need a lot of information, some of which will be easy to obtain and some more difficult. Sources to consider, in order of likely ease of access, include:

- This manual
- Your agency's Asset Management Coordinator
- Previous BCEs, cost dictionary, standards, etc., available in your agency's Asset Management Library
- In-house "experts" throughout your department
- Library materials and the Internet
- Outside subject matter experts.

With regard to the mechanics of a BCE, there is no single "formula" that fits every case. Every project is in some way unique and has its own arguments for existence. However, most BCEs proceed in five steps. Here they are, keyed to the sections of this report where you can find real-life examples.

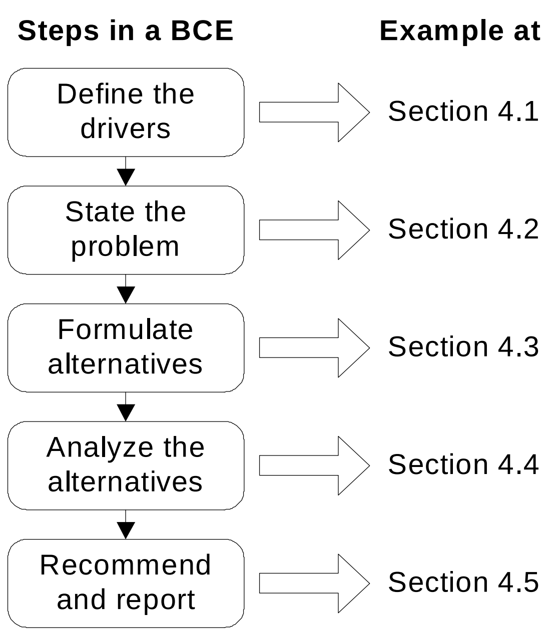

Figure 1: Typical Process Flow for BCE

Let's look at each of the steps in a bit more detail.

1. *Define the drivers*—First, define the "drivers" for the project. The primary drivers for a project may include safety and health requirements, environmental mandates, system capacity limitations, system reliability or other service level issues, efficiencies (cost savings), and/or aesthetic considerations.

   Without a clear definition of the drivers, it is easy to lose focus. If that happens, the problem statement and subsequent alternatives may drift away from directly addressing the original drivers for the project.

   ⇒ *See an example of defining the drivers for a project in Section 4.1.*

2. *State the problem*—Clearly state the problem that gives rise to the need for the project. This is a critical step because the way you think of a problem may limit the solutions you consider. Try to "step back" from the situation to understand the problem in a way that permits the formulation of creative alternative approaches to a solution.

   Stating the problem is probably the most critical step in the BCE process. It's easy to get it wrong! If this happens, the ultimate solution may not be the best one to address the problem that really exists.

   ⇒ See example *problem* statements in Section 4.2 and also in Appendix E.

3. *Formulate alternatives*—Define alternative ways of addressing the problem. Again, this is a critical step and it is important to have an open mind. If the BCE is being supported by a cross-functional team, the alternatives are usually developed in a brainstorming session. Nothing is left off the table at this point! As a last step in the alternatives formulation, it may be necessary to determine whether some alternatives have "fatal flaws" in order to narrow the scope of the subsequent analysis.

   You will be amazed at the number of reasonable alternatives that exist to solve a problem once it is clearly stated. Don't shortcut this process! Often the best alternative is not immediately apparent and, if the formulation process ends too soon, may never be raised at all.

   ⇒ *See examples of formulating alternatives and of fatal flaw analyses in Section 4.3 and also in Appendix E.*

   ⇒ *See an example of a winning alternative that was almost missed in Example 9.*

4. *Analyze alternatives*—Each remaining alternative is evaluated by a life-cycle present value benefit/cost analysis, considering not only budgetary impacts but also risks, environmental considerations, and societal costs.

   ⇒ *Descriptions of real-life alternatives analyses can be found in Section 4.4 and also in Appendix E.*

Much of this manual is about the analysis process, but two key points are:

- "Life-cycle" means simply that benefits and costs are considered over a long period of time, typically twenty years or more. To the extent possible these benefits and costs are expressed in dollar terms. Risks, if present or if reduced by an alternative, are likewise expressed in dollar terms.

  ⇒ *Benefits and costs, including risk costs, are discussed more fully in Section 3.*

- "Present value" means that the analysis takes the time value of money into account. Present value analysis is universally used by private companies to make investment decisions

  ⇒ *An introduction to present value analysis can be found in Appendix C. Appendix D has a discussion of discount rates, which are critical in present value analysis.*

  ⇒ *Present value analysis is taken care of you automatically if you use the department's NPV Tool, discussed in Section 3. Be sure to see your Asset Management Coordinator for the right numbers to use in your analysis.*

5. *Recommend and report*—All you need to do now is to summarize what you've done and make your recommendation. Remember that even with the best will and intent, you will still need to exhibit quality and objectivity in your presentation if you are to convince others.

   ⇒ *An example summary and recommendation can be found in Section 4.5.*

   Of course, you will also need a report to document your work. A typical BCE report is organized in accord with the five steps here, with the addition of an Executive Summary up front. The report should be clear, to the point, and concise.

   ⇒ *Example BCE reports are available in your Asset Management Library (located on the Management Drive).*

More on all this later. For the time being, suffice it to say that any BCE is done well if it finds the best solution to a problem and presents that solution convincingly and, of course, fairly.

1.3 What Does the BCE Have To Do with Asset Management?

The fundamental goal of asset management is to provide the customer with the required (and specified) level of service at the lowest possible life-cycle cost. It is almost reflexive in asset management to make sure, before making any expenditure, that this goal is being served—which means the benefits of the expenditure must be greater than the cost. And a BCE is, in the end, simply a benefit/cost analysis.

Several other aspects of asset management are reflected in a BCE:

- Asset management draws no distinction between "capital" and "operating" costs. Neither does a BCE. A dollar is a dollar and, regardless of which budget you take it out of, its source is always the same—the customer's pocketbook.
- Unlike a private business, whose primary goal is to maximize the wealth of its owners, a public agency practicing asset management aims at providing services at the lowest total cost to the community. Thus it aims to optimize the overall quality of life for its customers considering financial, environmental, and societal impacts of its actions. These three factors are commonly known as the "triple bottom line."
- The BCE, in accord with principles of asset management, always takes a long-term view of the costs and other impacts arising from asset decisions. This means that decisions must give the best results as seen from today's viewpoint, but with full consideration of tomorrow's impacts including future replacement and refurbishment needs. This assures sustainability of the infrastructure today and tomorrow both.

Users of this manual with an interest in the broader field of asset management are referred to the *International Infrastructure Management Manual*, which can be ordered on-line at http://www.ingenium.org.nz/.

1.4 What is Your Role in the BCE Process?

As the preparer of a BCE, either on your own or in a team, your role is simple—to advise the department on the best solution to a problem affecting customers, the community at large, or the environment. If your business case is persuasive, chances are that neither the Asset Management Steering Committee nor the Department Director is going to spend too much time second-guessing your analysis. So the responsibility is clearly yours to do a good job because your recommendation may impact the spending of millions of dollars of your customers' funds.

What does it mean to "do a good job?"

- *Be careful*—Make sure you understand a problem thoroughly before you try to solve it. Stand well back from the problem and ask, "Does this problem really need a solution? Will anything you do really make a perceptible difference to your customers?" Be sure you define the problem in a way that allows consideration of non-construction alternatives, other ways of configuring the system, and other non-obvious approaches to an ultimate solution.
- *Be creative*—Keep your mind open to all alternatives, no matter how far-fetched. Sometimes a solution that seems absurd needs only a slight twist, or one additional feature, to generate that "Aha!" experience.
- *Be objective*—Don't become overly attached to any one solution, even one that you thought of yourself. Be even-handed and consider benefits, costs, and risks in a consistent way across all possible solutions.
- *Be detailed*—Make sure you have captured all likely costs. You probably won't the first time around, or even the second. Be sure you talk with people from E&C about capital costs and people from O&M about other costs of ownership.
- *Be collaborative*—Depend on your Asset Management Coordinator to help with your BCE. If you are assigned to a team, learn from the other team members to make yourself more effective in the future. In any case, seek out the subject matter experts in the department and elsewhere in the city and use their expertise.
- *Be persuasive*—When you're finished, you will have done a lot of work that will benefit your customers, the environment, and the larger community. Don't let it go to waste. Present your work simply but effectively. Don't overstate your case, but if you are convinced you've found the best solution – say so clearly.

This chapter discusses some of the basic concepts involved in the BCE. None of these are difficult to understand, but some can be quite hard to deal with in the real world. So here we go.

2.1 The Benefit/Cost Analysis

Every BCE is, ultimately, a benefit/cost analysis. What is the benefit of the project to your customers, your community, and the environment? What is the cost? In the final analysis, do the benefits outweigh the costs?

Simply said, but often not so simply done. Many proposed projects have benefits and costs that are not easily quantifiable. These situations usually fall into one of two categories:

1. The project (or some solution) is needed because of policy or regulatory mandates. Examples might be spills occurring due to a known system problem, an immediate threat to safety or public health, the project is already irreversibly agreed, and so forth. In such cases, there really isn't any question that something needs to be done and, in fact, the path forward may be well defined and can't be changed. In such cases, the BCE may be very cursory—but still, you should be alert to better ways to implement the project in cases where there is some flexibility.
2. You can estimate some (but not all) of the benefits and/or costs. This is a very common situation. In such cases, you need to estimate the benefits and costs where you can, thus simplifying the decision in the final analysis. This is called a "Reasonable Person" test.

Sometimes this approach can yield startling results, as in the case of the water utility that planned some system improvements to increase the water pressure for a small group of customers whose pressures were somewhat under the levels set by policy. Upon "doing the numbers," it was found that the utility would be spending $40 thousand per customer to solve a problem that nobody had ever complained about. Somebody suggested that a better approach would be to pay each affected customer $10 thousand in return for a promise not to complain for twenty years!

This discussion has introduced the concept that there are other costs to consider beyond those that affect your departmental expenditures—a good segue to the next few topics: Internal costs, environmental and social costs, and risk costs. The "benefit" part of the benefit/cost analysis will be addressed at the end of the chapter.

Example 2: Tearing up the neighborhood.

The Water Department has already validated the need to increase the diameter of about eight miles of pipe in a certain area of the city. With normal excavation, the job will cost $140 per foot, take three months, and cause traffic delays, noise, and other disruptions along the residential and arterial streets affected. Less disruptive approaches (tunneling or some other technology) will cost $225 per foot and effectively eliminate the societal impacts. There are an average of 85 homes per mile of pipe in the affected area.

Let's do the numbers: At the known per-foot costs, it will cost $3.6 million more for the non-disruptive approach than for normal excavation. At 680 homes, this works out to $5,280 per home for the three-month period, of $1,760 per home per month, to avoid the disruption.

Would the average homeowner be willing to pay $1,760 a month to avoid having the street in front of his/her house torn up for three months? A Reasonable Person might say "probably not," in which case the department should drop the non-disruptive approach and settle on normal excavation. In any event, some simple analysis on your part has sharpened the problem's focus dramatically and given decision-makers a better handle on the best solution.

	8	miles of pipe		
equals:	42,240	feet of pipe		
	$9,504,000	cost of tunneling at	$225	per foot
less:	5,913,600	cost of excavating at	$140	foot
	$3,590,400	added cost of tunnelig		
divide by:	680	number of homes affected		
	$5,280	added cost per home		
divide by:	3	months disruption avoided		
	$1,760	montly cost per home of avoiding disruption		

2.2 Internal Costs

Direct costs are those that impact your utility's spending. These are the costs that "traditional" economic analysis focuses on. Without going into too much detail, here is a short list of internal costs that may be considered when making asset decisions:

- Asset acquisition costs including direct labor for planning, design, construction management, project management, and so forth. Acquisition costs may also include consultant or contractor fees, permits, an allocation of internal overhead, legal costs, contingencies, and so forth. Finally, acquisition costs include the actual delivered cost of the facility or asset being acquired as well as the cost of land if applicable.
- Annual maintenance and operation costs including direct labor, chemicals, energy, parts, rolling stock and other equipment costs, outside services such as security or janitorial, etc.
- Reinvestment to sustain the asset's functionality. This category of costs, which is often ignored in traditional analysis, includes long-interval but sometimes costly activities such as structural rehabilitation, new roofs, motor rewinding, pump impellor and bearing replacement, interior coating and floor repairs (e.g., steel water reservoirs), landscape renovation, cleaning or inspection (e.g., pipes), permit renewals, and so forth. Also, because your period of analysis may be thirty years or more, this category of cost may include replacement of sub-assets. For example, if you are analyzing the cost of a pump station over thirty years, you may want to assume that the electrical controls, motors, and pumps (at least) will need to be totally replaced at least once within that time frame.

If you are new to the BCE process, you can expect some difficulty identifying all the direct costs of asset ownership. Your Asset Management Coordinator can help by supplying a constantly-updated list of cost categories that have been developed in prior BCEs, in some cases including actual costs that you can adapt or use directly.

There are some other kinds of internal costs that you might expect when analyzing a project but can't pinpoint the timing. Such costs include items such as regulatory fines and lawsuit settlements. These are normally treated as risk costs and addressed further below.

Example 3: Ownership costs 101: Pop quiz.

A BCE Team is estimating the life-cycle costs of a planned water pump station. It believes the total facility life will be 40 years. The annual running costs it has identified are energy, chemicals, and labor for preventive maintenance.

Question: Can you think of at least five other categories of annual running costs the pump station might incur?

For longer-interval reinvestment (R&R) costs, the team has identified the likely need to replace the pumps at 20 years.

Question: Can you think of at least three other types of R&R costs that might be expected during the life of the pump station?

2.3 Environmental and Social Costs

Because your department is a public agency, your owners are your customers. This means that you have to consider all the ways your department affects the community at large. The bills you send out are only one of the ways you impact the community. Others include:

- As seen in Example 2, every time you need to dig up the road you are negatively impacting the community. This applies in all cases—for example, in the case of a planned pipe replacement as well as emergency excavation for a collapsed pipe.
- Spills may have both environmental and social impacts. These are, of course, a major area of concern for any wastewater agency. A whole host of asset decisions, including almost all pipe replacement decisions, depends on assessing the risk of spills.
- Failure to provide sufficient capacity may lead to spills, water use restrictions or, in some cases, connection moratoria. In the latter case, there may be damage to the economic viability of the community.
- Spills, failure to meet mandated effluent standards, sub-par water quality, and other situations may result in fines that the community must pay in addition to other social costs.

