Business Case:
UV Facility – Backup Generator

Eric Brainich
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Background

The Portland Water Bureau is currently working on the design for a new Ultra Violet (UV) Treatment Facility and the Bureau's Headworks Site within the Bull Run (BR) watershed. This new UV Facility will enable the Water Bureau to meet EPA cryptosporidium treatment requirements for its BR water supply.

The Headworks facility is in a remote location with a single feed power line. Power outages are frequent with supply interruptions of from seconds up to many hours occurring multiple times a year. Recent data show in a year's period there were four power outages up to 4 hours long each and another six power outages ranging from 5 to 14 hours. Outages lasting more than one day are much rarer. Data from Headworks for the past two years:

Table 1: Count of power outages > 1hour at Headworks

Duration	Annual Avg. (2009-2010)
1 to 4 hours	4
4 to 8 hours	2
8 to 24 hours	4
25 hours to 72 hours	0 (eight in the last 16 years)
> 72 hours	0 (three in last 16 years)

The Black and Veatch and Carollo study on Electrical Power Requirements (Technical Memorandum No. 3, November 23, 2010) states "in the past decade, PWB reported significant power outages at Headworks; some occurrences lasted for several days". The study also noted that "although 2009 was statistically a good year without power outages [*sic*], the PGE standard indicates outages could actually be much worse". PGE data for outages at Dunn's Corner show that the total outages, outages per customer and total duration of outages was actually less in 2008 and 2007 compared with 2009. However, the 6 miles of power line from Dunn's Corner to Headworks is vulnerable to outages (see section 2.2 of Technical Memorandum No. 3).

The UV Facility is required to have one back up generator. A 1,000-KW generator that would supply full capacity to the UV facility, and building costs $370,000. The annual maintenance cost is estimated at $1,500 and fuel estimates of $6,500 per year (running 70 hours per year including weekly exercise runs of 1 hour) for a life-cycle present value (PV, 3%, 50 years) of $206,000. This business case does a risk cost analysis to determine whether a second backup generator for the UV plant is warranted. Although there is a portable generator that can run the UV facility located at the Sandy River Station, this business case does not take into account the availability of that extra generator.

In addition to Bull Run, Groundwater Pump Station can supply up to 105 MGD (periods of less than 30 days). Therefore supply will be interrupted by electrical outages at Headworks only if all three of the following occur simultaneously:

1. Electricity supply to Headworks is disrupted,
2. The backup generator fails to start during the electricity supply outage period,
3. GWPS is unavailable.

Risk Analysis

For this report the risk analysis is defined as:

Probability of a Power Supply Interruption X *Consequence of the Power Outage*

The probabilities of a power outage to Headworks combined with the failure of the backup generator *and* an outage at GWPS vary depending on the length of the outage. Also, outages of different durations will have different consequences as defined below:

Duration of outage	Consequence
1 hour to 24 hours	$20,000 Regulations allow for water supply to be 5% of specification (off spec) during a calendar month. While this is roughly 1.5 days it is questionable if regulators would allow this all to occur in a single block of time. Therefore, we assume that up to 24 hour supply outage due to power interruption the Bureau would continue supply BR water without UV treatment but would prepare for emergency at a cost of $20,000 as a negative impact on the operations at Headworks. No health impacts on customers are assumed.
25 hours to 72 hours	$12.5 million The Bureau would supply non-treated BR water up to 24 hours. After that there is roughly 1.5 days of available storage during winter demand. During this period the Bureau would implement emergency contingencies as per the Water Management & Conservation Plan: voluntary curtailment, supply supplements from Clackamas River and Milwaukee, and wholesale offloads. These contingencies could save up to 24 MGD and delay further, more severe actions. Voluntary curtailments have a negative impact on customers and if we place a value of $20 per customer per day and add the cost of supply supplements and offload revenue loss, the sum of impacts is $12.5 million.