Because you want to minimize the total impact of your department's operations on the community, you need to consider all these costs in your BCEs. But how do you get the numbers? Well, there are several ways. In order of priority:

1. Some research has already been done on environmental and social costs, mainly by economists. An Internet search may yield some well-

founded estimates of the types of costs you are interested in.

2. Your department may have developed its own cost estimates during past BCEs. You should check with your Asset Management Coordinator to see if past work can support your current needs.
3. You can put together your own “Expert Panel” of people you consider wise and well informed and see if the group can generate a reasonable consensus estimates of the costs you need.
4. Finally, you can leave the cost unquantified and depend on the “reasonable person” approach as shown in Example 2 above.

If you choose the third approach and find some success, be sure to alert the Asset Management Coordinator so that the benefits of your work will be available to help others. Remember that in many cases there are no right or wrong answers, just the best thinking of smart people like yourself. Don’t be afraid to blaze trails for others!

In summary, you need to consider all the costs that your project is expected to cause, or as is often the case, to avoid.

2.4 Risk Costs

In considering costs, whether direct, social, or environmental, you will need to remember one thing: Most untoward events that generate these costs happen randomly. That is, you may expect such events to occur but can’t be sure where or when they will occur. This means that you are living and working in an environment of risk.

How do you take risk into account in your BCE? There are several approaches, the best of which is to consider risk an inseparable part of asset ownership, and risk cost of ownership a real component of overall asset ownership costs.

Dealing with risk as an annual cost: Risk cost is simply the product of the expected frequency of asset failure and the consequence of failure:

Risk cost =

Probability of Failure (in any year) X Consequence of Failure (Dollar cost of failure)

Risk Measure: $/year

Example 4: There will be a short delay.. .

Your department plans to replace two miles of pipe along an arterial. The direct costs of pipe replacement will be $120 per foot. The project, done by trenching, will take 180 days. 200 cars use this arterial, on average, each hour. The average traffic delay will be five minutes. Your Asset Management Coordinator tells you that the community cost of a traffic delay is $20 for each car delayed for one hour.

What is the real cost of the project, per foot, including both direct and traffic delay costs?

Let’s do the numbers. 864 thousand cars will use the arterial during the 180-day project. The total delay will be 72 thousand car-hours. At $20 per hour, that’s $1.44 million in community costs. Dividing by total footage, that works out to $136 per foot.

	180	days, project duration
equals:	4,320	hours duration
times:	200	cars per hour
	864,000	total cars affected
times:	5	minutes delay per car
	4,320,000	total delay-minutes
divide by:	60	minutes per hour
	72,000	total delay-hours
times:	$20	cost per delay-hour
	$1,440,000	total delay cost
divide by:	10,560	feet (two miles of pipe)
	$136	delay cost per foot

So the total cost of the project (so far) is $120 per foot in direct costs plus $136 in delay costs, or $256 per foot. This is over twice the project budget. And we haven’t yet considered the costs to homeowners and businesses along this two miles of arterial street of disruption, inconvenience, and so forth arising from the excavation!

Example 5: A failure-prone pump.

A water pump in a treatment plant of a certain type and age can be expected to fail unexpectedly every two years. The likely cost of each failure, including impacts on other equipment and excluding O&M, is $2,000. What is the risk cost of ownership?

Let’s do the numbers: The risk cost of ownership of this pump is 0.5 (annualized frequency of failure) times $2,000 (cost of a failure), or $1,000 per year.

Frequency:	0.5	failures per year
Consequence:	$2,000	Cost per failure
	$1,000	annual risk cost

In calculating cost of ownership for this pump, you would add this $1,000 to the expected annual O&M costs and possibly other items to arrive at a total annual cost of ownership.

Risk cost can also be applied to external consequences of failure.

Example 6: A risky pipe.

There is a sewer pipe in poor condition that is expected to fail within ten years, probably causing a small spill with an estimated a social/environmental cost of $15,000.

Let's do the numbers. The risk cost of ownership of this pipe is 0.1 (one failure in ten years) times $15,000, or $1,500 per year.

Frequency:	0.1	failures per year
Consequence:	$15,000	cost per failure
	$1,500	annual risk cost

This number can be used in your benefit/cost analysis of replacing the pipe.

When you think about risk in this way, you are able to make a sound judgment on how much your department should spend to avert the risk. The principle is that the benefit/cost ratio should be above 1.0; that is, *you should spend no more to avert a risk than the risk is worth.*

Example 7: How often to clean?

A 200-foot segment of 8-inch VCP serves the sewer needs of a suburban street. Given its age and past experience, the chance of unexpected failure of this pipe segment within the next ten years is about two percent. Internal and community costs of an unexpected failure of this type of sewer, over and above the cost of a planned replacement, is $50 per foot, or $10,000—and this assumes that the entire segment would need to be replaced. How often should your department CCTV this pipe if CCTV inspection costs $1.25 per foot?

Let's do the numbers: The probability of structural failure of this pipe segment in any one year is 0.1 (once in ten years) times 0.02 (two percent chance), or 0.002. The cost of failure is $10,000. So the risk cost of ownership arising from structural failure is $20 per year.

The cost of averting the unexpected failure is 200 feet times $1.25 per foot or $250. So a reasonable CCTV frequency is 12.5 years ($250 divided by $20 per year), because then you are spending $250 to avert a total of $250 in risk costs.

	2%	ten-year failure probability
divide by:	10	years
	0.2%	one-year failure probability
times:	$10,000	failure cost (consequence)
	$20	annual risk cost
divide into:	$250	CCTV cost (avoids the risk)
	12.5	years of avoided risk cost needed to cost-justify CCTV

If the inspections were more frequent, you would be paying more than the risk is worth.

This example is, of course, a bit simplistic in that it ignores the role of CCTV in supporting the cleaning program. However, a value can be placed on that as well and built into the analysis.

Dealing with risk qualitatively: Sometimes it is difficult to handle risk in a purely quantitative manner. In such cases, risk can be dealt with by informed judgment or by sensitivity analysis. If the latter, it is helpful to evaluate risk from several standpoints, for example:

- *Benefit risk*—Alternative won't fully achieve planned ancillary benefits.
- *Capital cost risk*—Alternative will cost more to implement than expected.
- *Running cost risk*—Alternative will cost more to own after construction than expected.
- *Technical risk*—Alternative won't work, or won't work sufficiently well.
- *Customer service risk*—Alternative won't totally solve the problem, or it may create new problems (spills, odors, etc.).

The first three types of risk can be dealt with by sensitivity analysis. For example, you might say, "I think the capital cost of this alternative is hard to nail down. How much could the capital cost increase before it becomes the second-best instead of the best alternative?" The NPV Tool used by the department supports this type of sensitivity analysis, allowing the evaluation of BCE results as affected by capital cost, running cost, and benefit risks.

Dealing with risk via the "Reasonable Person" test: In many cases it is difficult to quantify risk and, in fact, it may be unnecessary. You can deal with many situations by "working backwards" and isolating what the cost of a risk would have to be to justify a capital expenditure. What you are aiming for is a simple question that has a "yes" or "no" answer to which a Reasonable Person might respond.

The example below shows how this idea was applied when considering whether or not to move a major capital project forward by six years. This is the same type of test applied above to social disruption caused by excavation for pipe replacement in Example 2, except that here risk cost is incorporated.

Example 8: Doing it before it has to be done.

A major trunk water main, supplying water to 100 thousand mostly residential accounts, has a river crossing. It is subject to damage in a 200-year flood and repairs would take two to three weeks. Growth in the area means that a buried duplicate main, estimated at $3.4 million, will be required in six years time.

Some direct benefits of building the new main now have already been identified, but the cost still outweighs the benefits by $1.2 million. In other words, the social benefits of early construction need to be at least $1.2 million to justify building the buried main now.

The risk is that 100 thousand accounts will be without water for a period of two to three weeks due to a 200-year flood. The question is whether bringing forward the main duplication by six years and negating the flood risk for that period has a social benefit worth more than $1.2 million.

Let's do the numbers: The avoided social risk needs to be $200 thousand annually to justify spending $1.2 million to avoid this risk for six years. So the total social consequence of losing the existing main in a 200-year flood needs to be $40 million ($200 thousand a year times 200 years).

That consequence, $40 million, is equal to $400 per account given that 100 thousand accounts will be affected.

	$3,400,000	cost of main replacement
less:	2,200,000	benefits already identified
	$1,200,000	add'l benefits needed to justify replacement
divide by:	6	years replacement brought forward
	$200,000	add'l benefits needed per year
times:	200	years (interval between major storms)
	$40,000,000	add'l benefits needed over the risk period
divide by:	100,000	number of accounts potentially affected
	$400	add'l benefits needed per account

To put this $400 per account in perspective, a customer without water for a two or three week period would need to depend on bottled water for drinking, cooking and personal hygiene. Laundry functions would cease as facilities in the region would be closed. Sewerage services would cease, creating considerable disruption and potential health problems. Schools would likely close. Many commercial premises, and all food establishments, would close. Many people would choose to relocate for the duration of the disruption, some at considerable cost.

In addition to the domestic impacts outlined above there would be impacts to varying extent, on industry with associated job losses, and on hospitals, of which there are six including a major regional hospital. There would also be likely operational impacts on the nearby major power station.

This, then, is the simple question for the Reasonable Person: Will the average customer incur costs or losses worth more than $400 through having no water for two to three weeks? The Reasonable Person would probably say, "Yes." If so, the new main should be constructed now, six years before it will be required for capacity reasons.

(This example is based on a case study by Peter Buckland of Hunter Water, Australia.)

2.5 Benefits

In the public utility world, we are used to thinking of projects primarily in cost terms. In the private sector world, this would seem very strange. In that world, if somebody wants to spend money on a project, the idea will be very difficult to sell unless the *benefits* are clearly identified, quantified, and shown to generate a financial return.

In the public utility world, though, benefits are rarely defined with any rigor. A common pattern is to gather together all the projects that have been proposed each year, prioritize them in terms of perceived importance or urgency, and approve the "top of the list," cutting off the list at some predetermined spending limit.

The idea of the BCE, of course, is to move to an alternative approach. If you can fully define the benefits of a project as well as its costs, then you can know whether the project is worth doing—not just whether it is more or less important than some other project. The departments' decision to require BCEs on new projects is a signal that they are moving in this direction.

Having said that, what kinds of benefits might your projects have? Here are a few:

- *Direct cost savings:* A new kind of pump might require less preventive maintenance than the pumps you currently use. The avoided labor cost is a benefit because it can be reflected immediately in your expenditures.
- *Indirect cost savings:* Another new kind of pump might have an expected life of 30 years, longer than your current pumps. This is also a benefit that can be measured, even though it won't have an immediate impact.
- *Reduced environmental cost or risk:* Investing in cleaning sewers in a particular area may reduce the incidence of spills. If you know the direct and social costs of the spill volumes expected and can estimate the current and prospective spill frequencies, you can establish the benefit quite nicely.

Example 9: Not safe to swim.

Your department is evaluating a major system upgrade in a coastal community plagued by spill-related beach closures.

Questions: What will be the primary benefit of the upgrade? How might you attempt to quantify the value of this benefit?

- *Reduced social costs:* As mentioned in Example 2, above, tunneling techniques can reduce the social costs of traditional excavation when replacing pipes. The reduction is social costs is a benefit that can be estimated and compared with the incremental cost of tunneling.
- *New revenues:* The opportunity to earn new revenue is certainly a benefit. This type of benefit is often found in biosolids and reclaimed water projects.

- *Cost offsets:* Some projects can offset or replace costs that you would otherwise incur. The use of digester-produced methane to offset natural gas purchases is an example.
- *Deferral or avoidance of other expenditures:* Often spending money at point A means that spending at point B can be deferred or avoided entirely. An example is the case where an investment of several hundred thousand dollars in lowering a sewer interceptor meant that the construction of a pumping station at a different location was completely avoided (see Example 10, below).

The thoughtful identification and quantification of benefits is extremely important in the asset management world for a simple reason: Unless the benefits of a project are seen to clearly outweigh the costs, the project is unlikely to proceed. And the standard of proof is pretty high. Simple statements like, "This project will reduce maintenance requirements," or "The longer life of this motor makes the added cost worth it" aren't sufficient. So far as possible, you want to quantify your project's benefits as well as its costs.

Now we've looked at the concept of a benefit/cost analysis and the identification of the direct, social, and environmental impacts of a proposed project. However, in most BCEs you will be looking at a range of alternatives to solving the underlying problem. Some of these alternatives may have far greater or smaller initial capital outlays than others. Some may have high annual costs, some low. Some may realize benefits immediately while in others benefits may be larger but substantially delayed.

In short, the pattern over time of costs and benefits may be quite different from alternative to alternative. How can you make an apples-to-apples comparison among them? The answer is two-fold:

1. Capital decisions (*all* asset decisions for that matter) are made on a life-cycle basis. That is, all benefits and costs are analyzed over an extended period of time, typically twenty years or more.
2. All benefits and costs are brought back to their "present value" so that the net benefits or costs of a project can be represented by a *single number* that represents the value of the project to the community today.

There is a fuller discussion of present value in Appendix C. For the time being, just be aware that the NPV Tool used by the departments will handle all the present value calculations behind the scenes. The NPV Tool is used after all alternatives to address the problem have been identified.

NPV stands for Net Present Value. The purpose of the NPV Tool is to express all future benefits and costs of each project alternative as a single number in today's dollars. Although both benefits and costs are entered in their appropriate places as positive numbers, the NPV Tool internally treats benefits as positive numbers (cash inflows) and costs as negative numbers (cash outflows). If an alternative generates a positive NPV, then it is of value to the customer, the environment, and/or the larger community. If it generates a negative NPV *and all benefits have been fully quantified,* then it is not of value.

Very often, though, not all benefits can or will have been fully quantified. In such cases, the best alternative may be the one with the smallest negative NPV, that is, the alternative with the lowest life-cycle cost.

All information common to all alternatives as well as certain alternative-specific data are entered on the NPV Tool's *Summary* tab. Benefits and costs for each of up to twelve alternatives are then entered on alternative detail tabs named *Alt_1, Alt_2, Alt_3,* etc.

3.1 Entering the Basic Data

The first tab in the NPV Tool, named *Summary*, is where you enter your basic information. On this tab, make your entries in the yellow cells only, as shown in Figure 3, below. The entries are:

- *Agency*—You will normally enter the name of your department here.
- *Project/Problem*—The name normally used for the project you are evaluating or the problem being addressed.
- *Alternatives*—Enter in these cells the names of the alternatives you have identified. Be as descriptive as possible. You do not need to have all cells filled in.
- *Year of Analysis*—This will be the current fiscal year in all cases. For example, if the analysis is being done in fiscal year 2005-2006 (1 July 2005 through 30 June 2006), you will enter "2006."
- *Escalation Rate*—Enter the average rate of cost escalation expected over the life of your analysis. Your Asset Management Coordinator can help you choose the best rate.
- *Discount Rate*—Enter the discount rate currently used by your department. Again, the Asset Management Coordinator can help you here.

There are also entries for risk adjustments, discussed below.

Here's an example from a BCE prepared by an agency determining how best to reconfigure or rebuild a portion of its sewer collection system to deal with perceived failure risk.

Mt Pleasant Services District
North Willamette Wastewater Conveyance
Alternatives Net Present Value Analysis

			Sensitivity Adjustments (%)			Results ($000s)		
Agency:	Mt Pleasant Services District							
Project/Problem:	North Willamette Wastewater Conveyance	Risk Premium	Benefits	Capital Costs	Running Costs	Capital Cost	30-yr NPV	Benefit over 'Do Nothing'
Alternative 1	Do nothing/Investigate condition					$20	($27,973)	
Alternative 2	Rehab Pump Station/Reline Burnell					$4,120	($25,854)	$2,119
Alternative 3	Siphon/All new pipe/Eliminate PSs					$6,750	($9,083)	$18,890
Alternative 4	Gravity/siphon/pump to relined Burnell					$10,350	($19,402)	$8,571
Alternative 5	Rehab PS/New RR Bridge					$5,870	($17,326)	$10,647
Alternative 6	Rehab PS/Dedicated bridge					$5,120	($22,722)	$5,251
Alternative 7	Combine PSs/Road bridge/Reline Burnell					$10,300	($23,666)	$4,307
Alternative 8	No NNPS/Upstream EQ/27" as siphon					$19,400	($29,810)	($1,837)
Alternative 9	Modified Alt #2 (Replace FM & RC Now)					$7,620	($21,582)	$6,391
Alternative 10	Modified Alt #3 (Move Capital out to 2010)					$6,770	($13,322)	$14,650
Alternative 11	Modified Alt #7 (Move costs out to 2008)					$270	($23,848)	$4,124
Alternative 12	(not used)							

Year of analysis:	2005
Escalation rate:	2.50%
Discount rate:	5.50%

Make entries in yellow cells only.

Figure 3: NPV Tool, Example of Basic Data Entry, Summary Tab

The data entered onto this *Summary* tab is automatically transferred to the alternative detail tabs named *Alt_1, Alt_2, Alt_3,* etc., discussed further below. The Summary tab also shows the results of the analysis—the total capital outlays involved in each alternative and the net present value of each alternative. These are not entered on this tab but are brought forward from the alternative detail tabs.

3.2 Entering the Data for Each Alternative

As noted above, all the information entered into the yellow-shaded cells on the *Summary* tab is automatically transferred to the individual alternative detail tabs named *Alt_1, Alt_2, Alt_3,* etc. These detail tabs contain all information on costs and benefits over the period of analysis, which result in the total capital outlay required over the years (not time-adjusted) and the net present value of all the benefits and costs over the period of analysis, conditioned by the risk adjustments. These two numbers, the total capital outlay and the net present value, are the "results" of the analysis and are transferred back to the *Summary* tab as seen in Figure 1, above.

As on the other tabs, entries are made in yellow-shaded cells only. There are four types of entries:

- *Capital outlays*—Costs of the initial project or facility, including similar costs that might be incurred over the years (*e.g.*, facility expansion).
- *Benefits*—Direct facility-generated revenues, reductions in risk, avoidance of community costs, etc., as discussed in Section 2.5, above.
- *Annual running costs*—Costs that will be incurred annually due to ownership of the facility. These may be constant or increasing—for example, energy costs might increase over time for a pump station requiring increasing pumping due to development.
- *Refurbishment and Replacement (R&R) costs*—Costs that are incurred periodically, typically on a multi-year cycle, to keep the facility in good shape. Such costs typically include asset replacement, structural or electrical rehabilitation, new roof, etc. See the discussion in Section 2.2, above.

Here's an example of one alternative from the Mt. Pleasant analysis shown in Figure 3, with data already entered. Note that risk costs make up the majority of all annual running costs. Also, some significant R&R costs have been identified for the tenth year of the project.

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Expressed in 2005 dollars, unescalated												
Capital Outlays												
Inspection of 27" FM		20										
Other												
Other												
Other												
Other												
Other												
Total capital outlays		**20**										
Benefits:												
Other												
Other												
Other												
Total benefits												
Annual Running Costs:												
Annual O&M cost NNPS-EPS		65	65	65	65	65	65	65	65	65	65	65
Annual O&M cost Pipes		5	5	5	5	5	5	5	5	5	5	25
27" FM Risk Costs		317	317	317	317	317	317	317	317	317	317	95
27" FM River Crossing Risk Costs		567	567	567	567	567	567	567	567	567	567	170
NNPS Risk Costs		400	400	400	400	400	400	400	400	400	400	200
EPS Risk Costs		17	17	17	17	17	17	17	17	17	17	17
4" EPS FM Risk Costs		23	23	23	23	23	23	23	23	23	23	23
Burnell SS		250	250	250	250	250	250	250	250	250	250	63
Total running costs		**1,643**	**1,643**	**1,643**	**1,643**	**1,643**	**1,643**	**1,643**	**1,643**	**1,643**	**1,643**	**657**
R&R Costs:												
R&R for NNPS & EPS												3,500
Replace FM and River Crossing												3,500
Bernell Reline												600
Replce EPS 4" with 6" FM												
Other												
Total refurbishments												**7,600**
Net Benefit/(cost)		**(1,663)**	**(1,643)**	**(1,643)**	**(1,643)**	**(1,643)**	**(1,643)**	**(1,643)**	**(1,643)**	**(1,643)**	**(1,643)**	**(8,257)**

Figure 4: NPV Tool, Example of Alternative Data (partial)

3.3 Risk Premiums and Sensitivity Adjustments

You may want to assign a risk premium to one or more alternatives. Risk premiums increase the discount rate used in the analysis and reflect uncertainties over future project performance. They should *only* be used where all benefits are fully quantified and outweigh the costs (that is, the net present value or NPV in the right-most column is positive). See Appendix D for a more thorough discussion.

There is one last set of data entered on the *Summary* tab—sensitivity adjustments. These can be used, like the risk premiums, to reflect risk for specific alternatives, but in a more focused way. They can reflect the risk that an alternative won't fully realize its expected benefits, that it will cost more to build than current estimates, or that it will cost more to own year-to-year.

In the example shown in Figure 5, below, the agency sees some risk in proceeding with a certain water reclamation facility because of its lack of experience with such facilities and some known engineering issues. So it has reduced benefits (reclaimed water sales revenues) for the relevant alternative to reflect the potential that the plant will not be able to operate at designed capacity. The agency has also increased running costs for these alternatives due to uncertainties over the ongoing costs of facility ownership.

Note that the sensitivity adjustments (-10% and 15%) are not entered here directly but are brought forward automatically from the respective columns on the Summary tab (see next example).

The sensitivity adjustments can also easily be used for sensitivity analyses (thus their name). Sensitivity analysis is simply a name for doing "what if" analysis to identify which parameters have the greatest impact on results, or how much risk an alternative can bear before it becomes undesirable.

As an example, here's an analysis of the savings from deferring a new plant for one year and two years.

You can see from Figure 6 that deferring the new plant for one year reduces the life-cycle cost of plant ownership by about $4.5 million and a two-year deferral saves about $9 million.

But there is a risk that construction costs will increase faster than expected. How much faster than expected will these costs need to increase before the value of deferral is wiped out and it will be less expensive to build immediately?

Entering various values into capital cost sensitivity cell for Alternative 2 shows that the increase will need to be 17 percent more than expected for this to be the case. A similar exercise for Alternative 3 shows that the construction cost increase will have to be 33 percent more than expected over two years to make that alternative less attractive than building the plant now.

From Summary Sheet:		**Risk adjustments (+/- percent):**	
Year of analysis	**2005**	**Benefits**	**-10%**
Escalation rate	**3%**	**Capital costs**	
Discount rate	**5%**	**Running costs**	**15%**

Expressed in 2005 dollars, unescalated	2005	2006	2007	2008	2009	2010	2011	2012	2013
Capital Outlays									
Land acquisition		13,533							
WRP construction				69,845					
Sewer constuction				2,830					
Force main to outfall				6,182					
Acquire outfall capacity				5,259					
Engineering/Admin				11,829					
Total capital outlays		**13,533**		**95,944**					
Benefits:									
Reclaimed water sales					852	852	852	852	852
Other									
Other									
Total benefits					**852**	**852**	**852**	**852**	**852**
Annual Running Costs:									
Labor					3,311	3,311	3,311	3,311	3,311
Energy					655	655	655	655	655
Chemicals					655	655	655	655	655
Environmental compliance					115	115	115	115	115
Contractors					260	260	260	260	260
Security					150	150	150	150	150
Other upkeep					150	150	150	150	150
Other									
Total running costs					**5,296**	**5,296**	**5,296**	**5,296**	**5,296**
R&R Costs:									
Motor/pump replacement									
Minor structure rehab									
Landscape refresh									
Electrical rehab									
Other									
Total refurbishments									
Net Benefit/(cost)		**(13,533)**		**(95,944)**	**(4,444)**	**(4,444)**	**(4,444)**	**(4,444)**	**(4,444)**

Figure 5: Partial NPV Tool, Example of Data Entry with Sensitivity Adjustments

City of Williamsland
Build Plant Now versus Defer One or Two Years
Alternatives Net Present Value Analysis

			Sensitivity Adjustments (%)			Results ($000s)	
Agency:	City of Williamsland						
Project/Problem:	Build Plant Now versus Defer One or Two Years	Risk Premium	Benefits	Capital Costs	Running Costs	Capital Cost	30-yr NPV
Alternative 1	Build Plant in 2006					$30,000,000	($98,535,583)
Alternative 2	Defer One Year					$30,000,000	($94,050,166)
Alternative 3	Defer Two Years					$30,000,000	($89,692,296)
Alternative 4	(not used)						
Alternative 5	(not used)						
Alternative 6	(not used)						
Alternative 7	(not used)						
Alternative 8	(not used)						
Alternative 9	(not used)						
Alternative 10	(not used)						
Alternative 11	(not used)						
Alternative 12	(not used)						
Year of analysis:	2005						
Escalation rate:	2.50%						
Discount rate:	5.50%						

Make entries in yellow cells only.

Figure 6: NPV Tool, Analysis of the Value of Deferring a Plant

City of Williamsland
Build Plant Now versus Defer One or Two Years
Alternatives Net Present Value Analysis

			Sensitivity Adjustments (%)			Results ($000s)	
Agency:	City of Williamsland	Risk Premium	Benefits	Capital Costs	Running Costs	Capital Cost	30-yr NPV
Project/Problem:	Build Plant Now versus Defer One or Two Years						
Alternative 1	Build Plant in 2006					$30,000,000	($98,535,583)
Alternative 2	Defer One Year			17%		$35,100,000	($98,795,796)
Alternative 3	Defer Two Years			33%		$39,900,000	($98,642,445)
Alternative 4	(not used)						
Alternative 5	(not used)						
Alternative 6	(not used)						
Alternative 7	(not used)						
Alternative 8	(not used)						
Alternative 9	(not used)						
Alternative 10	(not used)						
Alternative 11	(not used)						
Alternative 12	(not used)						
Year of analysis:	2005						
Escalation rate:	2.50%						
Discount rate:	5.50%						

Make entries in yellow cells only.

Figure 7: NPV Tool, Sensitivity Analysis of Capital Cost Growth

In other words, the savings from deferral will be lost if capital costs increase by 17 percent or more over and above expectations in one year, or 33 percent in two years. Otherwise, deferral will still be the preferred approach.

Some things to be aware of when using sensitivity adjustments:

- As the adjustments are entered, the results will be reflected immediately in the displayed capital outlay and NPV of the alternative.
- Running cost sensitivity adjustments affect both annual O&M costs and periodic replacement and refurbishment (R&R) costs, described further below.

Some notes on costs:

- Capital costs need to include adequate contingencies and allowances for legal, administrative, permitting, and other related costs (see Appendix B). Your Asset Management Coordinator can help with this.
- There are always more costs involved in owning a facility than you will at first realize. Your Asset Management Coordinator can give you a "cost dictionary." You should review all the cost types in the dictionary and find those that the facility you are evaluating might incur.
- You should work closely with O&M staff to determine what is involved in owning facilities and what the likely costs will be.
- Be sure to enter all costs in current year dollars. The NPV Tool will handle inflation automatically. For very large projects, you may find it more convenient to express all benefits and costs, capital and otherwise, in units of thousands of dollars.
- Once you have entered all the data for each alternative, you can see the aggregate results on the *Summary* tab.

3.4 Housekeeping

Here are some tips to save work and re-work:

- Save your analysis with a unique name—for example, "Reclaimed analysis.xls."
- Save multiple versions of the analysis—for example, "Reclaimed analysis 8-16-2005.xls."
- Save on a server if you can. If your hard disk crashes, you don't want to start all over again!
- Review your analysis with O&M staff. Make sure you've identified all the costs of ownership.
- Use comments liberally. Right-click on a cell and choose "Insert comment" from the context menu. Add a comment like, "This estimate from Tom Harkness 8-12-2005, need to check with Frank on appropriate contingency." Afterwards, hovering your cursor over the cell will make the comment appear in a balloon.

The San Diego Water and Metropolitan Wastewater Departments have had considerable experience with BCEs, probably more so than all but one or two similar utilities in the United States. In 2004, an inter-departmental team performed four BCEs, and the Metropolitan Wastewater Department has since trained about 70 staff in the BCE methodology.

The example discussed here was one of the four BCEs performed in 2004. Although the example comes from the wastewater system, the BCE team was made up of people from both departments. The description of the BCE follows the steps discussed in Section 1.3, above.

What follows is a summary with comments.

4.1 Define the Drivers

First, the BCE team offered some background:

> "Pump Station 64 (PS 64) was constructed in two stages. The west station was opened in 1972 and houses two sets of 500 hp, two sets of 400 hp, and two sets of 200 hp pumps. The east station was opened in 1989 and houses two additional sets of 500 hp pumps. For several years PS 64 has been plagued with pump vibration problems that have cost millions of dollars in additional maintenance and equipment replacement."
>
> "Many recommendations have been acted on in the past several years, with little or no improvement in either reliability or cost."