Duration of outage	Consequence
> 72 hours	$25.8 million for the time beyond 72 hours $38.3 million for the entire period including the time up to 72 hours Outages > 72 hours would result in the Bureau issuing a boil water notification while still supplying BR water but without UV treatment. A social cost that our customers bear due to the notification is valued at of $100 per customer (a value used by Seattle Public Utilities) times the number of customers (including customers from our wholesale clients without alternate supplies) and added an additional $5 million for lost revenue and costs to restaurants suppliers of fresh produce. The impact of an outage > 72 hours is estimated at $25.8 million. For the total impact of a duration > 72 hours we also must add the cost of the impact from the periods up to 72 hours ($12.5 million see above) for a total impact of $38.3 million.

Power outages: The probability of outages estimates the likelihood of a power outage at Headworks combined with the backup UV generator not working and GWPS being unavailable. This probability analysis does not take into account the available generator located at Sandy River Station which could be transported to Headworks in an emergency. Even if the roads were un-passable during a severe storm, clearing the road is a priority at Sandy River Station and their worst case scenario is clearing the road in 12 hours or less.

Predicting future outages at Headworks was estimated using limited historical data (see Background section above) and interviews with Headworks and UV Team staff. Since future outages are hard to predict, a sensitivity analysis will be done in the benefit-cost analysis section in order to understand how the final B/C ratio is impacted with changes to the frequency of power outages.

The Black & Veatch / Carollo report cites IEEE data indicating that a generator will fail 0.4% of the time[1]. Table 2 shows our estimate of the frequency of power outages and their duration and also the probability of outages occurring when the generator fails.

Table 2: Headworks (HW) electrical power outage frequency estimate and combined power outage and generator start failure frequencies

	Outage recurrence (years)	
Duration of power outage	HW power outage only	Power outage and generator start failure
1 hour to 24 hours	10 times/year	13
25 hours to 72 hours	2 years	500
> 72 hours	10 years	2,500

[1] Based on IEEE 493 Electrical System Reliability estimates. This information does not state, however, if the generator failed if it could be repaired in time for the Bureau to avoid any of the higher consequences, i.e. repaired in 1 to 3 days time. Conversation with Tim Grandle indicated that when their generators fail they have always been able to make repairs and get them running again.

The outages that are most consequential (see below) are those that are more than 24 hour long. From our assumptions of power outages at Headworks in Table 2 above, the frequency of having an outage longer than 24 hours is once every 1.6 years (the sum of the 25 to 72 hour and > 72 hour probabilities).

If a second back-up generator is purchased for the UV facility then the probability that both of the generators would fail is 0.0016% of the time ($0.4\%^2$). This business case analyzes the net change in risk cost from having one generator (0.4% failure probability) to having two generators (0.0016% probability that both generators fail) at the UV facility.

The third part of the probability equation is that the power outage and generator failure occur at a time when GWPS is not available. Since the outages are most likely to occur when demands are lower (October to May), GWPS has enough capacity to supply retail and wholesale off peak demands.

The business case for the GWPS backup generator and transformer used data from the System Vulnerability Assessment report to determine outage scenarios and probabilities. For a mechanical/electric failure and/or an intentional act the combined recurrence is 300 years.

For the storms that cause power outages at Headworks we construct a probability that the same storm would cause a similar outage to GWPS. We assume that larger storms have a greater chance of causing a power outage at both Headworks and GWPS. A similar probability of an earthquake causing a power outage at Headworks and causing GWPS to be out of service is derived with longer outages being more probable. The power outage duration and the likelihood that a storm or earthquake would cause service interruptions at Headworks and GWPS is given in Table 3 below:

Table 3: Probabilities that a storm or earthquake caused power outage at Headworks will also cause GWPS to be out of service

Power outage duration	Storm caused	Earthquake
One to 24 hours	5%	10%
25 to 72 hours	20%	35%
> 72 hours	33%	55%

Note that the probabilities of an outage at both facilities due to an earthquake sum to 100% which assumes there would always be outages at both Headworks and GWPS during an earthquake *and* that there would be no other supply interruption that would last longer than the power outage at Headworks and/or the GWPS outage during an earthquake. In reality, an earthquake may break conduits and cause other supply interruptions that could outlast our above scenarios in duration. This assumption makes the probability estimate conservative, i.e. would increase the benefit-cost ratio and favor a second backup generator.

With the above assumptions, the likelihood of a power outage at Headworks with a single backup generator failing at the same time that GWPS is out of service would occur every 370 years (for outages 1 hour or greater). For the more consequential outages that last more than 24 hours the return period is every 1,700 years.

Benefit-Cost Ratio

The "best estimate" for the risk cost reduction is probabilities and consequences as outlined above. Table 3 shows the consequences and risk reduction when a second backup generator is added at the UV facility.

Table 4: Benefit-cost analysis using the best estimate of probability and consequence of power outages

Electrical Outage at HW	Consequence	Annual risk decrease	Annual risk cost decrease	PV; 50 yrs, 3%
Outage 1 - 24 hours	$20,000	0.00213	$43	$1,095
Outage 25 - 72 hours	$12,500,000	0.00042	$5,237	$134,735
Outage > 72 hours	$38,300,000	0.00015	$5,925	$152,449
PV Risk Cost Reduction				***$288,279***
Cost of second generator				$370,000
PV life-cycle O&M (3%, 50 year, $7,000/yr)				$206,000
Total life-cycle cost of 2nd backup generator				***$576,000***
Benefit-Cost Ratio				**0.50**

The benefit-cost ratio of 0.50 uses the "best" estimates on probabilities and consequences. The outages up to 24 hours have a low risk cost because Bull Run supply can be run off specification for up to 1.5 days per calendar month. The reduction in risk costs from a second backup generator is driven by the outages that are from 24 to 72 hours and > 72 hours because in the former the Bureau would implement emergency contingencies and in the later the Bureau would issue a boil water notice.

A sensitivity analysis was performed on the probabilities of the longer outages. In the case of 24 to 72 hour outages there would need to be an increase of 7% in the frequency of these events from the historical averages in order to get a B/C ratio of 1.0. For outages > 72 hours there would need to be an increase of 36% over their historical averages in order to get a B/C of 1.0.

Summary and Recommendations

The benefit-cost ratio of using the "best estimates" on probability and consequence result in a benefit-cost ratio of 0.50. This is based on having outages of 24 hours or more at Headworks once every 1.6 years. If we increase the likely of these estimates to a 24 hour outage or more every year then the B/C ratio is just above 1.0, being on the cusp of a recommended second backup generator or not.

Several factors in the analysis are on the conservative side and relaxing these assumptions would drive down the B/C ratio. These assumptions and issues include:

- There is a backup generator at Sandy River Station that can be deployed to the UV facility that was not considered in the analysis. Clearing the road in a storm is priority and worst case storm scenario the road should be cleared in 12 hours,
- The 0.4% generator failures do not indicate if these failures were repairable or if it was a total generator failure that would require a replacement. If the generator failed to start and was repaired in less than 24 hour there would be no impact on supply,
- The SPU Economist who led their group in a boil water notification valuation said that there were several in the group who thought the $100 per customer valuation was high. The $25 million estimate for the boil water notification is also on the high end of the CLEM consequence value range for a boil water notification for the entire city (it would be on the upper end of tier 4 which ranges from $10 to $30 million in consequences),
- The risk cost of an earthquake was assumed to take out power supply only to the UV plant and GWPS and that no other supply interruption would last longer than the power outage to the UV facility. In reality, other supply system assets might be damaged for longer periods making power restoration inconsequential in risk cost,
- There could be a scenario in which PGE knew they would not get power to Headworks within 72 hours. In that case, the Bureau would not have its customers go through a curtailment before a boil water notification but rather issue the boil water notification after 24 hours of outages. In this case the $12.5 million impact on our customers of the curtailments and other emergency impacts in the first 72 hours would be removed from the total consequence and reduce the overall risk cost, thus reducing the B/C ratio for a second backup generator.

While the consequence is very high, up to $35 million for longer outages, the risk cost does not justify the expense of $370,000 capital plus a $206,000 life cycle O&M costs for an extra generator due to the low probability of occurrence.

Based on the economic analysis the recommendation is:

- No 2nd generator for the UV facility,
- Develop standard operating procedures for the UV facility for scenarios of a power outage when the backup generator fails. The SOP should include scenarios with and without GWPS available and with and without communications (i.e. fiber optic and microwave).