Although the drivers were not overtly stated in the team's report, they were two-fold:

1. Cost to customers (high cost of O&M at the pump station); and
2. Environmental costs, due to a general perception, discussed by the team, that the problems at the station posed a significant spill risk.

4.2 State the Problem

Then the problem statement was given:

> "This BCE was initiated to identify alternatives for addressing the reliability and cost issues and to identify the relative costs and the risks involved with each alternative."

However, the BCE team did not keep its focus exclusively on improving operations at the pump station. It looked well beyond that to evaluate the possibility of major system reconfigurations. In retrospect, a better problem statement might have been:

> "This BCE was initiated to determine how to convey wastewater received from Pump Station 65, the Penasquitos drainage basin, and the Sorrento Valley area to the North City Water Reclamation Plant and/or the Point Loma Wastewater Treatment Plant in a reliable manner and at lowest cost."

So the team did not concentrate solely on *fixing* PS 64, but also considered alternative ways of approaching the pump station's function at the most basic level. As the team noted, the department had received all manner of expert opinion in the past, but without any real benefit. It was unreasonable for this team of "non-experts" to expect to arrive independently as a purely technical solution to the problems, but they could certainly put their businessman's hats on and make some business judgments.

In fact, the BCE is sometimes called a "business review" to differentiate it from similar exercises such as value engineering.

4.3 Formulate Alternatives

As in all cases where a team is preparing a BCE, alternatives were defined in brainstorming sessions. Here are the alternatives the team came up with:

1. *Do Nothing*—Live with the current problems.
2. *Make pump station modifications*—Make modifications to PS 64 as recommended by a recent wetwell modeling report to alleviate vibration problems and reduce maintenance. This alternative included the cost of 1,000 man-hours annually for the subsequent four years to investigate and optimize operational procedures at the pump station.
3. *Replace PS 64*—Replace PS 64 with a completely new pump station near the current site.

4. *Tunnel from PS 64 to the Rose Canyon trunk sewer*—Dig a tunnel to allow the majority of the flow to follow a gravity line down to the Rose Canyon Sewer. Pump the wastewater required by the North City Water Reclamation Plant with a second, smaller pump station from the tunnel entrance to North City.
5. *Replace some or all pumps with pumps with VFDs*—Replace some or all of the constant speed pumps currently installed at PS 64 with pumps that have variable speeds and are properly matched to the existing forcemain.
6. *Replace PS 64 and eliminate PS 65*—Replace Pump Station 64 with a completely new pump station near the current site including a wetwell deep enough that PS 65 wastewater currently pumped to PS 64 can instead flow by gravity.

Alternative 1, the so-called "Do nothing scenario," is included in every BCE. In some cases, such as mandatory or regulatory-driven projects, it may not be at all realistic; but it should always be present if only to highlight the reasons that another alternative must be found.

In this case, the team ultimately determined that the existing problems *could* be lived with if necessary. In fact, in economic terms and taking environmental risks into account, it was by no means the most expensive alternative.

Alternatives 2, 3, and 5 all dealt with "fixing" the pump station. These were the only alternatives that addressed the problem statement that the team had put forth somewhat narrowly (see discussion above).

Alternatives 4 and 6 were creative and went well beyond "fixing" PS 64. Alternative 4 would have eliminated PS 64 while Alternative 6 would have replaced it in its entirety but with modifications that would eliminate the need for another major pump station, generating obvious savings.

Thus the BCE team formulated a good list of alternatives to solving the problem. Was the "best" alternative ever put forward? It's hard to know, but the question suggests the importance of making sure all ideas are on the table, at least in the early going. If an alternative is not put forward, it will never be judged, analyzed, recommended, or adopted.

Example 10: An unexpected alternative.

In a recent BCE in Sacramento, the team was evaluating alternatives to a proposed $15 million relief sewer with a pump station in the middle. The team was in its third brainstorming session before someone asked if the receiving interceptor, then in design, could be lowered a few feet, eliminating the need for the pump station entirely. A brief investigation indicated the answer was "yes," and this ultimately became the recommended and adopted alternative. The project's capital cost was reduced by over $4 million, and life-cycle ownership costs were reduced by 43 percent.

If the team had only had two brainstorming sessions, this new idea would never have been put forward. The importance of concentrating on alternatives cannot be overemphasized!

(This BCE is described in more detail in Appendix E of this manual.)

Building complete life-cycle benefit/cost analyses for a large number of alternatives is very time consuming. In the Sacramento case above, no fewer than fifteen alternatives were formulated by the BCE team. Even in the case of PS 64, with six alternatives, building that number of detailed analyses would be onerous.

For this reason, some judgment is usually applied before deciding which alternatives to carry forward to analysis. This is called the "fatal flaw" process because you are looking for indications that an alternative has a fatal flaw and that further analysis would be a waste of time.

The fatal flaw process is dangerous because there is the possibility that you may eliminate an alternative that has value, or that with some rethinking might even be superior to all other alternatives. Caution is called for.

The PS 64 BCE team decided that two of the six alternatives, numbers 4 and 5, had fatal flaws:

Alternative 4: Tunnel from PS 64 to the Rose Canyon trunk sewer—Dig a tunnel to allow the majority of the flow to follow a gravity line down to the Rose Canyon Sewer. Pump the wastewater required by the North City Water Reclamation Plant with a second, smaller pump station from the tunnel entrance to North City.

Fatal flaw: The reclaimed water demand at North City is expected to increase in the next several years such that nearly all PS 64 flow would be reclaimed at North City. This increased flow to North City, and subsequent decrease in flow from PS 64 into the Rose Canyon Sewer, removes the primary operating cost savings of this project.

Alternative 5: Replace some or all pumps with pumps with VFDs—Replace some or all of the constant speed pumps currently installed at PS 64 with pumps that have variable speeds and are properly matched to the existing forcemain.

Fatal flaw: Physical modeling of the facility has shown that the pumps are not the cause of the vibration. Rather, the vibration is a result of the turbulent flow going into the pumps. Replacing the constant speed pumps with variable speed pumps will not address the cause of the vibration problem.

This left four alternatives to analyze.

4.4 Analyze Alternatives

The PS 64 BCE team decided to do a "cost only" analysis of the alternatives. They could also have done a true benefit/cost analysis, where the cost would be the initial outlay required and the benefit would be the avoided direct and risk costs present in the "do nothing" alternative.

In the former case, cost only, the team is looking for the lowest life-cycle cost of ownership. In the latter case, it is looking for the largest life-cycle benefit. Either approach yields the same answer in terms of the preferred alternative.

The BCE team generated a lot of capital and O&M costs in its work, the more important of which were described in its report:

- Ongoing pump maintenance costs are $500k/year if no corrective action is taken.
- Ongoing pump maintenance costs are $100k/year if corrective action is taken to mitigate pump vibrations.
- Ongoing facility maintenance exclusive of pumps is $500k/year.
- If no corrective action is taken, PS 64 will require replacement of one set of pumps every four years.
- Maintenance costs that remain constant over all alternatives (such as the cost of purchasing chemicals) are omitted from the NPV analysis and calculations.
- Risk associated with spills are assigned a value of $1 per gallon spilled.

This last item, spill risk, deserves some discussion. The salient points from the team's work were:

1. A risk cost of $1 per gallon spilled was reasonable because recent spill fines in the city were at about that level. The fines were presumed to reflect both the environmental impact of spills and a punitive portion as well, so there was no reason to set a higher cost on spills.
2. Given the probability, likely size, and resulting dollar consequence of spills, PS 64 was currently incurring a risk cost of spills of about $100 thousand annually.
3. The best possible outcome would reduce the annual risk cost by half, or by about $50 thousand. This amount was not very significant in the overall analysis.
4. Any major modifications to PS 64 would increase the risk cost to about $200 thousand a year during the period when the modifications were being made.

Significantly, the team found that the troubles at PS 64 did not, in fact, have great spill risk implications. The excessive O&M costs were far more important. Second, making improvements at the pump station would actually increase spill risk during the time that the improvements were being made. Finally, viewed rationally, spill risk was a relatively minor part of the overall project economics. All of this was somewhat of a revelation because, while there had been a lot of prior discussion over the potential for spills at PS 64, the issue had never been approached rigorously.

On to the analysis. The team used the then-current version of the NNPV Tool, which will look familiar from the previous section of this manual. Here's a portion of the detailed analysis tab for Alternative 2, *Make Pump Station Modifications*. Some potential benefits were identified but not costed (i.e., no values were assigned to these benefits in any year). Notice how the risk cost of spills changes.

The team prepared similar 30-year analyses for the other three surviving alternatives (remember, two alternatives had been found to have fatal flaws). The result was a single time-adjusted life-cycle cost of ownership for each alternative, fully taking environmental risks into account.

	2004	2005	2006	2007	2008	2009	2010	2011
Expressed in 2004 dollars, unescalated								
Capital Outlays:								
Construction								
Electrical Upgrades				750				
HVAC					750			
Wetwell Baffles		100						
Straightening Vanes / Gate Valves		220						
Solid Shafts			325					
Flex Couplings			50					
Facility Automation		200	200					
CONSTRUCTION TOTAL		520	575	750	750			
Project Management (20% of constr)		104	115	150	150			
Design (15% of constr)		78	86	113	113			
Construction Mgmt - City forces (5% of constr)		26	29	38	38			
Construction Mgmt - Consultant (10% of constr)		52	58	75	75			
Contingency (5% of constr)		26	29	38	38			
Total Capital Outlays		**806**	**891**	**1,163**	**1,163**			
Benefits:								
Improved design/technology (seismic)								
Better planning for future flows								
Improve PS Employee Morale								
Total benefits								
Annual Running Costs:								
O&M Pumps (materials/wages/fringe)		500	500	400	300	200	100	100
O&M Facility (materials/wages/fringe)		500	500	500	500	500	500	500
Operational labor (wages/fringe)		50	50	50	50			
Unexpected events		40	40	30	20	10	10	10
Spills/Risk		200	200	200	200	50	50	50
Power								
Total running costs		**1,290**	**1,290**	**1,180**	**1,070**	**760**	**660**	**660**
R&R Costs:								
Total refurbishments								
Net Benefit		**(2,096)**	**(2,181)**	**(2,343)**	**(2,233)**	**(760)**	**(660)**	**(660)**

Figure 8: Partial NPV Tool Data Entry for Alternative 2, PS 64 Analysis

Here are the final results:

	Alternative	Life-cycle costs (NPV)
1	Do Nothing	($34,757,000)
2	Make pump station modifications	($20,538,000)
3	Replace PS 64	($39,854,000)
6	Replace PS 64 and eliminate PS 65	($68,506,000)

Figure 9: Life-cycle Costs for Remaining Alternatives, PS 64 Analysis

Since this was a cost-only BCE, all the NPVs are negative and smaller numbers are better. Interestingly, if the physical modeling exercise had not suggested the specific set of improvements in Alternative 2, the least-cost option would have been to "live with the problems," because the next most attractive remedy, replacing the pump station, was considerably more expensive.

4.5 Recommend and Report

The team summarized its work and made the following recommendation:

> "Alternative 2 is the recommended approach. The wetwell modeling completed for this pump station indicates a significant improvement in pump vibration given a few minor modifications to reduce turbulence in the wetwell. These changes, along with adjustments to the DCS control of the station, should improve both the reliability and the maintenance costs at this pump station. It is by far the most cost effective alternative, with a savings of $14 to $48 million compared to the other alternatives."

The recommendation was approved. The Team's final report can be found in your Asset Management Library.

4.6 Observations on the Team's Work

Every BCE is different and provides different lessons. This one was no exception. The value of the team's work was apparent from several angles:

1. The costing of spill risk, the first-ever effort in this direction by the department, clearly showed the way for further work in this area. It also made the analysis fully quantitative.

2. There was some very interesting "out of the box" thinking, especially in alternatives 4 and 6. The idea of changing most outgoing flow to gravity via tunneling was new and had promise, although anticipated changes elsewhere in the system caused it to be discarded. The concept of rebuilding PS 64 in such a way as to eliminate PS 65 was also new and very interesting. Although the alternative turned out to be too expensive, it might have been otherwise!
3. The ultimate solution did not arise directly from the team's work, but its proposal found an attentive, educated, and engaged audience in the team. Equipped with a full understanding of the PS 64 situation, the team was ready to consider the proposal along with the other alternatives it had defined independently.

In this case, as in others, the BCE approach led to a solution that management could have confidence was the best solution to a problem at the right time.

Note: The following is a draft policy of San Diego's Metropolitan Wastewater Department. It has not been formally approved as of this writing. The Water Department has no formal policy requiring BCEs.

Purpose

This policy describes the organization and processes by which significant projects shall be proposed, evaluated and recommended to the MWWD Director for approval. The intent is to assure informed, effective and efficient decision making relative to planning and committing resources for new or significantly revised projects. It is emphasized that this policy is aimed at value-added organizational thinking and processes that balance the need to generate appropriate information for key resources allocation decisions with the desire to avoid onerous overly bureaucratic dictates that stifle creativity and waste individual and work group time. Refinements are anticipated over time to maintain this purpose.

Basic to the informed decision-making desired is the intent to consider total project costs and benefits in the context of the overall business concerns of the enterprise and its ratepayers. In that vein, the policy incorporates guidelines for use of the Business Case Evaluation (BCE) methodology to analyze life-cycle viability of projects.

Roles and Responsibilities

The **Asset Management Executive Committee** ("the Committee") is hereby chartered to evaluate submitted projects and recommend their disposition to the Director.

- The Assistant Director shall serve as the Committee Chair.
- The Department Asset Manager shall serve as the Committee Vice Chair. (The Vice Chair shall coordinate all administrative functions of the Committee such as assembling and distributing the meeting agenda, coordinating the attendance as desired of Project Proponents or other parties with information relevant to Committee deliberations, and tracking action items.)
- The Committee shall also have as permanent members at least one of the management team from each division except Environmental Monitoring and Technical Support, and Storm Water Pollution Prevention. Managers from these two divisions may attend and fully participate if interested.
- Specific rules for conduct of meetings and deliberations shall be generated by the Committee as desired.

The **Proponent** is any person or organization within the Department proposing to commit resources for a project meeting criterion under Qualifying Projects, below.

The **Technical Reviewer** is any designee (employee, consultant, working group) charged by the Committee to review and validate the correctness and appropriateness of an analysis (such as a BCE) or specific facts and logic pertinent to decision making.

The **Director** shall determine final disposition of each project after consideration of the Committee's recommendations.

Qualifying Projects

Unless specifically exempted from this policy by the Director, all projects meeting any of the criteria below shall be subject to this policy:

- The initial cost estimate is $50,000 or more. (Note: if an ongoing smaller project's subsequently revised total cost estimate through completion exceeds $50,000, the Committee should be notified immediately via memo or e-mail to the Vice Chair.)
- Project complexities, risks, impacts on the overall system, or other factors indicate the need for detailed analysis in the judgment of the Proponent or the Committee.
- The Director requires that the project be subject to this policy.

Key Factors for Recommending Project Approval

The Committee shall consider the factors below in determining recommendations to the Director:

- Safety & health (from inspections, operations & maintenance or engineering observations)
- Regulatory Mandates (from Administrative Orders, etc.)
- System capacity (either current deficiencies or future growth accommodations)
- Asset condition (Repair/Replacement bearing on system reliability)
- Operating efficiency (such as Energy Audit Recommendations)
- Maintenance optimization (not included in Repair/Replacement)
- Aesthetic considerations (from outreach with Community Planning Groups, etc.)

Initial Project Proposal for Consideration

The Proponent shall draft a succinct Project Abstract and submit it to the Committee (via the Asset Manager) at least one week prior to scheduled deliberations.

The Project Abstract is in effect a bare-bones BCE, summarizing the critical thinking that should go into an organizational decision to commit public resources to a project. As such, authors should articulate straight forward, sound rationale for the proposed project. For some projects (i.e., urgent or easily analyzed) it is envisioned that project approval may be recommended directly from a clearly worded, compelling Abstract. While orderly thought and some level of research are needed to produce the Abstract, it is not intended that this one page document be overly time-consuming to produce. In many cases, it is intended that the Abstract be the mechanism to justify the allocation of resources to dedicate additional time to produce a *More Complete BCE* (see below).

The submitted Abstract shall contain acknowledgement of the originating division's Deputy Director. (Signature or forwarding e-mail with comment if desired.)

To streamline Committee processes, it is encouraged that Proponents have informal discussions prior to the meeting with workgroups potentially impacted by the project and be able to summarize these discussions as requested.

The submitted Abstract shall generally not exceed 1 page in length and shall contain:

- A one sentence statement of the issue or problem that the project will address.
- A brief description of the project proposed to address the issue or problem.
- Project benefits in terms of customer service levels or cost reductions relative to the Key Factors for Approval cited above.
- Known alternatives and the relative advantages of the proposed project when compared with those alternatives.
- Other relevant considerations (if any) such as impacts on stakeholders
- The likely Acquisition Cost (through implementation / placement into operational use - range and basis of estimate)
- The likely ongoing annual operating, maintenance, and/or other costs of the project. (range and basis)

Initial Committee Consideration

From the Project Abstract, the Committee shall determine the type and level of further analysis (if any) necessary to properly evaluate the proposed project. The Committee's direction will normally fall into one of the following courses of action:

- Defer further consideration of the proposed project. (With criteria for such reconsideration stated)
- Require preparation of a more complete BCE to facilitate further consideration of the proposed project. (See More Complete BCE's below).
- Recommend to the Director that the project be approved immediately. (With comment as to urgency or sufficiency or justification with the rationale stated in the Abstract)

More Complete BCE's

Where a more complete BCE is required, the Committee shall specify the depth of analysis and effort to be expended, and authorize commensurate allocation of resources, including designation of Technical Reviewers with responsibilities as described below.

In general, the minimum requirement is that the BCE be prepared by the Proponent (or other such person as directed) with sufficient consultation with other staff to ensure the accuracy of the analysis.

For larger or more complex projects, the Committee may direct an in-depth consideration by a cross divisional team of subject matter experts, with or without involvement of outside experts or consultants. Whether or not this is specific direction from the Committee, it is emphasized that one of the intended strengths of a solid BCE is the synergy of a cross functional team that devotes sufficient time and perspective to the process of generating alternative. To the extent practicable, this synergy should be employed.

Where necessary, the Committee shall designate an individual already trained in the BCE process to assist the process.

All BCEs shall be prepared in accordance with the Water/Wastewater BCE Manual.

In all cases, minimum requirements of the BCE shall be:

- A meaningful statement of the problem and description of drivers for the project.
- A comprehensive list (with brief descriptions) of alternatives for addressing the problem, including the "do nothing" alternative.
- A justification for eliminating any alternatives from the detailed analyses.
- Detailed analyses of all surviving alternatives on a life-cycle cost basis to include benefits, costs of ownership, risks, and other relevant factors, all quantified to the extent practicable.
- Final recommendations to the Committee, with any qualifications specified.

BCE Validation

Prior to submitting the BCE to the Committee for final disposition, the proponent shall obtain a signed validation assurance from each Technical Reviewer designated by the Committee. These assurances are designed to make the Committee deliberations efficient and focused on the business impacts of the proposal as opposed to verifying the appropriateness and accuracy of the analysis. The divisions involved in every BCE, and their main areas for review and validation, are:

- Services and Contracts: Correct inflation and discount rates are used. The financial and present value analyses are formally correct, relevant, and complete.
- Engineering and Program Management: All reasonable alternatives are considered. Capital costs of alternatives are conservatively presented and inclusive of appropriate contingencies and associated costs such as legal, permitting, administrative, planning, design, etc. Capital cost risks are presented and adequately dealt with.
- Operations and Maintenance (Operations & Maintenance and/or Wastewater Collection): All reasonable alternatives are considered. Life cycle considerations are comprehensive and accurately costed, reflecting full ongoing costs of ownership. Project cost and other risks are presented and adequately dealt with.

For some projects, the Committee may designate Technical Reviewers outside of these three divisions. (Examples might be requiring a Technical Reviewer in Engineering and Capital Projects if the project is of a type that normally falls within that organization's purview, or requiring a legal Technical Reviewer when there are issues of fines, claims, or interpretation of regulatory mandates.)

If significant uncertainties remain, the Technical Reviewer's validation assurance shall so note and recommend how best to assess them.

Final Consideration

The Committee shall review the completed BCE for the proposed project and recommend one of the following:

- Deny or Defer further consideration of the proposed project, with stated rationale for denial or criteria for further consideration.
- If serious uncertainties remain, require that the BCE be further developed in specific areas to reduce the uncertainties.
- Recommend project approval to the Director (with initiation year specified).

Project Approvals and Associated Coordinations

The Director will receive recommendations from the Committee and make a final determination regarding disposition. The Chair and Vice Chair will work with all divisions to coordinate this process to be the most effective and efficient. (For example, it may be useful to arrange for the Director to attend select Committee meetings to participate in deliberations and provide timely input into the analysis process. Also, it is important that project approvals be synchronized with key analyses for rate setting and debt issuances).

Approved Project Tracking

The Committee shall monitor the progress of previously approved projects for changes in initial cost, projected ongoing ownership costs, technology, potential system impacts, etc. The monitoring shall continue through final bid for construction. Where changes suggest that the conclusions of the most recent BCE may be affected, the Committee shall direct that the BCE be updated or repeated prior to proceeding with the proposed project.

Supporting Activities

The Committee shall take such actions as required to sustain the implementation of this policy, including the assignment of duties to specified individuals, to establish and maintain:

- The Water/Wastewater BCE Manual & related past BCE's as example products.
- A library of prior BCEs and BCE training materials.
- Procedures and standards for estimating capital costs (contingencies, legal costs, administrative costs, etc.) and labor costs (percentages for benefits, overhead, etc.)
- An up-to-date library of cost categories & costs including direct, risk, environmental, and societal costs.
- An ongoing program to train existing and new staff in BCE preparation.

Many BCEs involve analyses involving the cost of new facilities and the need to add or reduce labor effort. This appendix briefly addresses both.

Costing Capital Outlays

Costing major capital works projects is a science familiar to those that do this sort of work everyday. You may need to do this in your own BCE. If so, there are two sources of help:

1. People in the Engineering and Capital Projects (E&CP) Department; and
2. Your own Asset Management Coordinator, who can provide guidance on some of the factors discussed below.

The starting point in most costing situations is the breakdown between land, construction, construction support, and contingencies.

- *Land*—The alternative you are evaluating may or may not require the purchase of land or rights-of-way. If it does, you should discuss the matter with people in E&CP to see how they are currently costing land. Remember also that the land purchase may need to precede actual construction by a year or more; that timing should be reflected in your analysis (see Figure 2 for an example).
- *Construction*—Actual costs of construction should be broken down by major system or even farther if possible. The more detail in your costing, the more confidence your analysis will earn. Again, E&CP can be of great help here.
- *Construction support*—There are quite a few activities that directly support construction. These include final planning, design, construction management, permitting, legal, and possibly other activities as well. Each is typically expressed as a percentage of construction cost (again, see the example at Figure 2). Your Asset Management Coordinator can help you determine the percentages currently used in the department.
- *Contingencies*—A proposed construction project always includes a cost for "contingencies." This is based on the fact that, when the dust settles, you will often find that the project cost more than was anticipated. Contingencies are typically highest (30-50 percent) when the project is at the conceptual stage and are reduced as the project becomes better defined and costs are known in more detail. Again, your Asset Management Coordinator can provide support.

When analyzing larger projects, you may need to consider how their costs will be incurred over a period of several years and reflect this timing in your analysis.

Costing Labor

Defined methods of costing labor, either new or avoided, are less commonly encountered. This appendix discusses the issue briefly.

Labor costs need to be built up from labor hours. Since costs are normally expressed in dollars per year, it helps to understand how many labor hours there are in a year. The example below is based on general experience in the industry.

2,080 hours	Potentially available time (52 weeks X 5 days a week X 8 hours a day)
–120 hours	Subtract three weeks vacation
–96 hours	Subtract 12 holidays and sick days
1,864 hours	Actual work time on department business
–514 hours	Subtract training and other internal activities
1,350 hours	"Attendance hours," available for work orders
70%	Multiply by typical utilization (charged to work orders)
945 hours	Productive time actually working on work orders

Figure 10: Sample Labor Hour Productive Time Analysis

Let's use these hours to determine an actual hourly rate that might be used in a BCE.

Example 11: The real cost of maintenance.

A senior maintenance technician position pays $65,000 a year. Fringe benefits such as health care and retirement average 40 percent of base compensation.

Let's do the numbers. The actual cost to the city of a technician is $65,000 plus 40%, or $91,000.

Dividing by the numbers above, the hourly cost of having the technician available for work orders is $91,000 divided by 1,350, or $67.41 an hour. The hourly cost of actually doing the work is $91,000 divided by 945, or $96.30 an hour.

	$65,000	annual direct salary
add:	26,000	benefits at 40%
	$91,000	total annual cost
divide by:	945	hours spent on work orders
	$96.30	cost per hour of productive work

In a BCE, labor will normally be costed using the higher number, $96.30 an hour. This is because if maintenance requirements are reduced by 945 hours, the need for staffing is reduced by one position. Conversely, if an alternative means that 945 hours are added to maintenance requirements, an additional technician will be needed.

Be aware that the hourly labor rates shown in most city compensation tables are based on full 2,080-hour years and are not suitable for use with BCEs.

How do you determine the base compensation to use? Different people in the same job classifications are paid different wages depending on accomplishments, experience, and seniority. Obviously you don't have specific persons in mind when evaluating additions or reductions in labor requirements.

It is usually safe (and easy) to simply use mid-grade compensation as the basis for costing both new and avoided labor hours. However, there are various exceptions, two of which are:

- *Avoided labor hours*—Due to average high longevity, in many agencies most people are near or at the top of their grades. If this is the case in the situation being addressed by the BCE, then the hours avoided are probably hours now being spent by people at the top of their grade, and the compensation rate should reflect this.
- *New labor hours*—In some cases where new labor hours are necessary, they may be worked by new people who will be paid at mid-grade or even lower. Again, the compensation rate should reflect this if it is the case.

In your BCE, it might be wise to gently remind management that a course of action requiring new labor may not work out unless that labor is indeed supplied through the budgeting and staffing process. Similarly, a course of action based on a benefit of reduced labor will not yield that benefit unless labor actually is reduced through attrition, redirection, or other strategy. It is possible to reduce labor repeatedly and significantly through the BCE process and find, at the end of the day, that you haven't saved your customers any money at all!

The concepts in this appendix are general and the numbers are merely "typical" for the industry. When you need to cost labor, your Asset Management Coordinator can supply you with the right approaches and numbers for your department.

The methods of present value (commonly abbreviated as PV) are used to determine the value of future case flows from today's viewpoint. Although they were originally developed to evaluate the economic feasibility of large infrastructure projects, they migrated to the world of private business and are universally used to determine whether new plants should be built, new stores opened, or similar investments should be made. From a private sector viewpoint, any outlay of funds must provide a return to the owners of the company, typically the shareholders. The required rate of return is defined and called a "discount rate" and used in the PV analysis. If an investment cannot generate this required rate of return, it is usually not made.

With the growth in asset management in the United States, economic analysis is increasing in importance among public sector utilities. And just as in the private sector, the justification of a project is typically made by PV analysis. The discount rate, typically set at the utility's borrowing rate (see the Appendix D for further discussion), is considered the required rate of return of the utility's customers.

PV Basics

Conceptually, PV analysis is simply compound interest analysis seen in reverse. So let's look first at an example of a compound interest calculation.

> ***Example 12: The grasshopper and the ant.***
>
> You have deposited $1,000 in a savings account earning 4 percent annually. How much will you have in the account after ten years?
>
> Let's do the numbers. The formula for the future value (FV) of an amount earning compound interest is:
>
> $$\text{Future value} = \text{Present value} \times (1 + \text{Interest rate})^{\text{Number of years}}$$
>
> Substituting the actual numbers for the elements of the equation:
>
> $$\text{Future value} = \$1{,}000 \times (1 + .04)^{10}$$
>
> After ten years you will have $1,480.24 in your savings account.

Now let's look at exactly the same situation "turned on its head" and see how this investment pencils out if you have a required rate of return of 5.5 percent.

> ***Example 13: A bad investment.***
>
> If you invest $1,000 dollars today, you will receive $1,480.24 ten years from now. Is this a good investment at your required rate of return of 5.5 percent?
>
> Let's do the numbers. The formula for the present value (PV) of a single future cash flow is:
>
> $$\text{Present value} = \frac{\text{Future value}}{(1+k)^{\text{Number of years}}}$$
>
> where k is the required rate of return. Substituting the actual numbers for the elements of the equation:
>
> $$\text{Present value} = \frac{\$1{,}480.24}{(1 + 0.55)^{10}}$$
>
> From this formula, the PV of the future cash flow is $866.58. In other words, you are being asked to invest $1,000 in return for an amount that, today, is worth less to you than $1,000. The investment is not a good one for you.

It is worth noting in this example that if your required rate of return were four percent, the present value of the future cash flow would be $1,000, exactly what you are asked to invest.[1]

The Value of Deferral

One impact of present value analysis is that the benefit of deferring expenditures can be clearly identified. Here's a simplified example, using the PV formula from Example 13.

[1] In any case where the present value of benefits exactly equals the outlay required to earn those benefits, or where the return on investment is exactly equal to our required rate of return (these two are actually the same thing), an economist would say that we are "indifferent" to the investment.

Example 14: In praise of procrastination.

Your department plans to build a new treatment plant for $30 million. It will take two years to build at $15 million a year and will incur running costs of $4 million a year starting in the third year. The start of construction is scheduled for next year, but there is some uncertainty over demand growth and whether the plant might be able to be deferred. What's the value of a one-year deferral in construction at a discount rate of five percent?

Let's do the numbers, considering only the capital costs (all costs in millions):

	No Deferral		Defer One Year	
Year	Outlay	PV	Outlay	PV
1	$15.0	$14.3		
2	$15.0	$13.6	$15.0	$13.6
3			$15.0	$13.0
Total PV		$27.9		$26.6

The value of a one-year deferral of the capital investment only is $27.9 million less $26.6 million, or $1.3 million. A two-year deferral is worth about twice this, or $2.6 million.

A more compete analysis would also consider the deferral of the annual running costs and would yield a higher savings. Doing the same analysis on a 30-year life-cycle basis with the department's NPV Tool and considering the $4 million annual running costs as well as capital outlay, the savings are:

1-year deferral: Savings of $4.8 million

2-year deferral: Savings of $9.3 million

Weighed against these savings, of course, would be the risk costs associated with not having the facility on line when needed.

The concepts used in valuing a deferral of a construction project also apply to valuing the benefit of longer life in an asset. Here's an example, again using the formula from Example 13.

You can see that the PVs get quite small after twenty years or so. When a cost or benefit is far in the future, its value today may become rather insignificant. Your long-lived pump had to struggle a bit to justify itself, even though its useful life was 50 percent longer and its cost was only 20 percent more! If the discount rate used were just one percent higher, the decision would have been a push. And at anything above six percent, the shorter-lived pump would have been preferable.[2]

Example 15: Is longer life worth it?

You need a new pump. You can buy one for $15 thousand that has an expected life of 20 years, or you can spend $18 thousand for a pump with a life of 30 years. Energy and maintenance costs will be the same. If your required rate of return is five percent, which should you buy?

Let's do the numbers. To make things fair we will look at what it takes to get a total pump life of 60 years. The 20-year pump will need to be replaced in years 20 and 40, the 30-year pump in year 30 only. Either way, you will end up in year 60 "even" because you'll need a new pump that year no matter which way you go.

Pump life:	20 years	30 years
Pump cost:	$15,000	$18,000
Year	Replacement cost PVs	
20	$5,653	$0
30	$0	$4,165
40	$2,131	$0
Total PVs	$7,784	$4,165

The PV of future replacement costs of the 30-year pump is $3,619 less than that of the 20-year pump. Since the initial cost is only $3,000 more, the 30-year pump is the better value.

A more direct analysis can be done using Excel's PMT function (see Example 18).

Annuities

Many instances will arise in BCEs where you will need to deal with costs or benefits that are the same year after year. The NPV Tool used by the department can deal with these situations quite well, but sometimes you may want to do a separate calculation of the PV of these "level cash flows."

Streams of identical cash flows for a specific number of periods are called "annuities." Examples might be (inflation not included):

- Reclaimed water sales after a plant is up and running
- Energy costs for a pump or pump station
- Chemicals or labor for a plant or pump station.

In fact, many or perhaps even most of the O&M costs in your BCE analysis will turn out to be annuities.

There are four parameters in any annuity situation. If you know any three, you can solve for the fourth using

[2] This brings up an important point: As interest rates rise, fewer and fewer projects will be justified. This is as true in the public sector (or should be) as in the private. The reason is that, as interest rates rise, the required rate of return goes up as well. And when the required rate of return increases, fewer and fewer projects among the universe of possible projects can generate that rate of return.

Excel's financial functions. Here are the four parameters:

- *Payment* (Excel's 'Pmt')—The amount received or spent each period.
- *Rate of return* (Excel's 'Rate')—The rate of return of the annuity.
- *Number of periods* (Excel's 'Nper')—The number of periods that the Payment is received or spent.
- *Present value* (Excel's 'PV')—The value of the annuity at its commencement.

Let's look at an example.

Example 16: Investing to avoid costs.

A new pump is expected to save $1,000 a year in energy and maintenance costs over its 20-year life. What is the value of those savings today if your required rate of return is 5.5 percent?

Let's do the numbers. You know that the payment (Pmt) is $1,000, the number of periods (Nper) is 20, and the required rate of return (Rate) is 5.5%. You need to solve for the present value (PV), which uses, by more than mere chance, Excel's PV function. Using Excel's help screens, you find that the proper format is **PV(rate,nper,pmt**,fv,type). The last two entries are not in bold so they aren't required (and you can just ignore them here).

So click on a blank cell and type in =PV(.055,20,1000). You hit the return key and see:

-11950.38

The amount looks reasonable, but it's negative. What's up? Excel is simply analyzing the annuity as an investment. It's saying, "A 20-year annuity consisting of inflows of $1,000 a year at a required rate of return of 5.5% is worth the investment (i.e., an outflow) of $11,950.38 today."

To excel, inflows are positive (they add to your checkbook balance) and outflows are negative. They always balance one another in annuity analysis. When you think about it, this makes sense.

In the case at hand, you now know that you are justified in spending up to $11,950 to achieve the savings anticipated from the new pump.

Sometimes you will want to solve an annuity situation for something other than present value. An example might be when we know the cost of something and want to see what kind of savings we will need to justify it. Here's an example.

Similarly, you can solve annuity situations for number of periods (Nper) and required rate of return (Rate) if the other three annuity parameters are known in each case. But first, another PMT example.

Back at Example 15 you looked at whether a 20-year pump or a more expensive 30-year pump was the better value. We will revisit the question here with a simpler and more direct approach, which is simply to

Example 17: Investing for increased sales.

Your department plans an expansion of a reclaimed water plant costing $4 million with a life of 30 years. New running costs of the expansion will be $100 thousand a year. What increase in reclaimed water sales will be needed to justify the expansion if the required rate of return is 4 percent?

Let's do the numbers. You know that the required rate of return (Rate) is 4%, the number of periods (Nper) is 30, and the present value (PV) is -$4 million (remember, this is an investment so it's negative). You need to solve for the payment (Pmt) of the annuity.

Using Excel's help screens, you find that the proper format is **PMT(rate,nper,pv**,fv,type). As before, you ignore the non-bold entries and consider the investment as a negative number since it's an outflow of money. So you click on a blank cell and type in =PV(.04,30,-4000000). You hit the return key and see:

231320.4

So you will need to increase annual water revenues by $231 thousand to justify the $4 million investment. Of course, you need to add in the new $100 thousand running costs as well, so the total water revenue increase needed is $331 thousand a year.

"annualize" the capital cost and see what the yearly equivalent payment would be.

The cost advantage is smaller than might have been expected. Just as in Example 15, any discount rate even fractionally above six percent would have made the shorter-lived pump preferable.

Now let's look at some more annuity situations where you might want to solve for number of periods (Nper) and required rate of return (Rate).

Let's first do an Nper calculation to update Example 7, originally given in Section 2.4 of this manual. You will remember that you calculated the economic frequency of inspecting a sewer pipe. A footnote following Example 7 noted that the analysis did not take into account the time value of money. Here's the example again, this time solved with the time value of money taken into account.

Example 18: Is longer life worth it? (revisited from Example 15)

You need a new pump. You can buy one for $15 thousand that has an expected life of 20 years, or you can spend $18 thousand for a pump with a life of 30 years. Annual energy and maintenance costs will be the same. If your required rate of return is five percent, which should you buy?

Let's do the numbers. You can simplify things compared with Example 15 by asking, "What are we paying for the pump each year?" You can answer this question quickly by using Pmt function **PMT(rate,nper,pv**,fv,type) as in the previous example: For the 20-year pump you type in PMT(.05,20,-15000) and get

1203.64

which is to say, "At my five percent required rate of return, paying $15 thousand today is exactly the same as making 20 annual payments of $1,203.64."

For the 30-year pump you type in PMT(.05,30,-18000) and get

1170.93.

So it's effectively costing you $1,204 annually to pay for the 20-year pump versus $1,171 for the 30-year pump. That's a $33 annual cost advantage for the long-lived pump—not much, but all other things being equal it looks like the 30-year pump is the way to go.

You've now looked at annuities three of four possible ways, so let's try an example of the fourth. Using the Rate function, you can determine whether an asset investment yields your required rate of return.

Example 20: More gas is good!

Your department is considering an upgrade to a digester methane recovery system that will yield additional gas for cogeneration and offset natural gas purchase. The upgrade, which costs $250 thousand, will reduce natural gas purchases by $24 thousand a year (after taking new O&M costs into account) over the 20-year life of the upgrade. Will this investment yield the required rate of return of 5 percent?

Let's do the numbers: You know the annual benefit (payment) of $24 thousand, the number of periods at 20 years, and the present value of the project, a negative (because it's an investment or outflow) of $250 thousand. You need to solve for the rate of return (we'll use Excel's Rate function) and see if it is higher than the required rate of return of 5 percent.

Using Excel's help screens, you find that the proper format is RATE(nper,pmt,pv,fv,type,guess). Ignoring the optional parameters as before, you click on a blank cell and type in =RATE(20,24000,-250000). You hit the return key and see:

.07218

In other words, the return on your investment (or ROI) will be 7.2 percent if everything works out as planned. Since this exceeds your required rate of return, and if there are no serious risk factors left to consider, you will go ahead with the upgrade.

Example 19: How often to clean? (revisited from Example 7)

A 200-foot segment of 8-inch VCP serves the sewer needs of a suburban street. Given its age and past experience, the chance of unexpected failure of this pipe segment within the next ten years is about two percent. Internal and community costs of an unexpected failure of this type of sewer, over and above the cost of a planned replacement, is $50 per foot, or $10,000—and this assumes that the entire segment would need to be replaced. One additional fact not given in Example 7: Your department's required rate of return is three percent. How often should your department CCTV this pipe if CCTV inspection costs $1.25 per foot?

Let's do the numbers: The probability of structural failure of this pipe segment in any one year is 0.1 (once in ten years) times 0.02 (two percent chance), or 0.002. The cost of failure is $10,000. So the risk cost of ownership arising from structural failure is $20 per year.

The cost of averting the unexpected failure is 200 feet times $1.25 per foot or $250. So, using annuity analysis, you need to determine how many annual risks of $20 you need to expose your community to before a $250 investment is justified at the required rate of return of three percent.

Once again using Excel's help screens, you find that the proper format is NPER(rate, pmt, pv, fv, type). So you click on a blank cell and type in =NPER(.03,20,-250). You hit the return key and see:

15.901

In other words, the economic cleaning interval for this low-risk line is about 16 years. This compares with the Example 7 analysis, not taking the time value of money into account, that suggested a 12.5-year interval.

A final thing to note. If you take the cost of money as zero and type in =NPER(0,20,-250), you will get 12.5 years, exactly the answer you got in Example 7.

The discount rate is simply the rate of return required by an investor to justify an investment. For example, if you are happy earning four percent in a bank with an insured deposit, it is unlikely that you will want to invest in a proposition that will yield only three percent.

Discount rates used by public utilities are typically the same as the borrowing rates expected over the next several years. Your Asset Management Coordinator can supply you with the rate currently used by your department

Other Approaches to Discount Rates

Aside from using the long-term cost of borrowing, are other ways to set discount rates:

- Some believe that using a long-term expected borrowing rate is inappropriate because the purpose of present value analysis is to evaluate the worth of an investment *today*, and therefore today's borrowing rate is the only relevant one.
- Others use the opportunity cost of investing in low-risk financial instruments rather than the borrowing rate, because they are using their customers' cash to create new assets when they could be investing it for an assured financial return instead.
- The "textbook" approach, theoretically sound but seldom encountered among public utilities, is to use the weighted cost of capital. For a public utility, this would be a mix of the borrowing rate and the return customers might expect if they rather than the utility were to invest the cash.

In this country, there is no consensus on discount rates in the water and wastewater industry. In fact, many utilities do not use present value analysis at all. Here, however, are some discount rates used by United States utilities known to the author of this manual:

- Orange County Water District (CA)—4.5 percent, based on the current borrowing rate.
- Montecito Sanitary District (CA)—6 percent, based on the expected long-term borrowing rate.
- Dublin San Ramon Services District (CA)—6 percent, based on the expected long-term borrowing rate.
- Metropolitan Water District of Southern California—5.5 percent, based on foregone investment opportunities.
- Massachusetts Water Resources Agency (MWRA)—6 percent, based on the expected long-term borrowing rate.

As can be seen, the rates fall within a very narrow rang, even though they have different bases. The courses of action suggested by BCE analyses are often not particularly sensitive to the discount rate used and will not change even with discount rates well outside this range.

Should Nominal or Real Values be Used?

As a preface to this discussion, there are three possible components to a discount rate: The risk-free cost of money, expected inflation, and a risk premium.

- *Risk-free cost of money*—This is what the cost of borrowing would be in a world where no inflation was expected and for a project that had no risks.
- *Expected inflation*—This is the general rate of inflation (i.e., rise in prices) expected during the period of the analysis.
- *Risk premium*—Many or most projects have some risk, so a risk premium may be used in some cases (see discussion further on).

You may want to consider all three when thinking about discount rates.

Example 21: A life decision.

You want to buy a home. You find that a 30-year fixed rate mortgage will cost you seven percent. This seven percent is simply the lender's required rate of return for a loan to a person with an income and credit profile like yours. Here's how the seven percent might break down:

Risk-free cost of money:	3.5%
Expected inflation:	2.5%
Risk premium:	1.0%
Total mortgage cost:	7.0%

Putting the risk premium aside for the moment, the question is often asked, "Should I use unescalated cash flows (so-called 'real dollars') in my analysis, or should I escalate the case flows ('nominal dollars')?"

In fact, either nominal dollars can be used for each time period and then discounted with a nominal discount rate, including inflation, or real cash flows can be used discounted by a "real" discount rate without inflation. There is no inherent reason to choose one rather than the other as both will provide the about the same answers. The important factor is that real and nominal cash flows and discount rates must never be mixed in one evaluation. Where cash flows are in real or unescalated terms, only the real discount rate should be used. Where nominal or escalated cash flows are used the nominal discount rate must be used.

In fact the White House Office of Management and Budget in Circular No.A94 "Guidelines and Discount Rates for Cost Benefit Analysis" says:

> **Real versus Nominal Discount Rates.** *The proper discount rate to use depends on whether the benefits and costs are measured in real or nominal terms.*
>
> 1. *A real discount rate that has been adjusted to eliminate the effect of expected inflation should be used to discount constant-dollar or real benefits and costs. A real discount rate can be approximated by subtracting expected inflation from a nominal interest rate.*
> 2. *A nominal discount rate that reflects expected inflation should be used to discount nominal benefits and costs. Market interest rates are nominal interest rates in this sense.*

Let's see how significant the difference between real and nominal approaches is by way of an example.

The NPV Tool currently used by the departments will support either approach. If you want to work in real dollars simply enter an inflation-free discount rate (e.g., 3.5%) and an inflation rate of zero. If you prefer nominal dollars, enter a nominal discount rate (e.g., 6%) and inflation at the rate actually expected (e.g., 2.5%).

Your Asset Management Coordinator can supply the best numbers to use in either case.

Example 22: Real versus nominal: Does it matter?

A pump has an energy cost of $1,000 a year. What is the PV of energy costs over ten years? Calculate this using both real and nominal approaches. The real cost of money is 3.5% and expected inflation is 2.5%.

Let's do the numbers. The table below shows both the real and nominal approaches. In the real approach, the energy cost does not escalate and only the real cost of money (3.5%) is used to discount costs. In the nominal approach, the cost of energy escalates at 2.5% annually and the nominal cost of money (real cost plus expected inflation) is used to discount costs.

Real cost of money:		3.50%		3.50%
Inflation:		0.00%		2.50%
Discount rate used:		3.50%		6.00%
	Real		Nominal	
	Amount	PV	Amount	PV
1	$1,000	$966	$1,025	$967
2	$1,000	$934	$1,051	$935
3	$1,000	$902	$1,077	$904
4	$1,000	$871	$1,104	$874
5	$1,000	$842	$1,131	$845
6	$1,000	$814	$1,160	$818
7	$1,000	$786	$1,189	$791
8	$1,000	$759	$1,218	$764
9	$1,000	$734	$1,249	$739
10	$1,000	$709	$1,280	$715
Total PVs:		$8,317		$8,353

The difference is only $36, or about 0.4%. This is insignificant given the usual margins of error in estimating benefits and costs of a project. It is better to concentrate on getting the benefits and costs down accurately than to worry about the "real versus nominal" issue!

Including a Risk Premium in the Discount Rate

Sometimes a risk premium, typically two to four percent, is included in the discount rate to reflect risks of not achieving in full the benefits anticipated. A simple example in everyday life is the risk premium that results in high yields from "junk" bonds. The premium in this case reflects the risk that the borrowing company will be unable to complete repayment on the bonds or that repayment will be materially delayed.

For a public utility project, the risk premium takes in a range of factors that would not normally be covered by project specific contingencies:

- Political stability
- Changes in inflation/cost of capital
- Likelihood of regulation change (environmental, safety)
- Input costs (such as power and materials)

- Impact of changes in technology
- Possibility that labor charges grow faster than inflation
- Capability of management to deliver project on time and budget.

Here's an example of using a risk premium.

Example 23: But will it really work?

The addition of an emergency generator costing $130,000 with a 30-year life should reduce spills at a sewer lift station resulting from power outages during storms. A typical spill is rather large and has a value of $100,000. Power-related spills currently occur about once every ten years; the emergency generator may eliminate such spills entirely. At other stations, however, transfer switch failures and other problems have shown that the emergency generator is not a panacea. Will the generator be justified if your normal discount rate is five percent? With a two percent risk premium? Ignore generator maintenance costs.

Let's do the numbers. You expect that by adding the generator we will avoid a risk cost of spills of $10 thousand a year ($100 thousand divided by ten years). But there is a risk that the benefits (avoided spill costs) will not be totally realized. The table below shows the value of the benefits at your base discount rate of five percent and also at seven percent, which includes the two percent risk premium. Calculations are done with Excel's PV function.

Risk-free discount rate:	5%
Risk premium:	2%
Analysis period:	30
Cost per spill:	$100,000
Interval in years:	10
Annual spill risk cost:	$10,000

	No Risk Premium	With Risk Premium
Discount rate used:	5%	7%
PV of benefits:	$153,725	$124,090

At your no-risk discount rate, the generator is justified since its benefits are greater than its cost. However, if you reflect the risk that the benefits will not be totally realized by adding a risk premium to the discount rate, then the generator's $130 thousand cost is not supported.

You can also address risk by entering a negative percentage value into the "Benefit risk" entry next to this alternative in the department's NPV Tool, which will reduce the $10 thousand benefit. This will likely have the same impact.

If you want to use a risk premium, make sure that it is used *only* when the project is an investment you are making now in order to achieve fully quantified future benefits that you expect to justify the expenditure. This is often not the case as many projects will *not* have fully costed benefits. Two examples:

- Some projects will have well-defined costs and you will be trying to determine if those costs on a present value basis support a "reasonable person" test that they are reasonable when compared with the expected but unquantified benefits. See Examples 2 and 6 in this manual.
- Other projects may be mandated for various reasons, or the risks being addressed are so severe that they need to be addressed even without a quantified estimate of benefits. In this case, the analysis is looking for the lowest life- cycle cost solution.

In either case, if a risk premium is used you will be reducing not future benefits but future costs, just the opposite of the effect you are trying to achieve.

The NPV Tool normally used by the departments supports the use of risk premiums that can be applied to alternatives individually. In most cases, however, risk can be handled better by adjusting the expected costs and benefits on an alternative-by-alternative basis (see discussion in Section 3.2, above).

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Abstract

The Business Case Evaluation (BCE) methodology is a key element of any asset management program. Applied to capital projects, it ensures that a utility has correctly identified the problem and defined an approach to solving it that best serves the customer.

The Sacramento Regional County Sanitation District (SRCSD), a large conveyance and treatment agency in California's Central Valley, recently applied the BCE methodology to two projects, well advanced in design, with a total capital cost of $75 million. One project was deferred, for an immediate capital savings of $60 million and a minimum whole-life present value savings of $12.5 million. The other, described in this paper, was re-defined for a capital savings of $3.5 million and a whole-life present value savings of $7.5 million.

SRCSD is now moving to integrate the BCE into its capital formation process and apply it more broadly within the organization.

Significant capital investments entail ongoing operating and capital costs over many years. Every addition to a utility's plant has an impact on costs and rates that will be felt for a very long time. Thus, it behooves responsible utility managers to make sure that their investments are the right ones, that they are truly needed, and that they benefit the customer. The BCE methodology is designed to those ends.

Background

The Sacramento County Regional County Sanitation District (SRCSD) and County Sanitation District-1 provide wastewater conveyance and treatment to 1.2 million customers in the Sacramento region. Through its benchmarking efforts and a high level assessment of its collection system and treatment plant infrastructure, SRCSD has identified a need to better manage its aging infrastructure in order to make more cost effective use of its available resources. In addition, there is the need to improve decisions regarding asset creation for a capital improvement program estimated at over $1.5 billion.

SRCSD has identified a comprehensive Asset Management Program (AMP) as the most effective and proven means of meeting its stated goals. The first stage of its AMP is the Strategic Planning Phase that was begun in June 2003 with consultant assistance. The Strategic Planning Phase encompasses the training and education of staff, the formation of AM working teams, an assessment of current asset management-related practices, a significant "visioning" process, and ultimately the formation of AM Strategic and Implementation Plans.

As a prelude to the development of the AMP, SRCSD asked its AMP consultants, Brown and Caldwell and Hunter Water Australia, to help staff evaluate two proposed capital projects:

- The **Primary Treatment Reliability Project** (PTRP), a $60 million project involving new primary sedimentation tanks and grit system improvements at the Sacramento Regional Wastewater Treatment Plant; and
- The **Upper Dry Creek Relief Interceptor Project** (UDCRIP), a $14 million project involving a new interceptor and pump station to provide additional conveyance capacity from a suburban area near Sacramento.

The methodology chosen was the Business Case Evaluation (BCE), which is further explored in this paper. The BCE is based on whole-life cost analysis, using present value analysis to "bring back" cost and revenue streams extending over many years to a single equivalent value today.

The results of the two evaluations were more than encouraging:

- Evaluation of the first project (the PTRP) resulted in staff's recommendation that the project be deferred until required by increased flows, resulting in an immediate capital savings of $60 million and an overall whole-life present value savings, worst case (that is, shortest deferral), of about $12.5 million.
- Evaluation of the second project (the UDCRIP) resulted in a reformulation of that project with an immediate capital savings of $3.5 million and a whole-life present value savings of $7.5 million.

This paper limits its scope to the second project for two reasons: (1) Most of the work was performed by SRCSD staff; and (2) the broad range of alternatives put forward and considered illustrates the creativity and fresh approaches that capable utility staff can bring to matters long considered "closed."

SRCSD considers its first two BCEs to have been highly successful. Although SRCSD had regularly done cost analyses of significant projects, these had not typically included a highly structured methodology such as the BCE or reviews by cross-functional teams with the ability to identify and evaluate all possible alternatives.

To complete this introduction, we note that both projects were at the 30% design stage and RFPs for final design were being prepared. Nevertheless, through use of the BCE process, staff was able to recommend the deferral of one project and the reformulation of the other, for an immediate capital savings or deferral of over $60 million and a whole-life present value savings of at least $20 million. Management accepted both recommendations, and so these savings were realized.

Introduction to the Business Case Evaluation

Briefly stated, the Business Case Evaluation (BCE) is a general approach to making asset decisions. Although applied to capital investment decisions in this paper, it is just as appropriate to analysis of maintenance frequencies, eligibility for condition assessment, replace or repair, and other asset decisions that utility personnel face on a day-to-day basis.

From a capital point of view, it is important to understand that a BCE is not performed on a *project*; it is performed on a *problem*. So the BCE proceeds through a series of questions:

First question: What's the problem?

Not necessarily as simple as it sounds, as we will see below.

Second question: What are the alternatives for dealing with this problem?

Assuming we have determined that the problem is real, creativity now comes into play. Again, we will see this below. Also note a very important alternative that is always thrown into the mix: Do nothing.

Third question: How well does each alternative address the problem given the economics, effects on service levels, and risk?

Here, of course, is where the analysis starts. A rule: *Avoid overkill*. Very often, and in both BCEs performed by the Districts, simple economic analysis will yield the proper answer. The BCE can obviously be expanded to be quite comprehensive, but that takes time and resources. *If you want a cost-effective solution, you should also be sensitive to the cost-effectiveness of the analysis.*

Before leaving the subject of the BCE, we want to make four points regarding its use:

1. The BCE is *not* a way to prioritize projects. It is a way to determine if a project is needed or not, and to define the most effective project *from the customer's point of view*. Consistent use of the BCE means the end of "continuation budgeting" for capital. A project is either justified (and should be budgeted) or it is not. The commonly-seen approach of prioritizing projects and cutting the list off at last year's expenditure level no longer applies.
2. While it shares some features in common with value engineering, the BCE is different in several ways: (1) It is normally performed internally as part of normal business processes and is a "businessman's" review rather than an exercise for an "expert"; (2) it always starts from first principles and is always applied to a problem rather than a project; and (3) it is uncompromisingly tied to the customer's interests.
3. The BCE is not a one-time exercise. It is (or should be) performed at several stages in the project development cycle. All utility managers have experienced projects that "took on lives of their own." A continuing BCE program, integrated into the capital formation process, ensures that capital expenditures, as projects change and are refined, remain commensurate with the benefits that they bring to customers.
4. As a utility develops its asset management program, it will find that it needs to define costs

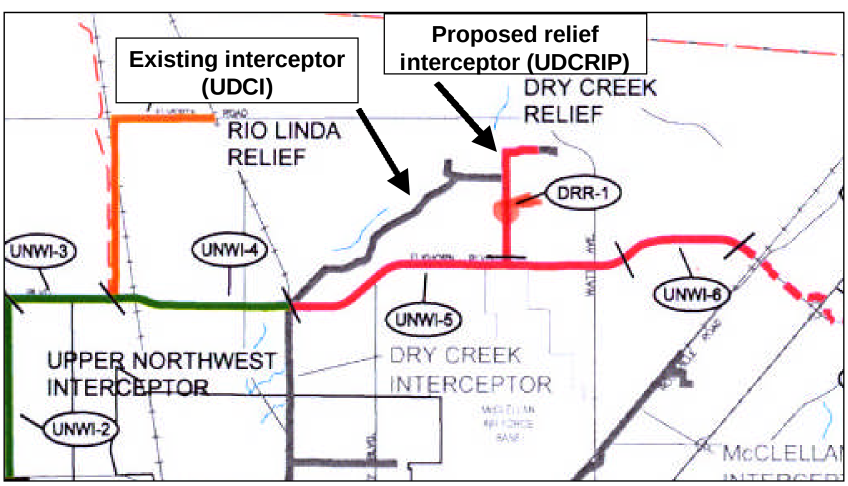
for untoward events such as equipment failures, overflows, and even permit violations. Without knowing these costs, there is not *and never will be* a valid method to determine how much money should be expended to avoid untoward events. As these costs are developed, BCEs become complete benefit/cost analyses where risk costs are fully quantified and risk amelioration costs can be set against the benefits of avoiding the risks. The BCEs described in this paper do not go that far. But they go far enough to support rational decisions that minimize risk and provide benefit to the customer.

Background to the BCE: the UDCRIP

The Upper Dry Creek Relief Interceptor Project (UDCRIP) was intended to add wastewater conveyance capacity to serve a northern Sacramento County Sanitation District #1 (CSD-1) sewershed area termed Dry Creek-11 (DR-11).

The additional capacity was deemed necessary because the existing interceptor serving DR-11 (Upper Dry Creek Interceptor, or UDCI), a 24-inch and 27-inch gravity line, was surcharging on a daily basis with the diurnal peak, a situation exacerbated by periods of heavy rainfall. The problem was expected to grow worse as additional development occurred in DR-11.

The proposed UDCRIP did not parallel the alignment of the existing UDCI but cut south along a shorter path to meet the Upper Northwest Interceptor segment 5 (UNWI-5 in the map below), now in the development stage. The UDCRIP was to be a 36-inch line with a lift station placed midway due to terrain. Both interceptors are shown in the map below.



Locations of the Existing UDCI and Proposed UDCRIP

The UDCRIP, like other alternatives discussed in this paper, was expected to result in sufficient total conveyance capacity to serve DR-11 through ultimate buildout, roughly estimated at 2050.

As noted earlier, the proposed UDCRIP had completed 30% design and an RFP was being prepared for final design, based on the concept of a 36" pipe with a pumping station midway (DRR-1 in the map on the previous page).

The UDCRIP, like other alternatives discussed in this paper, was expected to result in sufficient total conveyance capacity to serve DR-11 through ultimate buildout, roughly estimated at 2050.

Do Our Customers Need this Project?

SRCSD assembled a Business Case Evaluation Team (the Team) to examine the drivers for the UDCRIP and to determine if there were other alternatives that met project needs while being less expensive, in terms of whole-life costs of ownership, or were more effective in other ways.

The Team first addressed the underlying problem, or the need for the project. The Team quickly determined that not only was the existing UDCI surcharging in heavy rains, but that the surcharging was contributing to upstream overflows that had been observed by field personnel. Possible future consequences of these overflows included fines and a worsened regulatory climate for SRCSD.

Although SRCSD did not have a formal policy regarding overflows, the Team believed that failing to prevent them, when avoidable, did not meet reasonable customer service standards. Further, such overflows might be construed as violations of the Clean Water Act, resulting in fines or other enforcement actions.

In summary, the Team determined that not responding to the situation that created the impetus for the UDCRIP was not a viable option for SRCSD. The surcharging and overflows were not acceptable in terms of the levels of service that the Team presumed SRCSD was committed to providing its member agencies.

Alternative Approaches to Solving the Problem

The Team ultimately defined *no fewer than fifteen alternatives* to address the identified customer service problem, including the currently planned UDCRIP, and subjected seven to detailed quantitative examination.

The fifteen alternatives fell into five classes, numbered to correspond to the subsections in the Team's final report. Those that were deemed worthy of quantitative analysis are so identified below; others were determined to have "fatal flaws" early in the examination process and were not analyzed for life cycle cost of ownership.

A listing of all the alternatives follows:

- *Non-construction alternatives*—approaches to solving the problem that did not involve capital outlays.
  - Alternative 3-1 – Do nothing (fatal flaw)
  - Alternative 3-2 – Dry Creek connection moratorium (fatal flaw)
- *Use current UDCI alignment*—primarily approaches that did not require a new alignment and optimized capacity in the existing alignment.
  - Alternative 4-1 – Reduce Dry Creek infiltration and inflow (fatal flaw)
  - Alternative 4-2 – Parallel existing interceptor with gravity pipe (fatal flaw)
  - Alternative 4-3 – Expand diameter of current interceptor, bursting (fatal flaw)
  - Alternative 4-4 – Convert UDCI to force main (examined)
- *Use proposed UDCRIP alignment*—approaches using the proposed UDCRIP alignment.
  - Alternative 5-1 – Pipe plus lift station, as planned (base case—examined)
  - Alternative 5-2 – Redefine current project as gravity pipe (examined)
- *Peak-shaving storage*—using the disused Highlands Wastewater Treatment Plant, obviating the need for increased conveyance capacity.
  - Alternative 6-1 – Storage capacity to 2010 (fatal flaw)
  - Alternative 6-2 – Sub-grade storage to 2050 (examined)
  - Alternative 6-3 – Above-grade storage to 2050 (examined)
  - Alternative 6-4 – Above-grade storage, phased capacity (examined)
- *Upstream treatment and reclaimed water sales*—another form of "scalping" but with beneficial reuse of flows.
  - Alternative 7-1 – Reclamation for landscape irrigation, winter storage (fatal flaw)
  - Alternative 7-2 – Reclamation for landscape irrigation, winter surface discharge (fatal flaw)
  - Alternative 7-3 – Reclamation for year-round industrial end users (examined)

Several of these alternatives showed great creativity and promise. Of particular note were:

- *Alternative 4-3:* This involved **large-diameter pipe bursting**, a newer technology with a short track record. The Team ultimately decided that the technical risks in this approach were too great, especially since there were more economically promising alternatives.
- *Alternative 4-4:* Here the concept was to **slipline the existing interceptor** and built a small pump station to turn it into a force main, increasing conveyance capacity. Even though closer investigation showed that three separate pump stations would be required, this alternative retained its attraction and its economics were analyzed.
- *Alternative 5-2:* Upon investigating the proposed UDCRIP, the Team decided to examine whether **lowering the receiving interceptor** somewhat might eliminate the need for a pump station entirely.
- *Alternative 6 (all):* The Team considered several configurations and phasings for **interim peak-shaving storage** above the existing interceptor. A disused treatment plant was available that could provide siting for pumping facilities and either sub-grade or above-grade storage. These alternatives appeared quite attractive economically.
- *Alternative 7 (all):* **Beneficial reuse** was considered in the same light, as a way to reduce peak flows and obviate the need for increased conveyance capacity.

For those alternatives deemed worthy of quantitative examination, the methodology was:

- Estimate the alternative's capital cost and the year the alternative could most likely be placed in service. Some alternatives involved phased investment, so the years and costs of subsequent phases were estimated as well.
- Estimate the annual running costs of the alternative, by year, from start-up through the year 2052. For alternatives involving pumping or phased investment, these costs typically increased over the fifty-year period due to anticipated increases in sewage flow. The fifty-year period (2003 through 2052) was chosen because the various alternatives had differing cost patterns related to flow increases, which were expected to stabilize at build-out in 2050. Thus the fifty-year period ensured that all the alternatives were viewed on an equal basis.
- Define likely types of capital reinvestment (refurbishment) needed periodically by the alternative. These activities, such as tank coating or major pump repair, are distinct from annual running costs in that they are normally assigned to the capital budget and take place at intervals longer than a year. For each type of refurbishment, estimate the cost and typical interval in years
- For alternatives with ancillary benefits other than meeting basic project needs, estimate the dollar values of these benefits from start-up through the year 2052 (applied only to beneficial reuse alternatives).
- Since the above estimates were made in year 2003 dollars, escalate all costs and benefits to reflect the effects of inflation (three percent was used in this analysis).
- Calculate, for each year, the net ownership costs—capital investment plus annual running costs plus capital reinvestment minus ancillary benefits (if any).
- Discount the net annual ownership costs to year 2003 dollars at a rate of five percent, approximately equal to District's borrowing cost, to yield a single net present value of lifecycle ownership costs. Net present value is the accepted method of evaluating future costs and benefits, when expressed in dollar terms, from the standpoint of the present.
- Review project risks in qualitative terms to indicate the directions for further analysis of the alternative prior to making a final decision.

With respect to the risk review, the Team classified possible risks of each alternative examined into five categories:

- **Technical risk** – Alternative won't work, or won't work sufficiently well.
- **Customer service risk** – Alternative won't totally solve the problem, or it may create new problems (spills, odors, etc.).
- **Capital cost risk** – Alternative will cost more to implement than expected.
- **Running cost risk** – Alternative will cost more to own after construction than expected.
- **Benefit risk** – Alternative won't fully achieve planned ancillary benefits (applicable to Alternative 7-3, industrial reclaimed water, only).

A more sophisticated BCE might have quantified these risks in terms of *risk costs*, or that portion of asset ownership costs representing the probability and consequence of undesired events or outcomes. However, since SRCSD had not yet developed the necessary background to do this, each alternative was evaluated numerically in the five risk areas, and the risk profile of each approach was considered qualitatively rather than quantitatively.

This did not turn out to be a drawback since the economically preferred alternative (see below) was also, intuitively, the lowest risk alternative.

To perform the whole-life cost analysis, the Team used a template developed for this project. The template discounted annual ownership costs through the year 2052 back to a year 2003 basis so that the present values of the whole-life costs of the alternatives could be compared. A small portion of the template is shown in the figure below.

From Summary Sheet:

Year of analysis	2003
Escalation rate	3%
Discount rate	5%

Analysis Parameters

Sensitivity analysis (+/- percent):

Capital cost	
M&O cost	
Benefits	

Risk Factors

Expressed in 2003 dollars, unescalated

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Facility Costs				13,836							
O&M Costs:											
M&O					74	74	74	74	74	74	74
Power					1	1	1	1	2	2	2
Chemicals					7	7	7	7	9	9	9
Compliance monitoring					4	4	4	4	4	4	4
Unexpected events					10	10	10	10	10	10	10
Other											
Other											
Other											
Total O&M					96	96	96	96	99	99	99
Refurbishments:											
Pump refurbishment							10			10	
Site maintenance											
Other											
Other											
Other											
Total refurbishments							10			10	
Total costs				13,836	96	96	106	96	99	109	99

Capital Cost

Annual Running Costs

Capital Refurbishments

Template (small portion) used in Whole-life Cost Analysis

In the view of the Team, the alternative with the lowest net present value of whole-life ownership costs, if it otherwise met service requirements and did not entail undue risk or have other adverse impacts, would be the best solution to the problem because it met the needs of SRCSD's customers' needs in the most cost-effective manner.

Results of the Analysis

The results are shown in the figure below. Alternative 5-1 is the base-case UDCRIP project as originally planned, so the present values of the whole-life costs of the other alternatives are compared with that alternative.

Some observations on this analysis:

- As expected, the beneficial reuse alternative fared poorly because of the high capital and running costs. Since SRCSD is only in the initial stages of formulating its beneficial reuse plans, the Team did not believe the time was right to judge that the high costs were worth the social and other unquantified benefits that might be gained.
- Of the remaining alternatives, *all* were at least as economical as the UDCRIP as currently defined. In fact, four of the alternatives were clearly preferable on economic grounds.

Sacramento Regional County Sanitation District
Upper Dry Creek Relief Interceptor Project
Life Cycle Alternative Cost Analysis
Summary of Alternatives

Alternative	Name	Year in Service	Capital Cost (thousands)	50-yr NPV (thousands)	Savings over 5-1
Use Current UDCI Alignment:					
4-4	Convert Existing Interceptor to Force Main	2009	$14,745	$17,611	0%
Use Proposed UDCRIP Alignment:					
5-1	Currently Planned Interceptor and Lift Station	2007	$13,836	$17,524	0%
5-2	Currently Planned Alignment, Gravity Flow	2006	$10,418	$10,030	43%
Peak-shaving Storage at Highlands WWTP:					
6-2	Off-line Peak Storage, Sub-grade Basin	2008	$8,979	$16,468	6%
6-3	Off-line Peak Storage, Above-grade Tanks	2008	$9,622	$15,722	10%
6-4	Off-line Peak Storage, Phased Above-grade Tanks	2008	$9,709	$15,005	14%
Upstream Treatment and Reclaimed Water Sales					
7-3	Industrial Reclaimed Water	2010	$35,206	$32,082	-83%

Summary of Alternatives and Costs

- This BCE did *not* select the alternative with the lowest capital cost. Three alternatives had lower initial costs than the alternative with the lowest whole-life cost.
- Alternative 5-2 was the clear winner. This alternative involved lowering the receiving interceptor and removing the pumping station from the design, but still used the planned UDCRIP alignment and kept the 36" pipe intact. The present value of its whole-life costs was a *full 43 percent lower* than the UDCRIP as originally planned.
- Also in Alternative 5-2's favor were two additional factors: (1) The project risk signature was improved because of the elimination of the pumping station; and (2) the project could be put into place a year earlier, thus more quickly solving what the Team had determined was a serious customer service problem.

The Team recommended that the UDCRIP project be redefined in this manner, and management accepted the recommendation. Thus, SRCSD's BCE Team saved the District's customers over $3.4 million in up-front capital cost, saved about $7.5 million in whole-life costs on a present value basis, and solved a real customer service problem more quickly and with lower risk.

SRCSD has since applied the BCE methodology to other projects. As part of its asset management program development, it has also established a CIP Team charged with preparing the procedures necessary to integrate the BCE into its overall capital formation process.

Lessons Learned

1. The BCE, although time consuming, can be a high-value exercise. In SRCSD's case, best estimates are that the total cost of the first two BCEs was about $150 thousand in consultant and staff time. However, present value savings (and these are real savings, just as surely as if a check had come in the mail) were *at a minimum* $20 million, and will be much more if the larger project, the PTRP, can be deferred longer than expected. Thus the payback on the resources expended was at least 130 to one.

   SRCSD's future BCEs will be far more economical to undertake since the methodology is now understood and accepted, templates have been prepared, and the library of running costs has been partially developed.
2. An agency should not be wedded to a project even though identified in the master planning process. Situations, costs, technologies, demand, and the surrounding infrastructure are all subject to change. This is why the BCE should be performed at various stages in project development. Possible BCE points for major projects might be during the master plan, prior to pre-design, prior to design, and even after the bid in case costs have moved the wrong way.
3. Projects change and mutate. They often grow more expensive due to "scope creep" and other factors to the extent that they may bear little resemblance to what was originally envisioned. The BCE, if applied programmatically, can place a reliable control over project growth.
4. Quantification of project risks and social costs can be difficult, but the benefits of a newly considered alternative may be so great as to overshadow other non-financial factors. In many cases, the BCE will be very simple as a result.
5. BCEs can have major financial benefits and can also improve levels of service provided customers. Agencies should include their communications and media officers on BCE teams to ensure that customer considerations are fully taken into account and that effective communication takes place.
6. O&M personnel can make particularly valuable contributions to BCEs. They know what things cost, what works and what doesn't, and what assets cost to own (not just to build). Bringing O&M and engineering staff together in a BCE work environment adds a new and valuable dimension to the capital formation process.
7. There is a vast reservoir of knowledge among utility staff that may not be effectively tapped during consultant work on facilities and master plans. As a result, these plans may be less valuable than might be desired. *Considerably* increased staff participation in the capital planning process should be considered. This may not make planning exercises cheaper; but it will certainly improve the quality of planning and will help make sure that the CIP, where the *real* money is spent, is cost effective. This will be particularly true if a proven structure, such as the BCE, is used to facilitate staff participation.

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